Alameda District Water District – Clean Energy Plan Final Report

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EXECUTIVE SUMMARY

Alameda District Water District (ACWD or the District) operates and manages the water treatment and delivery system for parts of Alameda District including Fremont, Newark, and Union City. ACWD operates nearly 1,000 miles of pipelines, 13 reservoirs and tanks, three treatment facilities, pump stations, and other associated water conveyance structures. Additionally, ACWD manages the local Niles-Cone groundwater basin.

The District retained Michael D. Brown Consulting Engineers (MDB) to update and re-evaluate the renewable energy (solar, wind, fuel cells, hydro, biomass, geothermal, and battery) potential at sites which it previously studied in their 2016 Clean Energy Plan. The objective of this review is to determine which technologies and sites have sufficient development potential and warrant further study.

Following an initial screening analysis, MDB completed a more thorough evaluation of the top ranked sites including a financial analysis of the best potential project(s) at each site.

The District provided site information including address and coordinates; active/closed status; site maps; and utility data. Analyzing this data and other available sources, MDB completed an initial screening assessment of the potential for the feasible development for solar, wind, fuel cell, hydro, biomass, geothermal, and battery storage energy technologies at the District's identified sites.

Based on our initial screening analysis, MDB recommended that the following technologies and sites advance to the financial analyses stage:

- **Solar**
    - Alameda Reservoir
    - Decoto Reservoir
    - Mayhew Reservoir
    - Middlefield Reservoir
    - Patterson Reservoir
    - Whitfield Reservoir/Booster
    - Newark Desalination Facility
    - ACWD Headquarters
    - Pit T1
    - Pit T2
- **Wind**
    - Patterson Reservoir
- **Fuel Cell**
    - Newark Desalination Facility
    - Peralta-Tyson (PT) Wellfield and Blending
    - Mowry Wellfield
- **Battery Storage**
    - Peralta-Tyson (PT) Wellfield and Blending
    - ACWD Headquarters
    - Whitfield Reservoir/Booster
    - Water Treatment Plant #2
    - Mowry Wellfield

SITES ADVANCING TO FINANCIAL ANALYSIS

Following the screening analysis, MDB completed additional evaluation of the following sites/technologies including a financial analysis of the best potential project(s) at each site.

Solar

MDB performed a detailed financial analysis for the following possible solar projects:

Location	Available area (sq ft)	System Capacity (kW)
Alameda Reservoir	105,000	1,470
Decoto Reservoir	83,000	1,150
Mayhew Reservoir	45,000	650
Middlefield Reservoir	50,000	700
Patterson Reservoir	84,000	1,150
Whitfield Reservoir (non reservoir area)	147,000	640
Newark Desalination Facility	9,000	120
ACWD Headquarters	81,000	1,090
Pit T1	840,000	2,200
Pit T2	440,000	2,000
TOTAL		11,170

These sites have sufficient space to host solar PV systems over several hundred kW each making them ideal for a competitive RFP type procurement, particularly if multiple sites were combined into packages of 3 or more MW per RFP. They are also all located within 500 feet of a potential interconnection point likely leading to manageable interconnection costs.

Wind

MDB recommended that the following site undergo the full financial analysis for wind:

- Patterson Reservoir

This location has sufficient wind resources to power a nearly 1MW wind system and is near a PG&E distribution line.

Fuel Cell

MDB recommended that the following locations undergo the full financial analysis for fuel cells:

- Newark Desalination Facility
- Peralta-Tyson (PT)Wellfield
- Mowry Wellfield

These locations have sufficient electricity demand and usage to warrant the analysis.

Battery

MDB recommended that the following locations undergo the full financial analysis for battery storage systems:

- ACWD Headquarters
- Water Treatment Plant #2
- Whitfield Reservoir/Booster
- Peralta-Tyson (PT) Wellfield and Blending

These sites are on rate schedules with demand charges and have large maximum demand to average demand spreads which could be reduced with energy storage leading to lower electricity bills.

Further, MDB recommended that coupling of solar and battery technologies be included in the full financial analyses.

FINANCIAL ANALYSIS RESULTS

With ACWD staff concurrence, MDB completed financial analyses of the projects listed above. Based on the results of the financial analyses, it is recommended that the following solar PV projects be pursued for implementation.

No.	Location	Capacity (kW)	Generation (kWh)	Notes
Implement Near Term				
1	Whitfield Reservoir (non reservoir area)	640	1,232,000	Include on CIP; option for battery storage
2	Mayhew Reservoir	650	968,000	Roof replaced recently
3	Newark Desalination Facility	120	180,000	No roof replacement required
4	ACWD Headquarters (Phase 1 - canopies)	800	1,200,000	Option for battery storage
Implement w/ Roof Replacement				
5	ACWD Headquarters (Phase 2 - building roofs)	290	430,000	Roof replacement scheduled for FY20/21 and FY22/23; option for battery storage
6	Decoto Reservoir	1,150	1,734,000	Roof replacement scheduled for FY22/23
7	Alameda Reservoir	1,470	2,214,000	Roof replacement scheduled for FY23/24
If Feasible				
8	Pit T1	2,200	3,411,000	Site Feasibility Assessment Required
9	Pit T2	2,000	3,101,000	Site Feasibility Assessment Required
Possible Future Sites				
10	Patterson Reservoir	1,150	1,720,000	Roof replacement scheduled for FY24/25
11	Middlefield Reservoir	700	1,034,000	Roof rehabilitation scheduled for FY20/21

MDB recommends that the District engage in a competitive, Request for Proposal ("RFP") style procurement process in which the District aggregates at least three MW (preferably five MW or greater) of total solar capacity in order to attract the best pool of highly qualified solar PV developers. Moreover, MDB recommends that the RFP procurement include investigation of the Pit T1 and T2 floating solar projects with the developer responsible for providing a more in-depth feasibility analysis of these projects. Lastly, the solar procurement should encourage developers to include battery storage option in their proposals and to at least design the solar projects to be “battery-ready” for installation at a later date, if not offered initially.

In addition to these solar projects, the larger fuel cell project (600 kW) at the Desalination Plant may also be feasible. However, prior to moving forward with a procurement for a fuel cell, the District should consider the risks of natural gas pricing uncertainty as well as the capacity factor of the fuel cell system (a higher capacity factor will result in greater demand charge savings) as these considerations will greatly impact the financial benefits or costs of hosting a system.

The other fuel cell sites (Peralta-Tyson Wellfield and Blending, and Mowry Wellfield) are not feasible at this time due to high capital and O&M costs. Fuel cells may also be used as emergency backup generation and the District should evaluate the benefits of that application.

None of the locations analyzed for wind, hydroelectric and standalone battery storage projects as currently configured appear to be financially viable at this time. If physical changes to the Vallecitos Channel occur (replacing the channel with a pipeline) and the flow frequency increases, this hydroelectric project may become viable and should be reconsidered.

Standalone battery storage, while not economically attractive at this time, is undergoing reductions in cost, technology advancement and expansion in new value streams and may become feasible in the near future (two to four years). MDB recommends that the District continue to monitor advancements in this technology to determine future applicability.

SECTION 1 - BACKGROUND

Alameda District Water District (ACWD or District) provides water supply for 84,000 customers and over 350,000 people in Alameda County and within the Cities of Fremont, Newark, and Union City. The service area encompasses 105 square miles and includes pump stations, reservoirs, wells, and treatment facilities. The District is seeking to update and re-evaluate the renewable energy (solar, wind, fuel cell, hydro, biomass, geothermal, and battery) potential which it previously studied in their 2016 Clean Energy Plan. The objective of this clean energy review is to confirm which site/technology combinations are still feasible after the 2016 Clean Energy Plan and are appropriate for further consideration.

The District selected MDB Engineers to complete this analysis and provide recommendations regarding which site/technology combinations hold the most promise. To support this endeavor, the District provided site information including address and coordinates; site maps; utility data; and previous assessment calculations and findings. Analyzing this data and other available sources, MDB Engineers completed a screening analysis to evaluate the potential for solar, wind, fuel cell, hydro, biomass, geothermal, and battery storage technologies at the identified sites and then selected the most promising sites for the more thorough assessment. For the top sites that passed the initial screening, MDB completed a financial analysis of the best projects. The results of the initial screening and detailed financial analyses are summarized in this Assessment Report.

SECTION 2 - INITIAL SCREENING AND EVALUATION OF DISTRICT 2016 PLAN

The MDB Team evaluated District-owned sites for suitability for solar PV, wind, fuel cells, and hydro that were previously assessed in the District's 2016 Clean Energy Plan (Plan). The Plan concluded that biomass and geothermal technologies did not show potential for implementation at any of the District's sites. MDB confirmed these findings and did not conduct additional analysis of these technologies.

