WESTERN RIVERSIDE COUNTY ENERGY RESILIENCE PLAN

Final Grant Report

AUGUST 2, 2023

WESTERN RIVERSIDE COUNCIL OF GOVERNMENTS
3390 University Ave Suite 200 Riverside, CA 92501

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Acknowledgements

The Western Riverside Council of Governments would foremost like to thank all WRCOG Member Agencies that participated in the Energy Resilience Planning process that led to the creation of this plan. For their technical contribution to the Energy Resilience Plan through stakeholder feedback, analysis peer review, and a Water Systems Resilience Study, we would like to thank the UC Riverside's College of Engineer's Center for Environmental Research & Technology (CE-CERT). Finally, this study would not have been possible without the generous support and funding opportunity from the California Resilience Challenge by the Bay Area Council. The local governments and residents of Western Riverside County are better prepared for an uncertain climate and energy future thanks to the generous support of the California Resilience Challenge 2020 Grant Program.

City of Banning
City of Beaumont
City of Calimesa
City of Canyon Lake
City of Corona
City of Eastvale
City of Hemet
City of Jurupa Valley
City of Lake Elsinore
City of Menifee
City of Moreno Valley
City of Murrieta
City of Norco
City of Perris
City of Riverside
City of San Jacinto
City of Temecula
City of Wildomar
County of Riverside
Eastern Municipal Water District
Western Municipal Water District
Riverside County Superintendent of Schools

Executive Summary

Over the past few years, large swaths of California have been subject to power outages due to extreme weather events and the cumulative impacts of climate change, either directly affecting local infrastructure or necessitating public safety power shutoffs. The Western Riverside Council of Governments (WRCOG) developed an Energy Resilience Plan as a resource for WRCOG Members to develop and implement energy resilience solutions against power outages at critical facilities and infrastructure.

The Energy Resilience Plan provides a framework for WRCOG members to identify critical facilities and infrastructure, and assess solutions for maintaining power during outages. The Plan completes this in two ways: 1) identifying and prioritizing critical facilities; and 2) designing energy resilience solutions and assessing possibilities. The Plan utilizes four evaluation factors to prioritize critical facilities, including social vulnerability, operational needs, physical hazard sensitivity, and existing onsite power infrastructure. WRCOG was informed by a stakeholder-first approach to identify the resilience needs of the region as well as the facilities considered for microgrid case studies. WRCOG worked with its Member Agencies to identify critical facilities and critical loads, prioritize facilities based on the evaluation factors, and select facilities for microgrid case studies. The microgrid case studies were conducted at the following sites and found that a combination of onsite power generation sources and battery energy storage systems could maintain power during an outage:

1. Wastewater Reclamation Plant (Banning, CA)
2. Kay Ceniceros Senior Center (Menifee, CA)
3. Riverside County Fire Station 16 (Jurupa Valley, CA)
4. Riverside County Fire Station 17 (Jurupa Valley, CA)

Water and wastewater systems are critical and essential services requiring reliable and resilient operation during and after natural disasters. Incentivizing water districts to lower their energy consumption by lowering their electricity bills not only helps the district's bottom line and helps reduce greenhouse gas emissions, but also helps in optimal pumping operation and helps the system operators prepare for resilience during grid outages. With funding from the Bay Area Council, WRCOG completed a Water System Resiliency Study which assessed water facilities operated by one of WRCOG's Member Agencies to identify energy resilience solutions to maintain operation during unplanned power interruptions. This study evaluated resiliency measures at two pump stations:

1. Bergamont Pump Station
2. Holcomb Pump Station

With these documents, WRCOG Member Agencies are prepared with a decision-making guide regarding implementation of energy resilience projects to increase facility and community resilience against regional power interruptions. These documents can also serve as a guide and template for governance organizations outside of Western Riverside County to navigate community resilience through energy resilience.

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Problem Statement

Nearly 2 million people live in the Western Riverside County subregion. In the last five years power outages have been on the rise throughout California as the power grid deals with high energy consumption, clean energy transition, and impacts from climate events such as severe weather, extreme heat, and wildfires. Extreme heat days, wildfires, and severe weather are all predicted to increase in the subregion due to climate change. These challenges will be exacerbated by large population growth anticipated in the subregion, which will increase energy demand and further stress the energy grid.

Riverside County faces climate exposures that pose considerable health risks to the population, especially to vulnerable groups. The Western Riverside County subregion faces multiple socioeconomic challenges, including high rates of poverty, unemployment, and low education attainment making the residents more vulnerable to the effects of climate change. More than half of WRCOG's Member Agencies contain census tracts identified in the SB 535 Disadvantaged Communities Map, which are areas in the highest 25% percentiles for environmental burden in the state. Without planning for energy resilience, the combination of climate-change impacts and energy consumption has potential to disrupt power supply to critical facilities and communities in Western Riverside County.

Project Description

The Energy Resilience Plan is intended to guide decision making related to the identification of and investment into critical facilities and other community assets to increase adaptive capacity. This Plan achieves this in two stages: 1) identification and prioritization of critical facilities, and 2) evaluation of design and implementation options for energy resilience solutions.

Throughout development of the Plan WRCOG engaged with its Member Agencies to identify critical facilities that would be deemed appropriate for resilience upgrades. Several types of facilities were identified, including water system infrastructure, fire stations, emergency operations centers, and community centers. In seeking to understand how location, demographics, and socioeconomic status contribute to climate vulnerability, and to prioritize the facilities for energy resilience investments WRCOG developed a tool in the form of a matrix that assigns a score to each facility. The prioritization tool considers four evaluation factors: social vulnerability, physical and climate hazard sensitivity, operational needs and existing energy infrastructure.

By using this tool and integrating feedback from Member Agency staff, WRCOG selected several sites for microgrid case studies. In addition to these facilities, WRCOG partnered with UC Riverside's CE-CERT to conduct an energy resilience study on water systems at a local water district.

Project Results

The Energy Resilience Plan's prioritization tool was found to be useful in the selection of facilities. By basing the tool on the four evaluation factors the facilities that are most in need for energy resilience improvements were ranked higher, particularly the facilities that are located in or serve disadvantaged communities and those are risk to various climate hazards. The top three facilities resulting from the prioritization tool would then be considered as candidates for the microgrid case studies.

WRCOG staff created an advisory group of staff from Member Agencies and UCR CE-CERT consultants that could provide input and give feedback on the methods, findings, and selection of the facilities or infrastructure for the microgrid case studies. WRCOG held multiple workshops with the advisory group that were open to all Member Agencies as well, and found them to be very useful in gathering outside perspectives throughout development of the Plan. Once the top three facilities were selected, WRCOG staff conducted outreach to the Member Agency and facility managers that are responsible for the facility to gather building information, consumption data, and operational needs.

While the advisory group was helpful with providing feedback and input, it raised attention to an important issue which is additional education and training is needed for Member Agency staff and stakeholders to effectively work on climate adaptation, energy efficiency, and energy resilience work in the subregion. Some of WRCOG's Member Agencies are small to medium local governments that don't have the technical or staff capacities to work on climate adaptation and energy resilience planning projects. This made seeking input on a potential microgrid and energy resilience project limited at first until some education was provided to gain a better understanding of energy and climate resilience, the proposed microgrid case studies and how these fit into the overall goals of climate adaptation. One recommendation for future grant managers would be to include a small portion of grant funding for education and peer-to-peer learning so that staff and potential stakeholders can be knowledgeable in climate adaptation, energy efficiency, and resilience planning.

The microgrid case studies were completed by assessing various building construction documents and energy use data, along with microgrid modeling software. During the data and document sourcing process, staff encountered another barrier where not all documentation and construction documents were readily available for the facilities undergoing a case study. Staff and the consultant team were able to fill in information for the missing documents by working closely with facility managers for most case studies, however, the Fire Station 16 case study was more difficult and eventually found that the building was not fit to be a future microgrid and resilience center. An alternative facility, Fire Station 17, was selected as a replacement as it was still located within the city, scored highly in the prioritization matrix, and was of the same type of facility. Future agencies conducting similar case studies could consider the availability of construction documents and associated information as a prerequisite to qualify for a microgrid case study.

WRCOG's consultant, AECOM, conducted microgrid case studies by utilizing the HOMER microgrid modeling software to identify and assess potential energy resilience options. The software provided various scenarios and combinations of power sources, but overall found that installing solar photovoltaic (PV) systems with battery energy storage systems (BESS), and a backup generator were optimal to maintain power at each of the facilities during an outage. Each facility also showed a potential for a microgrid based on the energy resilience options identified, preliminary project economics, and the facility's setup and local grid infrastructure.

This Plan also recognizes that water and wastewater systems are important elements of resilience, but water systems were not a focus of AECOM's scope of work. Instead, UCR CE-CERT was hired to conduct a resilience analysis of water systems in Western Municipal Water District's (Western Water) service area, which was completed as a supplement to an existing project UCR had with Western Water. The analysis found that by reducing the energy consumption and demand at the two pump stations, the existing setup at the pump stations have capacity to maintain operations due to having both electric and natural gas-driven pumps. Additionally, the study assessed the power supply and natural gas pipeline and found potential interconnection points to add additional electricity and natural gas supply to these facilities. Finally, the study recommended the addition of backup generators along with solar PV and BESS could increase resilience to outages.

Next Steps

WRCOG completed the Energy Resilience Plan and presented the document to its Executive Committee at the December 5, 2022 meeting. The WRCOG Executive Committee approved the Energy Resilience Plan and directed staff to pursue funding opportunities to advance the identified projects further along in the design process and conduct energy resilience planning activities. Staff can continue to take steps towards implementation of the microgrid case study projects, such as seeking additional grant funding to conduct additional case studies, or funding to complete the microgrid engineering design process on the case study facilities to make them "construction ready".

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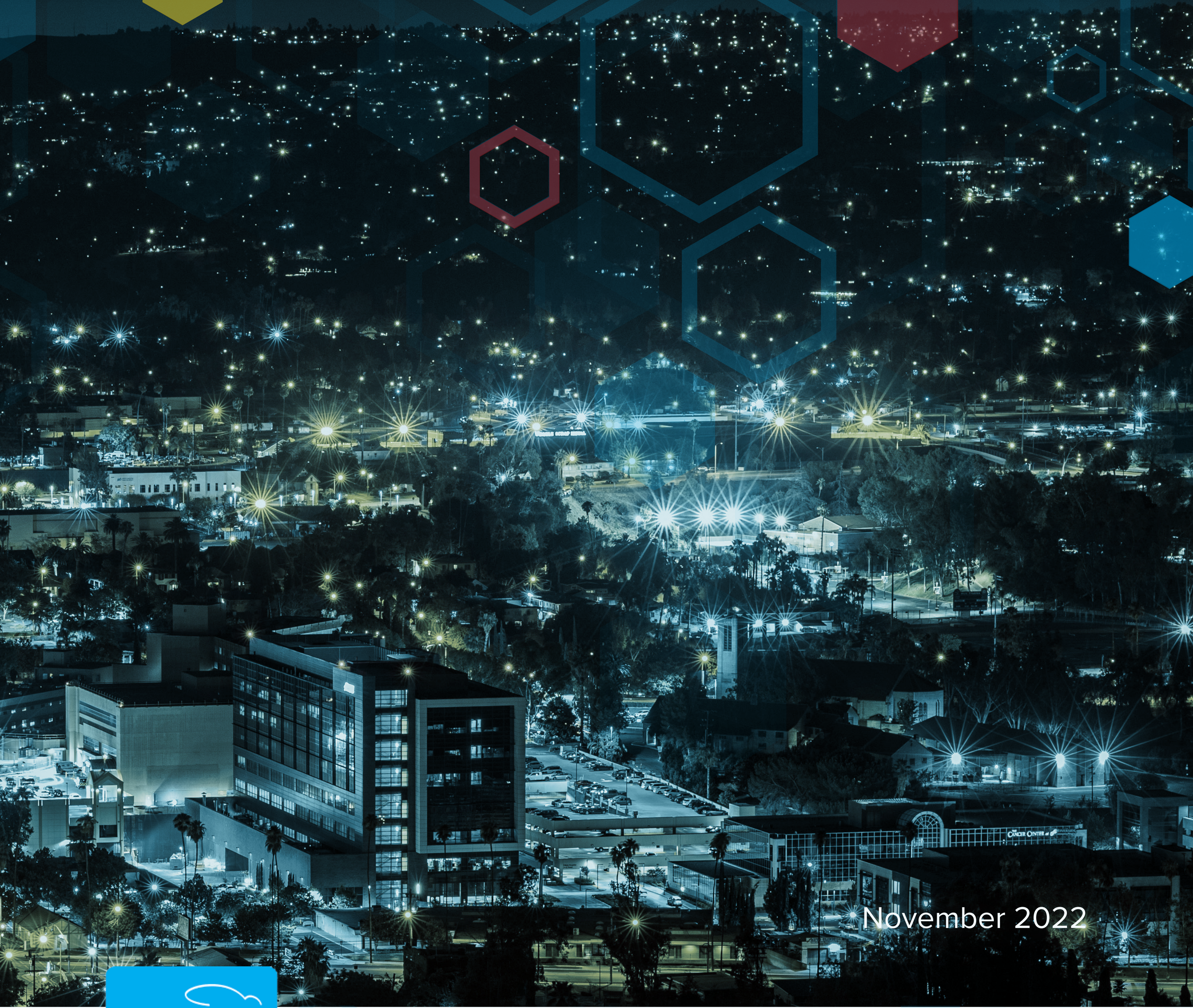
Appendix 1 – Energy Resilience Plan

