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Local Renewable Energy Report for CleanPowerSF

March 2020

Contents

1. Executive Summary

1.1 Background

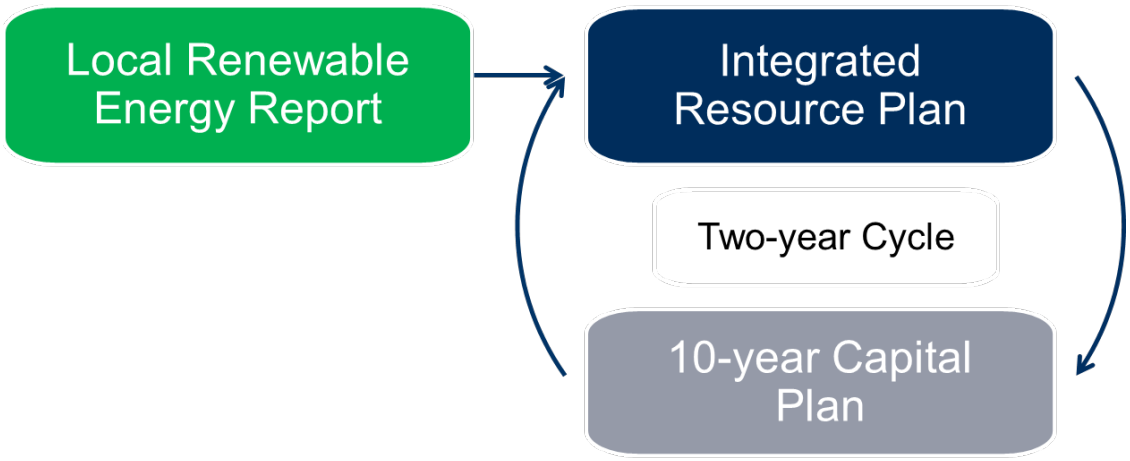
SFPUC Power Staff ("Power Staff") prepared this report on the development of local renewable energy facilities as part of CleanPowerSF's 2020 Integrated Resource Plan (IRP) and in response to Resolution No. 99-19, *Urging San Francisco Public Utilities Commission to Report on a Plan for Building Renewable Power Facilities on City-Owned Property.*[1] Resolution 99-19 urges the SFPUC to "develop a plan for the City to acquire and build cost-effective renewable energy resources on City-owned property without increasing costs to ratepayers, by 2030."

To prepare this Local Renewable Energy Report, Power Staff engaged with consultants, other City departments, and renewable energy project developers to evaluate opportunities to develop renewable energy projects on City-owned property and within and near the City and County of San Francisco.

Power Staff prepared the Local Renewable Energy Report as part of CleanPowerSF's IRP process, which it is required to prepare every two years under state law. The IRP charts a course for CleanPowerSF by forecasting the program's electricity demand 20 years into the future and evaluating the electricity resource options available to reliably and cost-effectively support that demand while also meeting the City's renewable and clean energy goals. CleanPowerSF's 2020 IRP must be submitted to the California Public Utilities Commission (CPUC) on May 1, 2020.

The Local Renewable Energy Report and IRP will also inform CleanPowerSF's first 10-year Capital Plan, which will be submitted for approval as part of the Fiscal Year 2020-21 and 2021-2022 City capital planning cycle to provide funding for new local renewable energy projects and programs. Consistent with State law, CleanPowerSF's IRP will be refreshed biennially, providing the City with the opportunity to evaluate new energy demand trends and incorporate new renewable energy supply opportunities as they emerge. Figure 1 below illustrates this biennial process.

Figure 1. IRP and 10-year Capital Planning Process



[1] For more information see: https://sfbos.org/sites/default/files/r0099-19.pdf (accessed on March 10, 2020)

This report is the result of a comprehensive analysis of potential cost-effective renewable energy projects that could be developed in the next 5 to 10 years on City-owned properties within San Francisco ("In-City, City-owned Sites") to supply the CleanPowerSF program. The report also identifies potential projects on regional sites outside of San Francisco that are within the SFPUC's service area ("Regional City-owned Sites"). Finally, the report assesses other renewable energy development opportunities within or near San Francisco, including opportunities to develop projects on public and private property by offering a Feed-in Tariff and other programs targeted at serving Disadvantaged Communities.

The projects featured in this report are the most cost-effective and feasible projects identified by Power Staff and consultants to date. The results will be incorporated into CleanPowerSF's IRP process to support the identification of a "preferred portfolio" of electricity supply resources to serve customer demand. The analysis of local project power generation and costs developed in this report and the integrated portfolio-level impacts that will be assessed in CleanPowerSF's IRP will help inform decisions that balance the affordability and local investment goals established by the SFPUC, the Mayor and the Board of Supervisors, and outlined in CleanPowerSF's 2015 Business Plan and 2017 Growth Plan.

1.2 Local Renewable Energy Analysis

The analysis presented in this report has been conducted from the perspective of the CleanPowerSF program, San Francisco's community choice aggregation (CCA) program. One of the SFPUC's two electric service programs, CleanPowerSF provides electric generation services to residents and businesses within the City and County of San Francisco that receive retail electric distribution service from Pacific Gas and Electric Company, the investor owned utility operating within San Francisco. Hetch Hetchy Power, the other electric service program operated by the SFPUC, is San Francisco's locally owned public power utility, providing full retail electricity service to municipal load and large commercial and real estate developments.

Under the Hetch Hetchy Power program, the SFPUC has developed a total of 23 solar PV projects throughout San Francisco. These projects total 3.25 MW of City-owned renewable power generating capacity and 5 MW of third-party owned capacity coming from the Sunset Reservoir project. Together the projects generate approximately 8,620 megawatt-hours (MWh) of renewable energy per year. The SFPUC estimates that it has invested approximately $27 million to develop the City-owned projects. Hetch Hetchy Power currently has 1.5 MW of additional planned solar PV capacity for development across nine project locations in San Francisco. The SFPUC is planning to include two battery storage projects representing 750 kW of energy storage capacity at these Hetch Hetchy Power sites.

For purposes of power supply, CleanPowerSF has defined its local area as the nine Bay Area counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma). While CleanPowerSF aims to prioritize projects in San Francisco, the greater Bay Area can provide opportunities to develop utility scale projects at a much lower cost to ratepayers while still generating valuable economic investment in the region.

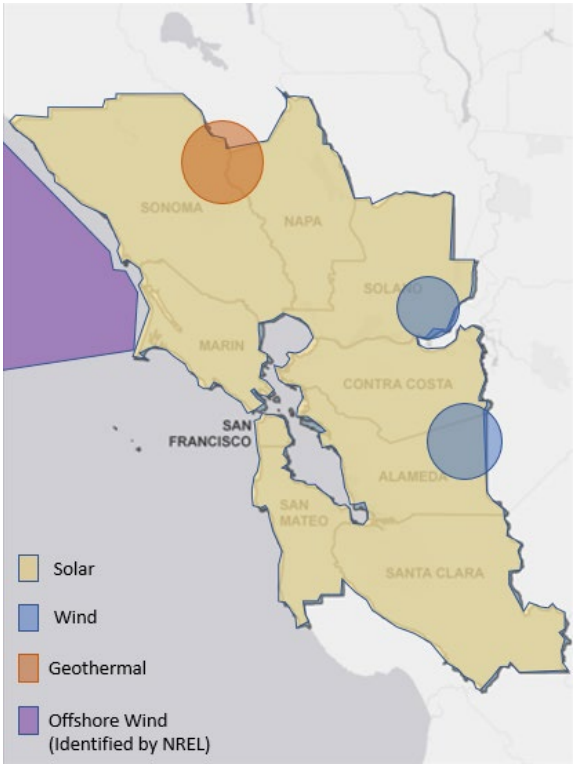
The City and County of San Francisco is a densely populated urban area, which is not able to support the development of utility-scale renewable energy projects (e.g., 10 MW or more on a single site) within its jurisdictional boundaries. San Francisco is among the most expensive places in the country to acquire

land and to build,[2] which has significant impacts on project costs. Due to the high value of land in San Francisco, any areas that could accommodate a large renewable energy project are likely to have competing development uses. San Francisco's density and urban development trends also create risks to solar access, by threatening to shade solar projects with future vertical development.[3] Additionally, San Francisco's summer fog decreases solar irradiance and solar panel energy production. CleanPowerSF can balance these negative cost impacts by procuring renewable power from lower cost regional projects or projects located in more favorable areas of California.

Looking to the broader Bay Area region also allows for consideration of renewable energy technologies that cannot be deployed cost-effectively within San Francisco, like wind and geothermal, and that help diversify CleanPowerSF's energy supply mix.

Figure 2 below provides a high-level indication of where Bay Area renewable energy resource sources are located and where CleanPowerSF can look to source the most cost-effective local renewable energy.

Figure 2. San Francisco Bay Area Renewable Energy Resources and Resource Areas[4]



[2] For more information see: https://www.sfchronicle.com/bayarea/article/SF-is-one-of-the-most-expensive-places-in-the-14888205.php (accessed on March 10, 2020)
[3] For more information see: https://sfenvironment.org/sites/default/files/fliers/files/protecting_solar_access.pdf (accessed on March 10, 2020)
[4] Map constructed by Power Staff using information from National Renewable Energy Laboratory (NREL) report "Potential Offshore Wind Areas in California: Assessment of Locations, Technology, and Costs," and the California Energy Commission's California Operational Power Plant Web App, which identifies existing renewable energy plants in the Bay Area

CleanPowerSF is committed to keeping rates affordable for its customers, so costs must be taken into consideration before moving forward with any renewable energy development, whether local or otherwise. CleanPowerSF must keep its electric generation service costs competitive with PG&E's (after accounting for the exit fees PG&E can charge CCA customers) because CCA customers can opt out of CleanPowerSF service at any time. The opt out rate has remained low since program launch, below 4%, because CleanPowerSF has provided customers with cost savings since it launched.[5] An increase in CleanPowerSF costs relative to PG&E could result in an increase in opt outs, which could put in jeopardy the program's ability to recover the costs of any investments it makes to serve customers.

For these reasons, this report focuses on the identification of projects that could deliver cost-effective locally generated electricity into the grid for use by CleanPowerSF and its customers. Since all City-owned buildings receive electric service from Hetch Hetchy Power, not CleanPowerSF, potential renewable energy projects on City property may be better suited to be developed through Hetch Hetchy Power to serve onsite load rather than export to the grid. As there is no overlap between Hetch Hetchy Power and CleanPowerSF customer bases, this generation may not be made available for use by CleanPowerSF. This report focuses on opportunities to develop renewable energy projects on City-owned property that are suitable for the production of renewable power for CleanPowerSF service. If renewable energy projects are currently considered technically or economically infeasible or impractical for other reasons, it is noted in the analysis below.

In response to Resolution No. 99-19, the analysis conducted here focuses principally on City-owned, in-City properties. However, this report also examines other opportunities to develop renewable energy projects within San Francisco (such as on private property) as well as on City-owned property outside of the City and County of San Francisco (such as on SFPUC land in Alameda County).

1.3 Methodology

Power Staff examined a comprehensive set of 132 in-City sites across City agencies. An overview of the total number of sites analyzed by agency is provided in Table 1 below. All but one of the sites listed are for solar PV projects. As noted above, rooftop and integrated solar PV is currently the best option for development in San Francisco because of space constraints and competing uses that make it difficult to develop renewable energy infrastructure within the City.

[5] Cost savings provided to CleanPowerSF customers through October 2019 has totaled approximately $12 million since CleanPowerSF began service in May 2016.

Table 1. Possible Renewable Energy Sites Examined by Agency

Agency	# Sites Reviewed
SFPUC	19
SFDPH	18
SFUSD	38
SFMTA	9
City College of San Francisco	3
SFDPW	2
Port of SF	23
Real Estate Division	7
SFDEM	1
DTIS	1
SFPL	7
Rec and Park	3
Arts Commission	1

The methodology used to analyze and prioritize potential projects is as follows:

- To focus on the most cost-effective projects that could supply power to the CleanPowerSF program, sites were screened by project size and those with less than 250 kW of potential capacity were removed from the analysis;[6]
- The remaining sites were analyzed for technical suitability and readiness for near-term development (within 5 years);
- Solar energy production and excess generation potential was then estimated at the sites identified for near-term development; and
- Finally, project development costs and the cost of energy from these projects was calculated to determine cost-effectiveness.

1.4 Findings

This analysis identified a number of in-City sites of either Medium or High Suitability for near-term renewable energy project development to support the CleanPowerSF program. In total, analysis identified approximately 25 megawatts in-City solar PV development of medium and high suitability that could be deployed on City-owned sites for CleanPowerSF supply. Of this 25 MW, 9.3 MW is rated as Highly Suitable and consist of SFPUC covered reservoirs for which no barriers to development were identified as of the time of this report. The 25-year Levelized Cost of Energy (LCOE) of these projects

[6] For this Report, Power Staff set 250 kW as the minimum threshold size for cost-effective projects to export power to CleanPowerSF based on market knowledge on average costs by project size and potential generation.

show them to be the most cost-effective in-City projects analyzed. These results are summarized in Table 2 below.

Before developing the remaining 16 MW (Medium Suitability), issues including structural upgrades to the buildings and possible power export limitations will need to be further assessed. Any additional structural or electrical infrastructure requirements that must be added to the projects are likely to increase project costs beyond what is reported in this report and should be further evaluated after the High Suitability sites have been addressed.