In addition, MDB reviewed the feasibility of battery storage systems which were not part of the 2016 Plan. The assessment includes a detailed review of the Plan as a starting point for the analysis, and was built upon with additional information gathered from new and updated sources including the Global Solar Atlas, PV Mapper, NREL's Wind Prospector, and Google Earth datasets. Using the information from these sources, MDB assessed the following characteristics:

- **Site size** – total size and area available for development (this excludes moderate to steeply sloped area)
- **Terrain** – slope, vegetation, and drainages
- **Direct Normal Irradiance (DNI)** – amount of solar energy received on a surface perpendicular to rays of sun measured in kWh/m2 per day; the DNI range in California is 4.0 to 8.5 kWh/m2 per day
- **Wind resource** – wind speed in meters/second (m/s) at 80m and 100m hub height as well as ridge shading; the minimum average wind speed required for utility scale wind turbines is 6 m/s
- Site electricity demand and usage characteristics.

The initial screening findings for each site are described below.

SOLAR

The Plan identified nine District-owned sites for solar potential. The sites are located in the southwestern portion of Alameda District which receives a Direct Normal Irradiance (DNI); the metric for solar energy received on a surface, on average between 6.02 to 6.29 kWh/m2 per day. This DNI value equates to conditions favorable for generating solar electricity.

Figure 1 – Reservoir roof-top solar PV installation

Whitfield Reservoir/Booster

The Whitfield Reservoir/Booster site consists of an approximately six-acre trapezoid shaped parcel of vacant land with an underground reservoir located on the western portion of the site. The non-reservoir portion of the site does not require structural site improvements to accommodate a solar PV array. The area over the underground reservoir should have a structural assessment to determine the ability to accommodate a solar array. The site has space for two types of systems: a single-axis tracker system (approximately 640 kW capacity) on the eastern side of the property (non-reservoir) and a fixed-tilt system (approximately 460 kW capacity) on the western side of the property over the reservoir. The single-axis tracker is aligned lengthwise north to south and tracks the sun throughout the day as it moves from east to west. This system produces more electricity per area relative to a fixed tilt system, but requires drilling piers to support the structure. The fixed tilt system faces south to southwest and would use a ballasted rack that would not require ground penetration, thus avoiding potential impacts to the reservoir roof. Based on its favorable characteristics, the Whitfield Reservoir/Booster site advanced to the full financial analysis.

Figure 2 – Whitfield Reservoir/Booster aerial image

ACWD Headquarters

The District Headquarters is a three building complex with staff and equipment parking lot and an uncovered outdoor storage area. There is an existing solar canopy in the northwestern edge of the property which is nearly 20 years old. The District Headquarters roof is due to be replaced in two phases, beginning with Phase 1 in FY 20/21 and Phase 2 in FY 22/23. The site has space for the following arrays:

Area	Capacity (kW)	System Type
Existing Solar Array - Parking and Material Area	160	Canopy
Office Building Array	220	Roof mount
Storage Rack Array	210	Canopy
Warehouse and Meter Shop Array	50	Roof mount
Fleet Garage Array	20	Roof mount
Main Employee Parking Lot Array	360	Canopy
"Back 40" Reserve Employee Parking Lot Array	70	Canopy

Based on its favorable characteristics, the District Headquarters site advanced to the full financial analysis stage.

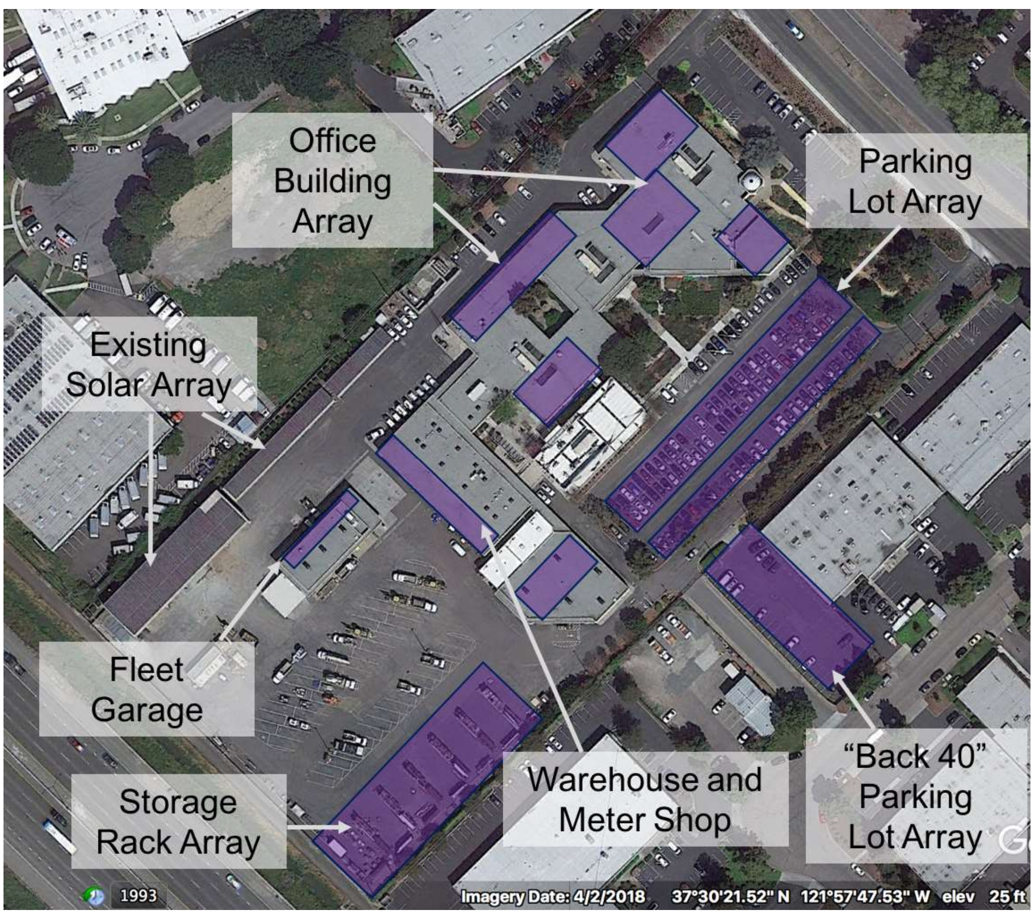

Figure 3 – District Headquarters aerial image

Desalination Plant

The Desalination Plant features an operations building and parking area for staff. The building has a pitched roof that can accommodate a 150 kW solar array. Due to its small area for solar, MDB recommends that the Desalination Plant be incorporated into a larger package of District sites for consideration. As a standalone site, the Desalination Plant does not have sufficient scale to warrant additional consideration by itself. An additional structural feasibility study of the existing roof and its ability to accommodate a solar array shall be evaluated to ensure the panels are properly supported.

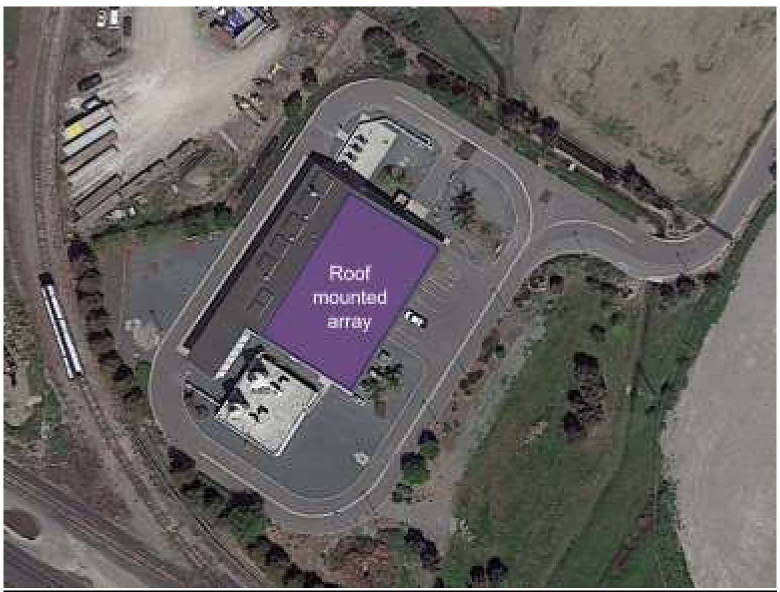

Figure 4 – Desalination Plant aerial image

Mission San Jose Water Treatment Plant

The Mission San Jose Water Treatment Plant (MSJWTP) is located on a hill overlooking I-680 east of Fremont. The site consists of a main building, small parking area, treatment equipment, and a storage tank. The surrounding hillside bordering the plant is also District property. There is insufficient feasible space to host a solar PV array because the hillside gradient is over 33 percent which is too steep to economically construct an array and the plant area has minimal open space to host an array. Additionally, North-bound I-680 traffic has a direct-view of the slope and an additional feasibility study of the panels and their impact on oncoming traffic would need to be evaluated. Due to the added complexity and cost of construction on a steep slope, MDB recommends that the MSJWTP site be excluded from further analysis.

Figure 5 – Mission San Jose Treatment Plant aerial image

Alameda Reservoir

The Alameda Reservoir site features a rectangular reservoir with an aboveground flat roof. The roof is scheduled for replacement in FY 2023/2024. The reservoir roof should be replaced with a design that can support the addition of solar panels. The reservoir is surrounded by trees which imposes shading on the reservoir roof limiting the area that can host a solar array. MDB estimates that the unshaded portion of the roof can accommodate a 1,580 kW solar array. Based on its favorable characteristics, the Alameda Reservoir site advanced to the full financial analysis.

