Water System Resiliency Study for Western Riverside Council of Governments (WRCOG)

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EXECUTIVE SUMMARY

Introduction

Water and wastewater systems are critical and essential services requiring resiliency and reliable operation during and after any natural disaster. Water systems in California have been developed to satisfy various communities' needs over the last 100 years. Today the water systems use as much as 19 percent of the state's electricity consumption for pumping, treating, collecting, discharging, wastewater, and customer end uses. The other mode of water pumping is by natural gas driven engines. Water Pumps are the dominant energy users in California and reduction of related energy use is a concern for both power companies and water districts. Incentivizing water districts to lower their consumption by lowering their electric bills not only helps the district's bottom line and helps reduce Green House Gases (GHG) but also helps in optimal pumping operation and helps the system operators prepare options for resilient operation during grid failures.

Project Purpose

The project objective is to evaluate resiliency measures for WRCOG member agencies.

To achieve these goals, University of California Riverside, CE-CERT personnel will satisfy the following objectives:

1. CECERT will work with WRCOG's staff, consultants, and member agencies to develop the Western Riverside County Energy Resiliency Plan;
2. Work with WRCOG's staff and the Project Team to educate and involve key member agency staff, officials, and to some degree community stakeholders in participating communities;
3. Leverage prior experience gained through energy projects including the Chemehuevi Tribe Microgrid and multiple water utility agencies;
4. Provide input and guidance in technical discussions;
5. Participate in workshops and meetings as needed; and,
6. CECERT will conduct feasibility analysis of targeted WMWD water facilities to improve resiliency and operations during critical power outage events. The analysis will focus on maintaining water delivery during unplanned power interruptions by using alternative energy sources including electric, natural gas, backup generators, solar PV, and battery energy system.
7. The two specific WMWD sites to be reviewed Bergamont Pump Station (PS) and Holcomb Pump Station (PS)

Project Approach

UC Riverside (UCR), College of Engineering-Center for Environmental Research and Technology (CE-CERT) researchers have been working on various aspects of electrical energy efficiency for over 10 years. As parameters related to each pumping station are different from each other, any generalized resiliency solution will be addressed appropriately for each site. Each mitigation strategy at Western Municipal Water District's two sites is assessed based on its potential to reduce the risks to the site, its difficulty to implement, and its cost. The overall project design will help design a plan that will implement solutions and measure the results of the mitigation action plan while satisfying water quality and user needs.

CHAPTER 1: Introduction

1.1 General Site Information

This project is to study energy resilience issues for two critical water pumping sites of Western Municipal Water District (WMWD) located in Riverside Public Utility's (RPU) service territory. The overall scope of this project is to evaluate site configurations and recommend a resilient water pumping solution after any major natural disaster which will help towards sustainable energy use at two of the larger sites at WMWD. The sites evaluated are Holcomb Pump Station and Bergamont Pump Station.

Two common themes in energy billing that occur are energy consumption and demand, and associated costs for each. Energy consumption and its costs are the more well-known of the two, and are defined as the amount of energy used by the customer, usually measured in kilowatt-hours (kWh), and is typically proportional to the amount of water pumped by that pumping station. This is calculated by summing up all the consumption for all the 15-minute intervals. The way energy is charged can either be time discriminate or indiscriminate. In residential and older industrial rates, only the total amount of energy is charged regardless of when the power is used. In modern industrial rates, Time-Of-Use (TOU) rates are charged, which charge different rates depending on the time of day the power is used. Energy costs are no longer one single flat rate, but a summation of charges pertaining to the time of day. Utilities tend to have four types of sub-charges: on-peak, mid-peak, off-peak, and super off-peak. These charges have two distinct seasons: summer (June – September) and winter (October – May).

Demand costs are not typically addressed outside of a few experts in the energy efficiency field. Most energy-efficiency/savings costs measures in the past did not consider this parameter in the savings model. The demand cost can be summarized as the maximum amount of power (kW) being used during any 15-minute interval. This is very critical for reducing the use and related costs in billing since even just one 15-minute kW use period in the entire month can significantly increase the total bill. For example, a water station uses an average of 500 kilowatts for the whole of the month, but for 15 minutes four pumps were used in unison to fill up the water tanks quickly since there were identical set points for all the pumps. The maximum demand doubled to 1000 kilowatts during this period; therefore, the demand and associated costs also doubled. Understanding the pattern of demand over time and finding ways of reducing it is critical in helping to find a sustainable and resilient solution. For example, instead of allowing all the pumps to run for filling a storage tank quickly, a solution can include running a reduced number of pumps to do the same work taking a longer time. This strategy reduces the demand on alternative energy sources during natural disasters. Many water districts are spending large capital investments on pumps and motors to satisfy the maximum demand which may occur only a handful of times in a year whereas the average water-need may be satisfied with fewer number of pumps. Identifying the number of pumps to satisfy required water-need requires analyzing 15-minute interval energy data for the whole year. The results of this analysis provide a base line for resiliency and reliability calculations.

Paying attention to TOU rates also offers opportunities of shifting energy consumption from high demand and cost periods to low demand and cost periods without violating water quality and supply needs.

This study's results present the greatest potential opportunities by optimizing both demand and energy consumption in two of the largest water pumping stations of WMWD.

1.1.1 Rate Schedules

Since the sites UCR is evaluating are within RPU territory, UCR gathered information such as Time of Use and Rates for each site. Table 1.1 shows the TOU rates for each of the two sites being evaluated.

		Per Meter, Per Month Effective January 1,				
		2019	2020	2021	2022	2023
Customer Charge	Flat Charge	$691.87	$679.08	$672.68	$666.28	$659.88
Reliability Charge	Flat Charge based on Maximum Demand					
Tier 1	< or = 100 kW	$912.50	$725.00	$537.50	$350.00	$350.00
Tier 2	> 100 - 150 kW	$1,012.50	$925.00	$837.50	$750.00	$750.00
Tier 3	> 150 - 250 kW	$1,050.00	$1,000.00	$1,050.00	$900.00	$900.00
Tier 4	> 250 - 500 kW	$1,100.00	$1,100.00	$1,100.00	$1,100.00	$1,100.00
Tier 5	> 500 - 750 kW	$1,287.50	$1,475.00	$1,662.50	$1,850.00	$1,850.00
Tier 6	> 750 kW	$1,487.50	$1,875.00	$2,262.50	$2,650.00	$2,650.00
		Per kW Effective January 1,				
		2019	2020	2021	2022	2023
Demand Charge						
On-Peak	Billing demand, per kW	$6.97	$7.06	$7.16	$7.27	$7.38
Mid-Peak	Billing demand, per kW	$2.93	$3.13	$3.34	$3.64	$3.69
Off-Peak	Billing demand, per kW	$1.42	$1.53	$1.65	$1.82	$1.85
Network Access Charge	Max Billing demand, per kW	$0.69	$1.24	$1.79	$2.34	$2.89
High Voltage Network Access Charge	Max Billing demand, per kW	$0.00	$0.06	$0.61	$1.16	$1.71
		Per kWh Effective January 1,				
		2019	2020	2021	2022	2023
Energy Charge						
On-Peak	All on-peak kWh	$0.1049	$0.1079	$0.1104	$0.1124	$0.1154
Mid-Peak	All mid-peak kWh	$0.0845	$0.0874	$0.0898	$0.0922	$0.0946
Off-Peak	All off-peak kWh	$0.0734	$0.0755	$0.0773	$0.0787	$0.0808

Table 1.1: Winter and Summer RPU Rate Schedules for the two Project Sites

In residential and older industrial rates, only the total amount of energy is charged regardless of when the power is used. In modern industrial rates, TOU rates are charged. Energy costs are no longer one single flat rate, but a summation of charges pertaining to the times of day the power is used. Companies tend to have four types of sub-charges: on-peak, mid-peak, off-peak, and super off-peak. These peak times and their rates are established by the utility company. These charges have two distinct seasons: Summer (June – September) and Winter (September –

June) as shown in Figure 1.1. The summer season strains the energy resources of a utility company severely, due to the use of high kW demand equipment such as Heating, Ventilation, and Air Conditioning (HVAC) during the peak hours. The high peak hours are generally towards the end of the day when solar generation is the lowest. Users are charged extra during high demand hours to discourage use during that time. During the winter (all the season except summer) period RPU's on-peak charges shift towards evening hours as listed below.

Daily Time Periods are Defined as Follows:

On-Peak:	12:00 p.m. to 6:00 p.m. summer weekdays except holidays 5:00 p.m. to 9:00 p.m. winter weekdays except holidays
Mid-Peak:	8:00 a.m. to 12:00 p.m. and 6:00 p.m. to 11:00 p.m. summer weekdays except holidays 8:00 a.m. to 5:00 p.m. winter weekdays except holidays
Off-Peak	All other hours Off-peak holidays are: New Year's Day, Washington's Birthday, Memorial Day, Independence Day, Labor Day, Veteran's Day, Thanksgiving Day, and Christmas.

Summer shall commence at 12:00 a.m. on June 1 and continue through September 30 of each year. Winter shall commence at 12:00 a.m. on October 1 of each year and continue through May 31 of the following year.

Figure 1.1: RPU TOU for Two Project Sites at WMWD

A common misconception is that a billing month is just a regular calendar month when looking at the billing data. A billing month is not the same as a calendar month. A billing month starts when the date from the billing meter is read and ends when the next reading is done as shown in Table 1.2. Both WMWD sites UCR is working with have similar billing dates, which may not be true for other sites.