We estimate that schools in the SFUSD system could support 17.8 MW of potential In-City solar PV development in addition to the 2.4 MW across 5 school sites identified as Medium Suitability. SFUSD's own sustainability goals prioritize on-site usage, which would reduce the amount of energy for export available to the CleanPowerSF program. Further coordination with SFUSD will help determine what opportunities may exist to supply CleanPowerSF or Hetch Hetchy Power with excess rooftop electricity from

Table 2. Medium and High Suitability In-City, City-Owned Project Site Characteristics

Site Name	Agency	Technology Considered	Med to High Suitability Potential Project Capacity (kW)	Med to High Potential Project Generation (kWh)	Estimated 25-Year Levelized Cost of Energy ($/MWh)		Current Suitability for Development
					Low	High	
Stanford Heights Reservoir	**SFPUC**	Solar PV	1,060	2,507,112	$81	$139	High
Sutro Reservoir		Solar PV	2,760	6,527,952	$76	$113	High
University Mound Reservoir North Basin		Solar PV	4,260	10,075,752	$83	$120	High
Summit Reservoir		Solar PV	1,230	2,909,196	$90	$133	High
Sunset Reservoir South Basin		Solar PV	5,670	13,410,684	$83	$120	Medium
University Mound Reservoir South Basin		Solar PV	5,170	12,228,084	$79	$116	Medium
College Hill Reservoir		Solar PV	1,560	2,272,863	$86	$123	Medium
SFUSD Schools (5 Sites)	**SFUSD**	Solar PV	2,398	3,151,660	$96	$151	Medium
Metro Green	**SFMTA**	Solar PV	388	917,698	$87	$113	Medium
Laguna Honda Hospital - Parking	**SFDPH**	Solar PV (Canopy)	1,380	3,263,976	$92	$132	Medium
Subtotal		Solar PV	25,876	58,681,826	**Potential Cost (Average)**		
					Low	**High**	
					$85	$126	

There also exist SFPUC-owned sites outside of San Francisco that can support larger scale renewable energy projects at a lower cost for CleanPowerSF's use. We estimate that the closed Sunol Valley golf course and adjacent parcels in Alameda County can support up to 40 MW of solar at $30 to $35 per megawatt hour less than the lowest cost in-City projects. The addition of battery storage has been analyzed at this site and can provide additional grid reliability and energy shifting benefits. The SFPUC is currently going through a process of evaluating the old Sunol Valley golf course property for various uses.[7] The Sunol Water Treatment Plant could support an additional 1.1 MW of solar in the same area. At Tesla Portal in San Joaquin County, there exists 1.6 MW of solar PV potential on SFPUC property. The project characteristics for Medium and High Suitability regional sites are summarized in Table 3.

Table 3. Regional Medium and High Suitability Sites for Renewable Development

Site Name	Ownership	Technology Considered	Med to High Suitability Potential Project Capacity (kW)	Estimated 25-Year Levelized Cost of Energy ($/MWh)	Current Suitability for Development
Sunol Valley	**SFPUC**	Solar PV	40,000	$42-$68	High
Sunol Valley (Storage)		Solar + Storage	40,000 (solar) 20,000 (battery)	$55-$98	High
Tesla Portal		Solar PV	1,600	$90-$96	Medium
Sunol Wastewater Treatment Plant		Solar PV	1,140	$98-$104	Medium

Power Staff also identified opportunities where CleanPowerSF may be able to further encourage development of renewable energy in San Francisco. The SFPUC is in the process of developing a Feed-in Tariff (FiT)[8] program that will allow additional in-City renewable energy projects to supply CleanPowerSF. In addition, the State has made greenhouse gas allowance revenues from the cap and trade program available to support solar PV projects in Disadvantaged Communities across California.[9] Emerging technologies in California, such as offshore wind, may also be able to contribute to CleanPowerSF's supply and complement solar resources in the portfolio. Table 4 below summarizes these opportunities.

[7] For more information see: https://sfwater.org/index.aspx?page=1268 (accessed on March 10, 2020)
[8] A Feed-in-Tariff is standard contract to purchase specified types of renewable energy from smaller scale projects at a fixed price, typically for a 20-year period of time.
[9] For more information see CPUC Decision 18-06-027, available at: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M216/K789/216789285.PDF (accessed on March 10, 2020)

Table 4. Other Renewable Energy Development Opportunities Within or Near San Francisco

Site Name	Ownership	Technology Considered	Med to High Suitability Potential Project Capacity (kW)	Estimated 25-Year Levelized Cost of Energy ($/MWh)	Current Suitability for Development
SF Rooftops (FiT)	Various	Solar PV	2,000-10,000	$180-$240[10]	High
DAC Green Tariff Program	Various	Solar PV	1,490	-	High
DAC Community Solar Program	Various	Solar PV	380	-	High
Offshore Wind	Ocean/Federal	Offshore Wind	600,000	$200 (2018) to $75 (2025)	Medium

1.5 Recommendations

Power Staff have identified in-City projects of Medium to High Suitability representing approximately 25 MW of renewable energy capacity that could be developed to supply the CleanPowerSF program. Of the 25 MW, 9.3 MW represents Highly Suitable sites on SFPUC covered reservoirs for which no barriers were identified for development. Power Staff further estimate that an additional 2-10 MW of in-City renewable energy can potentially be developed through a CleanPowerSF FiT program by 2030.

Power Staff have also identified up to 41 MW of solar and at least 20 MW of battery storage that could be developed on SFPUC land in the broader Bay Area region.

There may exist more potential for the development of additional renewable capacity on City property to offset onsite use, which can be further explored through coordination between the host agencies and Hetch Hetchy Power, which provides retail electric service to these customers.

To develop the identified local renewable energy potential in a cost-effective manner, Power Staff recommend the following:

High Suitability Sites

1. Analyze best project opportunities in CleanPowerSF IRP portfolio modeling process to understand portfolio integration and overall cost impacts to ratepayers.
2. Conduct any additional site-specific feasibility and business case analysis, environmental impact studies, and initial project design work prior to issuing any Requests for Proposals (RFP) for project development.
3. Include Highly Suitable project sites in CleanPowerSF 10-year capital plan to support required analysis, RFP development and project development.

[10] The SFPUC is currently analyzing the potential for a Feed-in Tariff to inform program design including pricing approach and levels.

Medium Suitability Sites

1. For sites where structural improvements are required, monitor the capital planning process, and where possible, incorporate design elements that would support the installation of solar and other renewable/clean energy technologies.
2. For sites where potential export limitations have been identified, conduct additional analyses to determine full export potential and determine which SFPUC program would be better suited to develop the project (e.g., Hetch Hetchy Power or CleanPowerSF).
3. Continue coordination with host agencies to develop mutually beneficial partnership structures and agreements to facilitate cost-effective project development and power offtake.

Non-City-owned Sites

1. Develop a Feed-in Tariff program to purchase renewable energy from new in-City renewable development within San Francisco.
2. Develop Disadvantaged Community solar programs to make renewable energy available to these communities and neighborhoods.
3. Continue to monitor the market for emerging renewable energy technologies to be considered in future power procurement efforts.
4. Explore opportunities to partner with regional power agencies (e.g., other CCAs or public power utilities) on possible demonstration projects for new/emerging technologies.

2. CleanPowerSF Program Goals and Procurement Requirements

CleanPowerSF provides electric generation services to residents and businesses within the City and County of San Francisco that receive retail electric distribution service from Pacific Gas and Electric Company (PG&E), the investor owned utility operating within San Francisco. CleanPowerSF was launched by the SFPUC to provide electric generation service that is affordable and reliable; cleaner and more renewable than the alternatives; supports local investments in clean energy technology; and provides customers with long-term rate and financial stability.

CleanPowerSF started serving customers in 2016 with an initial enrollment featuring annual electricity sales of approximately 565,000 megawatt-hours per year (representing an average demand of approximately 65 MW). After a comprehensive growth planning process and coordination with its Commission, CleanPowerSF expanded service to its remaining eligible customers in two major phases in 2018 and 2019, and now, having completed its City-wide auto-enrollment, supplies approximately 3,000,000 MWh per year to its customers (an average demand of about 340 MW).

2.1 Program Goals

As CleanPowerSF plans and develops its growing clean energy portfolio, it is guided by the Business Practice Policies and the following program goals, adopted by the Commission:

- **Lead with Affordable and Reliable Service:** CleanPowerSF is committed to providing service that is reliable and affordable for all San Franciscans. To do so, CleanPowerSF pursues the lowest cost energy supply possible that also satisfies its other program goals. Sourcing the most affordable energy requires execution of desirable, low-cost contracts, and the prudent and strategic management of the CleanPowerSF electricity portfolio to take advantage of market opportunities while minimizing risk. Keeping costs low also supports continued customer participation in the CleanPowerSF program.

Under the CCA model, customers can opt out and receive electricity services from PG&E. If CleanPowerSF electricity costs increase, the risk of customers leaving CleanPowerSF may also increase.

- **Provide Cleaner Electricity Alternatives:** Central to CleanPowerSF's mission is providing cleaner energy alternatives to San Francisco residents and businesses and helping realize San Francisco's goal to transition to an electricity system powered by 100% renewable energy.[11]
- **Invest in Local Renewable Projects and Local Jobs:** As CleanPowerSF sources additional renewable energy supply to meet its customers' demand and support the achievement of the City's target of 100% percent renewable energy by 2030, CleanPowerSF anticipates procuring a significant amount of energy from new (to-be-built) renewable energy projects. In 2019, CleanPowerSF issued a Request for Offers (RFO) for new renewable energy projects located in the nine county Bay Area.
- **Provide for Long-Term Rate and Financial Stability:** CleanPowerSF manages its program and its rates to minimize rate increases and provide a stable source of electricity for its ratepayers. CleanPowerSF's Business Practice Policies ensure a prudent supply portfolio and position management to manage financial risk and back its rates with a robust rate stabilization reserve.

2.2 Regulatory Requirements

In addition to providing San Francisco homes and businesses with clean electricity, CleanPowerSF is obligated to meet regulatory requirements regarding its power content and systemwide reliability set by the state. Procurement of the required products to meet these requirements also impact average portfolio costs A brief description of these requirements follows.

Renewables Portfolio Standard (RPS)

California's RPS program sets minimum procurement requirements for renewable energy within an electricity retail seller's portfolio. With the passage of Senate Bill 350 (SB 350) in 2015, the State Legislature increased the statewide RPS floor from 33 percent in 2020 to 50 percent by 2030. The CPUC, which oversees the implementation of the RPS program and compliance for investor-owned utilities, energy service providers, and community choice aggregation programs, has set procurement requirement floors for each compliance period and targets for each year within a compliance period. RPS requirements are defined in terms of a total RPS percent of an electricity seller's total procured supply, as well as percent breakdown of the different RPS product types, as summarized in Table 5.

Table 5. RPS Compliance Periods and Amounts

RPS COMPLIANCE PERIOD	CALENDAR YEAR	TOTAL PROCUREMENT REQUIREMENT	PORTFOLIO CONTENT CATEGORY (PCC) AMOUNTS ALLOWABLE/REQUIRED		
			% PCC1	% PCC2	% PCC3
1	2011-2013	20.0%	≥50.0%	≤50.0%	≤25.0%
2	2014-2016	21.7% to 25.0%	≥65.0%	≤35.0%	≤15.0%

[11] Board of Supervisors Ordinance 81-08, 4/29/08; San Francisco Climate Action Strategy: https://sfenvironment.org/sites/default/files/engagement_files/sfe_cc_ClimateActionStrategyUpdate2013.pdf (accessed on March 10, 2020)

RPS COMPLIANCE PERIOD	CALENDAR YEAR	TOTAL PROCUREMENT REQUIREMENT	PORTFOLIO CONTENT CATEGORY (PCC) AMOUNTS ALLOWABLE/REQUIRED		
			% PCC1	% PCC2	% PCC3
3	2017-2020	27.0% to 33.0%	≥75.0%	≤25.0%	≤10.0%
4	2021-2030	33% to 50%	≥75.0%	≤25.0%	≤10.0%

Governor Brown signed Senate Bill 100 (SB 100) into law on September 10, 2018. SB 100 increases the RPS requirement from 50 percent to 60 percent in 2030 with interim goals of 33 percent by the end of 2020, 44 percent by the end of 2024, and 52 percent by the end of 2027.[12] SB 100 also establishes a state policy to achieve 100 percent of total retail sales from eligible renewable energy resources and zero-carbon resources by December 31, 2045.[13]

RPS Long-Term Contracting Requirement

In addition to increasing the amount of renewable energy that a retail seller of electricity must include in its portfolio between now and 2030, the SB 350 significantly increased the amount of renewable energy a retail seller must procure under long-term contracts. Starting in 2021, 65 percent of the RPS energy used to meet the RPS compliance period (2021 to 2024) must be from contracts of 10 years or more in duration.[14]

Resource Adequacy (RA)

The CPUC requires all retail sellers of electricity or Load Serving Entities (LSE) within its jurisdiction, including CCAs, to demonstrate they have procured sufficient forward Resource Adequacy (RA) capacity (measured in MW) to meet the energy reliability needs of the California electrical system grid between one and three-years in advance. RA capacity is not an energy product. Purchasing RA capacity from a power plant does not mean that an LSE will be receiving energy from that power plant. Instead, RA capacity represents a commitment on the part of a power plant owner to make their power plant available to the grid operator (California Independent System Operator), if needed for reliability.

To demonstrate compliance with the RA program LSEs must report annually and monthly they have met the CPUC adopted RA program requirements which requires CCAs (including CleanPowerSF) to procure three distinct but related energy capacity products outlined below:

- **System RA**: CleanPowerSF's system RA procurement requirement is determined as a percentage of its share of the CPUC adopted, California Energy Commission (CEC) forecasted, California peak load demand, which is based on a 1-in-2 weather year for each month's load forecast plus a 15% Planning Reserve Margin.

- **Flexible RA**: CleanPowerSF's flexible RA procurement requirement is determined as a percentage of its share of the CPUC adopted, California Independent System Operator (CAISO) "Flexible Capacity

[12] SB 100 (De Leon) Statutes 2018 Chapter 312, Section 3.
[13] SB 100 (De Leon) Statutes 2018 Chapter 312, Section 1
[14] SB 350 (De Leon) Statutes 2015 Chapter 547

Need", defined as the quantity of resources needed by the CAISO to manage grid reliability during the greatest three-hour continuous ramp in each month.[15]

- **Local RA**: CleanPowerSF's local RA procurement requirement is determined as a percentage of its share of the CPUC adopted, CAISO "Local Capacity Requirement", which is determined using the CEC forecasted summer peak load based on a 1-in-10 weather year for seven distinct Local Areas defined by the CAISO within PG&E's service territory in California.[16]

3. Renewable Energy Overview

There are a growing number of renewable technologies that CleanPowerSF can procure or develop to generate electricity to supply its customers' demand. CleanPowerSF must consider a number of factors when evaluating the types of renewable energy resources it should pursue for its power supply portfolio, including but not limited to: energy production costs, time-of-day production, emissions of greenhouse gases and other pollutants, technology maturity, and project development risk (among others).

An overview of currently available and emerging technologies follows below. Where available, we have provided illustrative examples of the electricity production "profile" of the underlying renewable resource type. Each figure illustrates the power a renewable energy project of this technology type might produce over the course of a day, regardless of the size of the project.

3.1 Renewable Technologies

Battery Storage

Battery storage enables energy generated to be captured and used at a later time, offering increased resiliency and the opportunity to strategically shift energy delivery to a more optimal or beneficial time of day. Battery storage can be co-located with a power producing resource, such as solar PV, or it can exist as a stand-alone resource connected to the grid. Battery storage systems can charge when renewable generation is high, such as in the middle of the day, and discharge in the evening when market energy prices may be higher. While battery technology is still emerging, California leads the U.S. in energy storage with a total installed capacity of 7.2 GW,[17] as of August 2019. Recent public safety power shutoffs are expected to drive further growth in battery storage installations in California.