Western Riverside Council of Governments

Energy Resilience Plan



November 2022

WRCOG Western Riverside Council of Governments

California Resilience Challenge

UCR CE-CERT

AECOM

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Acknowledgments

The AECOM team and the Western Riverside Council of Governments and staff would foremost like to thank all WRCOG member agencies that participated in the Energy Resilience Planning process that led to the creation of this plan. For their technical contribution to the Energy Resilience Plan through stakeholder feedback and analysis peer review, we would like to thank the College of Engineering, Center for Environmental Research and Technology (CE-CERT) at the University of California, Riverside. Finally, this study would not have been possible without the generous support and funding opportunity from the California Resilience Challenge organized by the Bay Area Council. The residents and community members of Western Riverside County are safer and better prepared for an uncertain climate future thanks to the generous support of the California Resilience Challenge 2020 Grant Program.

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Acronyms and Abbreviations

ARPA	American Rescue Plan Act
ATSDR	Agency for Toxic Substances and Disease Registry
BESS	battery energy storage systems
CDC	Centers for Disease Control and Prevention
CDC SVI	Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry Social Vulnerability Index
CVAG	Coachella Valley Association of Governments
FEMA	Federal Emergency Management Agency
GHG	greenhouse gas
IIJA	Infrastructure Investment and Jobs Act
ISRF	Infrastructure State Revolving Fund
I-REN	Inland Regional Energy Network
ISRF	Infrastructure State Revolving Fund
kW	kilowatt
kWh	kilowatt hour
LOCA	localized constructed analogs
NPC	net present cost(s)
P3	public-private partnership
Plan	Energy Resilience Plan
PSPS	Public Safety Power Shutoffs
PV	Photovoltaic
SAIDI	System Average Interruption Duration
SAIFI	System Average Interruption Frequency
SBCOG	San Bernadino Council of Governments
SCE	Southern California Edison
SVI	Social Vulnerability Index
WRCOG	Western Riverside Council of Governments
WWTP	wastewater treatment plant

Executive Summary

Over the past few years, millions of Californians have lost power due to environmental hazards either directly damaging local infrastructure or necessitating public safety power shutoffs. Extreme heat days, wildfires, and flooding are all predicted to increase in the subregion due to climate change. These challenges will be exacerbated by large population growth in the region, which will increase energy demand and further stress the energy grid.

Western Riverside Council of Governments (WRCOG) developed this Energy Resilience Plan (Plan) as a response to these increasing power interruptions. When implemented, the Plan will allow WRCOG and its member agencies to be better prepared to withstand and adapt to the impacts of climate change. The Plan serves as a resource for developing and implementing energy resilience solutions in the subregion. It outlines a process consisting of two core actions: identifying and prioritizing critical facilities and designing for energy resilience (see Figure ES-1).

For future decision-making, the Plan provides information on how to prioritize public facilities for implementation of energy efficiency upgrades, local energy generation, microgrids, and energy storage systems to increase facility and community resilience.

The Plan also serves as a handbook to guide decision-making related to the identification of and investment in critical facilities and other community assets. The Plan outlines four evaluation factors—social vulnerability/community value, operational needs, physical hazard sensitivity, and existing infrastructure—that are used to identify and prioritize facilities in need of resilience upgrades and investment. These four factors, along with possible resilience interventions, are discussed in the Plan through case studies of four facilities located in three WRCOG member cities.

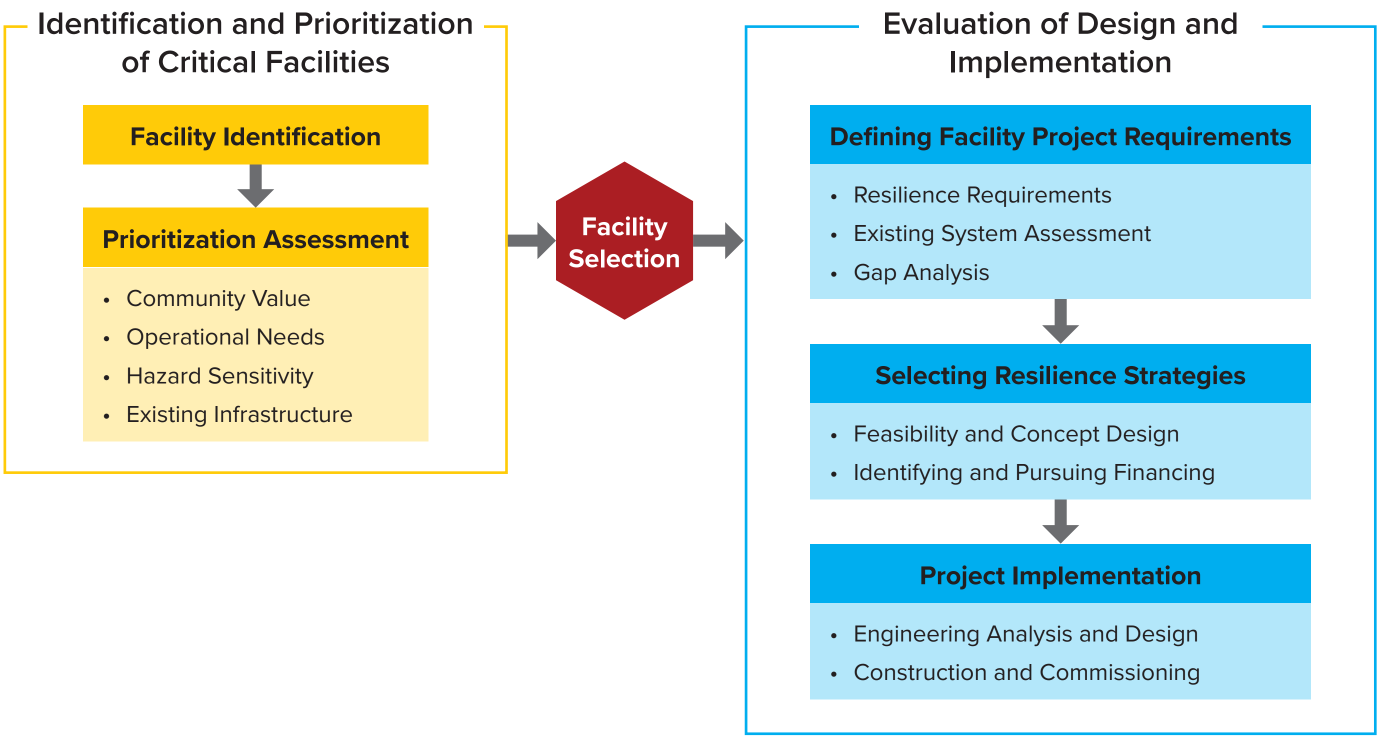


Figure ES.1. Overarching Energy Resilience Assessment and Project Development Framework

A concept-level component sizing and basis of design was applied to four case studies. The facilities that were chosen as case studies were facilities that ranked high according to the prioritization methodology presented in Section 2.4 and that were also representative of other common critical facilities in the WRCOG subregion. These case studies demonstrate specific solutions to enhancing energy resilience at fire stations, water treatment facilities, and community centers across the WRCOG subregion and inform the design approach for other facility types. The scope of potential projects is shown in Figure ES.2.

The combination of the Plan and case studies provided a foundation for a systematic assessment and project development process that considered both the technical and financial solution. The next steps for WRCOG include:

- Apply the technical solution development methodology at the other high-ranking critical facilities to define the applicable resilience projects for implementation.
- For selected facilities, develop concept and/or detailed designs that are suitable for funding, financing, and construction.
- Identify partnership opportunities for planning, funding, and implementing climate actions.
- Determine which strategies will require environmental review, technical analysis, and/or complex partnerships and permitting.
- Track new federal funding opportunities as guidance is released.
- Based upon the developed concept designs, begin preparing application materials for the state grants that have been allocated additional funding in the Governor's 2022-2023 budget.

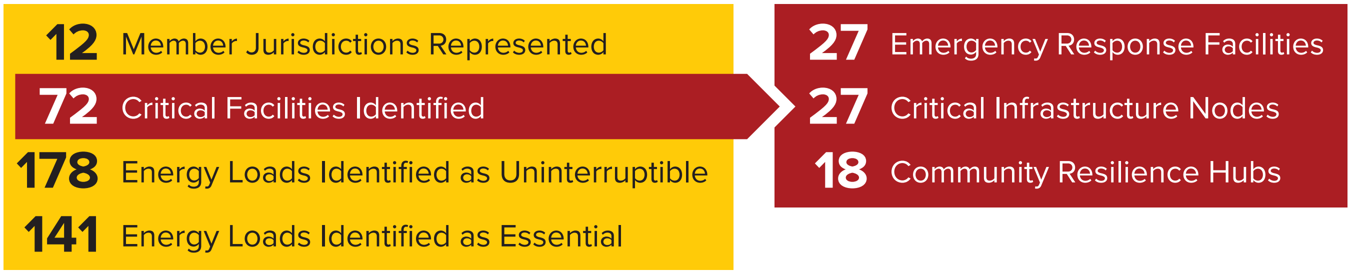


Figure ES.2. Scope of Potential Facility Energy Resilience Projects across WRCOG

With this report, WRCOG members are prepared with a decision-making guide regarding implementation of energy resilience projects to increase facility and community resilience against regional power interruptions. This Plan may also serve as a guide and template for governance organizations outside of Western Riverside County to navigate community resilience through energy resilience.

Photo Credit: WRCOG

1. Introduction

WRCOG represents the collective voice of 22 member agencies, including 18 cities, the County of Riverside, Eastern and Western Municipal Water Districts, and the Riverside County Superintendent of Schools. Western Riverside County is known for its warm, dry Mediterranean climate. Eleven of WRCOG's member's jurisdictions are located at the base of mountain areas, including the Santa Ana Mountains in the Cleveland National Forest (home to the "Holy Fire" in 2018). In recent years, millions of California power customers have gone without power due to Public Safety Power Shutoffs (PSPS) events, which have been standard practice for many years but not to the current scale until recently. Extreme heat days, wildfires, and flooding are all predicted to increase in the subregion due to climate change. These climate-related challenges will be exacerbated by large population growth in the region, which will increase energy demand and further stress the energy grid.

WRCOG has developed this Plan as a response to increasing power interruptions resulting from such strains and stressors as wildfires, extreme heat events, and PSPS. As the Plan is implemented, it will allow WRCOG and its member agencies to be better prepared in the coming years for climate change impacts. Building on the previous initiatives, CAPtivate and Resilient IE, the Plan provides a framework for decision-making to develop targeted and prioritized energy resilience projects.

The ability of each agency to respond locally to climate-related disruptions depends heavily on the dependability of the energy and power supply at critical facilities. This Plan contributes to improving resilience in the region by developing a blueprint for facility energy resilience assessment, technologies, projects, and applications for WRCOG's member agencies to be able to respond to environmental events when the need arises.