1.2 Pump Stations Billing Cycles

Bergamont Water District	Alessandro (Holcomb) Water District
November 25, 2019 to December 24, 2019	November 25, 2019 to December 24, 2019
December 24, 2019 to January 24, 2020	December 24, 2019 to January 24, 2020
January 24, 2020 to February 25, 2020	January 24, 2020 to February 25, 2020
February 25, 2020 to March 25, 2020	February 25, 2020 to March 25, 2020
March 25, 2020 to April 24, 2020	March 25, 2020 to April 24, 2020
April 24, 2020 to May 26, 2020	April 24, 2020 to May 26, 2020
May 26, 2020 to June 23, 2020	May 26, 2020 to June 23, 2020
June 23, 2020 to July 24, 2020	June 23, 2020 to July 24, 2020
July 24, 2020 to August 25, 2020	July 24, 2020 to August 25, 2020
August 25, 2020 to September 24, 2020	August 25, 2020 to September 24, 2020
September 24, 2020 to October 26, 2020	September 24, 2020 to October 26, 2020
October 26, 2020 to November 23, 2020	October 26, 2020 to November 23, 2020
November 23, 2020 to December 23, 2020	November 23, 2020 to December 23, 2020
December 23, 2020 to January 21, 2021	December 23, 2020 to January 21, 2021
January 21, 2021 to February 22, 2021	January 21, 2021 to February 22, 2021
February 22, 2021 to March 24, 2021	February 22, 2021 to March 24, 2021
March 24, 2021 to April 23, 2021	March 24, 2021 to April 23, 2021
April 23, 2021 to May 25, 2021	April 23, 2021 to May 25, 2021

Table 1.2: Billing Cycle for Two Sites

CHAPTER 2:
Holcomb Pump Station

2.1 General Site Information

Holcomb Pump Station (PS) has a total of 8 pumps, three of them are electric and five are gas driven pumps. At the site both input and output storages are very large and reservoir heights are around 45 ft high. Below are the specs of both output tanks that Holcomb PS delivers water to, as well as the current reservoir set points as seen in Figure 2.1.

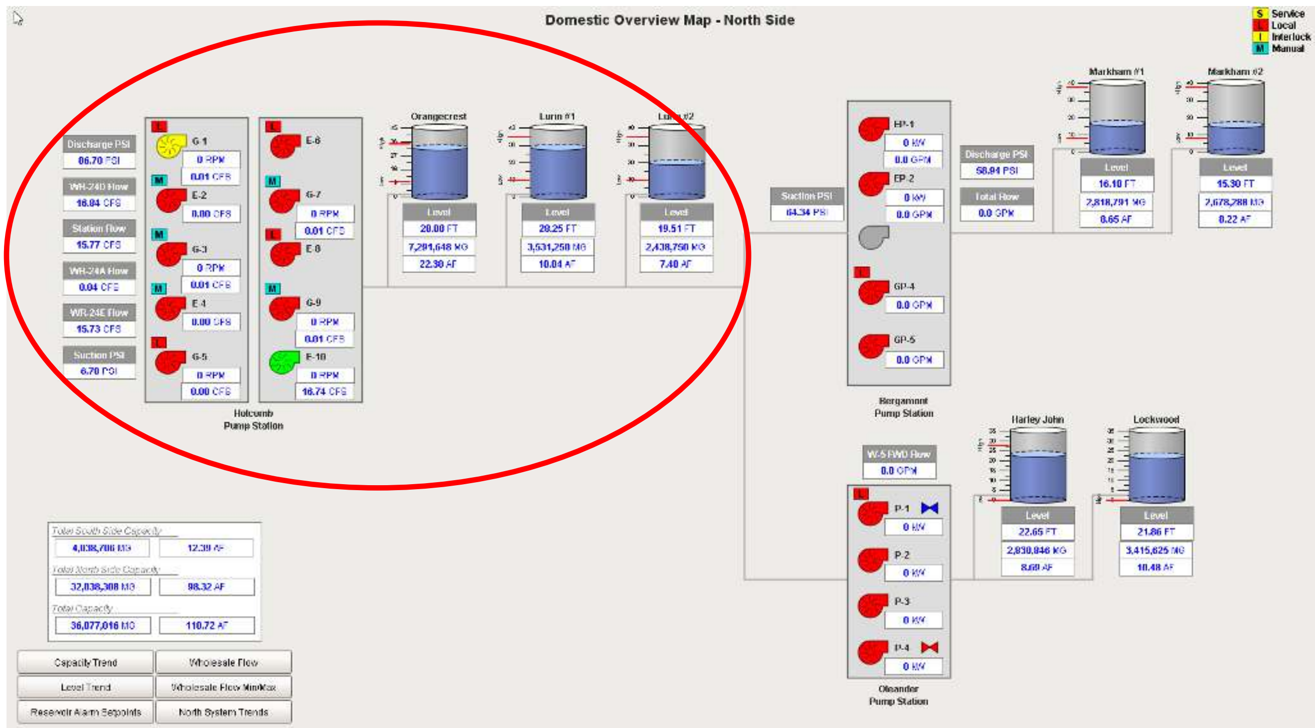


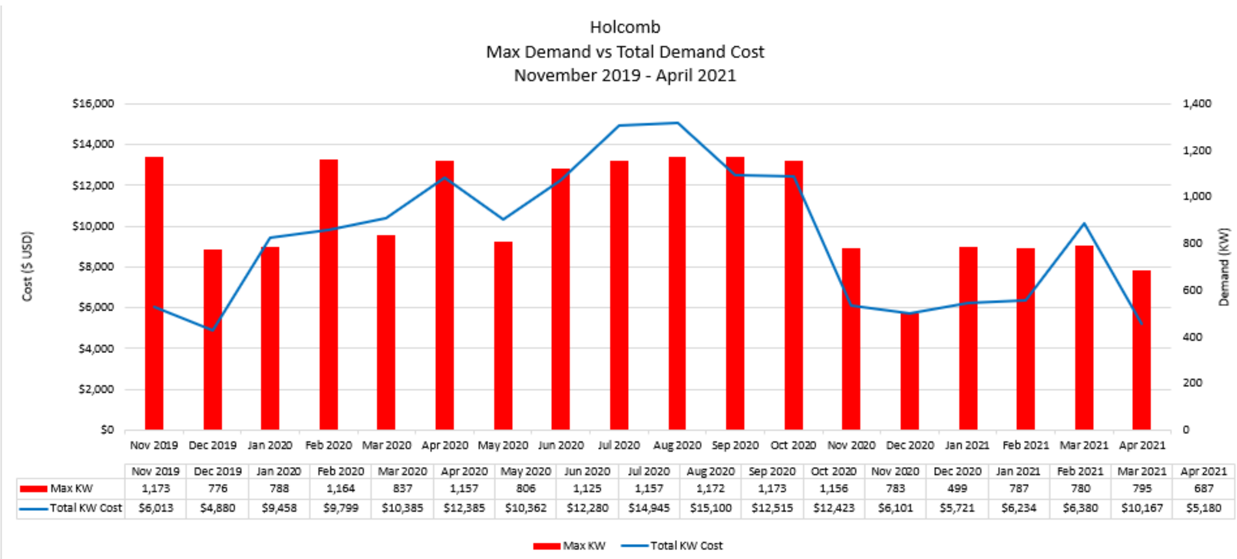
Figure 2.1: Holcomb Pump Station SCADA Overview

2.2 Baseline Data and Analysis

2.2.1 Total kW Cost versus Demand

When determining a possible demand reduction approach, all the monthly bills must be studied to determine the peak demand and associated costs. Typically, the total bill is largely influenced by the demand charges which are based on the peak kW values and the energy charges which are based on the amount of energy usage (kWh) all within a billing month period. Therefore, the major charges are broken into two categories: peak demand (kW) and energy usage (kWh) charges. In some cases, the peak demand may have the largest influence on the total bill amount since the rate for this charge is much higher than the energy charges. The way the peak demand works is best described using an example. If a site were operating at 300 kW for the entire month and then suddenly had a peak of 550 kW within that billing month, the billing company will take the peak value of 550 kW and multiply it by the rate to give the demand charge despite the site running below 300 kW for a majority of that month. A possible demand reduction for this site would be to reduce any kW peaks and try to keep running without creating sharp spikes. By looking at the most recent 12-month billing period, various trends for different months can be observed and then used for formulating a possible demand reduction strategy for the future. For example, if the peak demand and cost are higher than usual in a particular month, this opens the door for a possible demand reduction and cost savings opportunities. This will require an in-depth analysis by zooming into energy use data for this month for further studies.

In Figure 2.2 monthly kW demand charges are shown along with associated costs from November 2019 to April 2021. It shows that the maximum demand reached above 1,100 kW eight times over this 18 months period, while it was lower during the other months.



	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021
Max KW	1,173	776	788	1,164	837	1,157	806	1,125	1,157	1,172	1,173	1,156	783	499	787	780	795	687
Total KW Cost	$6,013	$4,880	$9,458	$9,799	$10,385	$12,385	$10,362	$12,280	$14,945	$15,100	$12,515	$12,423	$6,101	$5,721	$6,234	$6,380	$10,167	$5,180

Figure 2.2: Holcomb Pump Station Total Bill Amount versus Max Demand and Demand Cost

2.2.2 Electricity Cost Amount versus Total Electricity Usage

Similar to the method of looking at the demand charges, the total energy usage is the other item to be looked into for a base line for this site. While the kW demand is related to the actual rate of delivery of the electricity from the grid, the generation charge deals with the actual kWh generation of the electricity. Both of these have charges at different rates for different times of the day. A user has the choice of when they want to use the electricity which will result in creating different demand and energy charges consumption and related charges since the time of day is one of the main factors in the cost. Thus, by studying the previous billing history and the frequency of energy usage in a month, potential for both demand reduction and shifting of energy use can be identified.