Figure 6 – Alameda Reservoir aerial image

Decoto Reservoir

The Decoto Reservoir site features a rectangular reservoir with an aboveground flat roof. The roof is scheduled for replacement in FY 2022/2023. The reservoir roof should be replaced with a design that can support the addition of solar panels. MDB estimates that the roof can accommodate a 1,250 kW solar array. Based on its favorable characteristics, the Decoto Reservoir site advanced to the full financial analysis.

Figure 7 – Decoto Reservoir aerial image

Mayhew Reservoir

The Mayhew Reservoir site features a rectangular reservoir with an aboveground flat roof. The District has recently replaced the roof and it has been deemed suitable for some level of solar panel installation. However, a structural analysis should be performed to ensure suitability for solar panel installation and to confirm the size/type/configuration of solar panels the roof can accommodate. Based upon available roof area only, MDB estimates that the roof can accommodate a 680 kW solar array. Based on its favorable characteristics, the Mayhew Reservoir site advanced to the full financial analysis.

Figure 8 – Mayhew Reservoir aerial image

Middlefield Reservoir

The Middlefield Reservoir site features a reservoir with an aboveground flat roof. The roof is scheduled for improvements in FY 2020/2021. The nature and extent of improvements will be defined upon further analysis by the District, but such improvements may be limited to minor structural repairs or may involve a complete replacement of the roof system. In addition to the planned roof work, the District is also evaluating alternative future uses for the Middlefield Reservoir site, including options with or without the reservoir. Based only on the expected available roof area, MDB estimates that the roof can accommodate a 750 kW solar array. Based on its favorable characteristics, the Middlefield Reservoir site advanced to the full financial analysis.

Figure 9 – Middleton Reservoir aerial image

Patterson Reservoir

The Patterson Reservoir site features a reservoir with an aboveground flat roof. The roof is scheduled for replacement in FY 2024/2025. In addition to the planned roof replacement, the District is also evaluating alternative future uses for the Patterson Reservoir site, including options with or without the reservoir. MDB estimates that the roof can accommodate a 1250 kW solar array. Based on its favorable characteristics, Patterson Reservoir site advanced to the full financial analysis.

Figure 10 – Patterson Reservoir aerial image

Pit T1 and T2

The District requested that MDB review the potential for floating solar PV arrays, "floatovoltaics," on Pit T1 and T2 located in the City of Fremont south of the Quarry Lakes Regional Recreation Area. These pits are remnants of historic quarry operations and are bounded by predominantly low stability soils of varying slopes, some of which are routinely monitored for movement. The pits are also located in an urban area and are bounded on one (Pit T2) or two (Pit T1) sides by residential land uses. Pit T1 is approximately 11 acres and Pit T2 is approximately 14 acres. Combined, Pit T1 and T2 could host approximately 5 MW of floating solar arrays. Although feasibility issues related to slope stability, the urban setting and other factors would need to be further evaluated, Pit T1 and T2 site advanced to the full financial analysis.

Figure 11 – Pit T1 and T2 aerial image

WIND

The District territory features wind resources ranging from <3.5 m/s up to 6.0 m/s which is considered to be poor to marginal for generating wind power. The Plan identified two District sites for wind potential: Patterson Reservoir and the Newark Desalination Facility.

Figure 12 – Wind turbine system

Patterson Reservoir

Patterson Reservoir is located in an area with an 80m hub height average wind speed of 5 to 5.5 m/s and a 100m hub height average wind speed of 5.5 to 6 m/s which is considered marginal for power production. There are no anticipated impacts on wind speed/quality from ridge shading. Preliminary modeling of an 800 to 900 kW wind turbine system optimized for low speed wind capture indicates a capacity factor of 23 percent (the average capacity factor for wind systems in the US is 35 percent and the lowest single system capacity factor is 20 percent). MDB recommends further analysis of the Patterson Reservoir wind site before it could be deemed feasible. Such analyses may include an extended (perhaps one-year) study measuring and recording wind speeds on the site at one or more elevations in to capture more site-specific data which could be evaluated to determine feasibility.

Newark Desalination Facility

The Desalination Facility is located in an area with an 80m hub height average wind speed of 5 to 5.5 m/s and a 100m hub height average wind speed of 5 to 5.5 m/s which is considered poor to marginal for power production. There are no anticipated impacts on wind speed/quality from ridge shading. Preliminary modeling of an 800 to 900 kW wind turbine system optimized for low speed wind capture, indicates a capacity factor of 14 percent (the average capacity factor for wind systems in the US is 35 percent and the lowest single system capacity factor is 20 percent). Due to the relatively low wind resource and low production numbers, the lack of economies of scale for a single turbine system, and a viable off-take strategy, MDB does not recommend further analysis of the Desalination Facility wind site.

FUEL CELLS

Fuel cells operating on natural gas provide a high reliability, distributed generation resource typically at a cost premium over grid power. The fuel cell type specified in the Plan, solid oxide fuel cell (SOFC), is the most efficient type and is the technology considered in this report. SOFC is fueled by natural gas and is therefore not considered a renewable resource and is not eligible for PG&E's Renewable Energy Self-Generation Bill Credit Transfer (RES-BCT) Program which allows renewable energy generated on District property to offset energy usage for other District properties. However, SOFC technology is eligible for the Self Generation Incentive Program (SGIP) which provides incentives for on-site generation and energy storage resources. Eligible technology includes wind, biomass-to-energy, fuel cells, and battery storage as long as the resource reduces carbon emissions. SOFC technology presently meets the SGIP required emission rate (CO_2e/kWh produced) to qualify for incentives. Moreover, fuel cells are eligible for net energy metering (NEM) which credits customers at the full retail electric price for any excess electricity generated.

Figure 13 – Fuel cell system (Bloom Energy)

The Plan identified three locations for the potential implementation for fuel cells.

<u>Newark Desalination Facility</u>

The Desalination Facility energy demand and usage profile fits the profile for fuel cell generation with high usage (344,300 kWh average monthly usage) and relatively even demand with an average demand of 472 kW and an average monthly maximum demand of 578 kW. According to District staff, the demand and usage at the Desalination Facility is expected to increase (perhaps as much as double) as the plant was down for maintenance and only ran on average half of its capacity in 2018. MDB recommends further analysis of fuel cells at the Desalination Plant.

Peralta-Tyson (PT) Wellfield

The Peralta-Tyson (PT) Wellfield energy demand profile indicates moderate usage (158,900 kWh average monthly usage) with uneven demand with an average demand of 217 kW and an average monthly maximum demand of 524 kW. There are four months of the year that the average demand dips below 200 kW, though with net energy metering excess production in those months will offset excess usage in other months. MDB recommends further analysis of fuel cells at the Peralta-Tyson (PT) Wellfield.

Mowry Wellfield

The Mowry Wellfield energy demand profile indicates moderate usage (100,000 kWh average monthly usage) with uneven demand with an average demand of 136 kW and an average monthly maximum demand of 468 kW. There are four months of the year that the average demand dips below 100 kW, though with net energy metering excess production in those months will offset excess usage in other months. MDB recommends further analysis of fuel cells at the Mowry Wellfield.

ACWD Headquarters

The District Headquarters energy demand profile indicates moderate usage (96,300 kWh average monthly usage) and uneven demand with an average demand of 132 kW and an average monthly maximum demand of 273 kW. This does not fit the profile for fuel cell generation as the minimum size for a commercially-viable SOFC is 200 kW. Due to this system capacity constraint, MDB does not recommend further analysis of fuel cells at the District Headquarters.

HYDROELECTRIC

The District has water conveyance structures that feature either or both high head and flow which can be captured and transformed into electricity. The Plan identified four locations for possible hydroelectric installations. While most of these sites have adequate head for possible power generation, the flows are all too low for cost effective power generation. Accordingly, MDB recommends that there be no further consideration of hydroelectric power generation at District sites unless the Vallecitos Channel would be replaced with a pipeline alternative (a project currently under consideration by the District) and flow through the Vallecitos Channel corridor or the flow rates at SF Blender increases by 75 to 100 percent.

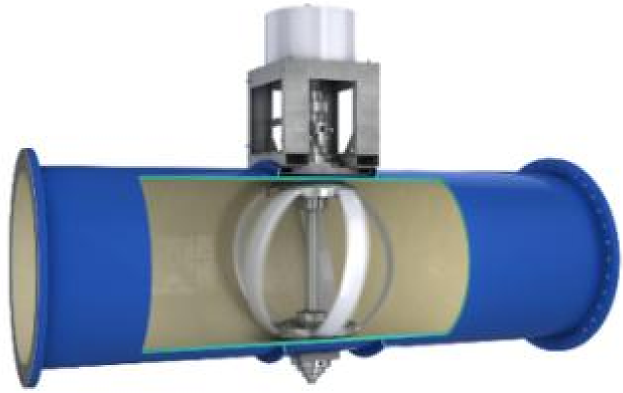

Figure 14 –In-line hydroelectric turbine (Lucid Energy)

Our evaluation of the four sites is summarized as follows:

Vallecitos Channel

The Vallecitos Channel is a potential future project and is located about 1.5 miles east of the Town of Sunol. At the lower portion of the proposed channel, there are 301 feet of head and an available flow of 13,465 gallons per minute ("gpm"). However, this flow is only present on average 38 percent of the time. Even with this high head, a more continuous flow rate would be required to warrant further investigation of this alternative. Further, the existing portions of the open channel would need to be replaced with a pipe system in the areas of the high head to capture the hydroelectric energy potential. The District is investigating a possible future project to replace the Vallecitos Channel with a pipeline. If flow through the channel is ultimately transmitted through a pipeline, and if the frequency of flows increase, the hydroelectric potential would increase. Accordingly, MDB does not recommend further analysis of this site for hydroelectric feasibility at this time. Should the flow durations increase and the projects piping systems be installed and completed in the future, the hydroelectric potential at this site would be worth reconsideration.