The Plan was informed by a stakeholder-first approach to identifying the energy resilience needs of the subregion. WRCOG worked with each member agency to identify critical facilities and critical loads, prioritize facilities based on a multiple-criteria methodology, and develop strategies to maintain the power supply during grid interruptions from environmental or PSPS events.

1.1. Why Energy Resilience?

Energy Resilience, like energy supply more generally, is a means to an end. When energy supply for a community is reliable and affordable, it is transformative, leading to greater prosperity and greater quality of life for all. Energy infrastructure has become so ingrained in the daily necessities of life that it has been taken for granted in many communities. It is only in recent years, through an uptick in energy disruptions caused by unprecedented environmental hazards and natural disasters, that communities have begun recognizing just how fragile this critical infrastructure can be.

This recognition has driven some communities, and WRCOG in particular, to action. As an agency charged with facilitating collective action on important issues that affect its members, WRCOG has developed this Energy Resilience Plan as a means to an end: a means to improve the social and economic resilience of the Western Riverside community through acting on the fragile yet critical infrastructure that the community relies on, energy.

WRCOG and its member agencies established goals for the Plan early on to guide the development process and ensure a Plan that best serves the needs of the community. These goals are:

- **Consistent access** to electricity for all critical public safety community facilities
- Fundamental **health and safety services** at critical public and private facilities for all members of the community
- **Replicable** examples of how energy resilience can be implemented at prototypical locations

1.2. WRCOG Context

WRCOG is a joint powers authority whose purpose is to unify Western Riverside County so that it can speak with a collective voice on important issues that affect its members. Member agencies include 18 cities in Western Riverside County, the County of Riverside, the Eastern and Western Municipal Water Districts, and the Riverside County Superintendent of Schools. WRCOG examines a range of regional matters critical to Western Riverside County's future. In April 2020, the Bay Area Council awarded WRCOG a grant to develop this Plan as part of the California Resilience Challenge Committee.

WRCOG has been a leader in promoting energy efficiency, sustainability, and resilience in Western Riverside County. It has numerous programs to assist its members in enhancing their sustainability efforts including:

- **Inland Regional Energy Network (I-REN):** a collaboration between WRCOG, the Coachella Valley Association of Governments (CVAG) and the San Bernardino Council of Governments (SBCOG) to actively participate in California's Clean Energy initiatives and build a stronger clean energy economy and community. I-REN has a vision to connect residents, businesses, and local governments to a wide range of energy efficiency resources to increase energy savings and equitable access throughout San Bernadino and Riverside Counties. I-REN programs and services include three sectors: a Public sector, a Codes and Standards sector, and a Workforce Education and Training sector.
- **Resilient IE:** A suite of resources to assist with local resilience planning and adaptation to climate hazards. Resilient IE resources include vulnerability assessments and adaptation strategies, hazard and evacuation maps, a Climate Resilient Guidebook, and Resilient IE toolkit/template Resilient Element.
- **Clean Cities Coalition:** A program designed to reduce petroleum use in the transportation sector through the integration of advanced alternative technologies, including zero-emission vehicles, and to improve air quality in Western Riverside County.

1.3. Climate Change

Climate is the long-term behavior of the atmosphere – typically represented as averages – for a given time of year. This includes average annual temperature, snowpack, or rainfall. Human emissions of carbon dioxide and other greenhouse gas (GHG) emissions are important drivers of global climate change, and recent changes across the climate system are unprecedented. Greenhouse gases trap heat in the atmosphere, resulting in warming over time. This atmospheric warming leads to other changes in the earth systems, including changing patterns of rainfall and snow, melting of glaciers and ice, and warming of oceans. Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes include heatwaves, heavy precipitation, droughts, and hurricanes.[1]

While climate projections cannot predict what will happen at a certain date in the future, projections can provide cities with information about what to expect from the climate in the future. For example, climate projections can estimate how much warmer the temperature will be in summer or how many more extreme weather events are likely to occur in the future. Climate projections, however, cannot forecast with precision when those events will occur.

In short, climate change is expected to make many natural hazards more frequent and more severe, which exacerbates the potential hazard sensitivity of critical infrastructure and assets and vulnerable populations.

1.4. Energy Resilience Definition and Context

Resilience can be defined as "**the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances.**"[2]

Energy resilience, meanwhile, has been defined as "**the ability of energy systems to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.**"[3]

1 Intergovernmental Panel on Climate Change. (2021). Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

2 Center for Climate and Energy Solutions

3 Presidential Policy Directive – Critical Infrastructure Security and Resilience

To make an energy system resilient requires an understanding of what can go wrong, what is the likelihood of it going wrong, and how to mitigate the likelihood of a disruptive event from happening or the impact of the event when it does happen. In other words, resilience is about the ability to mitigate risks, as defined[4] in Figure 1.1.

To provide context for this definition of energy resilience and how energy infrastructure changes might be applied in the WRCOG community, a literature review was conducted at the start of the planning process. Key findings from the literature review are discussed below.

Resilience measures (energy efficiency, load management, solar photovoltaics (PVs), battery storage) have been implemented at facilities owned by local governments, school districts, and community-based nonprofits. Most of the examples are of solar plus storage serving individual facilities. Several studies have been completed that address ways to link multiple facilities into a larger microgrid, but regulatory constraints and associated costs have been barriers to implementation. Good candidates for multiple-facility microgrids are locations with large parcels owned by a single entity, such as civic centers, schools, or corporate campuses. **Appendix A** includes references to a few case studies that highlight the applicability of these microgrids.

Electric resilience concerns across California include:

- Localized equipment failure – transformers, switchgear
- Overheating of transmission lines – heat-related impeded electricity flow
- Equipment failure or transmission loss due to wildfire
- Increasing electricity demand – building decarbonization, electric vehicles
- Rolling blackouts due to insufficient capacity (2- to 6-hour disruptions)
- Public Safety Power Shutoffs (up to 48-hour disruptions)
- Seismic, fire, or other extreme events (72 hours or more)

Due to their role serving a community either under normal operations or in an emergency, the types of facilities most often considered for resiliency upgrades include:

- Local Schools and Community Colleges
- Civic Center Public Buildings – City Hall, Police Station
- Other Public Buildings – Library, Community Center, Recreation Center
- Private Community Assets – YMCA/YWCA, Religious Organization Facilities, Boys and Girls Club

Finally, the types of resiliency interventions explored most often by other communities

RISK = THREAT x VULNERABILITY x CONSEQUENCES

potential issue that could have negative impacts	likelihood of being impacted by threat	effects and cost of being impacted by a threat

Figure 1.1. Definition of Risk for Energy Systems

4 Department of Homeland Security's Risk Assessment Methodology

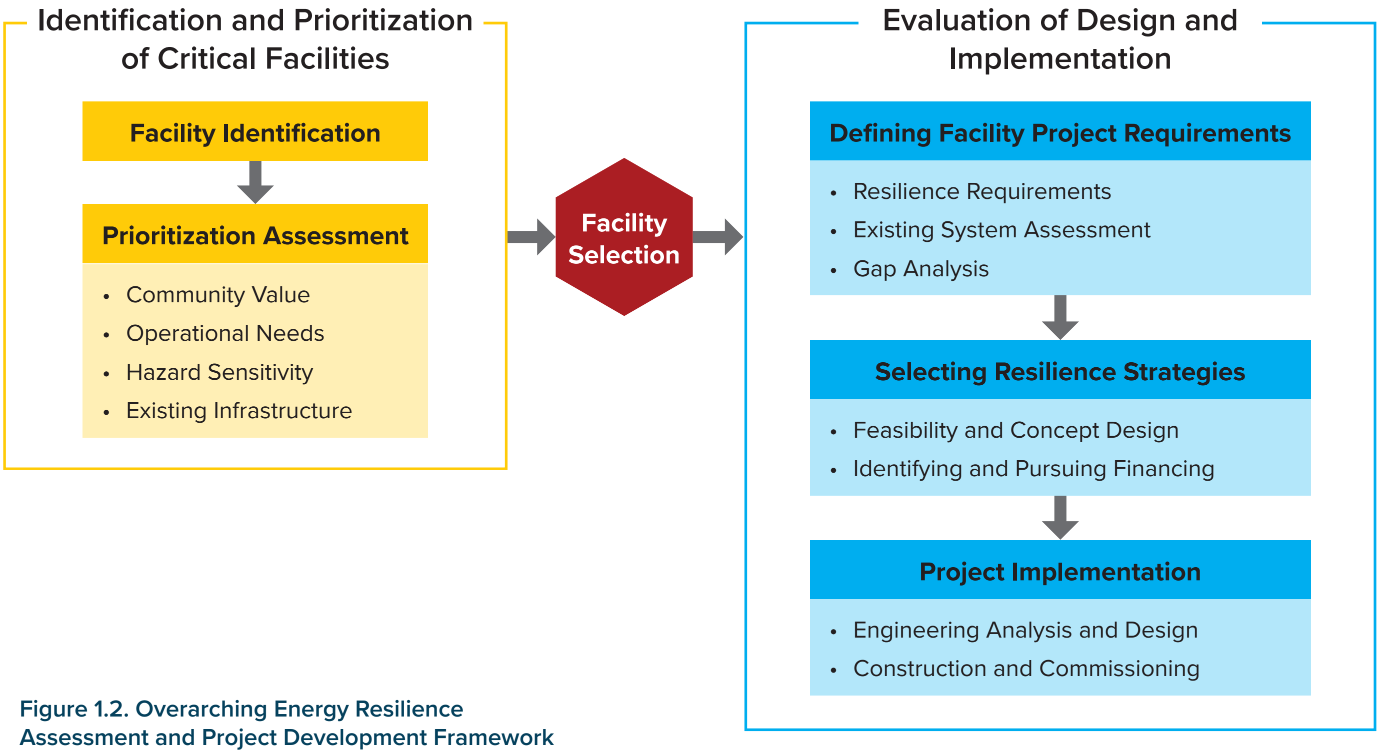


Figure 1.2. Overarching Energy Resilience Assessment and Project Development Framework

throughout California, due to their technological maturity and value brought to the community, include:

- Energy efficiency
- Solar PVs plus battery storage
- Microgrids
- Community resilience hubs

All of these angles for energy resilience helped provide context for and shaped the development of this Plan. In particular, with respect to how this Plan may be useful as a guide outside of WRCOG, these overarching topics provide a frame of reference for how challenges that this Plan attempts to address are being grappled with beyond Western Riverside County.

1.5. What Does This Plan Do?

WRCOG prepared this Plan to support WRCOG members and other agencies in preparing for and responding to power interruptions resulting from events such as wildfires, extreme heat, or PSPS. The Plan provides information for future decision-making regarding the prioritization of public facilities for energy infrastructure upgrades, including efficiency, on-site generation, energy storage systems, and microgrids, to increase facility and community resilience.

This Plan is also intended to serve as a handbook to guide decision-making related to the identification of and investment into critical facilities and other essential community assets. The Plan outlines four evaluation factors—social vulnerability/community value, operational needs, physical hazard sensitivity, and existing infrastructure—that are used to identify and prioritize facilities in need of resilience upgrades. These factors, along with possible resilience interventions, are discussed in case studies of four facilities located in three of the WRCOG member cities. The case studies present the analysis that was performed to identify requirements and arrive at conceptual designs for energy resilience upgrades.

After priority facilities are selected, the Plan describes how to define the requirements for energy resilience at each facility, how to identify and select appropriate energy resilience strategies, and ultimately how to approach energy project implementation. This process is summarized in Figure 1.2.

2. Framework for Identifying and Prioritizing Critical Facilities

The WRCOG Energy Resilience Plan is intended to guide decision-making related to the identification of and investment in critical facilities and other community assets. The Plan achieves this in two stages:

1. Identification and Prioritization of Critical Facilities
2. Evaluation of Design and Implementation Options for Energy Resilience Solutions

The framework for identifying and prioritizing critical facilities outlines four factors that should be evaluated to identify priority facilities and rank their needs for resilience upgrades and investment: social vulnerability/ community value, operational needs, physical hazard sensitivity, and existing infrastructure.