Figure 2.3 shows the monthly energy usage (kWh) as well as the total charge for electricity over the period from November 2019 to April 2021.

Figure 2.4 shows total monthly kWh energy use and kW demand along with total electricity cost during the period November 2019 to April 2021.

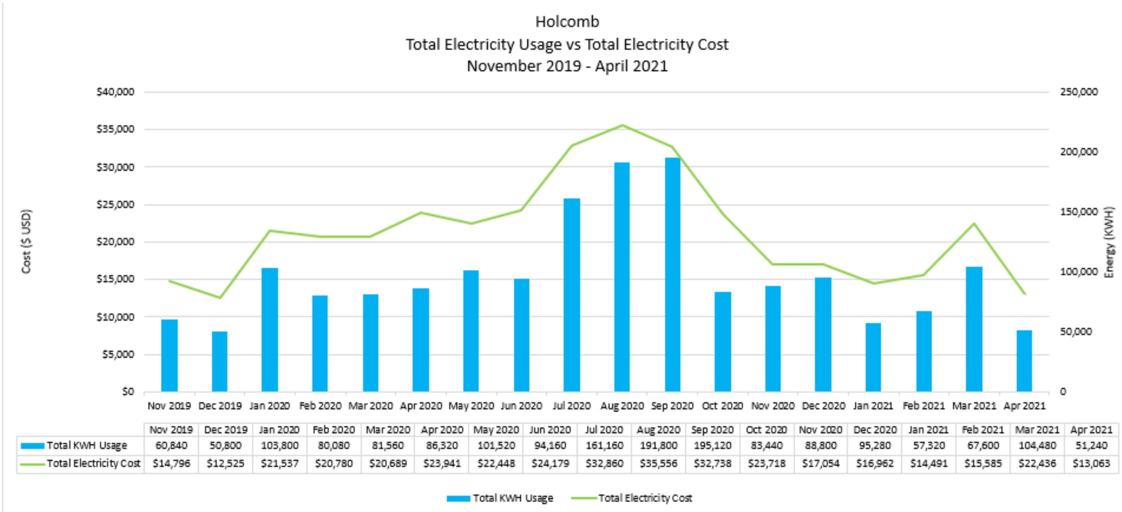


Figure 2.3: Holcomb Pump Station Total Electricity Usage versus Total Electricity Cost

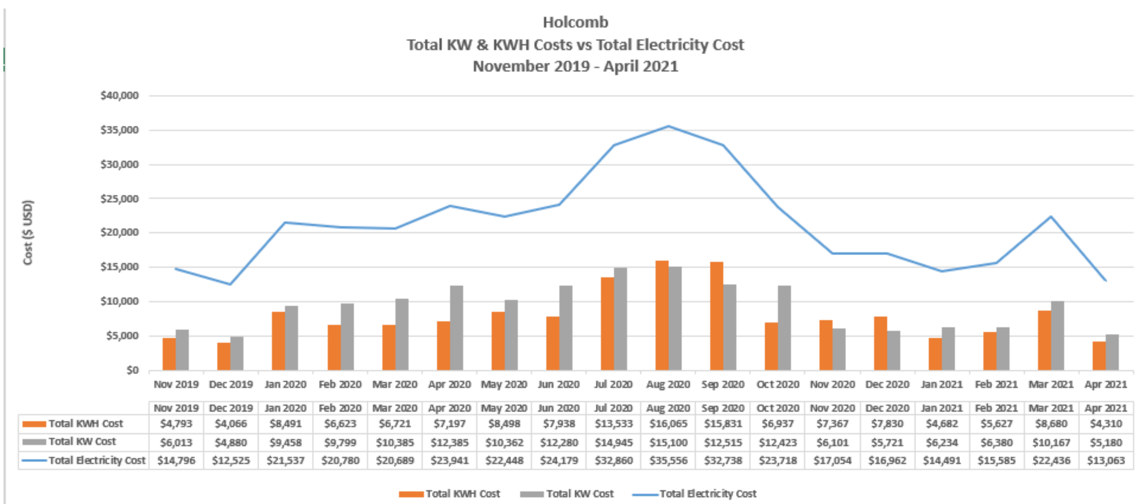


Figure 2.4: Holcomb PS kW, kWh, and Total Electricity Cost

2.2.3 RPU 15-Minute Interval Data

The data analysis and validation of WMWD required a compilation and comparison of RPU 15-minute interval data and RPU billing data. Analysis of 15-minute interval data is necessary to get a better understanding on when the highest peaks or demands happens each month. Figure 2.5 shows kW demand usage from July 2020 to April 2021. By looking at an entire year we are able to see what months have the highest kW demand. Based on this observation we can begin to zero in to specific months or days if necessary to see when the site used the most electricity. Once zoomed in we are able to see for how long, and how many times a peak happened in a given time frame. When looking at 15-minute interval data this is usually done in a three-step process. The first step is to plot the interval data for the full year and identify the top three highest peaks. Second step is to zoom into the highest peak for that month and get a better clarity of how and why operations were done this way. After understanding that we discuss with operators and finalize recommendations that will achieve the same amount of total water production over a longer duration of pumping time. For example, figure 2.5 shows that a number of high demand peaks of about 750 kW occurred between July and October 2020 caused by two large pumps running. These peaks were of shorter durations only followed by many other peaks of about 375 kW at other times where only one large pump was running. It is possible to pump same amounts of water by running one pump for double the amount of time and avoid running two pumps at the same time, thereby, reducing electrical demand by 50%.

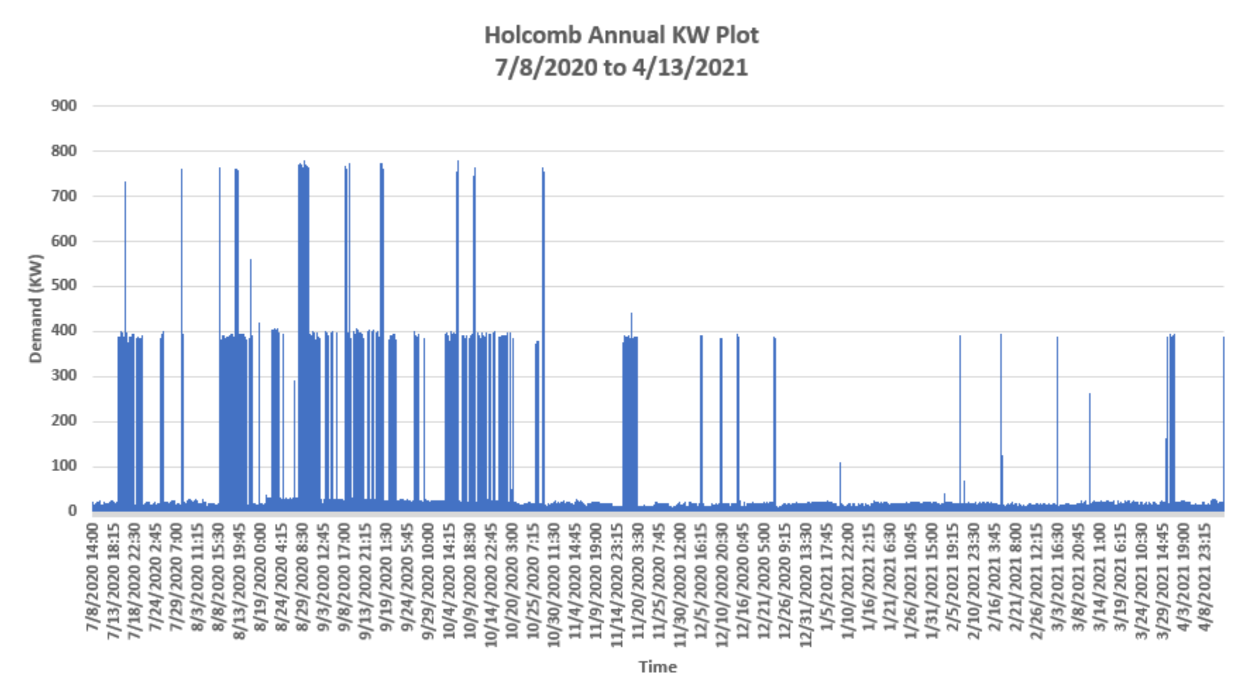


Figure 2.5: Holcomb PS 15-Minute Interval kW Demand Data for One Year

2.2.4 kWh Energy Cost Breakdown of Electric Bills

The following pie charts shown in this section are representations of the breakdown of the electricity bill of the Holcomb PS for the month September 2020.

In September 2020 kWh charges make up the single largest portion of the cost. The kWh energy costs together (on-peak + mid-peak + off-peak) are almost 50 percent of the total bill for the pie chart on the left as shown in Figure 2.8. If we look at demand, pie chart in the center on-peak demand is the smallest at 796kW but the on-peak cost is the highest at 45%. It is recommended to reduce electricity usage during on-peak hours and substitute with operation during mid-peak or off-peak hours.