Appian Tank

The Appian Tank is located in Fremont on a hill overlooking the Decoto Reservoir. It features a head of 389 ft and available flow of 268 gpm. Despite the relatively high head, the flow is too low and the frequency of flow too intermittent to cost-effectively produce electricity. Accordingly, MDB does not recommend further analysis of this site for hydroelectric feasibility.

Avalon Tank

The Avalon Tank is located in the hills of southern Fremont east of I-680. It features a head of 208 ft and available flow of 54 gpm. The flow is too low and the frequency of flow too intermittent to cost-effectively produce electricity. MDB does not recommend further analysis of this site for hydroelectric feasibility.

SF Blender

The SF Blender features a head of 100 ft and available flow of 4,815 gpm. The flow is too low and the frequency of flow too intermittent to cost-effectively produce electricity. MDB does not recommend further analysis of this site for hydroelectric feasibility.

Water Treatment Plant #2 to Whitfield Reservoir

The conveyance from Treatment Plant #2 to the Whitfield Reservoir features a head of less than 10 ft over the course of one mile with 9,771 gpm. The head is too low to cost-effectively produce electricity. MDB does not recommend further analysis of this site for hydroelectric feasibility.

BATTERIES

The District's 2016 Plan did not evaluate the feasibility of battery storage primarily because the technology had not matured to the point where it could be considered reliable and cost effective at that time. However, since the release of the original Plan, battery technology has improved significantly and customer sited battery deployments have increased leading to a robust market for battery storage.

Presently, the best way to realize economic value from a battery storage system is to reduce demand charges and/or shift grid electricity usage to lower cost periods. Future developments in rate structures and markets for ancillary services and other grid services are likely to further increase the value of energy storage. For example, utilities could pay a premium for electricity made available during high demand periods in a congested area of the grid.

MDB reviewed the electricity usage data from the District sites previously assessed for renewable energy systems looking for sites that have high maximum demand (> 200kW) as well as a high maximum demand to average demand ratio which would indicate opportunity to shave peak demand and significantly reduce demand charges.

Figure 15 – Battery energy storage system

MDB identified four District sites that would benefit from a more thorough battery storage assessment.

ACWD Headquarters

The District Headquarters is on the E19S rate schedule which features demand charges and the average monthly maximum demand is 273 kW and the average demand is 132 kW. This relatively large margin between the maximum demand and average demand indicates an opportunity to extract value from a battery energy storage system.

Water Treatment Plant #2

The WTP #2 site is on the SE19P rate schedule which features demand charges and the average monthly maximum demand is 357 kW and the average demand is 95 kW. This large margin between the maximum demand and average demand indicates an opportunity to extract value from a battery energy storage system.

Whitfield Reservoir/Booster

The Whitfield Reservoir/Booster is on the E19 rate schedule which features demand charges and the site average monthly maximum demand is 239 kW and the average demand is 94 kW. This large margin between the maximum demand and average demand indicates an opportunity to extract value from a battery energy storage system.

Peralta-Tyson (PT) Wellfield and Blending

The Peralta-Tyson (PT) Wellfield and Blending site is on the E19P rate schedule which features demand charges and the average monthly maximum demand is 524 kW and the average demand is 217 kW. This large margin between the maximum demand and average demand indicates an opportunity to extract value from a battery energy storage system.

Mowry Wellfield

The Mowry Wellfield in on the E19P rate schedule which features demand charges and the average monthly maximum demand is 468 kW and the average demand is 136 kW. This large margin between the maximum demand and average demand indicates an opportunity to extract value from a battery energy storage system.

SECTION 3 - FINANCIAL ANALYSIS

SITES ADVANCING TO FINANCIAL ANALYSIS

Following the screening analysis, MDB completed an additional evaluation of the following sites/technologies including a financial analysis of the best potential project(s) at each site as follows:

Solar

Location	Available area (sq ft)	System Capacity
Alameda Reservoir	105,000	1,470
Decoto Reservoir	83,000	1,150
Mayhew Reservoir	45,000	650
Middlefield Reservoir	50,000	700
Patterson Reservoir	84,000	1,150
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Newark Desalination Facility	9,000	120
ACWD Headquarters	81,000	1,090
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TOTAL		11,170

These sites have sufficient space to host solar PV systems over several hundred kW each making them ideal for a competitive RFP type procurement, particularly if multiple sites were combined into packages of 3 or more MW per RFP. They are also located within 500 feet of a potential interconnection point likely leading to manageable interconnection costs.

Wind

- Patterson Reservoir

This location has sufficient wind resource to power a nearly 1MW wind system and is near a PG&E distribution line.

Fuel Cell

- Newark Desalination Facility
- Peralta-Tyson Wellfield and Blending
- Mowry Wellfield

These locations have sufficient electricity demand and usage to warrant the analysis.

Battery Storage

- ACWD Headquarters
- Water Treatment Plant #2

- Whitfield Reservoir/Booster
- Peralta-Tyson Wellfield and Blending
- Mowry Wellfield

These sites are on rate schedules with demand charges and have large maximum demand to average demand spreads which could be reduced with energy storage leading to lower electricity bills.

Coupling of Solar and Battery Technologies

- ACWD Headquarters
- Whitfield Reservoir/Booster

These sites have good potential for solar and have large maximum demand to average demand spreads which could be reduced with energy storage.

The results of economic modeling of the various technologies at the recommended sites are presented below. The analyses utilize the Net Present Value (NPV) method for comparing and ranking projects with differing costs and benefits over a period of time. It calculates the sum of the projected financial benefits to the District over each project's lifetime, including discounting future year cash flows by a discount rate that recognizes the time value of money.

ANALYSIS METHODOLOGY

The economic modeling includes discounted cash flow analysis which evaluates the benefits and costs of the solar PV projects at the suitable locations. The District realizes project benefits through two different value streams. The first is from grid electricity usage offset in which the generating system displaces the site's electricity usage from the grid. This offset covers both the distribution and generation portion of the energy charge and is conservatively assumed to have no impact on demand charges.

The other value stream comes from the RES-BCT Program which allows excess renewable power produced at the generating facility site (Generating Account) to be used to offset utility bills at other sites owned by the same agency (Benefitting Account). The bill credit could be applied to up to a total of 50 individual PG&E meters. Accounts enrolled in East Bay Community Energy (EBCE) are not eligible for RES-BCT unless they were shifted back to being serviced by PG&E.

MDB's analyses included three different project capital funding methodologies, as follows:

- District owned and paid for using "pay as you go" (paygo) - District collected funds paying the full amount of capital cost
- District owned and financed through California Energy Commission (CEC) low interest loan which is capped at $3 million per project and a 20-year simple payback loan program requirement. This loan program was funded by the Energy Conservation Assistance Act. Since 1979, the program has provided over $400 million to California Public Agencies for implementation of energy efficiency and renewable energy projects. The program mandates a 1% interest rate, which remains fixed over the lifetime of the loan.

- Privately financed and third-party owned (TPO) solar PV system (with option for the District to purchase system in Year 11) generating bill credits through Renewable Energy Self-Generation – Bill Credit Transfer (RES-BCT) Program

District-owned using Paygo

The District-owned/Paygo scenario involves the District budgeting for the full capital cost of the project in the Capital Improvement Projects (CIP) Process and collecting the funds to pay for the project in full prior to implementation. The benefits that accrue to the District from this arrangement are from site electricity offset and RES-BCT utility bill credits and the costs are the upfront project payment and operation and maintenance (O&M) costs. The capital costs are in 2019 dollars.

District-Owned and Financed with CEC Loan

The District-owned/CEC financed scenario involves the District applying for a CEC loan which has a mandated, fixed interest rate of one percent ($3 million maximum loan amount per project) and using the proceed of the loan to pay for the project cost. The benefits that accrue to the District from this arrangement are from site electricity offset and utility bill credits, and the costs are the loan payments and O&M costs. The capital costs are in 2019 dollars.

Privately Financed and Owned

The privately financed RES-BCT scenario includes a private developer designing, constructing, owning, and operating the solar PV system and selling the power to the District through a power purchase agreement (PPA). This arrangement requires careful structuring of the public/private relationships in order to meet the requirements of the program. In this scenario, the private developer takes advantage of the IRS investment tax credit (ITC) and modified accelerated depreciation (MACRS). Unless structured with appropriate system performance guarantees from the selected developer, the District may bear the risk of an underperforming system, which although payment is only required for power produced, it could impact energy budget projections if bill credits are overestimated. The benefits that accrue to the District from this arrangement are from site electricity offset and utility bill credits and the costs are the estimated power purchase payments.