2.1. Identifying Critical Facilities

This Plan focuses on critical facilities because their operations provide everyday utility and benefit to the community and because of their importance for disaster response.

In the development of this Plan, WRCOG member agency Public Works departments and facilities managers were engaged to determine which municipal facilities best fit the Federal Emergency Management Agency (FEMA) description of critical facilities and met the vital needs for communities during hazard events to maintain health and safety.

FEMA defines critical facilities as:

"Facilities or infrastructure that are necessary for the health and welfare of the population and that are especially important following hazard events. Critical facilities include, but are not limited to, shelters, police and fire stations, and hospitals."[5]

Additional "essential facilities" can include:

- Transportation infrastructure
- Water and sewer infrastructure
- Health care facilities
- Substations
- Electric generation and distribution infrastructure
- Telecommunications infrastructure
- Aviation control towers
- Grocery stores
- Government facilities

5 FEMA, 2020, https://www.fema.gov/glossary/critical-facility

WRCOG members identified several types of facilities, including water system infrastructure, fire stations, emergency operations centers, and community centers, as critical facilities deemed eligible for resilience upgrades. Figure 2.1 shows the type of critical facilities identified throughout the WRCOG subregion based on responses from 12 member agencies. **Appendix B** includes a set of questions that were asked to identify the critical facilities and social vulnerability/ community value, operational needs, physical hazard sensitivity, and existing infrastructure.

2.2. Identifying Social Vulnerabilities Facing Western Riverside County

In addition to determining the facilities to focus on for resilience interventions based on typology, this Plan provides a framework for identifying which critical facilities should be prioritized for investment based on four social factors: community value, operational needs, physical hazard sensitivity, and existing infrastructure.

2.2.1. Understanding Community Value (Social Vulnerability)

Understanding how place, demographics, and socioeconomic status contribute to climate change vulnerability helps identify avenues for policy and/or programmatic interventions. Understanding which areas of Western Riverside County have more vulnerable residents helps decision-makers prioritize where and how to allocate resources when wildfires, extreme heat events, and other climate-related hazards occur.

Overall, there are many social, economic, and environmental factors that influence community

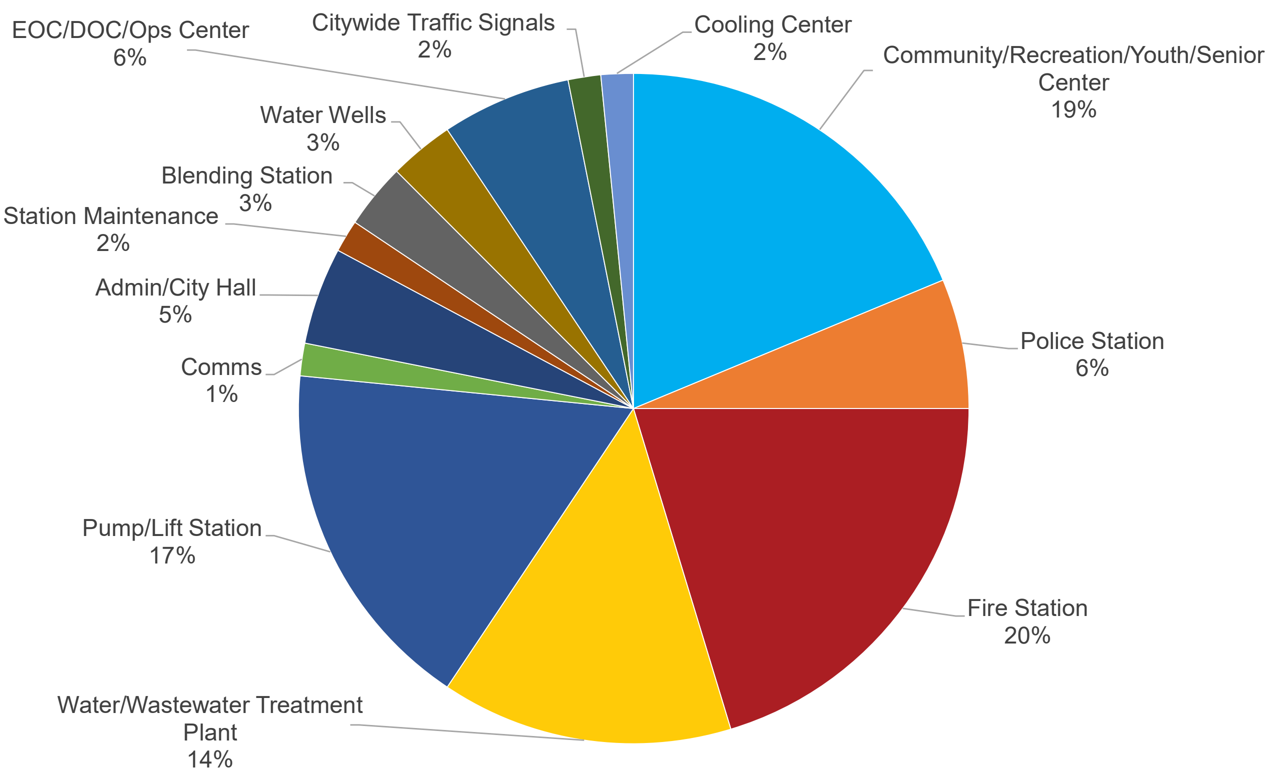


Figure 2.1. Critical Facility Typology Distribution across WRCOG

and individual vulnerability to climate impacts and the ability to adapt to climate change. For example, outdoor workers are at greater risk of heat stroke and related illnesses from extreme heat events; lower income residents have fewer resources to repair flood or fire damage and may live in poor housing conditions; and people with limited English language proficiency are less likely to access programs that could help during or after an extreme weather event. Moreover, individual biological factors, such as age or health status, can amplify a population's sensitivity to climate change.

Communities of color are often burdened with multiple, overlapping factors that cumulatively impact their ability to adapt or respond to climate change. Structural and institutional racism in economic, government, and social systems has resulted and continues to result in the disproportionate distribution of climate burdens and exposures, such as a low concentration of tree canopy coverage and a high concentration of impervious surfaces. In addition, a growing body of social epidemiological research has found that repeated experiences of racism become biologically embedded in the body and result in "weathering" or premature physiological deterioration, which in turn increases a population's sensitivity to climate hazards.

2.2.2. Social Vulnerability Findings in WRCOG

The Social Vulnerability Index (SVI) score and matrix prioritization identified which facilities serve residents with the greatest vulnerability to climate hazards. The social vulnerabilities identified in Western Riverside County include:

Socioeconomic Status: This category measures the proportion of the population that is below the poverty level, unemployed, and has no high school diploma; it also measures income levels. The most straightforward way in which socioeconomic status affects disaster resilience is related to income or assets. Households with lower incomes may not have the funds to prepare their home for climate change hazards, or the ability to recover if their home gets damaged. Lower income and unemployed populations are also less likely to have access to healthcare, leading to a higher incidence of chronic conditions (such as heart and pulmonary conditions) that put them more at risk of health effects from heat and wildfire.

Figure 2.2 depicts the spread of socioeconomic vulnerability within Western Riverside County. The communities of Moreno Valley, Banning, Jurupa Valley, and Lake Elsinore have high scores in this sector.

Household Composition and Disability: This category measures the proportion of households with people aged 65 or older, aged 17 or younger, people older than age 5 with a disability, and single-parent households. Older adults, children, and people with a disability are physiologically and socially more vulnerable to extreme events or climate stressors. For example, older adults and people with a disability may have reduced mobility, communication abilities, and/or mental functioning, which could make it difficult for them to evacuate (e.g., in a wildfire, flood, or landslide) or understand and/or carry out preparedness measures in their homes. Older adults are also more likely to have chronic illnesses (such as heart and pulmonary conditions) that increase the risk of heat illness and medical problems from wildfire smoke.

Children, particularly younger ones, are socially vulnerable because they do not have the resources or knowledge to cope with climate change hazards. They are typically dependent on their parents or other adults to keep them safe and healthy. Physical characteristics (such as the fact that they are still growing, their smaller size, the way they regulate body temperature) also put them more at risk of health effects from heat and wildfire.[6]

6 Kenney WL, Craighead DH, Alexander LM. 2014. Heat waves, aging, and human cardiovascular health. Medical Science Sports Exercise 46(10): 1891-1899.

Figure 2.3 shows that household composition is mixed throughout the subregion, but the communities of Banning, Moreno Valley, Jurupa Valley, Menifee, and Lake Elsinore have high scores in this sector.

Minority Status and Language: This category measures the proportion of the population that is a racial minority and/or speaks English “less than well.” Historic and current day social and economic marginalization makes populations of color more