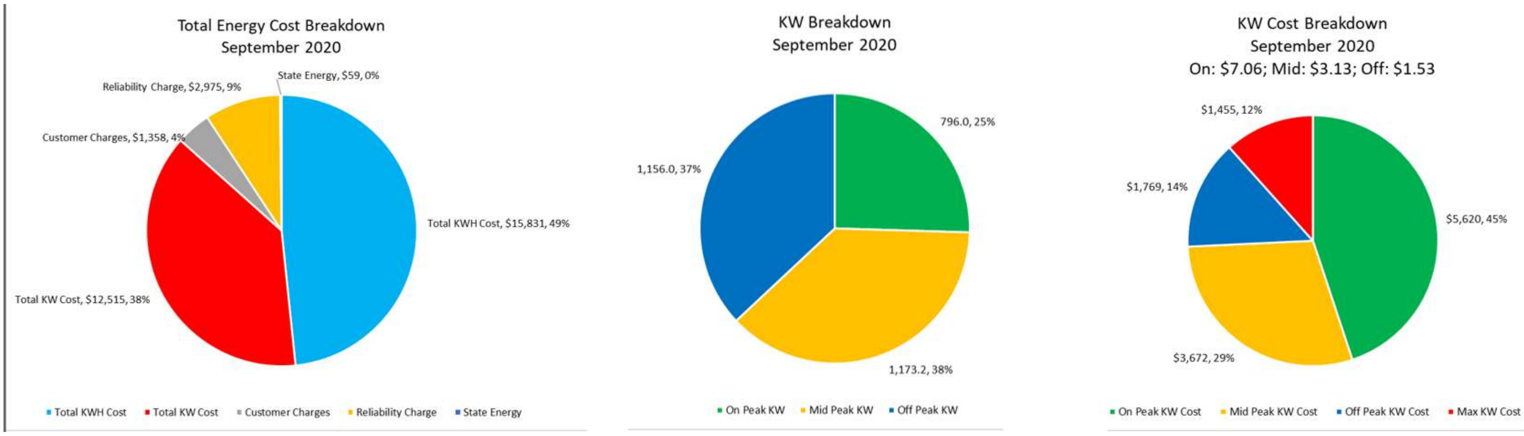


Figure 2.8: Holcomb Pump Station Cost Breakdown for September 2020

2.3 Gas Cost Breakdown

Figure 2.9 below shows the cost of Gas from December 2019 to December 2021. Since this pumping station also uses gas pumps to distribute water we analyze gas bills the same way we do electric bills. This not only offers diversity in energy sources for this site, but as the cost of natural gas is usually much lower, we encourage the use of gas pumps before electric pumps in order to reduce overall kW demand associated charges as well as total savings of combined gas plus electric charges.

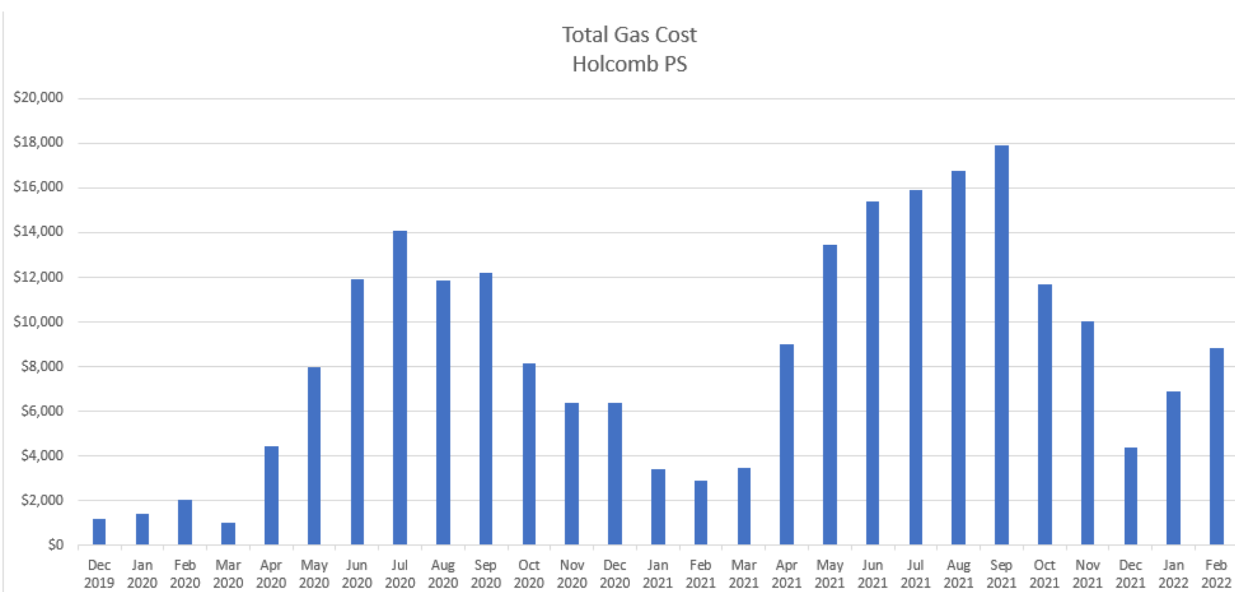
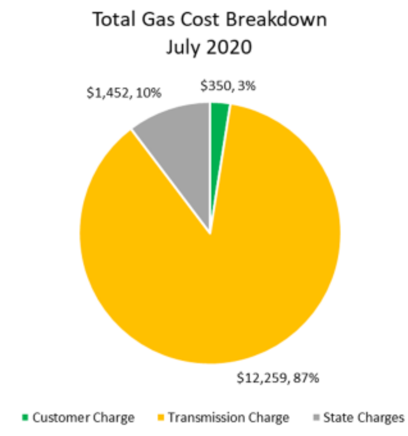


Figure 2.9: Holcomb PS Total Gas Cost Breakdown

Figures 2.10 shown below show the total gas cost breakdown for the months of July 2020 and December 2020, respectively. As seen in both months, Shell Gas commodity price is the highest cost followed by transmission charge, taking up 87% and 85% of gas costs, respectively. State and customer charges follow up with the middle and smallest percentages, respectively in both month breakdowns.



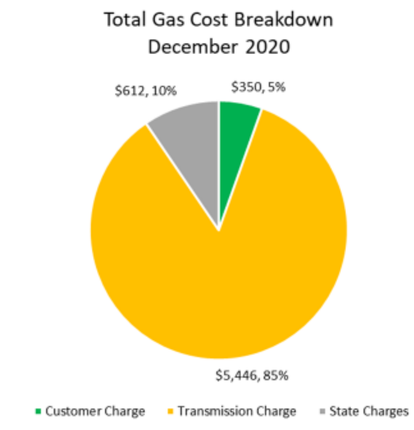


Figure 2.10: Holcomb PS Total Gas Cost Breakdown for July 2020 and December 2020

CHAPTER 3:
Bergamont Pump Station

3.1 General

Bergamont Pump Station (PS) has a total of 5 pumps, three of them are electric and two are gas-driven pumps. At the site, both input and output storage tanks are very large and reservoir heights are around 45 ft high. Below are the specs of both input tanks that Bergamont PS receives water from, as well as the current reservoir set points as seen in Figure 3.1.

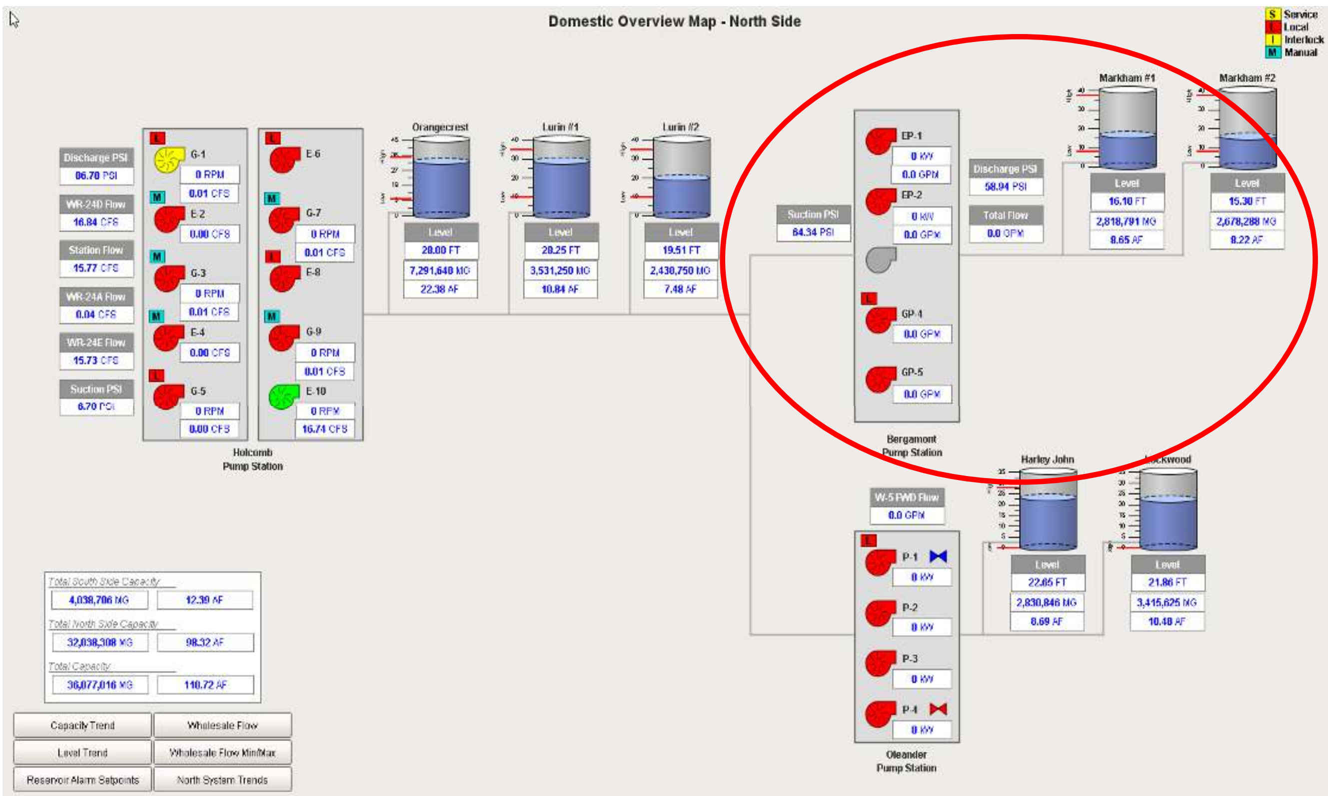
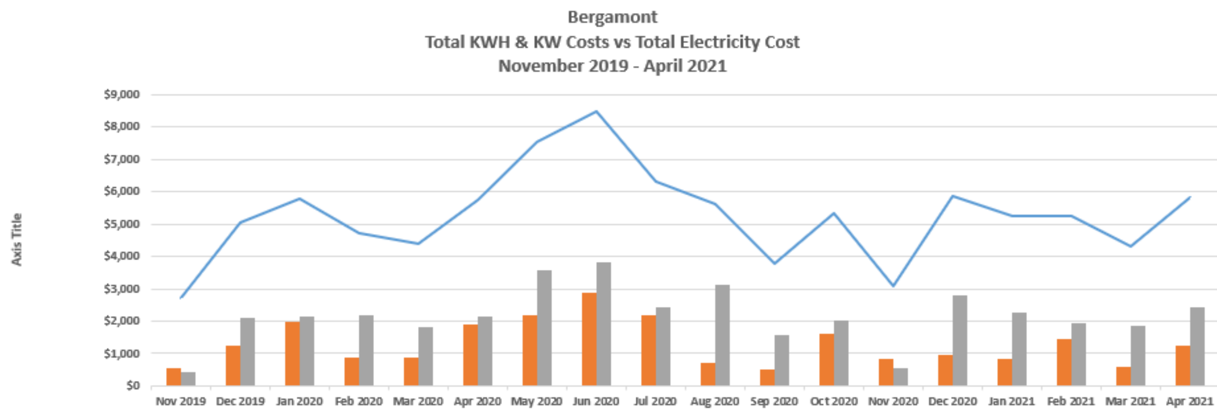