Well-developed battery storage technology is critical to the successful deployment of microgrid systems, which can disconnect or "island" from the utility grid while remaining fully or partially operational in the event of a utility grid outage or disturbance. For this reason, microgrids can be valuable assets to ensure critical facilities, such as police and fire stations, hospitals, and disaster-relief coordination centers can fulfill their functions during a natural disaster or other emergency event.

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[15] For more information see: http://www.caiso.com/informed/Pages/StakeholderProcesses/FlexibleCapacityNeedsAssessmentProcess.aspx (accessed on March 10, 2020)

[16] For more information see: http://www.caiso.com/informed/Pages/StakeholderProcesses/LocalCapacityRequirementsProcess.aspx (accessed on March 10, 2020)

[17] For more information see: http://css.umich.edu/sites/default/files/US%20Grid%20Energy%20Storage_CSS15-17_e2019.pdf (accessed on March 10, 2020)

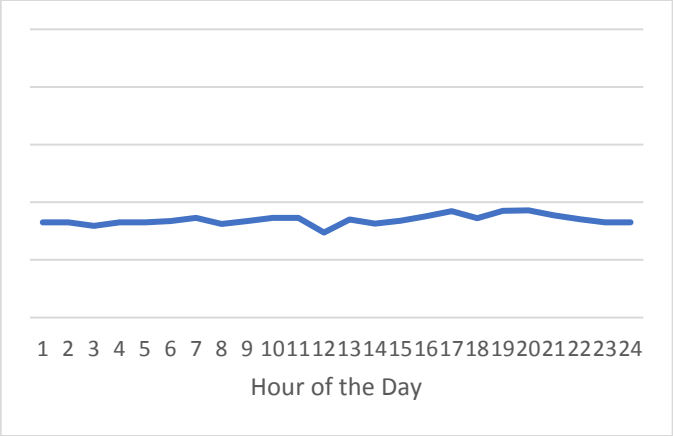
However, battery storage is still an expensive and emerging technology. Unsubsidized battery storage costs are projected to range between $45/kW-month to $65/kW-month for a 500 kW battery paired with solar to $20-$30/kw-month for a 20 MW battery paired with solar in the near term and before any tax credits or subsidies are applied.[18] Prices are also expected to decline as the technology continues to mature. The avoided costs associated with meeting Resource Adequacy requirements and market price exposure must be taken into consideration to comprehensively evaluate the value a battery storage system.

Biomass

Biomass is organic material derived from plants and animals that can be used as a renewable source of energy through combustion or decomposition. Biogas can be produced from biomass through anaerobic decomposition of biomass at sites like solid waste landfills or waste water treatment plants. These processes can generate electricity from waste matter that would have been released into the atmosphere (landfill gas), added fuel to forest fires, or burdened landfills.[19]

The primary advantages of using biomass as an energy source include its potential to be a carbon neutral fuel source and its favorable energy delivery profile. As shown below in Figure 3, the delivery profile of biomass energy sources remains relatively constant, making it a good resource to supply baseload energy demand. However, there are few biomass plants in operation in California as biomass and biogas has proven to be too expensive with levelized costs that can range between $55-$115 per megawatt hour.[20]

Figure 3. Biomass Hourly Delivery Profile[21]

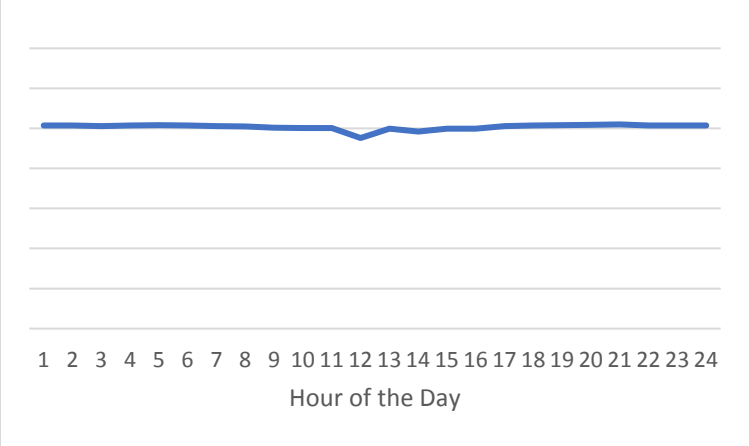


[18] For more information see: https://www.lazard.com/media/451087/lazards-levelized-cost-of-storage-version-50-vf.pdf (accessed on March 10, 2020)
[19] For more information see: https://www.energy.ca.gov/data-reports/california-power-generation-and-power-sources/biomass (accessed on March 10, 2020)
[20] https://www.lazard.com/perspective/levelized-cost-of-energy-2017/ (accessed on March 10, 2020)
[21] Illustrative renewable energy resource hourly delivery shapes were derived from California Independent System Operator renewable aggregated renewable resource time of day profiles available at: http://www.caiso.com/TodaysOutlook/Pages/supply.aspx (accessed on March 10, 2020)

Geothermal

Geothermal power plants typically capture geothermal energy by drilling holes into the ground to drive steam or hot water to the surface that can then drive electric generators. Geothermal is regarded as an advantageous energy source because it can provide a constant flow of energy to act as a baseload resource as shown in Figure 4 below. Geothermal resources are most abundant in areas that have volcanic activity, which is typically along the boundaries of the earth's tectonic plates. California sits at the border between two major tectonic plates, which means that geothermal is available, but the development of additional transmission infrastructure is required before California can access some of the more productive areas in the state. Additionally, costs to develop geothermal energy are high compared to other renewable energy resources, resulting in levelized costs between $77-$117 per megawatt hour for new projects. [22]

Figure 4. Geothermal Hourly Delivery Profile



In-Conduit Hydro

In-conduit hydropower is an emerging technology that leverages existing water pipes to generate reliable, carbon-free electricity.[23] Similar to their larger-scale and well-established hydroelectric counterparts, in-conduit projects use turbines to harness the energy in flowing water to produce power. The smaller size of in-conduit hydropower systems enables them to be deployed on a more local scale or even as a distributed energy resource. In-conduit hydropower energy generation is not dependent on weather patterns, and systems can be designed to operate as baseload or peaking resources. Despite the opportunities associated with this technology, adoption in California remains limited primarily due

[22] For more information see: https://www.lazard.com/perspective/levelized-cost-of-energy-2017/ (accessed on March 10, 2020)

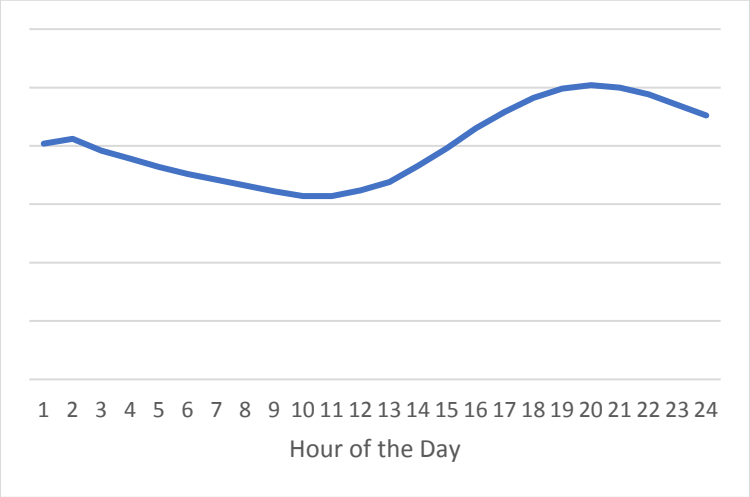
[23] Kim Quesnel, PhD Candidate, Stanford University, 2019 Policy Fellow, Imagine H20 Policy, "Deploying In-Conduit Hydropower Across California"; Available at: https://static1.squarespace.com/static/59a1c9504c0dbf71dd4f248e/t/5c8ff26e8165f55c73986a45/1552937584156/In-Conduit+HydroPower+-+FactSheet.pdf (accessed on March 10, 2020)

to high development costs. Prior SFPUC analysis has found that costs installing an in-conduit hydroelectric system in SFPUC-owned water delivery assets could range between $110-$360 per megawatt hour depending on project design and site structural requirements.

Offshore Wind

Offshore wind energy is generated by turbines mounted to the seabed or onto floating foundations over large bodies of water, typically the ocean. As demonstrated by the delivery profile in Figure 5 below, offshore wind is most productive in the evening and early morning hours, which can make it a good complement to solar. Offshore wind is in the nascent stages of development in California, with one power purchase agreement executed by Redwood Coast Energy Authority for a project off the Humboldt County coastline slated for development in 2024. Lease auctions for project sites are expected to occur in 2020, which will support further expansion of the technology in California. Currently, project costs are estimated to be between $75-$250/MWh, but are expected to continue to decline as offshore wind matures in the Western U.S.

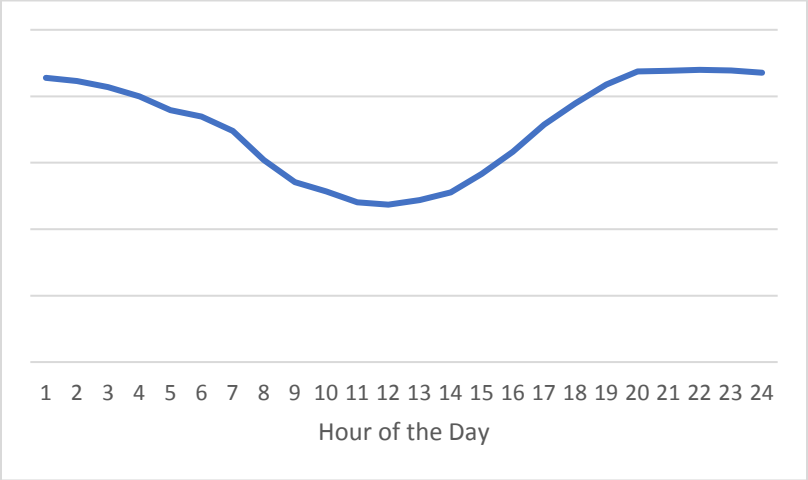
Figure 5. Offshore Wind Delivery Profile



Onshore Wind

Onshore wind is a mature technology that currently accounts for about 11% of California's electricity supply and 35% of its renewable energy production. To generate power, wind turbine blades are turned by the force or energy in the wind, which then drives a generator to produce electricity. In the right location with a suitable wind resource, wind turbines are relatively cheap to deploy, operate, and maintain on land, with costs ranging from $30-$60/MWh. The cost-effectiveness of onshore wind has contributed to the proliferation of the technology in California. As shown in Figure 6, onshore wind energy generation is complementary to solar's delivery profile. Wind turbines are most efficient at producing electricity when they are sited in an open environment, exposed to strong and consistent wind and mounted well above any type of obstructions.

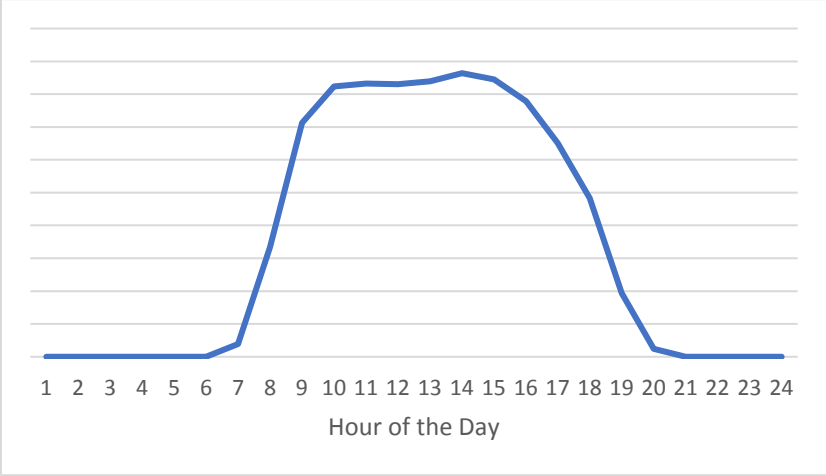
Figure 6. Onshore Wind Delivery Profile



Solar Photovoltaic (PV)

Solar PV panels generate energy directly from the sun. Solar PV systems can be constructed to any size based on energy and spacing requirements, which supports installation in a range of environments. In recent years, solar has become one of the lowest cost resources to develop, with utility-scale costs of between $20-$50/MWh. Solar has flourished in California, and accounts for over a third of renewable energy generation in the state. To generate electricity, solar panels must be exposed to sunlight, which means energy output declines dramatically in the early evening when demand for energy begins to peak. Pairing solar with other resources such as wind and/or energy storage can support meeting electricity demand when solar is not productive. Additionally, shading over a solar panel that may occur due to construction nearby after the panel's installation may impact its productivity.

Figure 7. Solar Delivery Profile



Wave Energy

Technology has been evolving to allow for the harnessing of ocean waves to supply energy to the grid at a utility-scale level. Wave technology can operate in concert with hydraulic accumulators (or, in concert with other solar and storage projects) to provide smoothed energy, offering improvements to the technology's cost-effectiveness. The majority of wave energy projects to-date are in Europe and Asia;[24] the few projects known to have been deployed in the United States appear to be demonstration projects used to hone the wave technology, rather than support a utility. And, significantly, the average per megawatt-hour costs of deployment, even in countries where the path to leasing and permitting has been established, remain significantly higher than other renewable energy technologies on the market today in California. Levelized costs are estimated to range between $300-$600 per megawatt hour.[25] At present in the U.S., wave technology is still experimental.