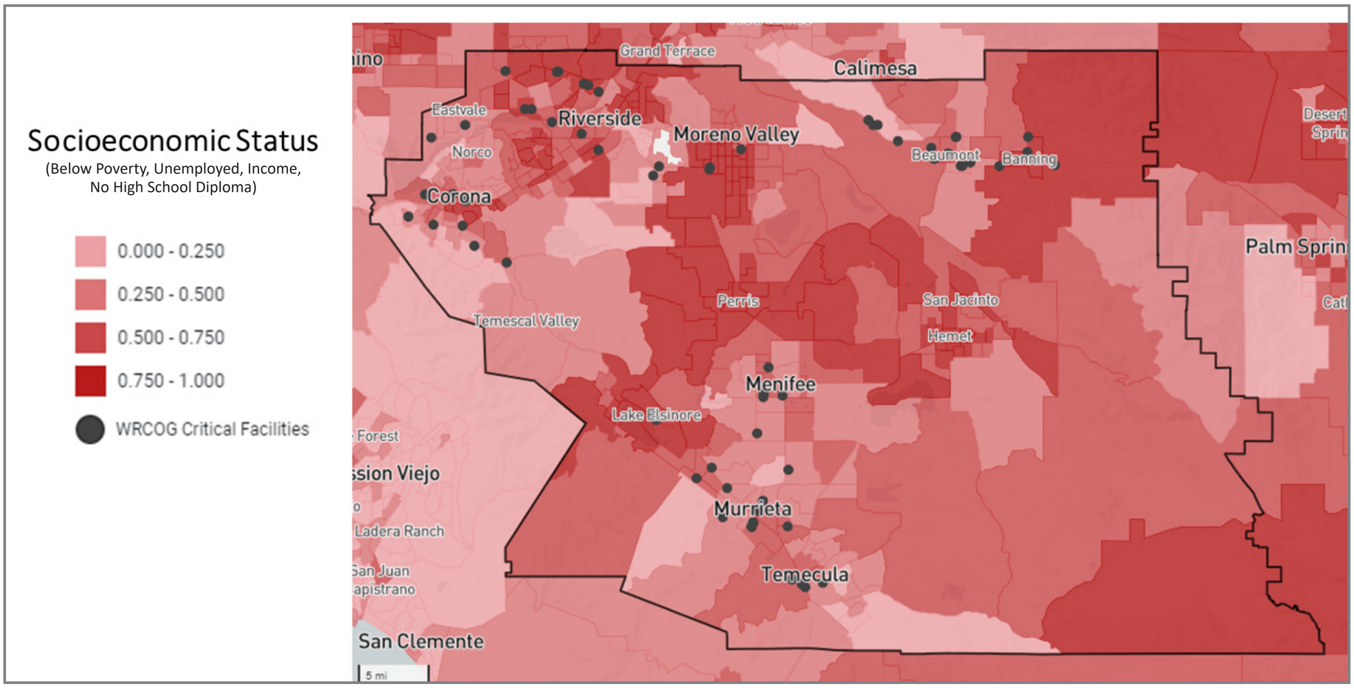


Figure 2.2. Socioeconomic Status Scores

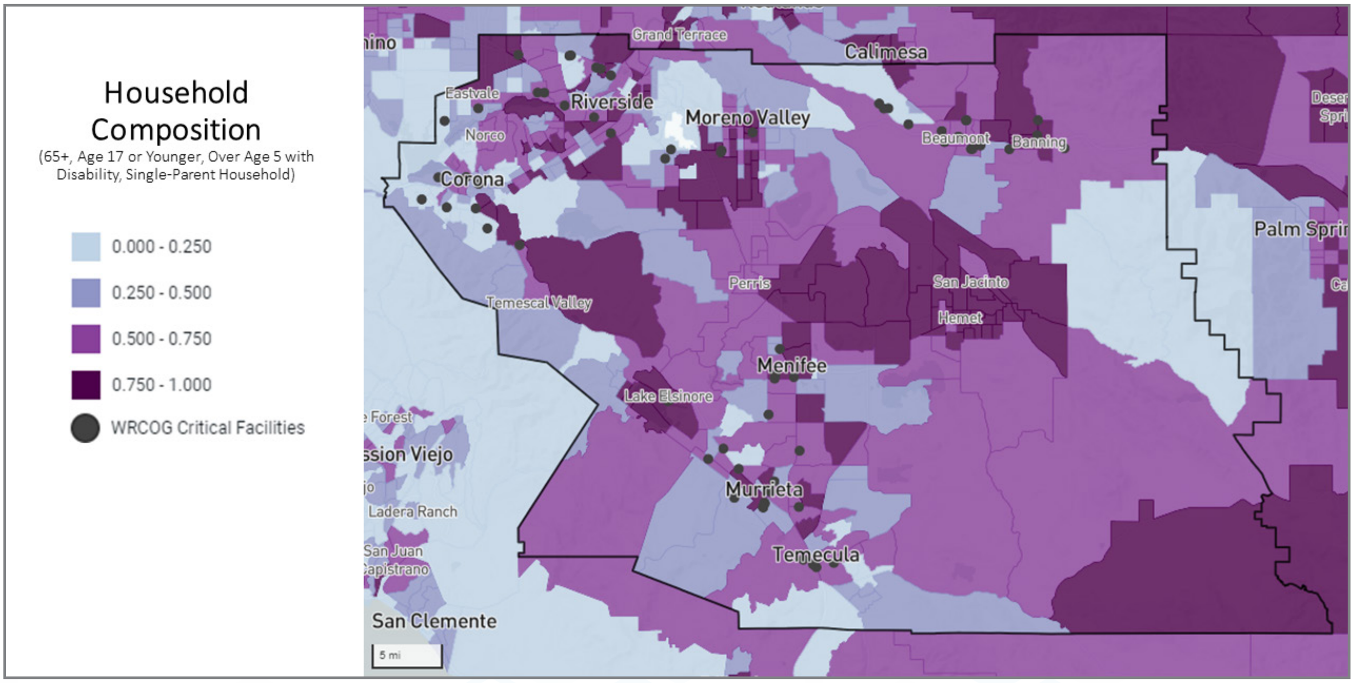


Figure 2.3. Household Composition and Disability Scores

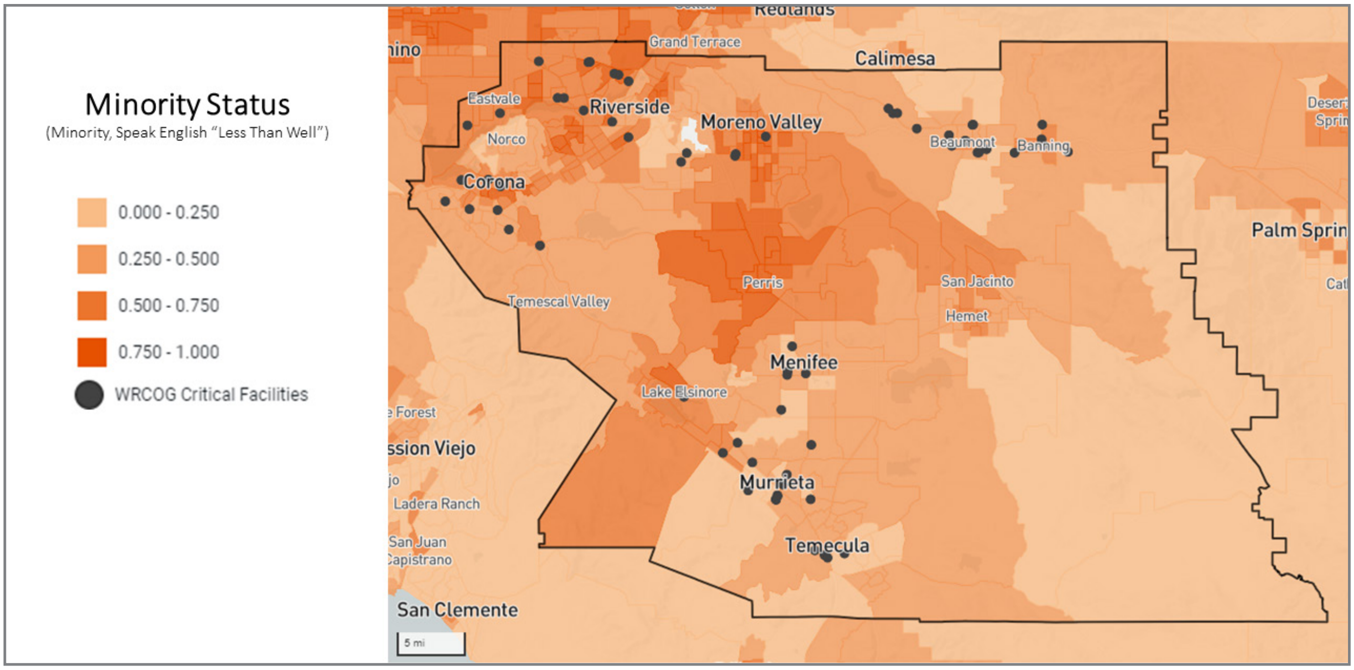


Figure 2.4. Minority Status and Language Scores

vulnerable to the impacts of climate change. Of course, race and ethnicity are connected to all three of the other SVI categories. People who are not proficient in English may have limited access to information and resources. Because of a lack of culturally relevant content, they may not fully understand climate hazards, preparedness actions, or emergency communications. Figure 2.4 shows the distribution of scores throughout the subregion. Jurupa Valley, Riverside, and Lake Elsinore have high scores in this sector.

Housing and Transportation: This category includes housing and transportation factors that lead to higher risk to natural disasters and public health threats for populations. Factors include the number of multi-unit dwellings, mobile homes, group quarters, crowding, and the proportion of households with no vehicle. Homes that are well constructed are better at protecting inhabitants from climate stressors and extreme events. For example, having better insulation and air conditioning reduces the effects of extreme heat. Or a stick-built home is likely to sustain less damage from a flood than a mobile home. Figure 2.5 shows the distribution of scores throughout Western Riverside County. The communities of Banning, Beaumont, Jurupa Valley, Moreno Valley, and Lake Elsinore have high scores in this sector.

The Socioeconomic Status and Household Composition & Disability Centers for Disease Control and Prevention (CDC) SVI themes are the greatest contributors to social vulnerability in the WRCOG region. This indicates the need for facility improvements that support populations of lower-income households, older adults, children, and people with disabilities. Figure 2.6 shows overall SVI scores for Western Riverside County.

The communities with the highest overall social vulnerability scores along with the number of critical facilities identified within them are as follows:

- Jurupa Valley (4 facilities)
- Moreno Valley (3 facilities)
- Lake Elsinore (3 facilities)
- Banning (2 facilities)
- Beaumont (2 facilities)