Figure 3.1: Bergamont Pump Station SCADA Overview

3.2 Baseline Data and Analysis

3.2.1 Total Bill Amount versus Demand

In Figure 3.2, the demand charges make up a large portion of the total bill amount throughout the year more specifically in the summer months. By analyzing each month's costs, potential demand and associated reductions may be recommended.



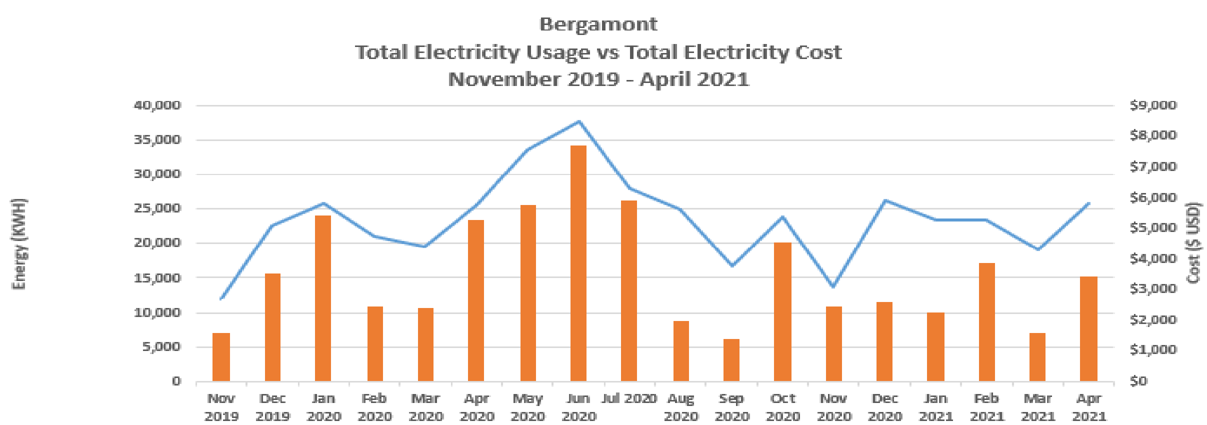
	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021
Total KWH Cost	$543	$1,255	$1,983	$870	$884	$1,901	$2,204	$2,873	$2,181	$711	$509	$1,627	$843	$971	$854	$1,443	$577	$1,252
Total KW Cost	$425	$2,107	$2,132	$2,174	$1,827	$2,157	$3,563	$3,810	$2,429	$3,122	$1,577	$2,037	$561	$2,784	$2,285	$1,938	$1,845	$2,430
Total Electricity Cost	$2,711	$5,061	$5,802	$4,727	$4,393	$5,744	$7,554	$8,472	$6,297	$5,615	$3,767	$5,349	$3,087	$5,881	$5,265	$5,271	$4,308	$5,813

Total KWH Cost   Total KW Cost   Total Electricity Cost

Figure 3.2: Bergamont PS Total Bill Amount versus kW and kWh Cost

3.2.2 Electricity Usage versus Electricity Cost

Figure 3.3 was derived by extracting the total bill amount and total energy usage data from the monthly RPU electric bills. The data was plotted to formulate a recommended method for reducing overall electricity demand and associated costs.



	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021
Total KWH Usage	7,040	15,680	24,080	10,880	10,640	23,440	25,680	34,240	26,240	8,720	6,080	20,160	10,800	11,520	10,000	17,120	6,960	15,200
Total Electricity Cost	$2,711	$5,061	$5,802	$4,727	$4,393	$5,744	$7,554	$8,472	$6,297	$5,615	$3,767	$5,349	$3,087	$5,881	$5,265	$5,271	$4,308	$5,813

Total KWH Usage   Total Electricity Cost

Figure 3.3: Bergamont Total Cost versus Total Energy Usage

3.2.4 RPU 15-Minute Interval Data

Figure 3.4 shows 15-minute kW demand usage for an entire year for the Bergamont PS. Plotting the entire duration gives everyone an overview of any unusual or unique kW usage throughout the year as well as seasonal variation. After the entire duration is plotted then we can zoom into any particular month either summer and/or winter to get a better idea on pump activity for that day and its duration. Based on this analysis we are able to determine if we can make any changes to pumping strategy to eliminate high peak demand.   Figure 3.4 shows that only a handful of times the peak demand exceeded 175 kW and these may be eliminated by running smaller number of pumps for longer durations and satisfy water needs.

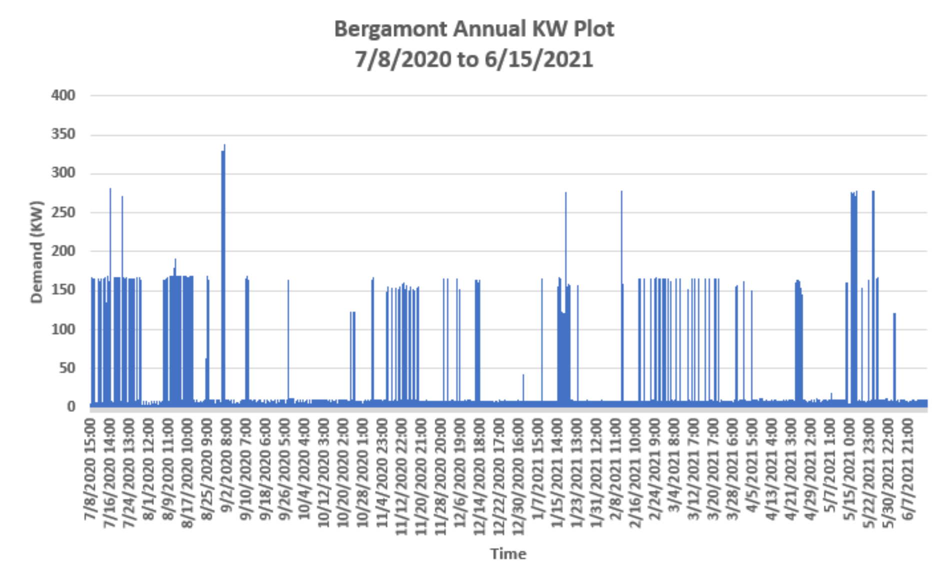


Figure 3.4: Bergamont 15-Minute Interval kW Demand Data for One Year

3.2.5 kWh Energy Cost Breakdown of Electric Bills

The following pie charts shown in this section are representations of the kW demand cost breakdown of the electricity bills and the breakdown of kW demand and kWh energy use amounts for Bergamont for the months of June 2020 and October 2020.

Figure 3.8 below shows the total kW cost breakdown for the month of June 2020. As shown, on-peak kW cost takes up most of the pie chart at 52 percent as a result of its cost rate at $7.06. Mid-peak kW cost follows up with 26 percent of the pie chart at a cost rate of $3.13, and the off-peak and max kW cost each take up 11 percent of the pie chart. Reducing the peaks will not only offer resiliency by using alternative energy resources of reduced ratings but also reduces associated costs.