The financial modeling uses Microsoft Excel to model project cash flows based on time of use and time of generation outputs from the National Renewable Energy Laboratory's (NREL's) System Advisor Model (SAM) for solar, wind and fuel cell generator and Electric Power Research Institute's (EPRI's) StorageVET model for battery storage. SAM incorporates the District's 15-minute power utilization data from PG&E as well as site specific data (solar insolation and wind speed to model a representative energy generating system (solar PV, wind, and fuel cell). StorageVET incorporated the same PG&E data along with a representative battery storage module to determine the value of demand charge reduction and shifting grid energy use to lower cost time periods.

SOLAR

Ten District solar PV sites were deemed suitable for further analysis. Below is the description of the technology, analysis methodology, and modeling assumptions, and parameters followed by an overview of each suitable location.

Technology Description

PV systems are assumed to consist of roof or canopy mount, fixed-tilt arrays on all sites except Whitfield which is ground-mount, single-axis tracking arrays mounted on drilled piers and Pit T1 and T2 which are fixed tilt on floating platforms. Systems were sized to maximize the capacity based on the available space at each site. All systems utilize crystalline silicon PV modules and central inverter systems. The PV systems will tie-in to the closest distribution-level grid interconnection which is typically on-site or in the case of Pit T1 and T2 located approximately 500 feet from the site.

Modeling Assumptions and Parameters

The following assumptions are utilized in the financial modeling of the solar PV projects:

All scenarios:

- Analysis period: 20 years
- Generation (kWh) modeled in NREL's System Advisor Model (SAM)
- Project capital costs: Estimated using industry knowledge
- Interconnection costs: Estimated using PG&E Interconnection Unit Cost Guide
- Operation and maintenance costs: $20/kW per year
- Insurance costs: one-half of one percent (0.5%) of capital cost
- Costs are in 2019 dollars
- Generator credit value based on the E19 Option R rate schedule (generation component of the energy charge) except for Patterson Reservoir which is on the A6 rate schedule
- Discount rate: 2 percent
- ACWD utility rate escalation: 2 percent
- Annual inflation rate (Alameda County ABAG Inflation): 3.4 percent
- Annual system degradation: 0.5 percent

Results

All sites selected for solar have positive net present value for the 20-year cash flow analysis for the third party owned PPA scenario

The table below shows the results of the financial analysis for the District sites selected for solar.

Table 3-1: Summary of Solar Information

				Year 1 Production				Net Present Value			
Location	Available area (sq ft)	System Capacity (kW)	Project Cost	Onsite Use	Onsite Value	RES-BCT Gen	BES-BCT Value	20- year NPV (Paygo)	20- year NPV (CEC loan)	20 year - NPV (PPA)	Est. PPA Price ($/kWh)
Alameda Reservoir	105,000	1,470	$ 3,940,000	25,100	$ 4,000	2,189,000	$ 277,000	$ 252,000	$ 579,000	$ 742,000	$ 0.13
Decoto Reservoir	83,000	1,150	$ 3,400,000	1,900	$ 300	1,732,000	$ 216,000	$ (185,000)	$ 98,000	$ 526,000	$ 0.13
Mayhew Reservoir	45,000	650	$ 2,269,000	47,900	$ 7,900	920,000	$ 114,000	$ (460,000)	N/A	$ 318,000	$ 0.13
Middlefield Reservoir	50,000	700	$ 2,390,000	21,500	$ 3,000	1,013,000	$ 126,000	$ (486,000)	N/A	$ 316,000	$ 0.13
Patterson Reservoir[1]	84,000	1,150	$ 3,400,000	67,500	$ 19,300	1,653,000	$ 282,000	$ 1,388,000	$1,672,000	$2,128,000	$ 0.13
Whitfield Reservoir (non res. area)	147,000	640	$ 2,400,000	232,000	$ 34,500	999,000	$ 129,000	$ 136,000	$ 335,000	$ 351,000	$ 0.14
Newark Desalination Facility	9,000	120	$ 520,000	180,400	$ 21,400	N/A	N/A	$ (213,000)	N/A	$ 6,000	$ 0.14
ACWD Headquarters	81,000	1,210	$ 3,660,000	558,000	$ 97,100	1,073,000	$ 136,000	$ 164,000	$ 469,000	$ 794,000	$ 0.14
Pit T1	440,000	2,200	$ 9,090,000	0	$ -	3,411,000	$ 419,000	$ (3,664,000)	N/A	$ 95,000	$ 0.15
Pit T2	400,000	2,000	$ 8,340,000	0	$ -	3,101,000	$ 381,000	$ (3,411,000)	N/A	$ 87,000	$ 0.15
TOTAL		11,290	39,409,000	1,134,300	$ 187,500	16,091,000	$ 2,080,000				

A detailed description of the analysis for each site solar project site evaluated follows below.

Alameda Reservoir

The recommended solar PV installation proposed for the Alameda Reservoir site consists of a 1,470 kW capacity fixed tilt system situated on the roof of the reservoir area. The roof of the reservoir is scheduled to be replaced in Fiscal Year (FY) 2023/24 and will be structurally upgraded to accommodate the addition of the solar PV system at that time. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-2: Alameda Reservoir solar characteristics

System size (kW)	1,470
System cost ($/kW)	$1,750
Estimated interconnection cost	$850,000
Turn-key solar PV plant cost	$3,937,000
Annual O&M ($/year)	$29,400
Offset average on-site rate ($/kWh)	$0.158
RES-BCT average rate ($/kWh)	$0.126
Assumed Third Party PPA rate ($/kWh)	$0.13
Year 1 solar generation (kWh)	2,214,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in all financing scenarios which indicates that it is financially beneficial to move forward with the project. The third party owned PPA implementation method projects the highest NPV.

Table 3-3: Alameda Reservoir solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	$252,000
CEC Loan	$579,000
Third Party Owned PPA	$742,000

Decoto Reservoir

The recommended solar PV installation proposed for the Decoto Reservoir site consists of a 1,150 kW capacity fixed tilt system situated on the roof of the reservoir area. The roof of the reservoir is scheduled to be replaced in Fiscal Year (FY) 2022/23 and will be structurally upgraded to accommodate the addition of the solar PV system at that time. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-4: Decoto Reservoir solar characteristics

System size (kW)	1,150
System cost ($/kW)	$1,850
Estimated interconnection cost	$850,000
Turn-key solar PV plant cost	$3,403,000
Annual O&M ($/year)	$23,000
Offset average on-site rate ($/kWh)	$0.169
RES-BCT average rate ($/kWh)	$0.125
Assumed Third Party PPA rate ($/kWh)	$0.13
Year 1 solar generation (kWh)	1,734,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in the Paygo and third party owned PPA financing scenarios which indicates that it is financially beneficial to move forward with the project using those financing methods. The third party owned PPA implementation method projects the highest NPV.

Table 3-5: Decoto Reservoir solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$185,000
CEC Loan	$98,000
Third Party Owned PPA	$526,000

Mayhew Reservoir

The recommended solar PV installation proposed for the Mayhew Reservoir site consists of a 650 kW capacity fixed tilt system situated on the roof of the reservoir area. The roof of the reservoir has been replaced recently and is understood to be able to accommodate solar PV. While additional structural review of the reservoir roof may be required in order to confirm, MDB assumed the majority of the existing reservoir roof area is available for solar PV. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-6: Mayhew Reservoir solar characteristics

System size (kW)	650
System cost ($/kW)	$2,000
Estimated interconnection cost	$709,000
Turn-key solar PV plant cost	$2,269,000
Annual O&M ($/year)	$13,000
Offset average on-site rate ($/kWh)	$0.165
RES-BCT average rate ($/kWh)	$0.124
Assumed Third Party PPA rate ($/kWh)	$0.13
Year 1 solar generation (kWh)	968,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in the third party owned PPA scenario which indicates that it is financially beneficial to move forward with the project using this financing method.

Table 3-7: Mayhew Reservoir solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$460,000
CEC Loan	N/A
Third Party Owned PPA	$318,000

Middlefield Reservoir

ACWD is evaluating options for the future use of this site, including with/without a reservoir. If the site continues to host a reservoir, the recommended solar PV installation proposed for the Middlefield Reservoir site consists of a 650 kW capacity fixed tilt system situated on the roof of the reservoir area. The roof of the reservoir is scheduled for an evaluation and some level of improvements to be completed in Fiscal Year (FY) 2020/21. This evaluation may result in a later replacement of the roof. If replaced, the new roof will be structurally upgraded to accommodate the addition of the solar PV system at that time. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-8: Middlefield Reservoir solar characteristics

System size (kW)	700
System cost ($/kW)	$2,000
Estimated interconnection cost	$709,000
Turn-key solar PV plant cost	$2,389,000
Annual O&M ($/year)	$14,000
Offset average on-site rate ($/kWh)	$0.137
RES-BCT average rate ($/kWh)	$0.125
Assumed Third Party PPA rate ($/kWh)	$0.13
Year 1 solar generation (kWh)	1,034,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in the third party owned PPA scenario which indicates that it is financially beneficial to move forward with the project using this financing method.