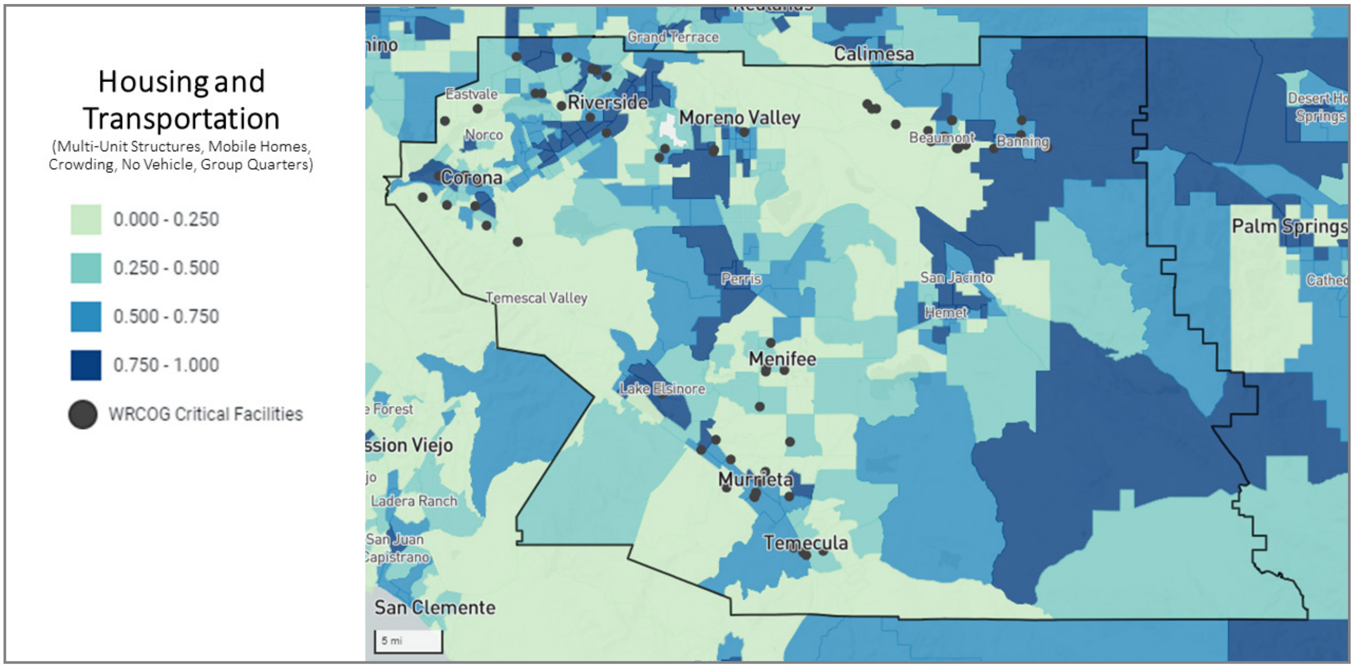


Figure 2.5. Housing and Transportation Scores

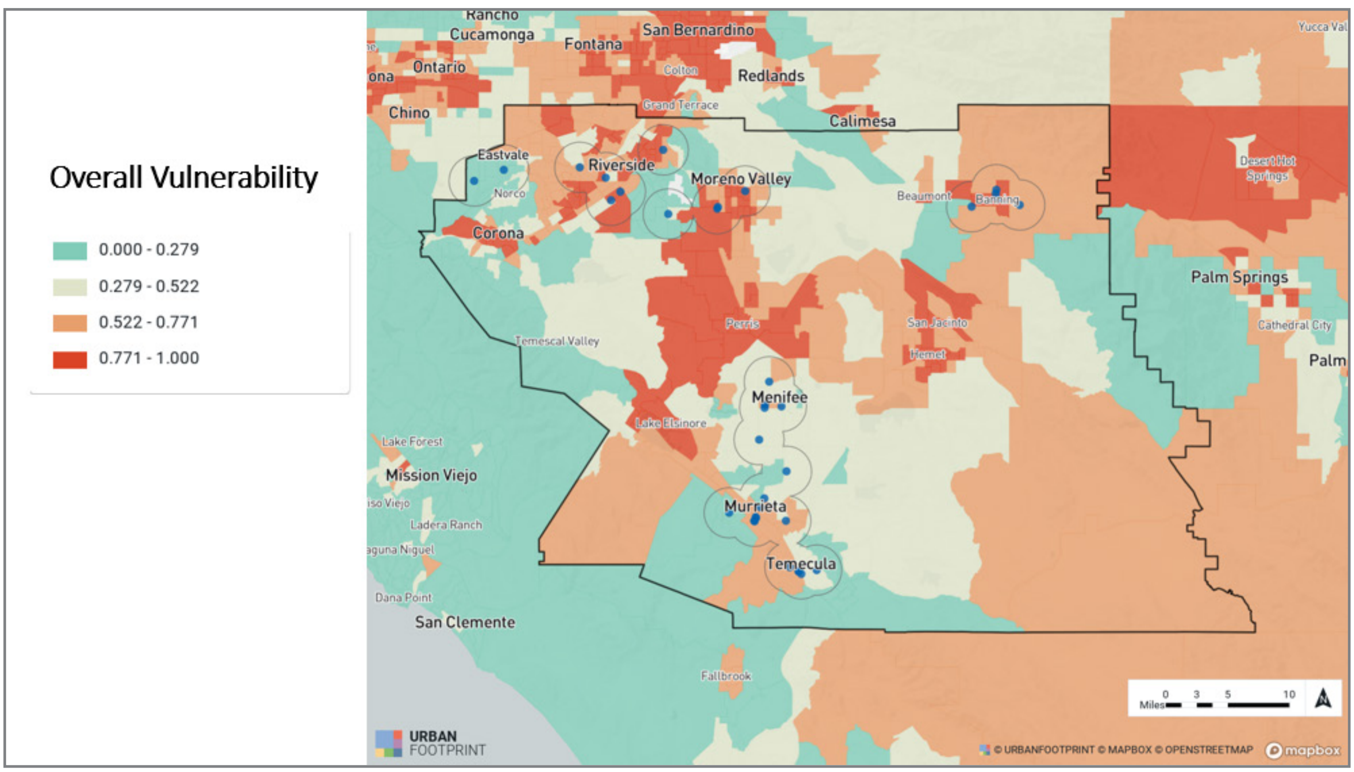


Figure 2.6. Overall Vulnerability Scores

2.3. Identifying Natural Hazards Facing Western Riverside County

The natural and climate hazards for Western Riverside County were identified using three resources: Cal-Adapt, Resilient IE, and member agency staff expertise. Cal-Adapt 2.0 is a collaboration between state agency funding programs, university, and private sector researchers to provide regionally downscaled climate projections and data that are sanctioned by the State of California to be used in climate adaptation resiliency and planning. Cal-Adapt uses California's Fourth Climate Change assessment to model the extent and impact of climate hazards on communities.

Resilient IE is an adaptation and resilience strategy with a focus on transportation infrastructure, community vulnerability assessments, and resilience planning, prepared for the WRCOG subregion of the Inland Empire in collaboration with the San Bernardino County Transportation Authority and the California Department of Transportation (Caltrans).

Several working sessions were held with WRCOG and some member agencies to identify which hazards posed the greatest threat to their communities and assets, based on local experience and institutional knowledge.

Based on these sources, the following subregional climate hazards were identified:

Air Quality: Air quality within the WRCOG subregion is impacted by high levels of ozone and particle pollution that has plagued the region. Rising temperatures can exacerbate the air pollution and trap harmful ground-level ozone in the air due to increased water vapor. Poor air quality can have direct health effects, such as reduced lung function, pneumonia, asthma, cardiovascular diseases, and premature death. Ozone concentrations are projected to increase by five to 10 parts per billion by 2050 in the Los Angeles region, especially in those areas that currently experience high levels of ozone.[7]

Drought: 75% of water supplied to customers in the WRCOG subregion is imported from the Sacramento-San Joaquin Bay Delta via the State Water Project or the Colorado River. Much of the water is from the Sierra Nevada snowpack, which is projected to decrease by 2100 under all climate scenarios, as illustrated in Figure 2.7.[8]

7 Resilient IE (2020).
8 Data derived from 32 LOCA downscaled climate projections generated to support California's Fourth Climate Change Assessment. Details are described in Pierce et al., 2018.

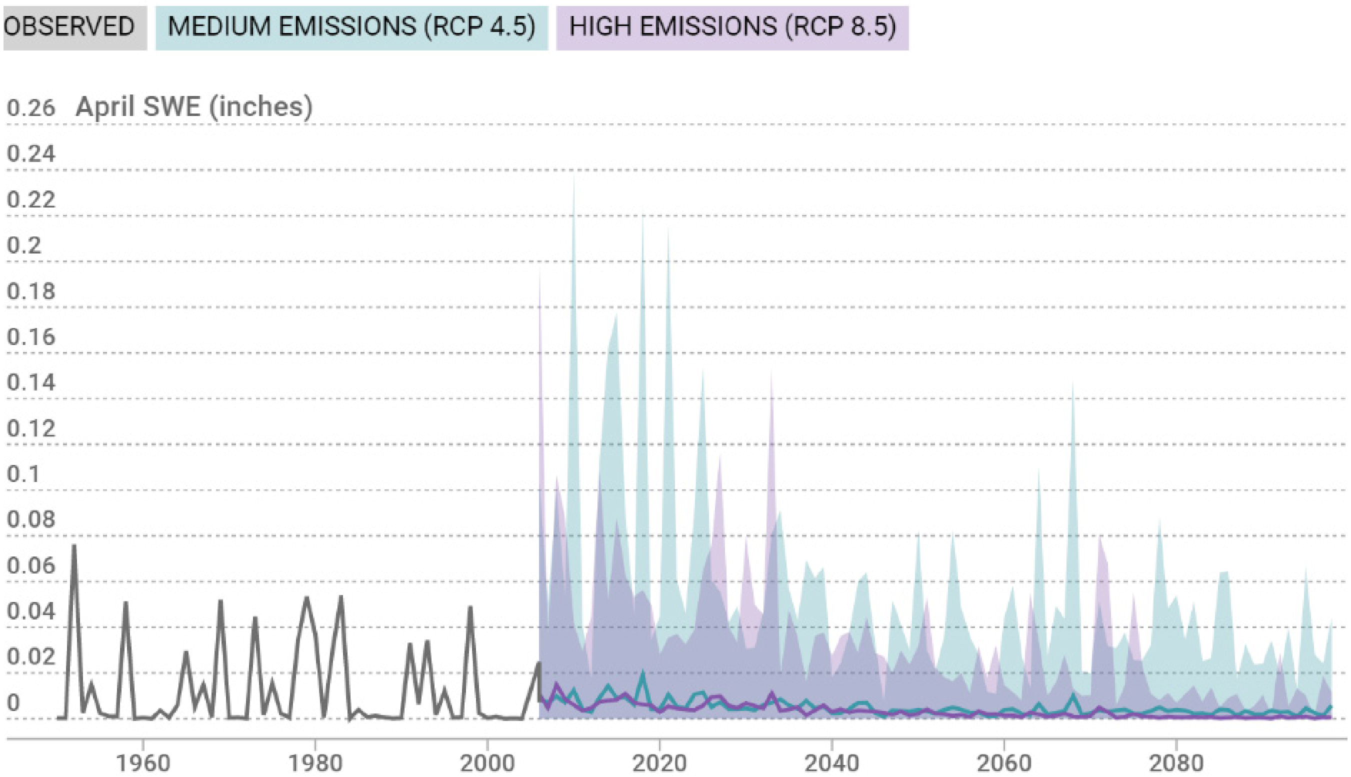


Figure 2.7. April Sierra Nevada Snow Water Equivalent (Source: Cal-Adapt, 2022)

Flooding: Although Southern California is likely to experience a decrease in overall precipitation levels due to climate change, the region is also expected to see an increase in the number of extreme precipitation events. Although flooding may occur in areas not designated as flood zones, the regulatory standard for identifying flood areas is found in the FEMA special hazard flood zone maps, which identify 100-year flood zones. Figure 2.8 identifies FEMA 100-year flood zones for the subregion.

Extreme Temperature: Climate change is expected to increase overall global temperatures (IPCC 2013). The subregion will experience this increase in average annual heat in a variety of ways, including an increased number of extreme heat days [9] and heat waves, warmer summer evenings, and warmer average annual temperatures.

As identified in Figure 2.9, the number of extreme heat days is projected to rise through 2050, where the average year could include 23 to 29 extreme heat days, and 30 to 59 extreme heat days per year by 2099.[10]

Wildfire: Higher temperatures and drought create extremely dry fuel conditions that can increase the likelihood and intensity of wildfire. According to the California Fourth Climate Change Assessment, the WRCOG region may see a 13.4% increase in average annual acres burned above historic levels by mid-century. By the end of the century this increase is projected to decrease to 2.3% above historic levels due to wildfire fuel reductions

9 Threshold temperature for a location is defined as the 98th percentile value of historical daily maximum/minimum temperatures (from 1961–1990, between April and October) observed at that location. In Riverside County, the threshold temperature is 106.0 °F.

10 Data derived from 32 LOCA downscaled climate projections generated to support California's Fourth Climate Change Assessment. Details are described in Pierce et al., 2018.

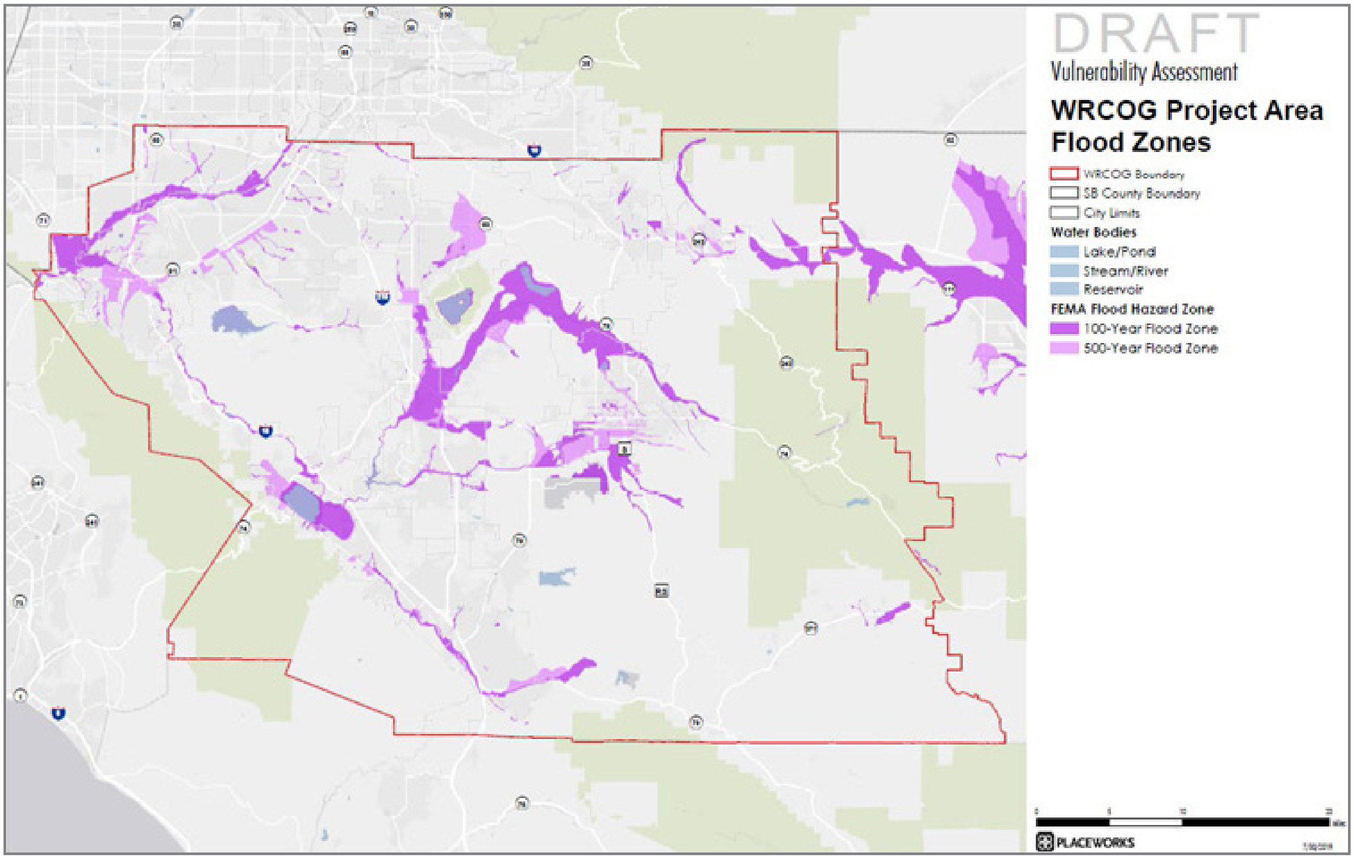


Figure 2.8. FEMA 100-Year Flood Zones (Sources: FEMA, 2018; WRCOG, 2019)