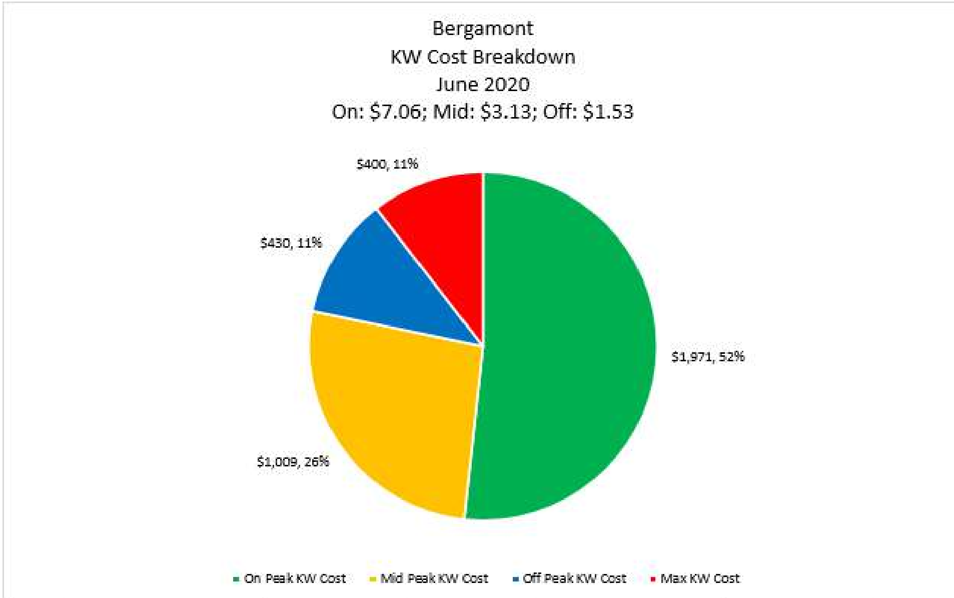


Figure 3.8: Bergamont kW Cost Breakdown for June 2020

The pie chart in Figure 3.9 below shows the kW amount breakdown for June 2020. As seen, the breakdown is about same among the different peaks. While mid-peak takes up 36 percent of the pie chart, the on-peak and off-peak amount each take up 32 percent of the kW breakdown. The kW amount breakdown can also associate closely with the kWh cost breakdown in Figure 3.10, especially given the individual cost rates of the three peaks.

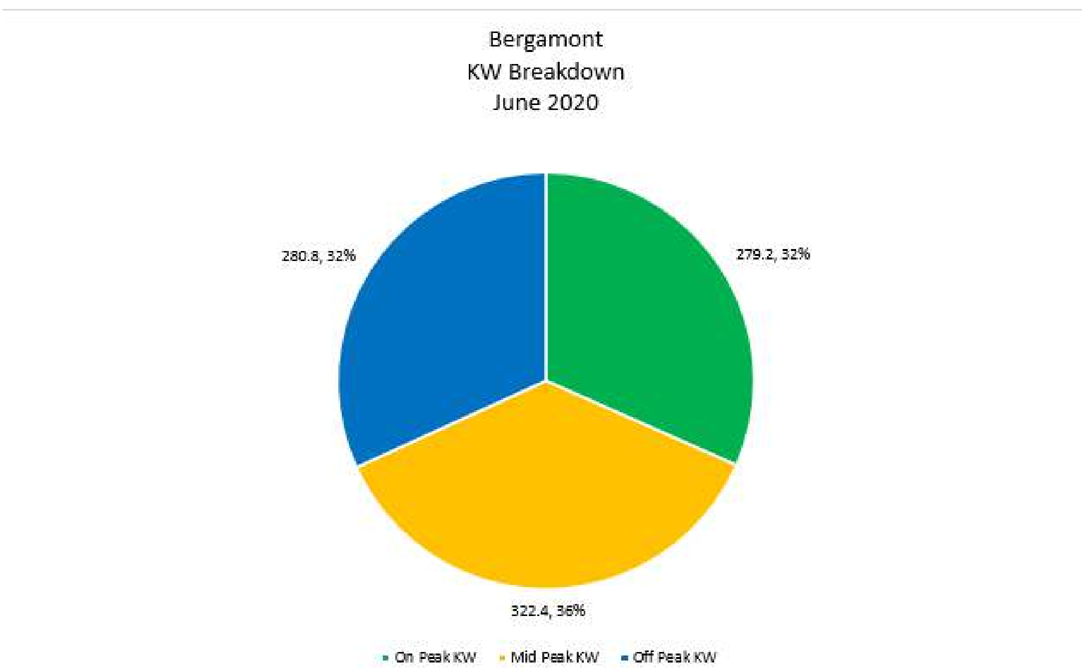


Figure 3.9: Bergamont kW Amount Breakdown for June 2020

In figure 3.10 below, the pie chart shown displays the breakdown for the kWh energy amount. Unlike the kW demand amount, off-peak kWh makes up most of the pie chart at around 59 percent. Mid-peak kW follows up with 24 percent of the breakdown and on-peak takes up the smallest chunk of the pie chart at 17 percent.

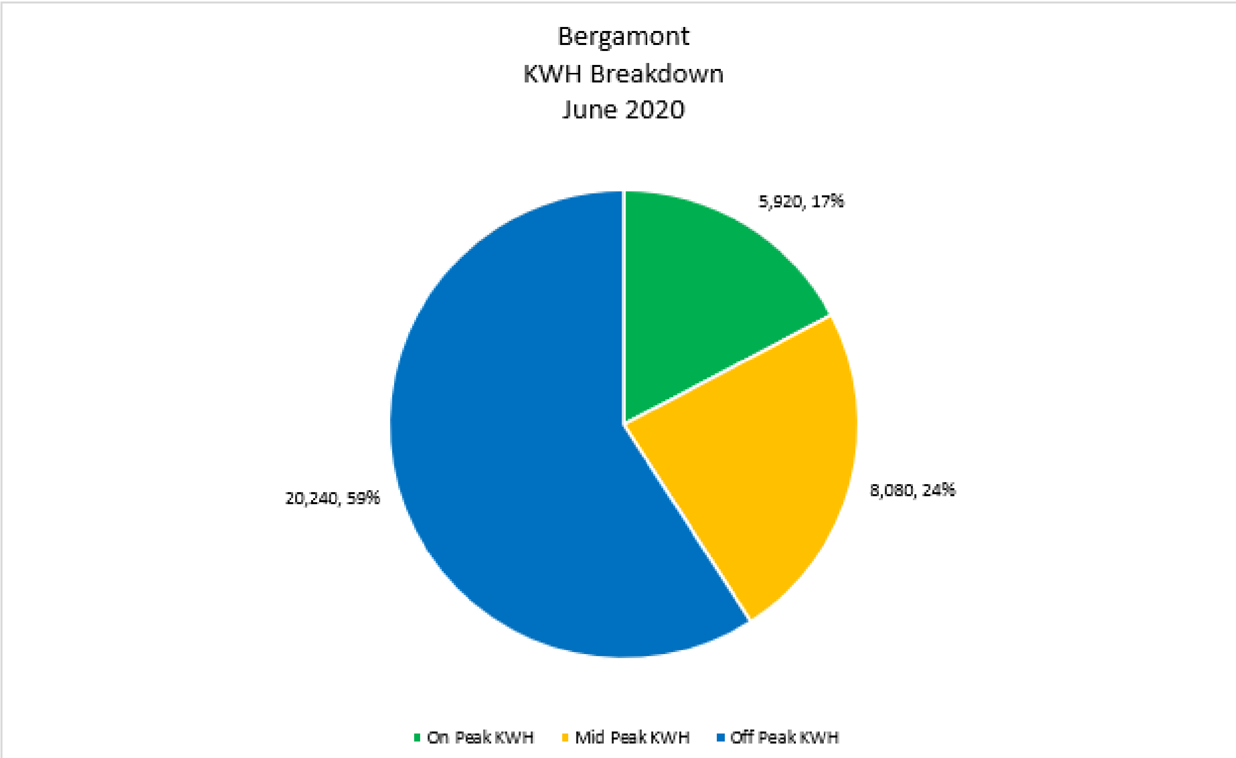


Figure 3.10: Bergamont kWh Amount Breakdown for June 2020

Figures 3.11 and 3.12 below display the kW cost breakdown and kW amount, respectively, for the month of October 2020. These breakdowns have resemblance to the ones for June 2020 shown in figures 3.9 and 3.10. Here, the on-peak kW cost covers most of the cost breakdown at 54 percent. Mid-peak cost follows up with 24 percent of the breakdown, and off-peak covers 12 percent. The individual cost rates for the peaks are the same as in June 2020. Here, the pie chart is very similar, almost the same to that shown in June 2020, in which on-peak kW cost is most of the breakdown. The kW amount breakdown is also very similar to June 2020, in which the pie chart shows a very even breakdown among the different peaks. Here, off-peak kW has a very slight majority at 35 percent, while mid-peak amount makes up 33 percent and on-peak amount makes up 32 percent.