Table 3-9: Middlefield Reservoir solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$486,000
CEC Loan	N/A*
Third Party Owned PPA	$316,000

*Does not appear to meet CEC's maximum 20-year payback criteria

Patterson Reservoir

The recommended solar PV installation proposed for the Patterson Reservoir site consists of a 1,150 kW capacity fixed tilt system situated on the roof of the reservoir area. The roof of the reservoir is scheduled to be replaced in Fiscal Year (FY) 2024/25 and will be structurally upgraded to accommodate the addition of the solar PV system at that time. Additional structural and geotechnical feasibility analysis for this site will be required due to pre-existing seismic concerns. ACWD is currently evaluating options for upgrades at this site, both with and without a reservoir. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-10: Patterson Reservoir solar characteristics

System size (kW)	1,150
System cost ($/kW)	$1,850
Estimated interconnection cost	$850,000
Turn-key solar PV plant cost	$3,403,000
Annual O&M ($/year)	$23,000
Offset average on-site rate ($/kWh)	$0.286
RES-BCT average rate ($/kWh)	$0.170
Assumed Third Party PPA rate ($/kWh)	$0.13
Year 1 solar generation (kWh)	1,720,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in all financing scenarios which indicates that it is financially beneficial to move forward with the project. As shown in the Table below, the third party owned PPA implementation method projects the highest NPV.

Table 3-11: Patterson Reservoir solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	$1,388,000
CEC Loan	$1,672,000
Third Party Owned PPA	$2,128,000

Whitfield Reservoir/Booster

The recommended solar PV installation proposed for the Whitfield Reservoir consists of a 640 kW capacity single-axis tracking system situated on the eastern portion of the property (non-reservoir area). The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-12: Whitfield Reservoir/Booster characteristics

System size (kW)	640
System cost ($/kW)	$2,200
Estimated interconnection cost	$709,000
Turn-key solar PV plant cost	$2,399,000
Annual O&M ($/year)	$14,000
Offset average on-site rate ($/kWh)	$0.149
RES-BCT average rate ($/kWh)	$0.129
Assumed Third Party PPA rate ($/kWh)	$0.14
Year 1 solar generation (kWh)	1,232,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in all financing scenarios which indicates that it is financially beneficial to move forward with the project. As shown in the Table below, the third party owned PPA implementation method indicates the highest NPV. Additionally, ACWD may elect to also include the portions of the reservoir area to add additional solar generation capacity at this site in the areas where panel will be above the reservoir. An additional structural feasibility analysis will be required to see how feasible adding additional panels directly above the reservoir may be.

Table 3-13: Whitfield Reservoir/Booster solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	$136,000
CEC Loan	$335,000
Third Party Owned PPA	$351,000

Newark Desalination Facility

The recommended solar PV installation proposed for the Newark Desalination Facility consists of a 120 kW capacity fixed-tilt system situated on the roof of the main building. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-14: Newark Desalination Facility solar characteristics

System size (kW)	120
System cost ($/kW)	$2,500
Estimated interconnection cost	$160,000
Turn-key solar PV plant cost	$460,000
Annual O&M ($/year)	$2,400
Offset average on-site rate ($/kWh)	$0.119
RES-BCT average rate ($/kWh)	$0.110
Assumed Third Party PPA rate ($/kWh)	$0.14
Year 1 solar generation (kWh)	180,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in the third party owned PPA scenario which indicates that it is financially beneficial to move forward with the project using the third party owned PPA financing method. An additional structural analysis will be required to confirm the existing roof may accommodate a solar PV installation.

Table 3-15: Newark Desalination Facility solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$213,000
CEC Loan	N/A
Third Party Owned PPA	$6,000

ACWD Headquarters

The recommended solar PV installation proposed for the District Headquarters consists of the following:

Area	Capacity (kW)	System Type
Existing Solar Array - Parking and Material Area	160	Canopy
Office Building Array	220	Roof mount
Storage Rack Array	210	Canopy
Warehouse and Meter Shop Array	50	Roof mount
Fleet Garage Array	20	Roof mount
Main Employee Parking Lot Array	360	Canopy
"Back 40" Reserve Employee Parking Lot Array	70	Canopy

The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-16: ACWD Headquarters solar characteristics

System size (kW)	1,090
System cost ($/kW)	$2,150
Estimated interconnection cost	$850,000
Turn-key solar PV plant cost	$3,660,000
Annual O&M ($/year)	$21,800
Offset average on-site rate ($/kWh)	$0.174
RES-BCT average rate ($/kWh)	$0.127
Assumed Third Party PPA rate ($/kWh)	$0.14
Year 1 solar generation (kWh)	1,630,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in all three financing methods which indicates that it is financially beneficial to move forward with this project. As shown in the Table below, the third party owned PPA implementation method indicates the highest NPV.

Table 3-17: ACWD Headquarters solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	$164,000
CEC Loan	$469,000
Third Party Owned PPA	$794,000

Pit T1

The recommended solar PV installation proposed for Pit T1 consists of a 2,200 kW capacity fixed-tilt system situated on floating pontoons in the pit. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-18: Pit T1 solar characteristics

System size (kW)	2,200
System cost ($/kW)	$3,100
Estimated interconnection cost	$902,000
Turn-key solar PV plant cost	$9,086,000
Annual O&M ($/year)	$66,000
Offset average on-site rate ($/kWh)	N/A
RES-BCT average rate ($/kWh)	$0.123
Assumed Third Party PPA rate ($/kWh)	$0.145
Year 1 solar generation (kWh)	3,411,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in the third party owned PPA scenario which indicates that it is financially beneficial to move forward with the project using the financing method. However, these values are preliminary numbers and further analysis (including: community meetings, to determine project acceptability to the neighbors, an in-depth engineering study, and more refined cost estimates) is required to determine the feasibility of this project.

Table 3-19: Pit T1 solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$3,644,000
CEC Loan	N/A
Third Party Owned PPA	$95,000

Pit T2

The recommended solar PV installation proposed for Pit T2 consists of a 2,000 kW capacity fixed-tilt system situated on floating pontoons in the pit. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-20: Pit T1 solar characteristics

System size (kW)	2,000
System cost ($/kW)	$3,100
Estimated interconnection cost	$902,000
Turn-key solar PV plant cost	$8,342,000
Annual O&M ($/year)	$60,000
Offset average on-site rate ($/kWh)	N/A
RES-BCT average rate ($/kWh)	$0.123
Assumed Third Party PPA rate ($/kWh)	$0.145
Year 1 solar generation (kWh)	3,101,000

The result of the financial analysis is shown in the table below. The solar PV system has a positive NPV in the third party owned PPA scenario which indicates that it is financially beneficial to move forward with the project using the financing method. However, these values are preliminary numbers and further analysis (including: community meetings, an in-depth engineering study, and more refined cost estimates) is required to determine the feasibility of this project.

Table 3-21: Pit T2 solar financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$3,411,000
CEC Loan	N/A
Third Party Owned PPA	$87,000

WIND

Patterson Reservoir is the sole District wind site deemed suitable for further analysis. Below is the description of the technology, analysis methodology, modeling assumptions, and parameters of this location followed by an overview of the site.

Technology Description

The wind system is assumed to consist of a three-blade, horizontal axis wind turbine rated for 850 kW and designed for low wind speed sites. The system was sized based on the available space and the availability of a wind turbine tailored to the wind conditions at the site. The wind system will tie-in to the closest distribution-level grid interconnection which is on-site.

Modeling Assumptions and Parameters

The following assumptions are utilized in the financial modeling of the wind projects:

All scenarios:

- Analysis period: 20 years
- Generation (kWh) modeled in NREL's System Advisor Model (SAM)
- Project capital costs: Estimated using industry knowledge
- Interconnection costs: Estimated using PG&E Interconnection Unit Cost Guide
- Operation and maintenance costs: $45/kW per year
- Insurance costs: one-half of one percent (0.5%) of capital cost
- RES-BCT Generator credit value based on the A6 rate schedule (generation component of the energy charge)
- Discount rate: 2 percent
- ACWD utility rate escalation: 2 percent
- Annual inflation rate (Alameda County ABAG Inflation): 3.4 percent
- Annual system degradation: 1 percent

Results

The results for the wind project at Patterson Reservoir are shown below.

Patterson Reservoir

The wind installation modeled at Patterson Reservoir consists of a single 850 kW capacity wind turbine. The system characteristics, estimated cost, and generation cost/value is shown in the table below.

Table 3-22: Patterson Reservoir wind characteristics

System size (kW)	850
System cost ($/kW)	$3,500
Estimated interconnection cost	$850,000
Turn-key wind plant cost	$3,953,000
Annual O&M ($/year)	$38,000
Offset average on-site rate ($/kWh)	$0.233
RES-BCT average rate ($/kWh)	$0.123
Assumed Third Party PPA rate ($/kWh)	$0.145
Year 1 wind generation (kWh)	1,720,000

The result of the financial analysis is shown in the table below. The wind system has a negative NPV in all scenarios which indicates that it is not financially beneficial to move forward with the project. In addition, wind projects have inherent implementation challenges including the need for at least one year of on-site wind monitoring with a weather station located on a tower at the proposed height of the wind turbine hub and the requirement of additional environmental study to determine visual, avian, FAA and other potential impacts.