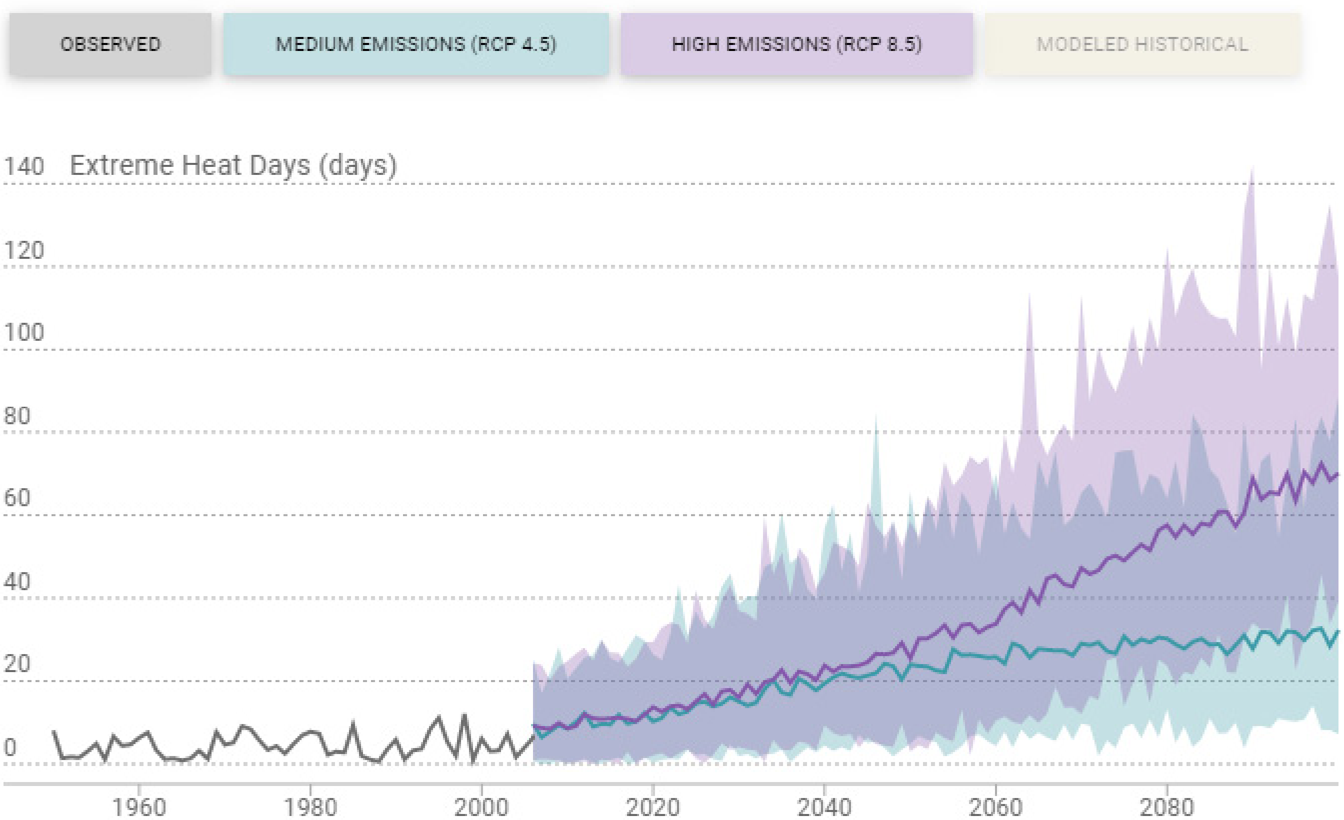


Figure 2.9. Number of Days in a Year When Daily Maximum Temperature is Above a Threshold Temperature of 106.0 °F in Riverside County (Source: Cal-Adapt, 2022)

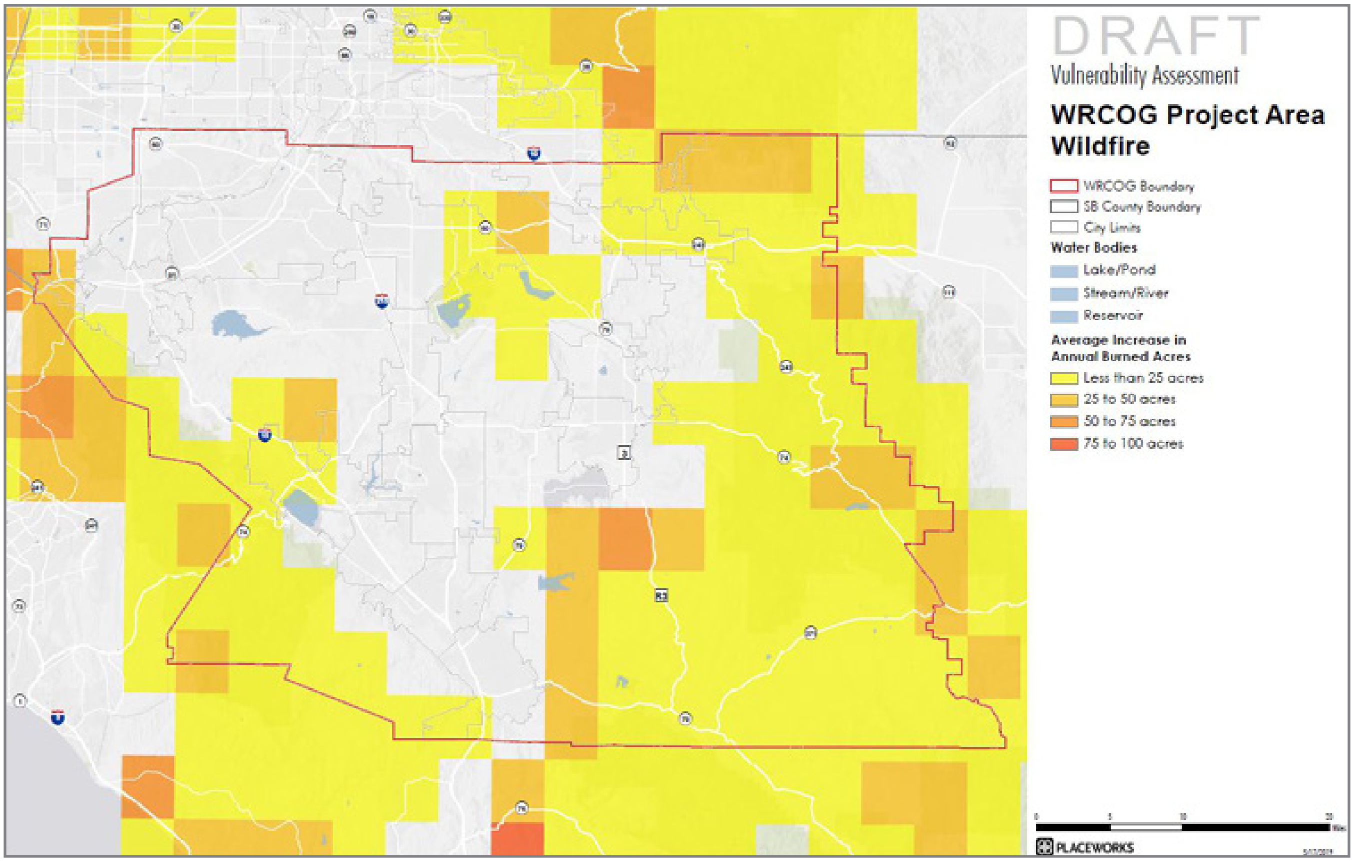


Figure 2.10. Average Increase Between Historic (1962-1990) and Future (2070-2099) Annual Burned Acres (Source: CEC, 2019)

associated with increased drought and extreme heat conditions. In addition to the direct physical threat to life and property, smoke released during an event can have a detrimental effect on the subregion's air quality. Figure 2.10 shows the average increase between historic and future annual acres burned within the Western Riverside subregion.

Human Health Hazards: Climate hazards can have detrimental health impacts on communities, especially vulnerable populations, as discussed in the Social Vulnerability section. Californians face a variety of increasing health problems, such as more heat-related illnesses, breathing and heart troubles, food and water contamination, traumatic injuries, mental health challenges, and exposure to infectious diseases.[11] Extreme heat can exacerbate the air pollution and trap harmful ground-level ozone in the air due to increased water vapor.[12] Flooding can threaten food and water safety and result in more contaminated runoff and failure of wastewater treatment facilities, which can lead to outbreaks of gastrointestinal infections.[13] Wildfire smoke produces particle pollution, which is the principal public health threat from short- and long-term exposure to wildfire smoke. The health effects of particle pollution exposure can range from relatively minor (e.g., eye and respiratory tract irritation) to more serious health effects (e.g., exacerbation of asthma and heart failure, and premature death).[14]

11 Louise Bedsworth et al. (2018). Statewide Summary Report. California's Fourth Climate Change Assessment, California Governor's Office of Planning and Research, Scripps Institution of Oceanography, California Energy Commission, and California Public Utilities Commission.
12 Resilient IE (2020).
13 Juli Trtanj et al. (2016) "Climate Impacts on Water-Related Illnesses," chapter 6 in The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment, USGCRP health2016.globalchange.gov/downloads.
14 US EPA (2021)

2.4. Prioritizing Critical Facilities

2.4.1. Overview of Prioritization Framework

An evaluation matrix was developed to review the characteristics of the various critical facilities identified by WRCOG member agencies **(Appendix C)**. The purpose of the matrix is to provide an objective method to integrate a broad range of important facility factors and characteristics that impact the overall resilience of the facility as well as the broader community. A scoring system was developed to place each facility on 100-point scale, with higher scoring facilities seen as having the greatest need for intervention to enhance their resilience. For example, a facility with a score of 80 is less resilient than a facility scoring 60 and is less able to meet its needs in order to sustain its operations during a disaster event. Different weighting factors were attributed to each aspect of the facility that was evaluated. The factors ranged from the facility's impact on community value; its operational characteristics, such as providing shelter or a place of assembly; its potential sensitivity to nearby hazards; and the services or resources provided relative to the anticipated community needs during a disruption in the energy system (Figure 2.11).

Based on discussion with WRCOG member agencies, several factors were weighted more highly, such as security, ability to maintain medical care, and the ability to meet the needs of the most vulnerable populations and community. The weighting used to reflect the conditions in West Riverside County could be adjusted if the matrix were to be used in another location with different threats, risks, vulnerabilities, and community composition.