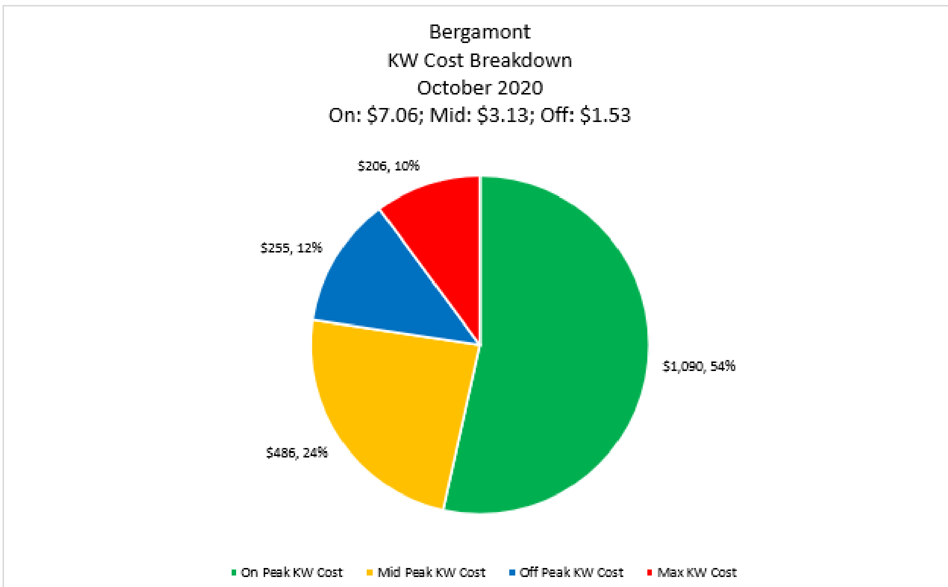


Figure 3.11: Bergamont kW Cost Breakdown for October 2020

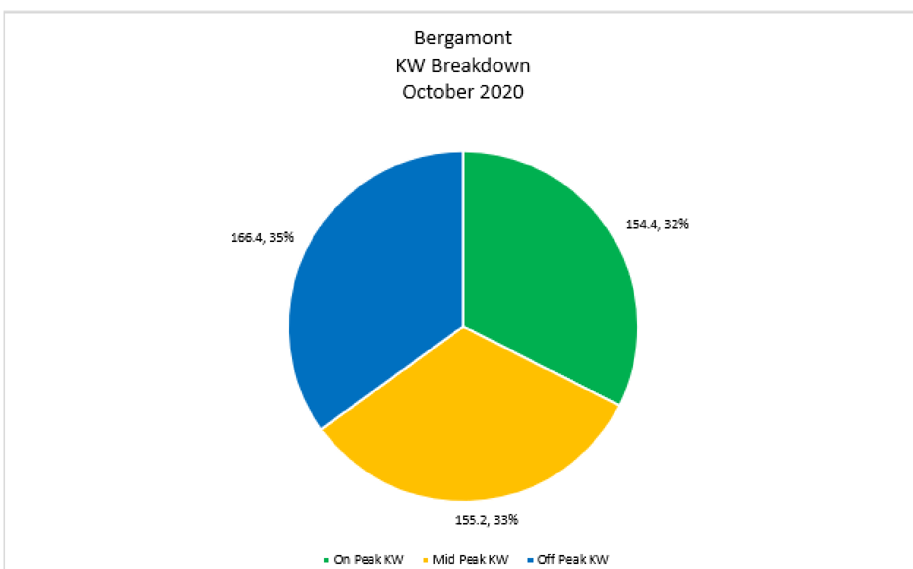


Figure 3.12: Bergamont kW Amount Breakdown for October 2020

Figure 3.13 below displays the kWh energy breakdown for October 2020. Just like with the previous two pie charts, this breakdown also has a resemblance to the kWh energy breakdown for June 2020 where the off-peak kWh takes up most of the breakdown. However, in this month, the breakdown is much more drastic, as the kWh breakdown here takes up 73 percent of the pie chart, with mid-peak and on-peak taking up 18 percent and 9 percent respectively.

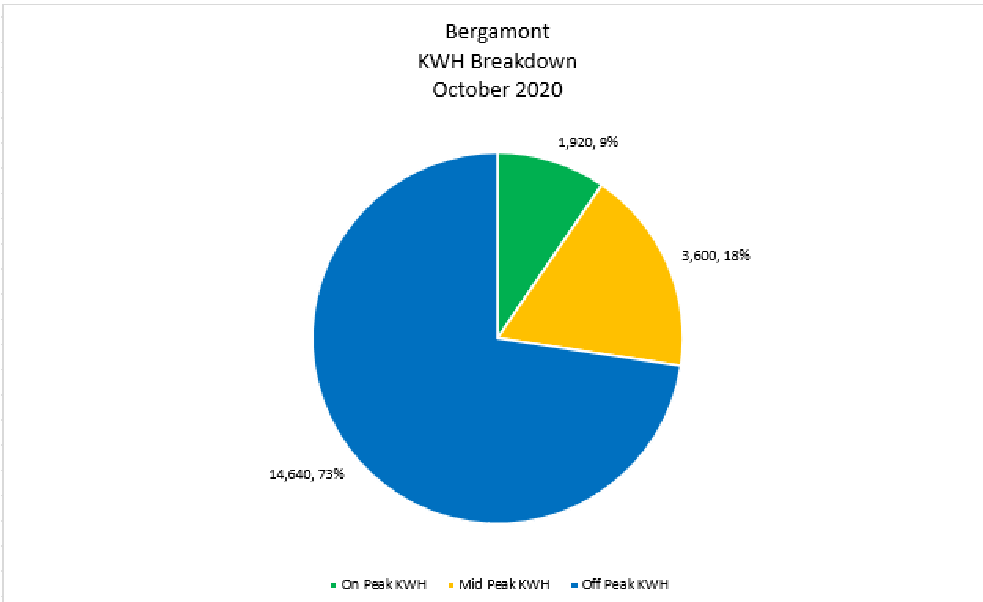


Figure 3.13: Bergamont kWh Amount Breakdown for October 2020

3.3 Gas Cost Breakdown

Figure 3.14 below shows the cost of Gas from December 2019 to December 2021. Since this pumping station uses natural gas pumps to distribute water, we analyze Gas bills the same way we do electric bills. Due to the cost of Gas being much lower, we encourage the use of Gas pumps before electric pumps in order to reduce overall Demand and associated charges as well as total combined savings of Gas plus electric charges.

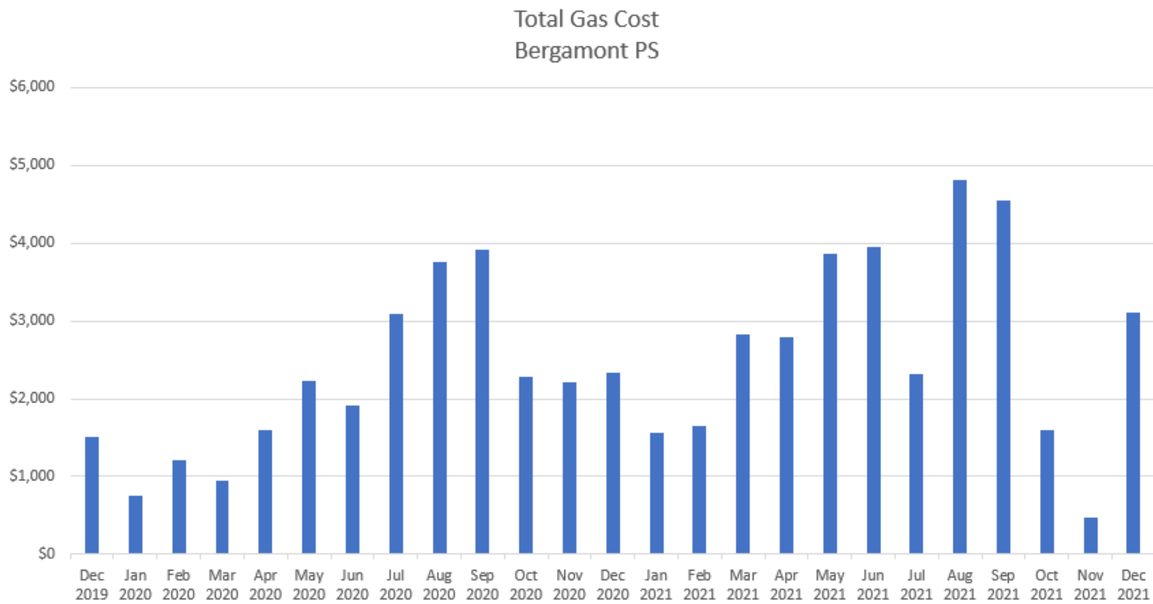
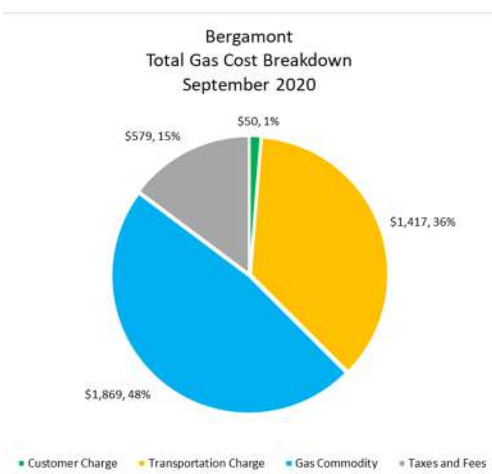


Figure 3.14: Bergamont PS Total Gas Cost Breakdown

Figure 3.15 below shows the total gas cost breakdown for the months of September 2020 and December, 2020 respectively. As seen in both months, Gas Commodity charge takes up a vast majority of the breakdowns, taking up 48% and 57%, respectively. Transportation and customer charges follow up with the middle and smallest percentages, respectively, in both months breakdown.

The information and plots provided in the sections above provide a baseline demand and energy information which helps in analyzing resiliency issues.



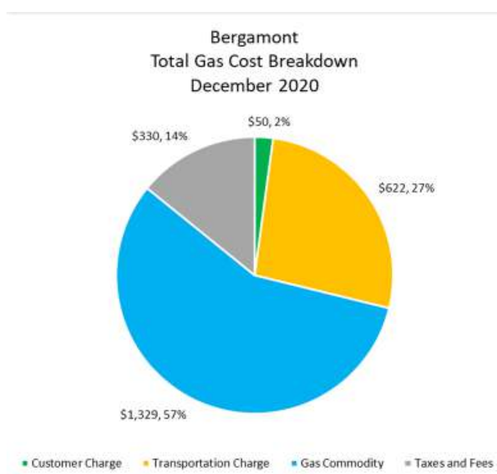


Figure 3.15: Bergamont Total Gas Cost Breakdown for July 2020 and December 2020

CHAPTER 4:
Identify and Prioritize Mitigation Strategies

Each mitigation strategy at Western Municipal Water District's two sites is assessed based on its potential to reduce the risks to the site, its difficulty, and its cost. The risk reduction score is based on a potential percentage of reduction. Site-specific information, low to high reduction scores are assigned, where low = 20%, low-medium = 35% medium = 50%, medium-high = 65%, and high = 80% risk reduction. The cost and difficulty of each site are estimated on a low to high (1 to 10) scale. The site can then use the scores to prioritize mitigation actions based on their cost and difficulty of implementation, and ability to reduce risk. Table 1 provides score mitigation actions.