3.2 Resource Costs and Cost Effectiveness

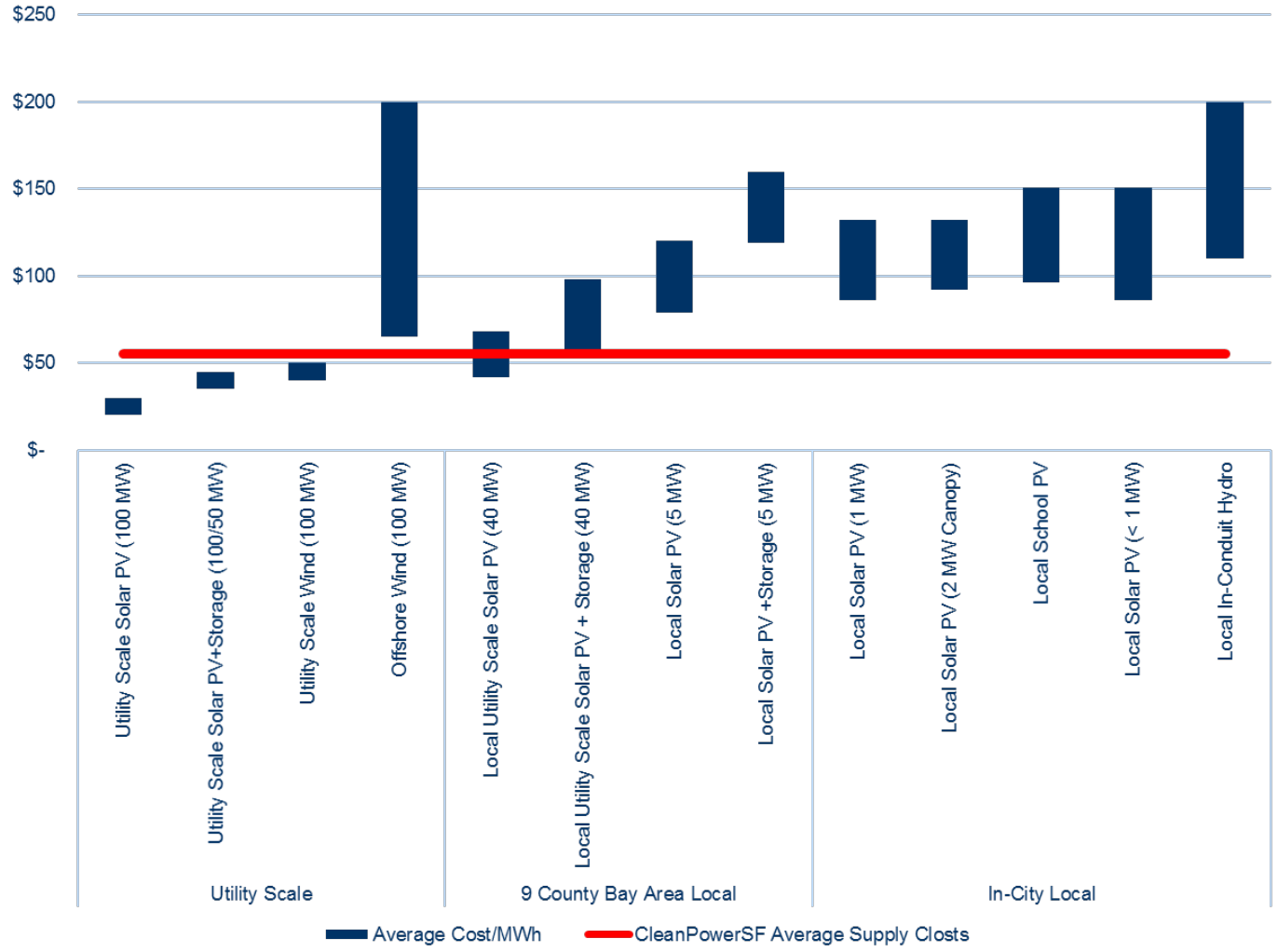
Many factors must be considered when choosing to invest or commit long-term to a renewable energy project. These factors include, but are not limited, to: (1) energy production potential and performance, including the time-of-day and seasonality characteristics of power production; (2) technology installation and operation costs; and (3) development and delivery risk, including environmental, regulatory, permitting, and interconnection risks that may be associated with the technology or a possible project's location.

Poor energy production performance of a project may increase CleanPowerSF operating costs or undermine achievement of its environmental goals. Sources of energy supply with costs that are above CleanPowerSF's average cost may necessitate rate increases that could financially burden CleanPowerSF customers. Higher rates could cause customers to opt out of the CleanPowerSF program in favor of more affordable generation supply services.

The data presented in Figure 8 (on the next page) show cost ranges, in dollars per megawatt-hour ($/MWh), that one may expect to see for different kinds of renewable energy technologies, at different scales and locations. CleanPowerSF's energy supply cost currently averages between $55 to $60 per MWh. In comparison, recent utility scale solar and wind contracts fall below and within average CleanPowerSF costs, from $20-$50 per MWh depending on the technology and project's size and location.

[24] For more information see: "Top five trends in wave power." *Power Technology*, 12 March 2019. https://www.power-technology.com/features/wave-power-energy/ (accessed on March 10, 2020)
[25] For more information see: https://www.oceaneconomics.org/offshore_renewables/costs/ (accessed on March 10, 2020)

Figure 8. Renewable Energy Costs by Project Type vs. CleanPowerSF Average Costs



Analysis of local project options found that we can expect pricing of a local utility scale solar project greater than 10 MW in total capacity to be within the $35-$68 per MWh range, with the addition of battery storage increasing costs by $20-$40 per MWh. Smaller projects within San Francisco are considerably more expensive, ranging from $80 to $160 depending on project size and site.

At present, in-conduit hydro and offshore wind can cost up to $200 per MWh, but costs are expected to decrease in the future as the technologies mature.

Table 6 below further demonstrates how the addition of battery storage can impact costs for a range of different solar project sizes and locations expected to come online between 2022 and 2024. Battery storage costs are also dependent on the size of the battery relative to the solar PV system size. The numbers in the table below represent costs for systems sized between 20-100% of the solar projects capacity.

Table 6. Estimated Battery Storage Costs by Project Size[26]

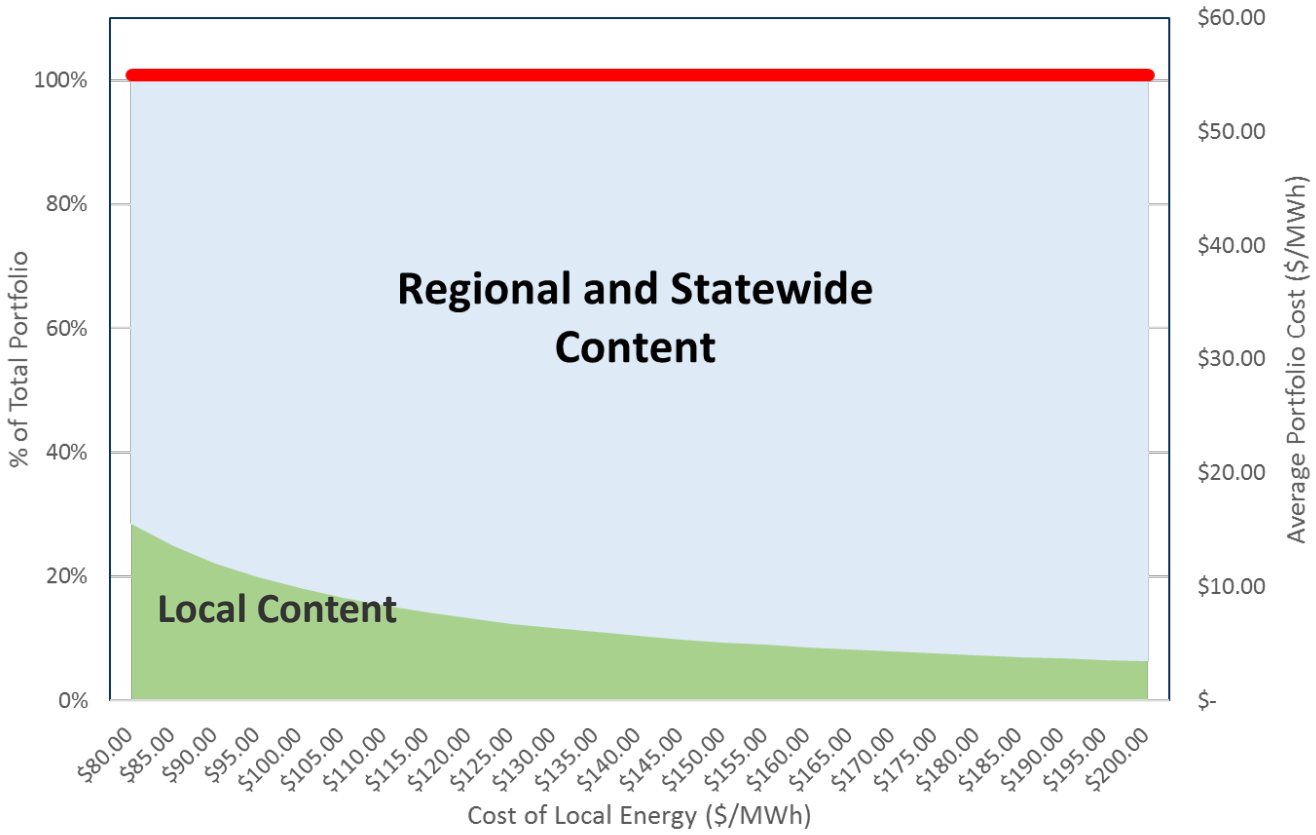
Storage Size	$/kw-mo	$/MWh Adder
Local Small Scale (<1MW)	$15-$30	$25-$100
Local Large Scale (>1MW, <10MW)	$10-$20	$25-$40
Local Utility Scale (>10MW)	$7-$15	$15-$30
California Utility Scale (>10MW, Local)	$5-$10	$7-$20

To maintain its energy supply costs within budgetary and rate constraints, CleanPowerSF must balance the procurement of higher cost local renewable energy with more cost-effective regional and statewide options. Committing (either through ownership or long-term contracting) to higher cost resources will limit the total amount of local renewable energy CleanPowerSF is able to procure and provide to its customers in a competitive manner.

Figure 9 below provides a conceptual illustration of this trade off. The more expensive the local projects CleanPowerSF procures, the less local energy CleanPowerSF can integrate into its portfolio while maintaining its costs and rates.

[26] Costs calculated using information from the following sources: NREL Report, https://www.nrel.gov/news/program/2018/costs-continue-to-decline-for-residential-and-commercial-photovoltaics-in-2018.html (accessed March 10, 2020); and Lazard's Levelized Cost of Storage Analysis – Version 5.0, https://www.lazard.com/media/451087/lazards-levelized-cost-of-storage-version-50-vf.pdf (accessed March 10, 2020)

Figure 9. Illustrative Portfolio Cost Impacts of Portfolio Makeup



As the example above illustrates, if local projects average $80 per MWh of energy delivered to CleanPowerSF *and* the balance of CleanPowerSF's supply is able to average $55 per MWh delivered, local resources could contribute up to 30% of CleanPowerSF's portfolio without increasing average costs. As the average cost of these local resources increase, however, the total percentage CleanPowerSF could cost-effectively incorporate into its portfolio also declines.

4. Local Project Analysis Overview

To prepare this report, Power Staff gathered data and analyzed a comprehensive list of City-owned sites that could potentially be developed for in-City and regional renewable energy generation. When possible, Power Staff leveraged previous work performed to assess renewable project development opportunities, including:

- Local Build-out of Energy Resources of the Community Choice Aggregation Program (Enernex 2015)
- SFPUC Reservoir feasibility studies (AEPC, various years)
- Renewable Energy Assessment (Black & Veatch, 2014)

Power Staff reviewed the project sites and related data in the above-mentioned reports and updated project information, to develop a list of potential renewable projects on City property. Power Staff solicited input from site host agencies, where applicable. Since not all the local sites analyzed are located within the city, these projects were then broken out into two categories: potential in-City projects on City property and other City-owned regional options. Power Staff also examined other renewable energy resource opportunities that might be developed on either public or private property within or near San Francisco.

Power Staff assessed all sites deemed potentially feasible – including in-City and out-of-City SFPUC-managed sites – using the criteria described in Section 5.1 below. Using site visits and helioscopic analysis,[27] as well as industry and SFPUC data to determine project construction, management and financing costs, Power Staff worked with consultants to develop estimated achievable project sizes, energy production, and cost projections for the selected sites. Cost projections include ranges for levelized costs of energy under three financing options (Power Purchase Agreement (PPA), PPA with a year 7 buyout by the SFPUC, and SFPUC ownership) for all projects. According to the analysis, a PPA with a year 7 buyout is the most cost-effective option for all projects due to the ability to capture federal tax benefits, including the accelerated depreciation of the asset leading up to the purchase opportunity date.

4.1. Understanding optimal sites for renewable energy development to serve CleanPowerSF

There are many factors that contribute to making a site suitable for renewable energy project development, which Power Staff and consultants considered in the preparation of this report. These factors include:

1. **The site has sufficient space to develop a cost-effective project**. Renewable energy projects have a number of fixed costs, making scalability important for cost-effectiveness. To identify the most cost-effective projects, the analysis conducted for this report focuses on sites with enough space to support the installation of a project with a minimum capacity of 250 kilowatts (kW).

[27] Helioscopic analysis combines 3D modelling of a solar PV array and its surroundings, along with analysis that calculates the sun angle and sunlight at each hour of the year, to estimate how much (or little) sunlight a solar PV module will receive. The result is a forecast of energy production from a solar PV system layout that allows a planner to calculate project cost-effectiveness.

While there are many more sites than those identified in this report that can support renewable energy projects less than 250 kW, most of these will be more suitable for on-site utilization of the renewable energy, not for supplying CleanPowerSF.

2. **The development of a project will not interfere with existing primary and critical site functions**. A renewable energy project should be able to be constructed, operated and maintained without compromising the primary functions at the site. For example, a project on a hospital site should not impact the services and level of care the hospital offers to its patients.

3. **The site can provide suitable access to maintain, operate, and protect the infrastructure of the energy project for the duration of its useful life**. Renewable infrastructure must be accessible for general maintenance and must be placed in a location that limits risk of damage to the equipment or voiding of warranty. As of the time of this report, there are no existing or known near-term shading risks from construction on adjacent properties that could materially diminish the energy production potential of the site.

4. **The site has suitable structural support and electrical systems in place to develop the project (and allow for interconnect and export).** A renewable energy project requires a suitable load-bearing area that can structurally support the project's infrastructure. If structural conditions are not suitable, required upgrades could significantly increase the price of the project or must be separately borne by the site owner. A renewable energy project also requires appropriate electrical infrastructure on-site (and ideally near the project location) to support connection to the grid. If electrical upgrades are required, or if a significant distance between the project location and the grid electrical equipment require significant construction (e.g., trenching of conduit), the cost of the project could increase dramatically and become cost prohibitive.