Table 3-23: Patterson Reservoir wind financial statistics

FINANCING SCENARIO	20 -year Net Present Value
Paygo	-$913,000
CEC Loan	N/A
Third Party Owned PPA	-$891,000

FUEL CELLS

Three District sites were deemed suitable for further analysis for fuel cells. Below is the description of the technology, analysis methodology, and modeling assumptions, and parameters followed by an overview of this location.

Technology Description

The fuel cell systems are assumed to consist of 200 kW solid oxide fuel cell modules fueled by natural gas. The systems were sized to nearly match the electricity usage (kWh) at the site and in 200 kW increments since that is the smallest commercially available fuel cell module. The fuel cell system will tie-in to the closest distribution-level grid interconnection which is on-site.

Modeling Assumptions and Parameters

The following assumptions are utilized in the financial modeling of the fuel cell projects:

All scenarios:

- Analysis period: 15 years
- Generation (kWh) modeled in NREL's System Advisor Model (SAM)
- Project capital costs: Estimated using industry knowledge
- Interconnection costs: Estimated using PG&E Interconnection Unit Cost Guide
- Natural gas cost: $0.90/therm
- Operation and maintenance costs: $300/kW per year
- Insurance costs: one-half of one percent (0.5%) of capital cost
- Generator credit value based on the E19 S rate schedule (generation component of the energy charge)
- Discount rate: 2 percent
- PPA rate escalation: 2 percent
- Natural gas cost rate escalation: 2 percent
- ACWD utility rate escalation: 2 percent
- Annual inflation rate (Alameda County ABAG Inflation): 3.4 percent
- Annual system degradation: 1.3 percent

Results

The fuel cell projects at each site have a negative net present value for all scenarios in the 15-year cash flow analysis with the exception of the Desalination Plant 600 kW third party owned PPA scenario. The table below shows a summary of the findings.

Table 3-24: Fuel cell project summary

Location	Fuel cell (kW)	Cost	Year 1 Generation	Offset Value	15 year - NPV (Paygo)	15 year - NPV (PPA)	PPA Rate ($/kWh)
Newark Desalination	600	$2,665,000	4,729,000	$672,000	$(843,000)	$71,900	$0.145
Newark Desalination	200	$1,115,000	1,576,000	$224,000	$(340,000)	$(164,000)	$0.15
Peralta-Tyson Wellfield and Blending	200	$1,115,000	1,576,000	$224,000	$(420,000)	$(160,000)	$0.15
Mowry Wellfield	200	$1,115,000	1,199,000	$180,000	$(638,000)	$(753,000)	$0.15

Newark Desalination Facility

Two different sized fuel cell installations were modeled at Newark Desalination Facility. These were a 200 kW system and a 600 kW system. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-25: Newark Desalination fuel cell characteristics

System size (kW)	**200**	**600**
System cost ($/kW)	$4,000	$3,800
Estimated interconnection cost	$275,000	$289,000
Turn-key fuel cell plant cost	$1,115,000	$2,665,000
Annual O&M ($/year)	$60,000	$180,000
Offset average on-site rate ($/kWh)	$0.106	$0.106
NEM average rate ($/kWh)	$0.106	$0.106
Assumed Third Party PPA rate ($/kWh)	$0.15	$0.145
Year 1 fuel cell generation (kWh)	1,576,000	4,729,000

The result of the financial analysis is shown in the table below. The fuel cell system has a positive NPV in the 600 kW PPA scenario.

Table 3-26: Newark Desalination fuel cell financial statistics

FINANCING SCENARIO	15 -year Net Present Value 200 kW	15 -year Net Present Value 600 kW
Paygo	-$340,000	-$843,000
CEC Loan	N/A	N/A
Third Party Owned PPA	-$164,000	$71,900

Natural gas price is a significant cost in the operation of fuel cell and is a major factor in determining the cost effectiveness of a fuel cell project. Since changes in natural gas cost and the value of offset and RES-BCT power are not directly linked, it is possible that natural gas price increases could outstrip the value of the power the fuel cell produces.

Accordingly, an additional sensitivity analysis was completed for the Desalination Plant 600 kW fuel cell project. The table below shows the effect on the projected NPV comparing the base case two percent natural gas escalation rate, which shows a small positive NPV value in the PPA option, to four percent and six percent natural gas escalations, without a correspondingly high increase in power value.

As indicated by this analysis, increases above the base case 2 percent escalation, quickly turn the project to be economically unattractive. Should ACWD decide to further pursue the fuel cell option, this risk should be considered carefully and mitigated to the extent possible.

Table 3-27: Newark Desalination fuel cell natural gas escalation sensitivity analysis

Scenario	15 year - NPV (Paygo)	15 year - NPV (PPA @ $0.145/kWh)
2 percent gas escalation	$ (843,000)	$ 71,900
4 percent gas escalation	$ (1,371,000)	$ (563,600)
6 percent gas escalation	$ (2,735,000)	$ (1,516,900)

Peralta-Tyson (PT) Wellfield and Blending

A 200 kW fuel cell system was modeled at the Peralta-Tyson Wellfield and Blending site. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-28: Peralta-Tyson (PT) Wellfield and Blending fuel cell characteristics

System size (kW)	200
System cost ($/kW)	$4,000
Estimated interconnection cost	$275,000
Turn-key fuel cell plant cost	$1,115,000
Annual O&M ($/year)	$60,000
Offset average on-site rate ($/kWh)	$0.106
NEM average rate ($/kWh)	$0.107
Assumed Third Party PPA rate ($/kWh)	$0.15
Year 1 fuel cell generation (kWh)	1,576,000

The result of the financial analysis is shown in the table below. This fuel cell system has a negative NPV in each scenario.

Table 3-29: Peralta-Tyson (PT) Wellfield and Blending fuel cell financial statistics

FINANCING SCENARIO	15 -year Net Present Value (200 kW)
Paygo	-$420,000
CEC Loan	N/A
Third Party Owned PPA	-$160,000

Mowry Wellfield

A 200 kW fuel cell system was modeled at Mowry Wellfield. The system characteristics, estimated cost, and generation cost/value are shown in the table below.

Table 3-30: Mowry Wellfield fuel cell characteristics

System size (kW)	200
System cost ($/kW)	$4,000
Estimated interconnection cost	$275,000
Turn-key fuel cell plant cost	$1,115,000
Annual O&M ($/year)	$60,000
Offset average on-site rate ($/kWh)	$0.098
NEM average rate ($/kWh)	$0.100
Net Surplus Compensation rate ($/kWh)	$0.036
Assumed Third Party PPA rate ($/kWh)	$0.15
Year 1 fuel cell generation (kWh)	1,576,000

The result of the financial analysis is shown in the table below. This fuel cell system has a negative NPV in each scenario.

Table 3-31: Mowry Wellfield fuel cell financial statistics

FINANCING SCENARIO	15 -year Net Present Value (200 kW)
Paygo	-$638,000
CEC Loan	N/A
Third Party Owned PPA	-$753,000

BATTERY STORAGE

Five District sites were deemed suitable for a financial analysis for battery storage. Below is the description of the technology, analysis methodology, modeling assumptions, and parameters of this location followed by an overview of the site.

Technology Description

The battery storage systems are assumed to consist of 250 kW/500kWh lithium ion battery modules. The systems were sized in 250 kW increments since that is the typical battery module size. The battery storage system will tie-in to the closest distribution-level grid interconnection which is on-site.

Modeling Assumptions and Parameters

The following assumptions are utilized in the financial modeling of the solar PV projects:

All scenarios:

- Analysis period: 10 years
- Value generation modeled in EPRI's StorageVET tool
- Project capital costs: Estimated using industry knowledge
- Interconnection costs: Estimated using PG&E Interconnection Unit Cost Guide
- Operation and maintenance costs: $25/kW per year
- Insurance costs: one-half of one percent (0.5%) of capital cost
- Demand charge reduction and load shift value based on the E19S rate schedule
- Discount rate: 2 percent
- ACWD utility rate escalation: 2 percent
- Annual inflation rate (Alameda County ABAG Inflation): 3.4 percent
- Annual system degradation: 4 percent

Results

The standalone battery storage projects at each site have a negative net present value for all scenarios in the 10-year cash flow analysis and are therefore not feasible projects. The table below shows a summary of the findings.

Table 3-32: Battery storage project summary

Location	Battery system size (kW)	Cost	Demand Charge Reduction	Energy Shift Value	10 year - NPV (Paygo)	10 year - NPV (CEC debt)
Headquarters	250	$ 420,000	$ 28,000	$ 2,000	$ (184,000)	$ (167,000)
Whitfield Reservoir/Boosters	250	$ 420,000	$ 22,000	$ 800	$ (265,000)	$ (247,000)
WTP#2	250	$ 420,000	$ 19,000	$ 180	$ (301,000)	$ (284,000)
Mowry	250	$ 420,000	$ 11,000	$ (490)	$ (384,000)	$ (366,000)
PT Well and Blending	250	$ 420,000	$ 9,700	$ 700	$ (391,000)	$ (374,000)

ACWD Headquarters

A 250 kW battery storage system was modeled at District Headquarters. The system characteristics, estimated cost, and reduction value are shown in the table below.