Mitigation Action	Difficulty	Cost	Risk Reduction
Propose Plan that will build resilience against power shutoffs at critical facilities by developing a blueprint for energy resiliency technologies, projects, and strategies	4	2	High (80%)
Add backup power to critical loads by adding backup Gas Line to Water District Existing Site	4	4	Medium-High (65%)
Add backup power to critical loads by adding Solar Energy Storage to Water District Existing Site	4	4	Medium-High (65%)
Add backup power to critical loads by adding Battery Energy Storage to Water District Existing Site	4	4	Medium-High (65%)
Develop action plan with county to establish clear contingency plans	4	1	Med (50%)

Table 4.1: Risk Reduction Scoring of Mitigation Action Plan

CHAPTER 5:
Create Action Plan and Implement Solutions

The action plan will implement solutions and measure the results at the two sites at WMWD. Currently the two sites, Bergamont and Holcomb Pumping Stations, are being supplied by 3 sources of energy:

1) Electricity: Power lines
2) Natural Gas: Gas Distribution Lines
3) Diesel: Backup Generators

Below in the following subsection are full descriptions of the three sources of energy along with their mitigation action description. Based on those action plans the table below was created to show what the list of mitigation strategies, next steps, and the overall priority of each step to achieve the overall goal of resiliency. Table 2 shows mitigation action plan.

Mitigation Action	Next Steps	Priority
Develop action plan with water district	Draft memorandum of understanding	1
Add backup power to critical loads by adding backup Gas Line to Water District Existing Site	Meeting with Gas Company and Water district, discuss overall plan	2
Add backup power to critical loads by adding Solar Energy Generation to Water District Existing Site	Procure Solar Panels	3
Add backup power to critical loads by adding Mobile Battery Energy Storage to Water District Existing Site	Deploy Battery Energy Storage	4
Commission Microgrid	System Operation Test	5

Table 5.1: Mitigation Action Plan

5.1 Electricity Supply

The pumping stations are being supplied with electricity by the Riverside Public Utility (RPU) from their Orangecrest Electrical Substation. RPU power lines shown in color red, distribute the electricity throughout the facility, including the Mills Water Treatment Plant, as shown below:

Source: Google Maps

Table 5.1: Electrical Supply

Current Threats: In the event of a natural disaster, like a major earthquake, wildfire, or flood, if the Orangecrest Electrical Substation (South of the facility) goes down, an alternative electrical energy source will be needed.

Recommendations: We suggest routing electricity from RPU's other electrical substations, which may have survived the natural disaster. In the case one substation goes down, any of the other one listed below can keep on supplying the facility.

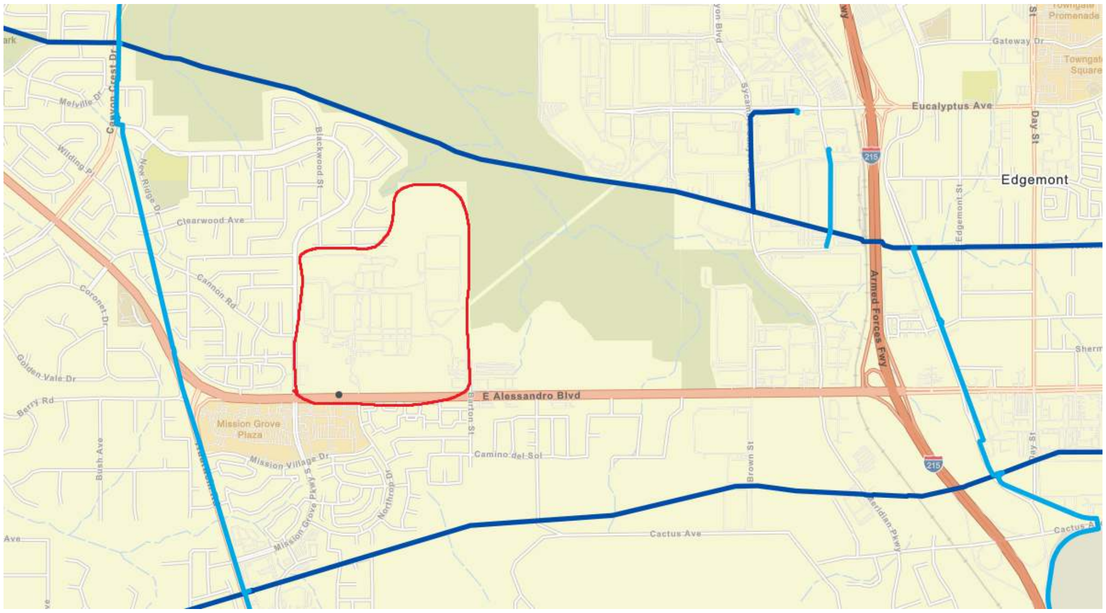
- La Colina Substation (North of facility) [Now Temporarily Closed]

    - Around 4 miles
- Springs Generation (East of facility) [Now Temporarily Closed]
    - Around 2-3 miles
- Tanker Substation (East of facility)
    - Around 5 miles
- Mountain View Substation (West of facility)
    - Around 8 miles
- Source: California Electric Transmission Lines
- Price: --- Unknown at this time

As these substations and connecting high voltage lines already exist, relatively simple modifications in distribution circuit breakers can achieve this.

5.2 Natural Gas Supply

The Bergamont and Holcomb pumping stations are also being supplied by the SoCal natural gas company through nearby pipelines as shown below:



Light Blue = High Pressure Distribution Lines
Dark Blue = Transmission Lines
Red = Site Outline

Source: https://socalgas.maps.arcgis.com/apps/webappviewer/index.html?id=aaebac8286ea4e4b8e425e47771b8138

Table 5.2: Natural Gas Supply

Current Threats: In the event of a natural disaster, like a major earthquake, wildfire, or flood, the pipeline supplying gas to this facility may be damaged.

Recommendations: We suggest connecting this facility to an alternative high-pressure distribution line. In case where one line has to be shut down due to damages, the other line may remain functional.

Price: --- (natural gas distribution line cost/mile) Unknown at this time.

5.3 Diesel

Some of the pumping stations at the larger Mills facility have backup diesel generators. For resiliency of the water systems, diesel generators may be used when either grid power or natural gas supply is disrupted due to a major natural disaster. If the highway system is also damaged at that time, preventing new deliveries, larger diesel storage on site will be needed to provide energy resiliency for a longer period.

5.4 Self-Sustaining Renewable Energy

Long term sustainability is only possible from on-site generation, which may be provided by Solar PV. This site currently has large open areas which may be utilized for installing solar panels. Long term availability of space is a major challenge. There are 3 possible options of solar PV as listed below:

<u>Ground Mounted Solar Panels:</u>

Pros: Easier to build & maintain. Greater energy productivity. Fewer electrical hazards. More efficient cooling

- Very little space restrictions

Cons: More ground clutter

Source; https://luminasolar.com/the-pros-and-cons-of-ground-mounted-solar-panels/

Price: Medium expense

- Price: --- (per kW) Unknown at this time.

Source: Google Images & Google Maps

Table 5.3: Ground Mounted Solar and Area of Installation

<u>Raised Solar Panels:</u>

Pros: Less ground clutter. Usable space below panels.

- For example: Solar Carports

Cons: Harder to build and maintain

Source: https://www.solarreviews.com/blog/are-solar-canopies-worth-it

Price: Higher expense

- Price: --- (per kW) Unknown at this time.

Source: Google Images & Google Maps

Table 5.4: Carport Mounted Solar and Area of Installation

Rooftop Solar on Existing Buildings:

Pros: Better use of unused space. Easy to install.

Cons: Harder to maintain. Some roof orientations might not provide the best energy production

Source; https://aesinspect.com/the-pros-and-cons-of-ground-vs-roof-mounting-solar-panels/

Price: Low-Medium expense due to less structural costs

- Price: --- (per kW) Unknown at this time.

Source: Google Images & Google Maps

Table 5.5: Rooftop Mounted Solar and Area of Installation

5.5 Battery Energy Storage Systems (BESS)

For enhanced resiliency, on site solar can be made more beneficial by implementing BESS to store extra solar electricity during the daylight hours for pumping water during the night also. For offering energy resiliency in a flexible format, UCR has designed and built a mobile BESS platform on a trailer shown below. This trailer along with its 100kW on board inverter is capable of moving around and deliver power to any location where and when needed.

Table 5.5: CE-CERT Battery Energy Storage Trailer

ACRONYMS AND GLOSSARY

Term/Acronym	Definition
CEC	California Energy Commission
CE-CERT	College of Engineering-Center for Environmental Research and Technology
GHG	Green House Gases
GPD	Gallons Per Day
GPM	Gallons Per Minute
HP	Horsepower
HVAC	Heating, Ventilation, and Air Conditioning
kW	kilowatt
kWh	kilowatt-hour
kVar	Kilo Volt Ampere Reactive
PS	Pump Station
SCADA	Supervisory Control and Data Acquisition
RPU	Southern California Edison
TOU	Time of Use
UCR	University of California Riverside
WMWD	Western Municipal Water District