5. **The site is suitable for exporting power to the grid to support CleanPowerSF service**. All in-City municipal sites analyzed in this report receive retail electricity service from the City's public power provider, Hetch Hetchy Power. Therefore, as Power Staff considered sites suitable for development of renewable energy for export to CleanPowerSF service, Staff identified whether the expected energy production of a project would exceed the site's usage. Based on this information, a potential project at a site was identified as:
    - **Unlikely to have generation exceed on-site usage**: in this case, it has been assumed that a project's generation would be prioritized for on-site usage,[28] and would therefore contribute to Hetch Hetchy Power service. Projects that are otherwise suitable but do not have significant export potential may be examined further for behind-the-meter development by Hetch Hetchy Power or the site managing agency.
    - **Likely to have generation exceed on-site usage**: In this case, it has been assumed that a project's generation would be used first to offset on-site usage, and the remaining renewable energy would be available for export to CleanPowerSF service.

[28] For purposes of this report Power Staff assumed that projects would be prioritized for on-site usage unless a representative from the site's managing Agency stated otherwise.

- **No need for coverage of on-site usage/all export**: In this case it may be that a site already has had a renewable energy project built scaled to its load and has no additional need for coverage of on-site load, or that a site has negligible on-site load to begin with; in either case, such a project would be designed as fully exportable to CleanPowerSF service.

Any site within San Francisco hosting a project that is 20 MW or less in capacity and exporting to CleanPowerSF service will have to coordinate with the electricity grid owner, Pacific Gas & Electric Company, and follow the procedures to put in place a Small Generator Interconnection Agreement (SGIA).[29] Power Staff have some experience coordinating with PG&E on an SGIA from the interconnection of the Sunset Reservoir.

4.2 Local Renewables Investments through Hetch Hetchy Power to Date

The SFPUC has been actively investing in local renewables with in-City solar PV projects developed through Hetch Hetchy Power. The SFPUC has developed a total of 23 solar PV projects throughout San Francisco, totaling 3.25 MW of City-owned power generating capacity and 5 MW of third-party owned capacity coming from the Sunset Reservoir project, generating approximately 8,620 MWh per year. These projects are on municipal sites and most serve only onsite load and do not export to the grid (only the Sunset Reservoir project exports to the grid). Approximately $27 million has been invested by the SFPUC locally for City-owned projects.

On City sites where there is significant onsite usage or a preference to serve onsite load first, it may be more beneficial to develop a project through Hetch Hetchy Power rather than to export power to the grid for use by CleanPowerSF. Currently, Hetch Hetchy Power has 1.5 MW of planned new renewable energy capacity for development across nine project locations in San Francisco. Two battery storage projects representing 750 kW of energy storage capacity are also under development for Hetchy Power customer sites.

5. Site Review and Results

As noted above, renewable energy development opportunities analyzed for this report have been broken down into the following categories:

- In-City, City-owned sites, arranged by managing City Agency (Section 5.1);
- Regional, City-owned sites managed by the SFPUC (Section 5.2); and
- Other renewable development opportunities within or near San Francisco (Section 5.3).

The information presented here is preliminary and represents the start of a planning process. As the process progresses, and as plans mature, specific projects will be subjected to City development steps, like funding authorizations, community engagement, and California Environmental Quality Act compliance.

[29] For more information see: https://www.pge.com/includes/docs/pdfs/b2b/newgenerator/wholesalegeneratorinterconnection/PGE_Wholesale_Distribution_Tariff_SGIA.pdf (accessed on March 10, 2020)

5.1 In-City, City-owned Sites

For this report, Power Staff identified 132 In-City City-owned Sites on which a renewable energy project could be developed. Building on previous analyses, potential project sites have been reviewed for this report and energy production and cost estimates have been updated for the most promising sites, including those at locations managed by the San Francisco Public Utilities Commission, Department of Public Health, Municipal Transit Agency, Unified School District, City College, Department of Public Works and the Port of San Francisco.

What follows below are narrative summaries of the status of a subset of the 132 sites within the city that have been reviewed for this report. The narrative summaries focus on sites identified as having either High or Medium Suitability for near-term development to support the CleanPowerSF program. In some cases, sites identified as having Low Suitability for supplying the CleanPowerSF program have been described to illustrate important feasibility issues that may be problematic for other, similar types of sites.[30] A summary of these in-City sites, including estimated energy production potential and project costs, are presented in Table 7 below.

[30] For example, sites that are located within PG&E's downtown distribution network will be unable to export power off-site due to PG&E interconnection rules for that part of the distribution system.

Table 7. In-City, City Owned Site Summary

	Agency	Technology Considered	Potential Project Capacity (kW)	Potential Project Generation (kWh)	Estimated 25-Year Levelized Cost of Energy ($/MWh)		Current Suitability for Development
					Low	High	
Stanford Heights Reservoir	**SFPUC**	Solar PV	1,060	2,507,112	$ 81.00	$ 139.00	High
Sutro Reservoir		Solar PV	2,760	6,527,952	$ 76.00	$ 113.00	High
University Mound Reservoir North Basin		Solar PV	4,260	10,075,752	$ 83.00	$ 120.00	High
Summit Reservoir		Solar PV	1,230	2,909,196	$ 90.00	$ 133.00	High
Sunset Reservoir South Basin		Solar PV	5,670	13,410,684	$ 83.00	$ 120.00	Medium
University Mound Reservoir South Basin		Solar PV	5,170	12,228,084	$ 79.00	$ 116.00	Medium
College Hill Reservoir		Solar PV	1,560	3,689,712	$ 86.00	$ 123.00	Medium
Merced Manor Reservoir		Solar PV	878	2,076,646	$ 76.00	$ 132.00	Low
University Mound Hydro		Small Hydro	250	1,661,000	$ 110.00	$ 200.00	Low
Laguna Honda Hospital - Parking	**SFDPH**	Solar PV	1,380	3,263,976	$ 92.00	$ 132.00	Medium
SFUSD Schools (5 Sites)	**SFUSD**	Solar PV	2,398	5,671,750	$ 96.00	$ 151.00	Medium
Metro Green	**SFMTA**	Solar PV	388	917,698	$ 87.00	$ 113.00	Medium
Mission & 5th Parking		Solar PV	644	1,523,189	$ 96.00	$ 156.00	Low
SF General Parking		Solar PV	408	640,975	$ 89.00	$ 160.00	Low
City College Ocean Campus	**City College**	Solar PV	385	910,602	$ 96.00	$ 151.00	Low
Port of SF (9 Sites)	**Port of SF**	Solar PV	9,856	23,311,411	$ 90.00	$ 203.00	Low
SFDPW Maintenance Yard	**SFDPW**	Solar PV	616	1,456,963	$ 91.00	$ 124.00	Low
Hunters Point Parcel E	**CCSF**	Solar PV	4,060	6,251,829	$ 74.00	$ 103.00	Low

Candidate sites of High or Medium suitability will be the focus of continued planning and development efforts.

San Francisco Public Utilities Commission (SFPUC)

Stanford Heights Reservoir. (Solar PV) [High Suitability]

A feasibility report completed by the consulting firm AEPC Group in 2007 found that Stanford Reservoir's flat roof could support a 1 MW solar PV project across 138,000 square feet of developable area. The

initial report identified hybrid membrane/crystalline PV as the preferred technology choice due to the reservoir roof's weight limitations at the time. AEPC determined that solar PV was the ideal renewable technology type for the site, and updated analyses conducted with Sage Renewables confirm this determination. However, although our analysis shows that there is a smaller developable area of 81,750 square feet, because the reservoir has undergone upgrades that will allow its roof to support more weight more efficient tilted solar panels with a capacity of 1.1 MW may be installed.

Power Staff considers Stanford Heights Reservoir to be a suitable candidate site to develop renewable energy in support of the CleanPowerSF program. Next steps for the site include preparing initial project design work, reviewing interconnection options, re-confirming cost estimates and cost effectiveness and issuing a request for proposals (RFP) for project development.

Sutro Reservoir. (Solar PV) [High Suitability]

Sutro Reservoir near Sutro Tower in San Francisco was identified as a suitable renewable energy project location by a number of consultants engaged by the SFPUC in recent years, including AEPC Group, Black & Veatch, and most recently Sage Renewables. The reservoir's large flat roof makes it an attractive site for solar PV. An initial feasibility report prepared in 2007 projected the site could support 1.5 MW of flat solar photovoltaic panels. Sutro Reservoir subsequently underwent retrofits and upgrades in 2014 that allow it to hold more weight. More recent analysis shows that the Sutro Reservoir roof can support a larger 2.76 MW project across 233,600 square feet of developable area.

Power Staff considers Sutro Reservoir to be a good candidate for local renewable development. Next steps for the site include, initial project design work, reviewing interconnection options, and issuing a request for proposals (RFP) for project development.

University Mound Reservoir North Basin. (Solar PV) [High Suitability]

University Mound Reservoir North Basin in the Portola neighborhood has a developable roof area of 300,000 square feet to support 4.26 MW of solar PV. This reservoir has been seismically retrofitted and undergone upgrades that will allow it to withstand the weight of solar. Power Staff considers this site a suitable candidate location to be developed for the CleanPowerSF program. Next steps for the site include initial project design work, reviewing interconnection options, reconfirming cost estimates and cost effectiveness, and issuing a request for proposals (RFP) for project development.

In-City Covered Reservoirs. (Solar PV) [Medium Suitability]

A portion of SFPUC covered reservoirs have undergone the structural upgrades required to support a solar array. Analysis conducted in conjunction with Sage Renewables has identified College Hill, Sunset Reservoir South Basin, and University Mound Reservoir South Basin as in-City reservoirs that *cannot* currently support the weight of a solar project. Aggregated, these projects represent 8.35 MW of potential in-City renewable energy capacity.

Structural improvements to Sunset Reservoir and University Mound Reservoir South Basins are listed in the SFPUC City Distribution Division's Capital (CDD) Improvement Plan to be completed by 2028 and 2029 respectively. College Hill Reservoir is also scheduled to undergo structural upgrades and a roof replacement in 3-5 years. Power Staff will coordinate with CDD to monitor the capital improvement process for these reservoirs and incorporate design features that will accommodate solar panels when possible.

Merced Manor Reservoir. (Solar PV) [Low Suitability]

Initial feasibility analyses by Sage Renewables has found that Merced Manor could support a 878 kW solar installation. However, the reservoir's roof is currently accessible to the community as public open space. Installation of solar PV may limit public access to the site, which needs to be taken into consideration before SFPUC moves forward with any project at Merced Manor. Due to the site's current use as open public space, Power Staff view Merced Manor as having a low potential for near-term development.

University Mound Reservoir. (In-conduit small hydro) [Low Suitability]

Feasibility analyses conducted for an in-conduit small hydro project at University Mound Reservoir found that there are 250 kW of potential developable capacity at the site. SFPUC began efforts to develop the site, but work on this project was halted in 2016 due to infrastructure requirements that would have made the project uneconomic to construct.

The SFPUC will continue to monitor developments in technologies that may lower the costs of in-conduit hydro without impacting drinking water quality and delivery.

San Francisco Department of Public Health (SFDPH)

Laguna Honda Hospital. (Solar PV) [Medium Suitability]

There are three surface parking lots at Laguna Honda on which solar PV carports could be installed. Power Staff analysis has identified a total of 1.38 MW of potential capacity between the three lots. Developing the carport sites could be advantageous as they provide shading benefits, pose a lower risk to existing structures, do not require structural upgrades, and have minimal impacts on regular hospital operations. However, carport installations can cost up to 40% more than a rooftop solar installation. Due to expected higher costs, Power Staff have designated this site as a Medium Suitability site.

Laguna Honda Hospital's roof has 30,000 square feet that could support a 231 kW system. However, SFPUC and SFDPH Staff have identified load limits of the roof that would impede its ability to support the weight of solar panels. Remodels of the original Laguna Honda buildings are planned, but they do not include upgrades that would increase the site's suitability for solar PV.

An expansion to the hospital opened in 2010. The Pavilion, which joins the new and old hospital building segments, was designed to allow photovoltaic panels to be installed. When opened in 2010, SFDPH did not install panels in anticipation of improvements in technology and lowering costs. Discussions with SFDPH revealed that the new construction is under the Office of Statewide Health Planning and Development's (OSHPD) jurisdiction, which could result in an extended project development process and decreased total capacity due to roof setbacks. Analysis conducted for this report shows that 77 kW would be able to be accommodated on the Pavilion, which is below the minimum threshold set for cost-effectiveness in this report. Installing solar on this facility could also impact day to day hospital operations. As a result, Power Staff have designated the Hospital roof and Pavilion areas as Low Suitability sites.

Next steps for renewable energy development at Laguna Honda hospital include further collaboration with SFDPH to support preparing a detailed site-specific feasibility report, completing initial project designs, and updates to cost estimates following the completion of this work.

San Francisco Municipal Transportation Authority (SFMTA)

SFMTA has expressed a preference for offsetting onsite load with any renewable energy projects installed on their property. Agency Power Staff have indicated that they would be open to an agreement in which excess generation is exported to contribute to CleanPowerSF supply.

Mission and 5th Parking. (Solar PV) [Low Suitability]

The SFMTA parking garage at Mission and 5th Streets in the South of Market (SOMA) neighborhood has been identified as a potential candidate for a solar canopy project with a projected capacity of 604 kW. The site's primary function as a parking garage with limited on-site load initially made it a top site for CleanPowerSF development. Further analysis of the site revealed that it is interconnected to the PG&E downtown network,[31] which does not allow projects to export to the grid.

Muni Curtis E. Green Light Rail Center (Metro Green). (Solar PV) [Medium Suitability]

The Muni Metro Green yard serves as a rail yard for light rail car storage and maintenance. The available roof space at this facility could support a 388 kW project. SFMTA has identified the Green Facility as a potential site for solar PV to offset onsite usage in their 2019 SFMTA 20-Year Capital Needs report. The roof at this site is around 5 years old and can readily support solar PV. SFMTA's preference to offset onsite usage and the transition to an all-electric Muni fleet may impact the amount of excess electricity available for export to contribute to CleanPowerSF's supply. Further analyses are required to better understand the forecasted increase in energy demand before determining whether this is a more suitable site for the CleanPowerSF or Hetch Hetchy Power program.

Muni Flynn Division. (Solar PV) [Low Suitability]

SFMTA's Muni Flynn Division is the location of one of the Agency's motor coach vehicle pools. The facility was built in 1941 and acquired by SFMTA in 1989. The aging roof requires structural upgrades before a solar PV project can be installed. Prior SFPUC and SF Environment feasibility analyses revealed that pursuing energy efficiency upgrades at this site would be more cost effective than upgrading the roof and installing solar. SFMTA Staff have confirmed that they are actively following this recommendation. Power Staff is not aware of any planned upgrades that would enable to roof to support solar at this site. Additionally, Muni's transition to an all-electric fleet will limit the amount of electricity available for export from a project at Flynn Division. Further analysis should be conducted to forecast projected increases in demand on this site to determine whether it could be a suitable project for CleanPowerSF or Hetch Hetchy Power if the necessary roof upgrades are completed.