Table 3-33: District Headquarters battery storage characteristics

System size (kW)	250
Storage capacity (kWh)	500
System cost ($/kW)	$1,400
Estimated interconnection cost	$100,000
Turn-key fuel cell plant cost	$420,000
Annual O&M ($/year)	$6,250
Demand Charge Reduction ($)	$28,000
Energy Shift Reduction ($)	$2,000

The result of the financial analysis is shown in the table below. This stand-alone battery storage system has a negative NPV in each scenario.

Table 3-34: District Headquarters battery storage financial statistics

FINANCING SCENARIO	10 -year Net Present Value
Paygo	-$184,000
CEC Loan	-$167,000
Third Party Owned PPA	N/A

Whitfield Reservoir/Booster

A 250 kW battery storage system was modeled at Whitfield Reservoir/Booster. The system characteristics, estimated cost, and reduction value are shown in the table below.

Table 3-35: Whitfield Reservoir/Booster battery storage characteristics

System size (kW)	250
Storage capacity (kWh)	500
System cost ($/kW)	$1,400
Estimated interconnection cost	$100,000
Turn-key fuel cell plant cost	$420,000
Annual O&M ($/year)	$6,250
Demand Charge Reduction ($)	$22,000
Energy Shift Reduction ($)	$800

The result of the financial analysis is shown in the table below. This stand-alone battery storage system has a negative NPV in each scenario.

Table 3-36: Whitfield Reservoir/Booster battery storage financial statistics

FINANCING SCENARIO	10 -year Net Present Value
Paygo	-$265,000
CEC Loan	-$247,000
Third Party Owned PPA	N/A

Water Treatment Plant #2

A 250 kW battery storage system was modeled at Water Treatment Plant #2. The system characteristics, estimated cost, and reduction value are shown in the table below.

Table 3-37: Water Treatment Plant #2 battery storage characteristics

System size (kW)	250
Storage capacity (kWh)	500
System cost ($/kW)	$1,400
Estimated interconnection cost	$100,000
Turn-key fuel cell plant cost	$420,000
Annual O&M ($/year)	$6,250
Demand Charge Reduction ($)	$19,000
Energy Shift Reduction ($)	$200

The result of the financial analysis is shown in the table below. This stand-alone battery storage system has a negative NPV in each scenario.

Table 3-38: Water Treatment Plant #2 battery storage financial statistics

FINANCING SCENARIO	10 -year Net Present Value
Paygo	-$301,000
CEC Loan	-$284,000
Third Party Owned PPA	N/A

Mowry Wellfield

A 250 kW battery storage system was modeled at Mowry Wellfield. The system characteristics, estimated cost, and reduction value are shown in the table below.

Table 3-39: Mowry Wellfield battery storage characteristics

System size (kW)	250
Storage capacity (kWh)	500
System cost ($/kW)	$1,400
Estimated interconnection cost	$100,000
Turn-key fuel cell plant cost	$420,000
Annual O&M ($/year)	$6,250
Demand Charge Reduction ($)	$11,000
Energy Shift Reduction ($)	-$500

The result of the financial analysis is shown in the table below. This stand-alone battery storage system has a negative NPV in each scenario.

Table 3-40: Mowry Wellfield battery storage financial statistics

FINANCING SCENARIO	10 -year Net Present Value
Paygo	-$384,000
CEC Loan	-$366,000
Third Party Owned PPA	N/A

Peralta-Tyson (PT) Wellfield and Blending

A 250 kW battery storage system was modeled at Peralta-Tyson (PT) Wellfield and Blending. The system characteristics, estimated cost, and reduction value are shown in the table below.

Table 3-41: Peralta-Tyson (PT) Wellfield and Blending battery storage characteristics

System size (kW)	250
Storage capacity (kWh)	500
System cost ($/kW)	$1,400
Estimated interconnection cost	$100,000
Turn-key fuel cell plant cost	$420,000
Annual O&M ($/year)	$6,250
Demand Charge Reduction ($)	$9,700
Energy Shift Reduction ($)	$700

The result of the financial analysis is shown in the table below. This stand-alone battery storage system has a negative NPV in each scenario.

Table 3-42: Peralta-Tyson (PT) Wellfield and Blending battery storage financial statistics

FINANCING SCENARIO	10 -year Net Present Value
Paygo	-$391,000
CEC Loan	-$374,000
Third Party Owned PPA	N/A

SOLAR COMBINED WITH BATTERY STORAGE

While standalone battery storage is not currently financially feasible, combining solar with battery storage may provide greater benefits to the District than solar alone. The table below shows a summary of the solar plus storage scenario findings.

Table 3-43: Solar plus battery storage financial statistics

Site	PV System Capacity (kW)	Battery System Capacity (kW)	Project Cost	Year 1 Production	Solar plus Storage 20 year - NPV (PPA)	Solar only 20 year - NPV (PPA)
ACWD Headquarters	1,090	250	$3,660,000	1,808,000	$ 792,000	$ 836,000
Whitfield Reservoir	640	250	$2,400,000	1,226,000	$ 142,000	$ 351,000

The 20-year NPV for solar plus battery storage is only slightly lower at the ACWD Headquarters site compared to a solar-only option. The NPV calculations in this report for solar plus storage may be understated in this analysis as project developers likely have proprietary, more sophisticated control algorithms to maximize the value of the stored electricity. Also, battery system costs are dropping and their effectiveness is increasing.

Because of this, the District should include provisions for battery storage as an “add-on option” in any solar project implementation process.

SECTION 4 - RECOMMENDATIONS

The most feasible projects for implementation at the District sites are solar PV utilizing a third party owned PPA financing structure which consistently is projected to provide the highest NPV of benefits to the District. Accordingly, MDB recommends that the District engage in a competitive, Request for Proposal ("RFP") style procurement process in which the District aggregates at least three MW (preferably five MW or greater) of total solar capacity in order to attract the best pool of highly qualified solar PV developers. Moreover, MDB recommends that the RFP procurement include investigation of the Pit T1 and T2 floating solar projects with the developer responsible for providing a more in-depth feasibility analysis of these projects. Lastly, the solar procurement should encourage developers to include a battery storage option in their proposals and at least design the solar projects to be "battery-ready" for installation at a later date, if not offered initially.

Based on information provided by District staff, the table below shows the solar projects separated into four categories of descending priority: "Implement Near-Term," "Implement with Roof Replacement," "Implement If Feasible," and "Possible Future Sites." Each of these projects should be included in the solar procurement to develop an attractive package for Proposers.

No.	Location	Capacity (kW)	Generation (kWh)	Notes
Implement Near Term		**2,210**	**3,580,000**	
1	Whitfield Reservoir (non reservoir area)	640	1,232,000	Include on CIP; option for battery storage
2	Mayhew Reservoir	650	968,000	Roof replaced recently
3	Desalination	120	180,000	No roof replacement required
4	Headquarters (Phase 1 - canopies)	800	1,200,000	Option for battery storage
Implement w/ Roof Replacement		**2,910**	**4,378,000**	
5	Headquarters (Phase 2 - building roofs)	290	430,000	Roof replacement scheduled for FY20/21 and FY22/23; option for battery storage
6	Decoto Reservoir	1,150	1,734,000	Roof replacement scheduled for FY22/23
7	Alameda Reservoir	1,470	2,214,000	Roof replacement scheduled for FY23/24
If Feasible		**4,200**	**6,512,000**	
8	Pit T1	2,200	3,411,000	Site Feasibility Assessment Required
9	Pit T2	2,000	3,101,000	Site Feasibility Assessment Required
Possible Future Sites		**1,850**	**2,754,000**	
10	Patterson Reservoir	1,150	1,720,000	Roof replacement scheduled for FY24/25
11	Middlefield Reservoir	700	1,034,000	Roof rehabilitation scheduled for FY20/21

In addition to these solar projects, the larger fuel cell project (600 kW) at the Desalination Plant may also be feasible. However, prior to moving forward with a procurement for fuel cells, the District should consider the risks of natural gas pricing uncertainty as well as the capacity factor of the fuel cell system (a higher capacity factor will result in greater demand charge savings) as these considerations will greatly impact the financial benefits of hosting a system. The other fuel cell sites (Peralta-Tyson Well and Blending and Mowry) are not feasible at this time due to high capital and O&M costs. Fuel Cells may also be used as emergency backup generation and the District should evaluate the benefits of that application.

None of the locations analyzed for wind, hydroelectric and standalone battery storage projects as currently configured appear to be financially viable at this time. If physical changes to the Vallecitos Channel occur (replacing the channel with a pipeline) and the flow frequency increases, this hydroelectric project may become viable and should be reconsidered.

Standalone battery storage, while not economically attractive at this time, is undergoing reductions in cost, technology advancement, and expansion in new value streams and may become feasible in the near future (two to four years). MDB recommends that the District continue to monitor advancements in this technology to determine future applicability.