San Francisco General Hospital Parking Garage. (Solar PV Canopy) [Low Suitability]

A solar parking canopy has been analyzed for installation on the top level of the San Francisco General Hospital Parking Garage. Site analyses have shown that a projected that 408 kW of solar trellises or canopies could be installed on site. SFMTA has expressed a preference for self-use of any power generated on their facilities, additionally, Power Staff have identified existing challenges with infrastructure to tie the project into the grid which would increase total project costs. Given that the

[31] For more information see: https://www.pge.com/includes/docs/pdfs/b2b/interconnections/SecondaryNetworks.pdf (accessed on March 10, 2020)

excess generation at this site is projected to be small, Power Staff conclude it would not be cost-effective to develop this site as a CleanPowerSF project.

San Francisco Unified School District (SFUSD)

San Francisco Unified School District operates more than 160 facilities to serve 55,500 students. The SFPUC has partnered with SFUSD in the past to develop solar PV projects on a number of school sites including Thurgood Marshall High School, Alvarado Elementary School, and Cesar Chavez Elementary School. SFUSD has set a goal of generating all its power onsite by 2050 and is making strides towards that goal with the help of the SFPUC to install up to three new solar PV systems each year. Therefore, any solar PV installation on SFUSD property will first be utilized to serve their on-site load. However, if a site's usable space is ample enough to allow for the installation of a project large enough to produce excess generation, that generation may be used to supply CleanPowerSF customers.

Analysis shows that the developable rooftop area across the SFUSD building portfolio can support 17.8 MW of solar PV capacity. Of all SFUSD sites, Power Staff have identified the following as High Suitability candidates for solar development: June Jordan School for Equity, George Washington High School, Everett Middle School, Lowell High School, and Garfield Elementary School.

Power Staff will maintain communication with SFUSD to collaborate on the design and development of solar installations to support both agencies' clean energy goals.

City College of San Francisco (CCSF)

Ocean Campus: Science Hall. (Solar PV) [Low Suitability]

Power Staff have identified Science Hall at CCSF as a potential site for a 385 kW rooftop solar PV project. A Facilities Condition Assessment conducted by CCSF has found the building to be in very poor condition and expect high renovation costs. As such, the site's current roof conditions are not suitable to support a solar PV installation. However, continued communication with CCSF Buildings and Grounds Staff is recommended to track updates to the site and its suitability for solar development.

Ocean Campus: New Buildings. (Solar PV) [Low Suitability]

The CCSF 2019 Facilities Master Plan includes recommendations for new structures at the Ocean Campus. In most cases, construction of the new buildings would require removal of existing structures. The proposed sites can be seen in yellow in the map in Figure 10 below. While near-term solar development at these sites is unlikely, communication with CCSF throughout the planning and construction process may facilitate the identification of potential opportunities for solar project development either for on-site usage or in support of either the CleanPowerSF or Hetch Hetchy Power services. As there remains significant uncertainty regarding which of the proposed buildings will be constructed and when, Power Staff currently consider these projects a Low Suitability for near term development.

Power Staff will maintain communication with CCSF to identify opportunities to collaborate on the design and development of renewable energy installations that support both agencies' goals.

Figure 10. City College of San Francisco New Recommended Facilities Map[32]

San Francisco Department of Public Works (SFDPW)

SFDPW Maintenance Yard (Solar PV) [Low Suitability]

SFDPW manages a maintenance yard that consists of seven buildings. Together, they represent 80,000 square feet of potential solar PV development area for a project total of 616 kW. However, based on a review conducted for this report, Power Staff believes that the buildings would need structural upgrades to support solar panels. SFPUC is not aware of any planned upgrades by SFDPW to the site in the near-term and have designated it as a Low Suitability site for near-term development.

Port of San Francisco (Port)

The Port of San Francisco manages and has properties along San Francisco's waterfront from Fisherman's Wharf to India Basin. Past analyses and feasibility reports have identified the following Port Piers as potential sites for solar PV development: Pier 35, Pier 38, Pier 45, Pier 48, Pier 50, Pier 54, Pier 80, and Piers 90-94. All proposed projects would be rooftop installations, except for Piers 90-94, which have enough area to support a ground mount single axis tracker.

While the large available area at the Port indicates that the facilities could be potentially good sites for solar PV, there exist site specific risks that make them less attractive and likely unsuitable for development in the near-term.

[32] For more information see City College of San Francisco 2019 Facilities Master Plan: https://www.ccsf.edu/dam/Organizational_Assets/About_CCSF/Admin/facilities_planning/2017FMP/20190318/FMP_03182019_4Recommendations.pdf (accessed on March 10, 2020)

The location of these sites on the San Francisco waterfront in a marine environment poses risks that can increase project costs and negatively impact ratepayers. The presence of salt in the marine air at the Port is likely to result in the corrosion of solar modules and require repairs or replacement faster than at other locations within the city. Power Staff review of solar module warranties found that they were void for panels placed in marine environments or exposed to direct contact with salt water.[33] The SFPUC's current installation at Pier 96 has also been negatively impacted by bird activity in the area, which has significantly increased project maintenance requirements. The risks presented by developing projects within the marine environment need to be further evaluated and mitigated before moving forward with additional projects at these sites.

Additionally, there are structural and contractual challenges that would delay construction of renewable energy projects at Port sites. Most of the buildings on the piers are older construction and cannot currently support the weight of solar photovoltaic infrastructure and would need to undergo structural upgrades at significant cost prior to installing power generation equipment. For example, upgrading Pier 38 alone to usable condition could cost upwards of $20 million,[34] which is expected to be several times the cost of the solar PV system that could be accommodated at the site.

Many of the buildings and areas on the piers are also leased out to private entities, including but not limited to Pier 45, Pier 48, Pier 50, and Pier 80. Long-term leases at these and other sites will complicate the solar PV contracting process as the Port may not have total control of the facilities on site.

Power Staff believes that the above challenges must be addressed before moving forward with additional renewable energy projects at the Port. Next steps include further engaging the Port to learn more about opportunities to leverage capital upgrades to increase the sites' suitability for solar PV and continued monitoring of successful installations in marine environments to learn more on best practices for these types of projects.

Other Possible City and County of San Francisco Sites

Hunters Point Parcel E (U.S. Navy, City of San Francisco). [Low Suitability]

Hunter's Point Parcel E had been identified as a potential site for a 3 MW ground mount PV project in previous analyses including the Enernex Report. Investigation of the site by Power Staff revealed that it has not yet been transferred to the City from the Navy. Staff at the Office of Community Investment and Infrastructure informed Power Staff that the U.S. Navy currently maintains ownership of the site. The earliest transfer date for the entire site is not until 2025, but the timeline is dependent on contamination sampling work that is not planned to commence until Spring of 2020. If it is found that remediation will have to be conducted, the transfer timeline will be delayed. City development on Hunters Point Parcel E cannot commence until it is under San Francisco's jurisdiction. Power Staff will continue to monitor the status of site transfer and discussions regarding possible use of the site as it could be an attractive future site for renewable energy project development.

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[33] Staff review of warranties for: SunPower, LG, Mission Solar, Jinko Solar, Panasonic, Canadian Solar, Mitsubishi Electric, and Sunpreme solar modules found mentions of marine environments or contact with salt water under exclusions and limitations of product warranties.

[34] For more information see: https://www.sfchronicle.com/politics/article/SF-Port-wants-ideas-floated-for-decaying-piers-12262572.php (accessed on March 10, 2020)

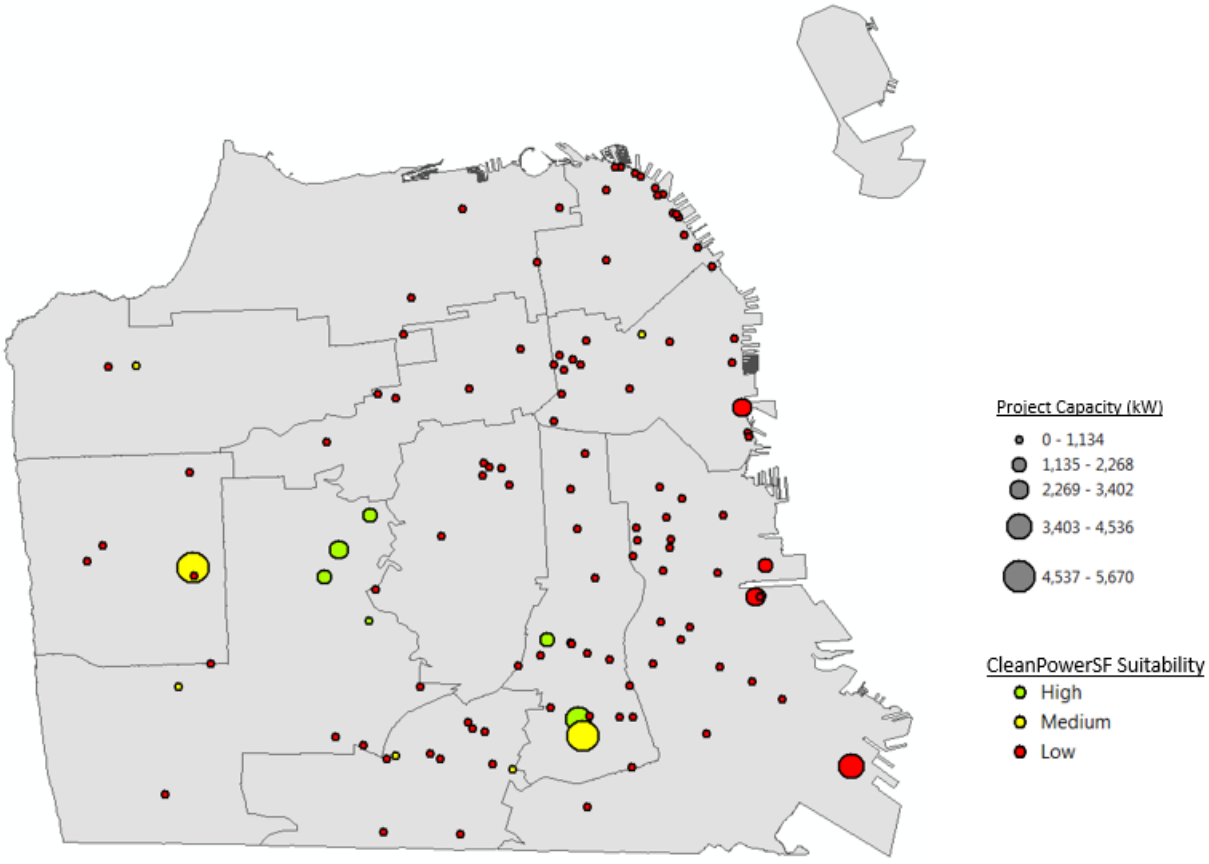
In-City City-owned Sites Summary

Power Staff identified an initial list of 132 total sites across San Francisco on which a renewable energy project could be developed. Feasibility screens and analyses resulted in the list of projects described in this section.

Based on this review and analysis, Power Staff find the SFPUC covered reservoirs to be the most suitable in-City candidate sites for renewable energy project development to supply CleanPowerSF service. As described above, Sutro Reservoir, Stanford Heights Reservoir, University Mound Reservoir North Basin, and Summit Reservoir have undergone structural upgrades and are able to support the weight of solar PV panels. They also have minimal on-site load, so they are well suited to export energy for consumption by CleanPowerSF customers.

The figure below shows all in-City and City-owned project sites analyzed and their final suitability ranking.

Figure 11. In-City, City-Owned Sites



A summary of high-level findings arrayed by the City Agency responsible for managing the site is included in Table 8 below. Individual sites, as part of this review, have been assigned a suitability rating for CleanPowerSF development of Low, Medium, or High. Medium and High Suitability sites have been itemized with high-level site details below in Table 9.

Table 8. Potential In-City Renewable Projects on City Property: Sites Reviewed by Agency

					# Sites Identified					
Agency	**# Sites Reviewed**	**Technologies Considered**	**# Med to High Suitability Sites Identified**	**Med to High Suitability Potential kW**	**Structural Improvements Required**	**Environ. /Wildlife Impacts**	**Risks to Asset Identified**	**Export Limitations: Technical**	**Export Limitations: On-site usage**	**Contractual Risks/Competing Usage**
SFPUC	19	Solar PV, Small Hydro	8	21.710	5	1	1	0	9	1
SFDPH	18	Solar PV	1	1,380	0	0	0	1	17	0
SFUSD	38	Solar PV	4	2,398	2	0	0	0	38	0
SFMTA	9	Solar PV	1	388	3	0	0	2	9	0
City College of San Francisco	3	Solar PV	0	0	1	0	0	0	3	0
SFDPW	2	Solar PV	0	0	1	0	0	1	2	0
Port of SF	23	Solar PV	0	0	23	23	23	0	21	9
Real Estate Division	7	Solar PV	0	0	0	0	0	1	7	0
SFDEM	1	Solar PV	0	0	0	0	0	0	1	0
DTIS	1	Solar PV	0	0	0	0	0	0	1	0
SFPL	7	Solar PV	0	0	0	0	0	0	7	0
Rec and Park	3	Solar PV	0	0	0	0	0	0	3	0
Arts Commission	1	Solar PV	0	0	0	0	0	0	1	0

Table 9. Medium and High Suitability In-City Renewable Projects on City Property

Site Name	Agency	Technology Considered	Med to High Suitability Potential Project Capacity (kW)	Med to High Potential Project Generation (kWh)	Estimated 25-Year Levelized Cost of Energy ($/MWh)	Current Potential Suitability for Development	Next Steps	Issues Identified with Development for CleanPowerSF					
								Risk to Asset	Structural Improvements Required	Environ./Wildlife Impacts	Export Limitations: Technical	Export Limitations: On-Site Usage	Contractual Risks/Competing Usage
Stanford Heights Reservoir	**SFPUC**	Solar PV	1,060	2,507,112	$81-$139	High	Begin additional feasibility analyses and design work prior to issuing RFP	Low	No	Low	Low	Low	Low
Sutro Reservoir		Solar PV	2,760	6,527,952	$76-$113	High	Begin additional feasibility analyses and design work prior to issuing RFP	Low	No	Low	Low	Low	Low
University Mound Reservoir North Basin		Solar PV	4,260	10,075,752	$83-$120	High	Begin additional feasibility analyses and design work prior to issuing RFP	Low	No	Low	Low	Low	Low
Summit Reservoir		Solar PV	1,230	2,909,196	$90-$133	High	Begin additional feasibility analyses and design work prior to issuing RFP	Low	No	Low	Low	Low	Low
Sunset Reservoir South Basin		Solar PV	5,670	13,410,684	$83-$120	Medium	Monitor structural upgrade completion to begin feasibility and project design process	Low	Yes	Low	Low	Low	Low
University Mound Reservoir South Basin		Solar PV	5,170	12,228,084	$79-$116	Medium	Monitor structural upgrade completion to begin feasibility and project design process	Low	Yes	Low	Low	Low	Low
College Hill Reservoir		Solar PV	1,560	3,689,712	$86-$123	Medium	Monitor structural upgrade completion to begin feasibility and project design process	Low	Yes	Low	Low	Low	Low

Table 10. (cont'd) Medium and High Suitability In-City Renewable Projects on City Property

								Issues Identified with Development for CleanPowerSF					
Site Name	**Agency**	**Technology Considered**	**Med to High Suitability Potential Project Capacity (kW)**	**Med to High Potential Project Generation (kWh)**	**Estimated 25-Year Levelized Cost of Energy ($/MWh)**	**Current Potential Suitability for Development**	**Next Steps**	**Risk to Asset**	**Structural Improvements Required**	**Environ./Wildlife Impacts**	**Export Limitations: Technical**	**Export Limitations: On-Site Usage**	**Contractual Risks/Competing Usage**
SFUSD Schools	**SFUSD**	Solar PV	2,398	3,151,660	$96-$151	Medium	Continue communication with SFUSD to develop preferred partnership model; identify any necessary structural upgrades	Low	Yes	Low	Low	Med/ High	Med/ High
Metro Green	**SFMTA**	Solar PV	388	917,698	$87-$113	Medium	Conduct analyses to determine future export potential	Low	No	Low	Low	Med/ High	Low
Laguna Honda Hospital - Parking	**SFDPH**	Solar PV	1,380	3,263,976	$92-$132	Medium	Coordinate with SFDPH on additional project feasibility analyses	Low	No	Low	Low	Low	Low

5.2 Other City-Owned Regional Options

In parallel with analysis of in-City projects, Power Staff have been working with consultants to analyze development opportunities on SFPUC property located outside of the City and County of San Francisco, but within the Bay Area region. A number of these sites have been reviewed in past project development analyses and were found to be promising. For example, renewable project development at SFPUC's Sunol and Pulgas sites was included CleanPowerSF's 2018 IRP analysis.

Sunol Valley. [High Suitability]

The SFPUC owns land and maintains assets in the town of Sunol, in Alameda County. A request for information (RFI) was issued for the Sunol Valley Golf Course, which the SFPUC plans to redevelop for alternative uses in the coming years. This site, along with adjacent parcels has the potential to support 40 MW of solar PV and battery storage systems. A number of additional uses were submitted through the RFI process. Community feedback continues to be gathered, with some indications that there is concern that a large-scale solar project may have visual impacts and reduced access to the site. These competing uses may limit the total amount of solar PV installed at the Sunol Golf Course.

The Sunol Water Treatment Plant is undergoing upgrades that may improve its suitability of onsite solar. SFPUC Water Enterprise Staff have confirmed that there is a preference to offset onsite usage with a solar project, but high costs may result in solar being excluded from planned upgrades. In this case, a project in support of CleanPowerSF may be feasible at this site. However, additional feasibility analysis will be required to evaluate a project's cost-effectiveness at the Sunol Water Treatment Plant.

Tesla Portal. [Medium Suitability]

Tesla Portal in San Joaquin County is the site of the SFPUC's Tesla Portal Hypochlorite Station. Open land at this location would be able to accommodate up to 2.95 MW of ground mount solar PV. The availability of contiguous areas of relatively flat land make this a favorable site for regional renewable energy development. However, on-site usage is equivalent to the projected renewable energy generation by solar PV at Tesla Portal, making it a potentially good candidate for a Hetch Hetchy Power developed project.

Pulgas Balancing Reservoir. [Low Suitability]

The roof at Pulgas Balancing Reservoir in Redwood City was replaced in 2013. However, it was constructed of a membrane material that would need to be upgraded before it is able to support solar PV panels. No additional structural work is planned for Pulgas Reservoir in the Water Enterprise Capital Improvement Plan and is not anticipated given the roof is relatively new. This site will not be suitable for CleanPowerSF development until it is completed in the 5 to 10-year window.

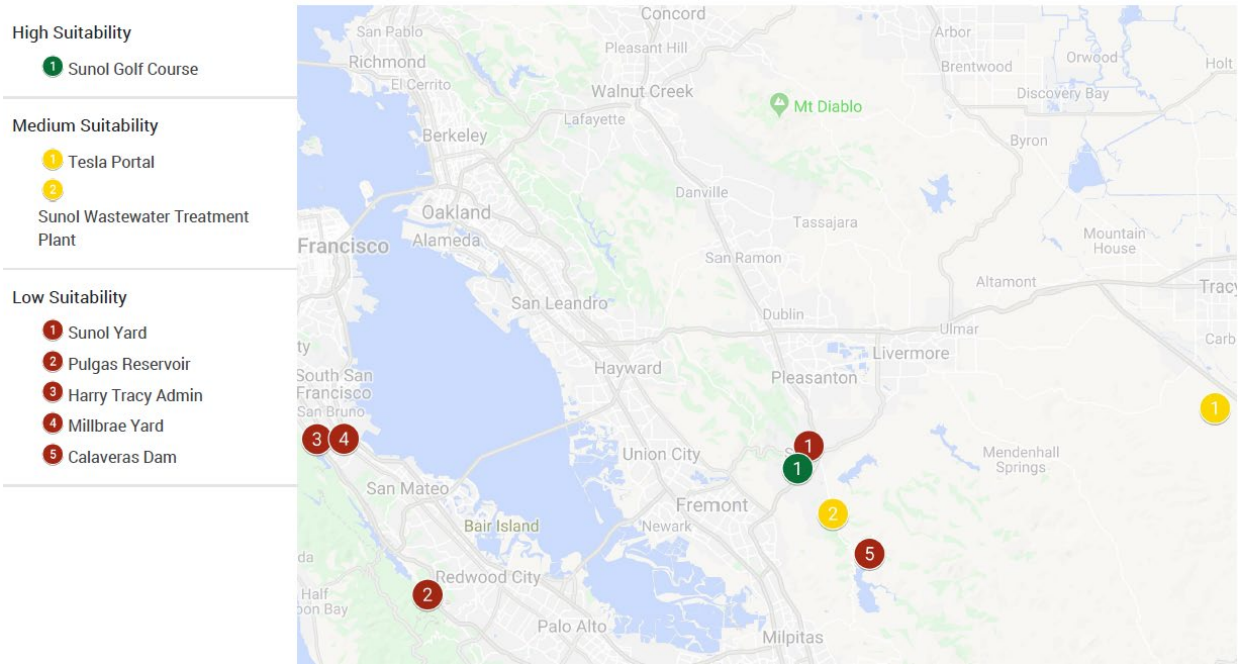
Other City-owned Regional Options Summary

Power Staff identified an initial list of 8 SFPUC owned sites in the 9-county Bay Area region where a renewable energy project might be developed. Feasibility analyses resulted in the list of sites presented in this section.

Findings from Power Staff review and analysis suggest a utility scale solar project at Sunol Valley has the best potential within the Bay Area region, from a scale and cost-effectiveness standpoint. The site can accommodate approximately 40 MW of solar and at least 20 MW of battery storage. However, additional feasibility analysis and community engagement will be required to better understand whether a project can be developed in this area.

Figure 12 below shows all regional projects analyzed and their final suitability ranking.

Figure 12. Regional City Owned Sites



Additional information regarding the analysis of the SFPUC sites is provided in Table 10 below.

Table 11. Regional Medium and High Suitability Sites for Renewable Development

Site Name	Ownership	Technology Considered	Potential Capacity (kW)	Estimated 25-Year Levelized Cost of Energy ($/MWh)	Current Suitability for Development	CleanPowerSF Next Steps	Issues Identified with Development for CleanPowerSF					
							Risk to Asset	Structural Improvements Required	Environ./Wildlife Impacts	Export Limitations: Technical	Export Limitations: On-Site Usage	Contractual Risks/Competing Usage
Sunol Valley	**SFPUC**	Solar PV	40,000	$42-$68	High	Begin additional feasibility analyses and design work prior to issuing RFP	Low	No	Low	Low	Low	Medium
Sunol Valley (Storage)		Solar + Storage	40,000 (solar) + 20,000 (storage)	$55-$98	High	Begin additional feasibility analyses and design work prior to issuing RFP	Low	No	Low	Low	Low	Medium
Tesla Portal		Solar PV	2,950	$90-$96	Medium	Conduct analyses to determine export potential for CleanPowerSF	Low	No	Low	Low	High	Low
Sunol Wastewater Treatment Plant		Solar PV	1,140	$98-$104	Medium	Maintain communication with Power Staff evaluating project to offset onsite use to identify opportunities for CleanPowerSF development	Low	No	Low	Low	Medium	Low

5.3 Other Renewable Energy Development Opportunities Within or Near San Francisco

In addition to examining opportunities to develop renewable energy projects on City-owned property, Power Staff have researched other renewable energy technology and development opportunities within and near San Francisco. This section reviews the near-term potential to foster the development of new renewable energy facilities through a CleanPowerSF Feed-in Tarff program as well as under new Disadvantaged Communities Green Tariff and Community Solar initiatives. The section also examines the current prospects of emerging technology, like small-scale urban wind turbines, utility-scale off-shore wind turbines, and wave power.

Feed-in Tariff for in-City Renewable Energy Development [High Suitability]

Power Staff, together with consultants, are analyzing the opportunity for incentivizing development of solar PV within San Francisco using a Feed in Tariff (FiT) program. Under a FiT program, CleanPowerSF would pay owners of small-scale (<1MW) projects in CleanPowerSF's service area to deliver electricity to the grid on behalf of CleanPowerSF. CleanPowerSF would pay project owners a fixed price over a specified contract term, typically 20 years. The program development potential is being estimated using Google's Project Sunroof tool, combined with more in-depth and site-specific helioscopic analyses.

As of the release of this report, it is estimated that, depending on FiT program pricing levels and Net Energy Metering (NEM) uptake, 2-10 MW of solar PV could be economically viable and appropriate for development under a FiT program within the next 5-10 years.

Analysis is still underway to determine a best estimate for FiT program potential at different FiT price levels. A refined estimate of FiT program potential is expected to be available with the release of CleanPowerSF's 2020 Integrated Resource Plan in the Spring of 2020.

Disadvantaged Communities Community Solar and Green Tariffs [High Suitability]

Assembly Bill 327 (2013, Perea) directed the California Public Utilities Commission (CPUC) to develop programs and incentives to increase the adoption of renewable energy in disadvantaged communities (DACs), as identified by California Communities Environmental Health Screening Tool (CalEnviroScreen). CalEnviroScreen identifies California communities by census tract that are disproportionately burdened by, and vulnerable to, multiple sources of pollution. In 2018, the CPUC launched three programs to increase renewable energy development within California's disadvantaged communities.

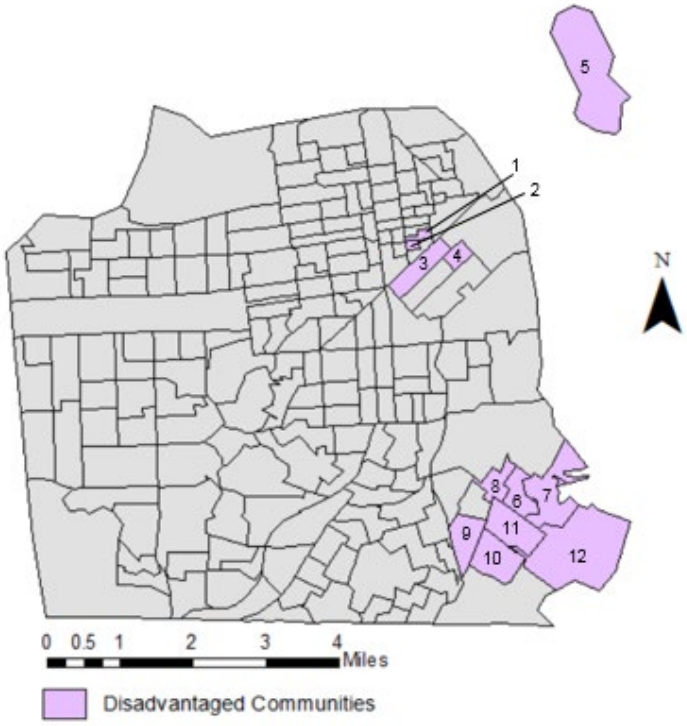
The first program, the Disadvantaged Communities – Single Family Solar Homes (DAC-SASH) program, is administered by Grid Alternatives statewide and allows income qualified homeowners to install rooftop solar at no cost. The SFPUC's GoSolarSF program is supporting the implementation of this program in San Francisco.

The other two programs, DAC Green Tariff (DAC-GT) and DAC Community Solar Green Tariff (DAC-CSGT), allow for the increased adoption of renewable energy by residents who may not be homeowners or are not able to install rooftop solar on their homes. Both the DAC-GT and DAC-GTCS programs allow customers in disadvantaged communities to subscribe to 100% renewable energy through their electricity provider.

There are 12 census tracts in San Francisco that are CalEnviroScreen 3.0 Disadvantaged Communities and eligible for these programs. As Figure 13 shows, nearly all the customer accounts in these tracts are eligible for CleanPowerSF service and can benefit from these programs.

Figure 13. CalEnviroScreen 3.0 Disadvantaged Communities in San Francisco

Map ID	Census Tract	% Accounts Eligible for CleanPowerSF
1	6075012301	100%
2	6075012502	100%
3	6075017601	99%
4	6075017801	99%
5	6075017902	n/a
6	6075023102	99%
7	6075023103	95%
8	6075023200	100%
9	6075023300	99%
10	6075023400	99%
11	6075061200	99%
12	6075980600	99%



The DAC-GT program requires that new solar projects be sited within a disadvantaged community in the customer's respective investor owned utility service territory (i.e., PG&E's service area for CleanPowerSF) while the DAC-CSGT program requires new projects be located in a DAC within 5 miles of the subscribing customers. Both programs provide California Alternative Rate for Energy (CARE) and Family Electric Rate Assistance Program (FERA) eligible customers with a 20% discount off their total electricity bill, on top of their standard CARE/FERA discounts. DAC-GT and DAC-CSGT program administrators can recover above market costs approved by the CPUC associated with developing new solar in DACs, program administration costs, and marketing, education, and outreach costs associated with the program from the state's Greenhouse Gas Reduction and Public Purpose Program Funds.

CleanPowerSF received an allocation from the CPUC of 1.49 MW for the DAC-GT and 0.38 MW for the DAC-CSGT program.[35] These programs provide an opportunity for CleanPowerSF to leverage state funding (at least up to these amounts) to develop local renewables in the region's most vulnerable communities in a more cost-effective manner.

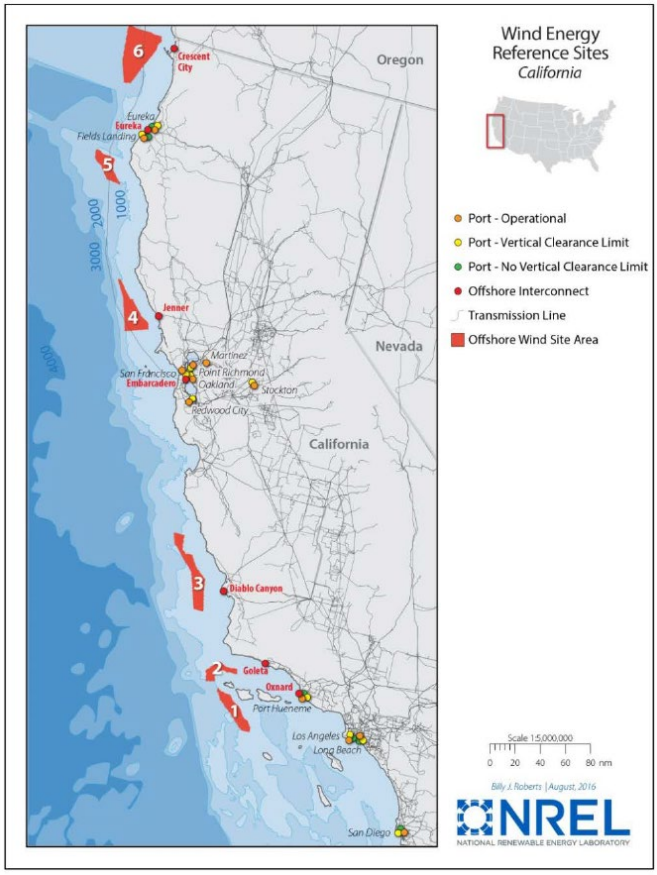
Offshore Wind on the San Francisco/Northern California Coast [Medium Suitability]

While no off-shore wind projects currently exist in California, projects are being explored and a path to deployment of the technology is being forged. The Redwood Coast Energy Authority, the community choice aggregation program serving Humboldt County, has partnered with offshore wind developers, Aker Solutions and Principle Power, to build a 120 MW off-shore wind project in Humboldt Bay, with an estimated project cost of $500 million.[36] This potential project is expected to come online in 2024, pending a successful lease application with the Bureau of Ocean Energy Management.

Castle Wind LLC is also leading the development of an additional 1,000 MW floating offshore wind project off the coast of Morro Bay, in San Luis Obispo County. The project is expected to be commercially operational around 2025, but this is dependent on the Bureau of Ocean Energy Management (BOEM) lease process and the subsequent environmental impact and permitting processes. The project's output is expected to be competitive in the California market by 2025 and thereafter.[37] Figure 14 below shows potential offshore wind BOEM lease sites in California, including the two mentioned above.

[35] For more information see: http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M297/K211/297211380.PDF (accessed on March 10, 2020)
[36] For more information see: https://www.wind-watch.org/news/2018/10/20/trump-administration-opens-california-coast-to-wind-power-projects/ (accessed on March 10, 2020)
[37] For more information see: http://castlewind.com/faq/ (accessed on March 10, 2020)

Figure 14. Offshore Wind Lease Sites in California[38]



Although costs are still high, the delivery profile (see Figure 5 above) and energy availability of offshore wind make it a potentially attractive option for procurement in coming years. Power Staff will continue to monitor offshore wind deployment and will stay engaged with technology developers to continue to assess the costs, risks, and opportunities for offshore wind energy procurement. More areas along California's coast, including those closer to San Francisco, could become offshore wind site areas as BOEM conducts more lease auctions.

In-City Urban Wind [Low Suitability]

Power Staff have investigated siting small-scale wind turbines within San Francisco as a potential source of renewable energy supply. A review conducted by the National Renewable Energy Laboratory (NREL) of demonstration projects deployed in cities across the country suggests that the technology is not mature enough for serious pursuit at this time.[39]

[38] For more information see: https://www.boem.gov/sites/default/files/environmental-stewardship/Environmental-Studies/Pacific-Region/Studies/BOEM-2016-074.pdf (accessed on March 10, 2020)
[39] For more information see: https://www.nrel.gov/docs/fy16osti/65622.pdf (accessed on March 10, 2020)

Small urban wind has not yet developed into commercially viable technology like rooftop solar, which has flourished thanks to its comparative price advantage and reliable performance. The inherent challenges in collecting wind in an urban setting are driving this discrepancy. Two factors determine the energy producing potential of a wind energy project: (1) the quality of the wind resource present at the project's location, and (2) the technical abilities of the turbine used to collect the wind energy and then convert it into electricity. Due to the many obstructions inherent in the built environment, the wind resource is generally poor in urban settings, and new technologies that may enable better performance are still years from maturity. Examples of urban wind demonstration projects may be seen in Figure 15 below.

Figure 15. Urban Wind Installations at Brooklyn Naval Yard and Detroit Metro Airport[40, 41]

[40] Image from: https://www.environmentalleader.com/2009/04/wind-turbines-solar-coming-to-historic-brooklyn-navy-yard/ (accessed on March 10, 2020)
[41] Image from: https://www.internationalairportreview.com/news/2260/earth-day-breezes-into-detroit-metro-airport/ (accessed on March 10, 2020)

Challenges in generating wind power in urban settings arise from the generally poor wind resource present in urban environments due to surrounding buildings and the low efficiency of turbines in harvesting the wind power. The NREL study found that most small wind projects in urban settings have failed to be economically viable. A range of technical issues have resulted in the most successful projects generating only 61% of their predicted output and have kept a number of projects from functioning at all. Table 11 provides a summary of the urban wind projects highlighted in the NREL report.

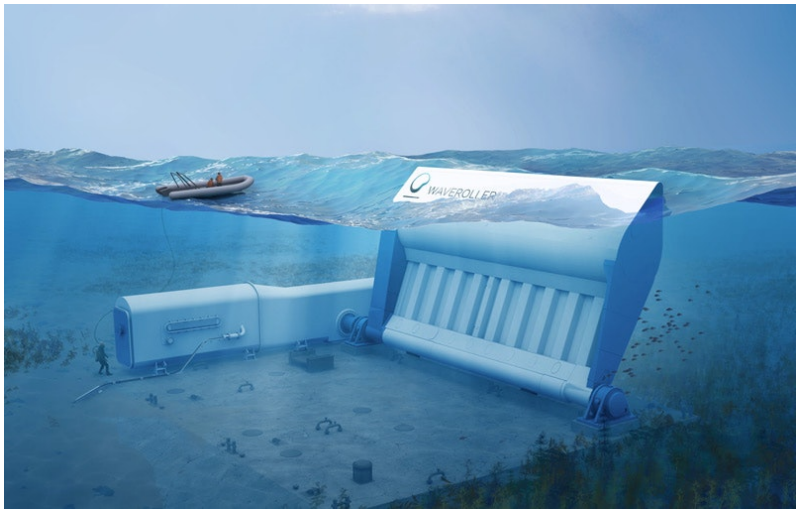
Table 12. Example Urban Wind Project Performance and Costs

Project	Twelve West	Detroit Metro Airport	Museum of Science	Brooklyn Navy Yard	Pearson Court Square	NASA Building 12
Location	Portland, OR	Detroit, MI	Boston, MA	Brooklyn, NY	Long Island City, NY	Houston, TX
Installation Date	2009	2010	2009	2008	2015	2014
Capacity (kW)	9.6	7.2	15.6	6	9.6	4
Estimated Production (kWh/yr)	9,000	2,000	20,498	14,400	6,000	1,250
Actual Production (kWh/yr)	5,500	N/A	4,229	127	TBD	0.116
Cost	$240,000	$75,000	$350,000	$39,000	$185,000	$100,000
Payback	~40 years	N/A	>20 years	N/A	TBD	N/A
Maintenance Issues	Minor issues being managed by building owner	Bankrupt manufacturer limiting part availability	One turbine not functional, all have needed service	N/A	Adjustment to resolve noise and vibration	Currently waiting on manufacturer for software update

Wave Energy on the San Francisco Coast (US Federal Government) [Low Suitability]

Power Staff have explored the potential for deployment of wave energy to supply energy to San Francisco. In 2011, SFPUC analyzed the feasibility, opportunities, and challenges of a project's development along the San Francisco coastline. At that time, the cost of leasing ocean space and permitting procedures for a technology not yet established in the United States were significant challenges. For this report, Power Staff conducted research to understand the status and prospect of wave energy development near San Francisco.

Figure 16. Wave Roller Technology Deployed in Portugal[42]



Research conducted for this report found that wave energy technology is still an experimental and emerging technology. While demonstration projects have been developed, there are no operating utility-scale examples in the United States. Partly due to its early stage of development, data on these projects is not publicly available. Information available from the Middlebury Institute of International Studies, however, suggests that the average cost per megawatt-hour (MWh) of energy from these projects, even in countries where the path to leasing and permitting has been established, is significantly higher than other renewable energy technologies on the market today in California[43].

Power Staff believe that near-term investment in local wave energy is likely cost prohibitive, and project development is potentially infeasible due to a lack of vendors in the US market and unclear permitting processes. Power Staff will continue to monitor wave energy technology development and progress on U.S. deployment and costs.

In-City Non-City-Owned Sites Summary

The above opportunities have the potential for providing new supplies of local renewable energy to the CleanPowerSF program. Power Staff believe that development of a Feed-in Tariff and leveraging State funding to launch DAC solar programs are the most viable near-term approaches for fostering additional local investment at this time. Power Staff are also optimistic about offshore wind and will continue to monitor its development and cost. The remaining technologies – urban wind and wave energy – are still in the early stages of development and are unlikely to be ready for deployment or cost-effective within the next five years. The SFPUC will continue to monitor the development of these and other renewable energy technologies for future iterations of CleanPowerSF's Integrated Resource Plan.

[42] For more information see: https://aw-energy.com/waveroller/ (accessed on March 10, 2020)
[43] For more information see: https://www.oceaneconomics.org/offshore_renewables/costs/ (accessed on March 10, 2020)

Table 13. Other Renewable Energy Development Opportunities Within or Near San Francisco

Site Name	Ownership	Technology Considered	Med to High Suitability Potential Project Capacity (kW)	Projected Costs ($/MWh)	Current Potential Suitability for Development	Next Steps	Issues Identified with Development for CleanPowerSF					
							Risk to Asset	Structural Improvements Required	Environ./Wildlife Impacts	Export Limitations: Technical	Export Limitations: On-Site Usage	Contractual Risks/Competing Usage
SF Rooftops (FiT)	Various	Solar PV	2,000-10,000	$180-$240	High	Develop and launch FiT Program (2020)	Low	No	Low	Low	Low	Low
DAC Green Tariff Program	Various	Solar PV	1,490	-	High	File Program Advice Letter and begin program development	Low	No	Low/ Unidentified	Low	Low	Low
DAC Community Solar Program	Various	Solar PV	380	-	High	File Program Advice Letter and begin program development	Low	No	Low/ Unidentified	Low	Low	Low
Offshore Wind	Ocean / Federal	Offshore Wind	600,000	$200 (2018) to $75 (2025)	Medium	Monitor for future procurement opportunities	Low	No	Low/ Unidentified	Medium	Low	Low

6. Conclusion

After reviewing 132 in-City, City-owned sites, Power Staff have identified 9.3 MW of in-City renewable energy capacity that is suitable for near-term development and supply for the CleanPowerSF program. All of this capacity is on SFPUC owned covered reservoirs that have undergone the structural upgrades necessary to support a solar installation. These High Suitability sites include:

- Stanford Heights Reservoir (1.1 MW)
- Sutro Reservoir (2.8 MW)
- University Mound North Basin (4.2 MW)
- Summit Reservoir (1.2 MW)

For these sites, it is recommended that SFPUC move forward their inclusion in CleanPowerSF's 2020 IRP, initial project design work, reviewing interconnection options, and issuing a request for proposals (RFP) for project development. These projects may be considered for inclusion in CleanPowerSF's capital plan.

Sites rated in this report as Medium Suitability either require structural upgrades before a solar PV project can be installed or need to undergo additional analyses to better understand the site's suitability for power export to supply CleanPowerSF. Those sites that have a limited export potential may be better suited for development by Hetch Hetchy Power or the host agencies themselves to serve onsite load. For sites that could have excess generation capacity, but require structural upgrades, CleanPowerSF can monitor planned upgrades through the City's capital planning process, and where appropriate and cost effective, provide support to ensure planned upgrades include those required to support solar PV.

Power Staff does not recommend prioritizing the development of Low Suitability sites in the near-term. However, as renewable technologies continue to evolve and improve, these sites may become better positioned to host a renewable energy project. These sites can be revisited and analyzed for improved suitability once High and Medium Suitability sites have been addressed.

Opportunities to develop renewable energy projects at SFPUC managed property in Sunol could add as much as 41.6 MW of solar capacity with an additional 20 MW of battery storage. Power Staff propose that these projects be considered further for possible inclusion in CleanPowerSF's capital plans.

There may also exist opportunities for CleanPowerSF to procure renewable energy in the 9-county Bay Area that can increase the diversity of supply and provide baseload or time of delivery benefits, such as from offshore wind. Power Staff will monitor opportunities for procurement of these resources and of other emerging technologies in the region that can add value to the CleanPowerSF portfolio.

CleanPowerSF may also be able to encourage private in-city development of renewables through a FiT program. Initial analysis has found that CleanPowerSF could reasonably expect to develop 2-10 MW of new solar capacity in San Francisco within ten years. Power Staff continues to work on FiT program design and are exploring the possibility of launching a FiT program in 2020.

Going forward, the SFPUC will continue to monitor and evaluate City-owned properties for opportunities to develop renewable energy to serve either CleanPowerSF or Hetch Hetchy Power customers. Each program regularly prepares an IRP to identify future power supply needs and optimal resource investment opportunities. The IRP provides a regular opportunity to incorporate new sites and new renewable energy technologies into our power supply plans. The local renewable development options

can be reevaluated biennially in future versions of the IRP as the CleanPowerSF program and California's renewable energy landscape continue to evolve.