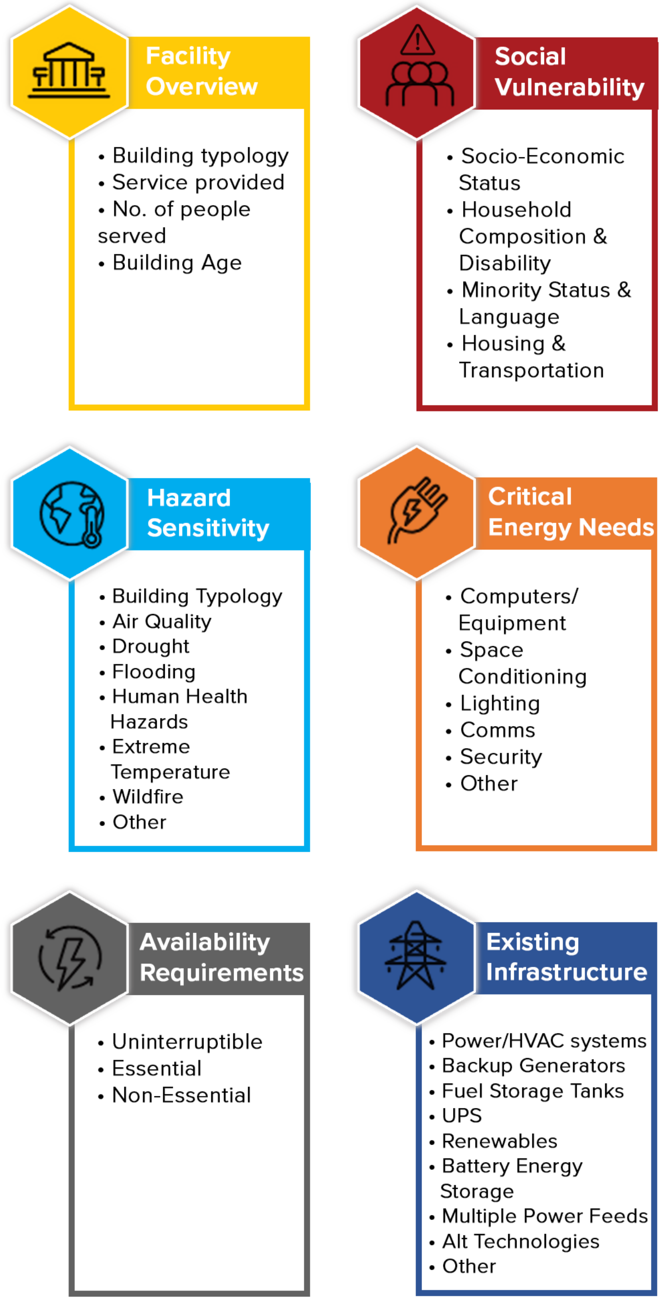


Figure 2.11. Facility Prioritization Factors

2.4.2. Community Value (Social Vulnerability)

This assessment uses the CDC/Agency for Toxic Substances and Disease Registry (ATSDR) Social Vulnerability Index (CDC SVI) [15] to identify census tracts in the member agency's jurisdiction that have greater vulnerability to climate-related hazards such as wildfire and extreme

15 https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

heat. The index uses data from American Community Survey 2014-2018 5-year estimates for 15 variables grouped into four themes: Socioeconomic Status, Household Composition and Disability, Minority Status and Language, and Housing Type and Transportation (see Figure 2.12).

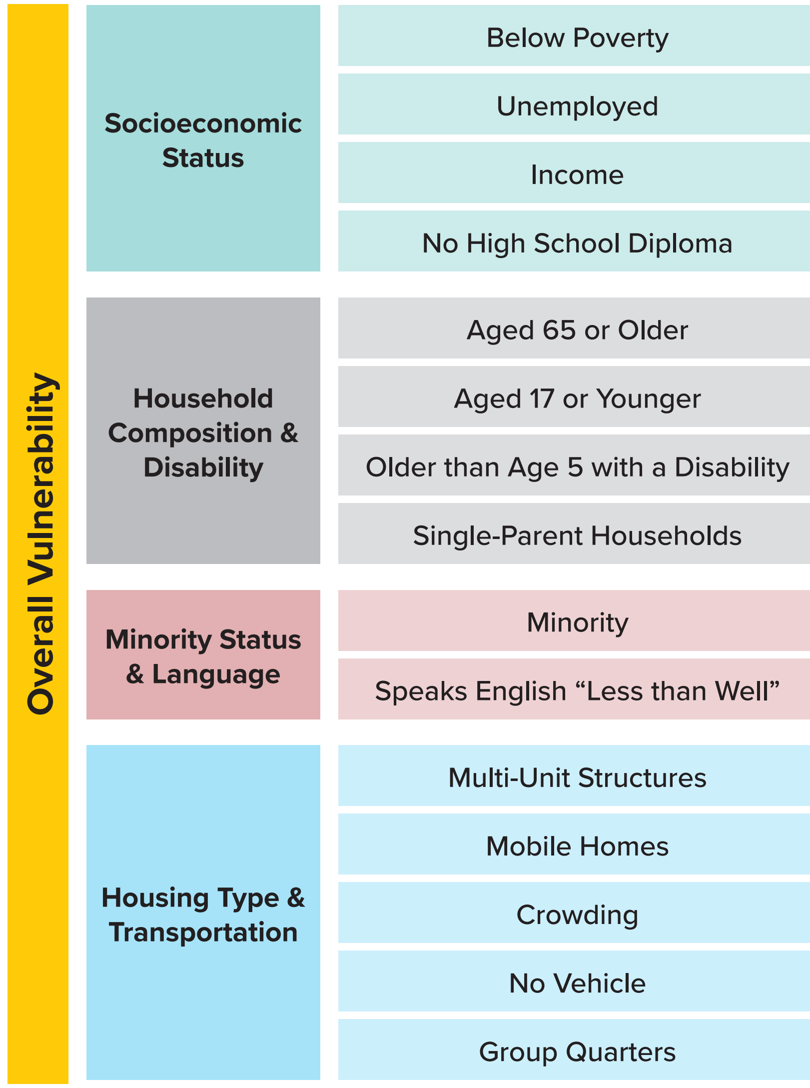


Figure 2.12. CDC/ATSDR SVI Variables Used (Source: CDC, 2022)

The 2018 SVI dataset for California was used to analyze the CDC SVI data for the WRCOG member agency’s jurisdiction.[16] This dataset shows the relative vulnerability, as a percentile ranking, of all census tracts within California (rather than all US census tracts). The WRCOG facilities were then mapped so they could be matched up with the SVI data for the census tract they belong to, using UrbanFootprint software.

To translate the CDC SVI percentile results into the WRCOG Facility Prioritization Matrix Community Value (Social Vulnerability) sector, each facility received points for its tract’s overall SVI score. The following methodology is used to convert the percentile score to points in the matrix:

- Over 75th percentile = 4 points
- > 50-75th percentile = 3 points
- > 25-50th percentile = 2 points
- 0-25th percentile = 1 point

To determine the community value of a facility, several criteria should be evaluated, including number of people served, socioeconomic status, household composition and disability, minority status and language, access to housing and transportation, and overall social vulnerability of the population served by the facility. This analysis determines the scale and vulnerability of the community served by the asset/facility. The higher the vulnerability of the population served, the higher the priority of the facility for resilience interventions.

16 Centers for Disease Control and Prevention/ Agency for Toxic Substances and Disease Registry/ Geospatial Research, Analysis, and Services Program. CDC/ATSDR Social Vulnerability Index 2018 Database California. https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html. Accessed August 2021.

Key stakeholders to engage on this topic to validate the analysis and learn more about specific community needs include:

- **Representatives from populations identified as socially vulnerable**
- **Community-based organizations**

During the development of this Plan, the SVI analysis was validated by speaking with WRCOG staff and representatives from the cities identified as most at risk.

2.4.3. Operational Needs (Energy Needs and Availability Requirements)

This category addresses the various functions and services that the facilities are currently providing or services that are provided to community members. The analysis of this component of facility prioritization is used to determine the feasibility of continuing to provide these services in a time of electrical grid disruption or other emergency situation.

Each facility feature is ranked on three-point scale. Three points are assigned to services that cannot be interrupted, such as refrigeration of medication; two points to services that are essential, such as heating and cooling; and one point to services than are non-essential. Figure 2.13 shows the type of critical energy needs at various facilities and how important it is to preserve these functions during power disruptions.

The evaluation starts with a determination of whether the function of the services of the facility can be relocated. Having location flexibility enables the services to be brought to the specific community that is being impacted, rather than requiring community members to travel to the facility.

The next factor is the presence of computers and other operations or communications equipment. Given their sensitivity, preservation of electronic resources is seen as a high priority. Facilities with computers are allocated a higher score to reflect the importance of protecting these resources and ideally being able to maintain operations of data and communications.

Space conditioning, either heating or cooling, can be vital to protecting people who have health-related concerns that can be exacerbated by extreme heat or cold. These concerns can include persistent cardiovascular or respiratory illnesses. Over time, exposure to extreme heat or cold can be life-threatening.

Lighting is important to maintain for the security and safety of people occupying the building. Facilities with the ability to provide lighting in an area where people can congregate and access other resources are considered to be significant resilience assets.

Maintaining communications during disruption or emergency, through the cell phone or internet networks, is critical. This can be as simple as providing phone charging and as significant as having a secure server or server room that is connected to a long-term backup power source.

Location in a secure area is considered to be a positive attribute. This could be a facility located in a secure city building or maintenance yard or a secure school site in the community. The ability to monitor who comes in and out the facility, provide lighting, provide separation between people or families, and generally protect those using the facility from harm are critical concerns in facility selection.

During the development of this Plan, a request for information was sent to facility managers to collect

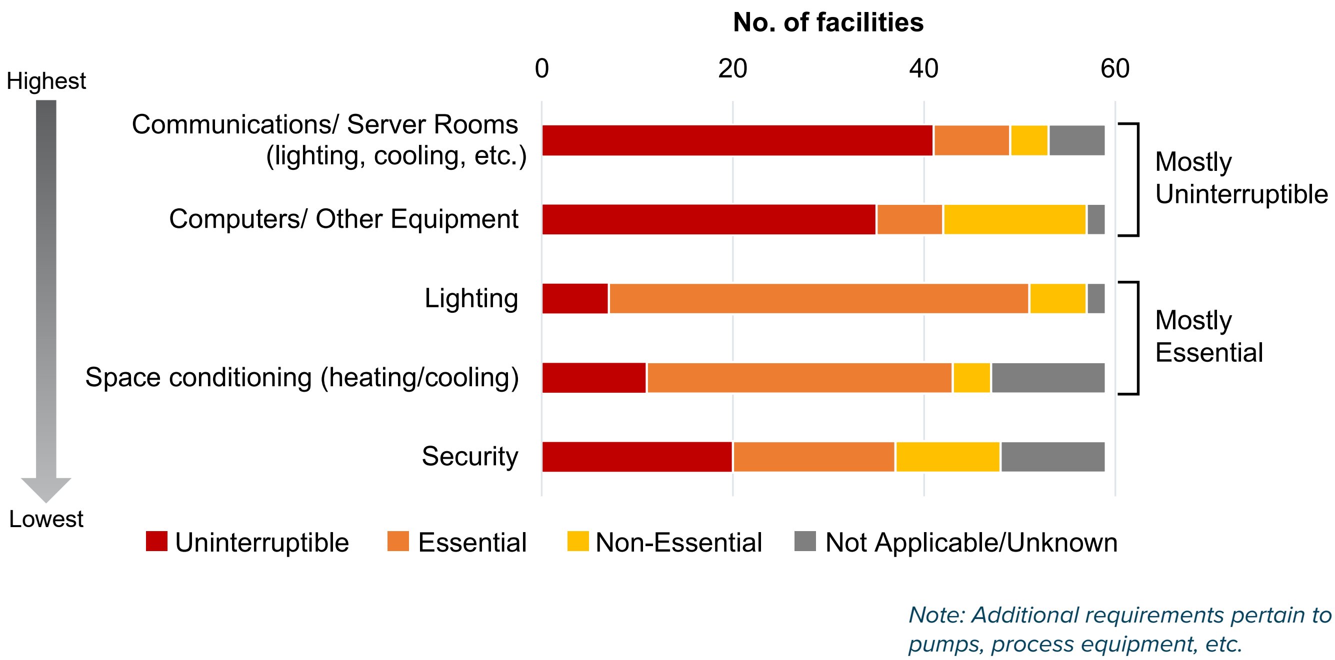


Figure 2.13. Facility Critical Energy Needs and Availability Requirements

data about the operations of critical facilities. Responses were followed up with stakeholder interviews to provide more details and confirm information.

Key stakeholders to engage at this step in the process to provide insight into the details of facility operations and systems include:

- **Municipal and/or regional emergency management personnel**
- **Public safety departments including Fire, Police**
- **Public and critical facilities managers**
- **Public works and/or utility departments**

2.4.4. Physical Hazard Sensitivity

The third prioritization factor is physical hazard sensitivity, which results from assessing the scale and nature of the physical threats to the asset/ facility. Physical threats are measured on a three-point scale, where three points are assigned for high sensitivity, two points are assigned for medium sensitivity, and one point is assigned to low sensitivity for each hazard. Zero points are assigned if the hazard does not apply.

Physical threats to critical facilities include:

- PSPS
- Extreme heat
- Wildfire
- Flood
- Earthquake

Physical threats can interrupt the power supply to critical facilities as a result of physical damage to infrastructure and or preemptive shutoff of the energy supply to minimize possible damage to infrastructure and/or the community. Many critical facilities across the WRCOG subregion are susceptible to physical threats from climate hazards.

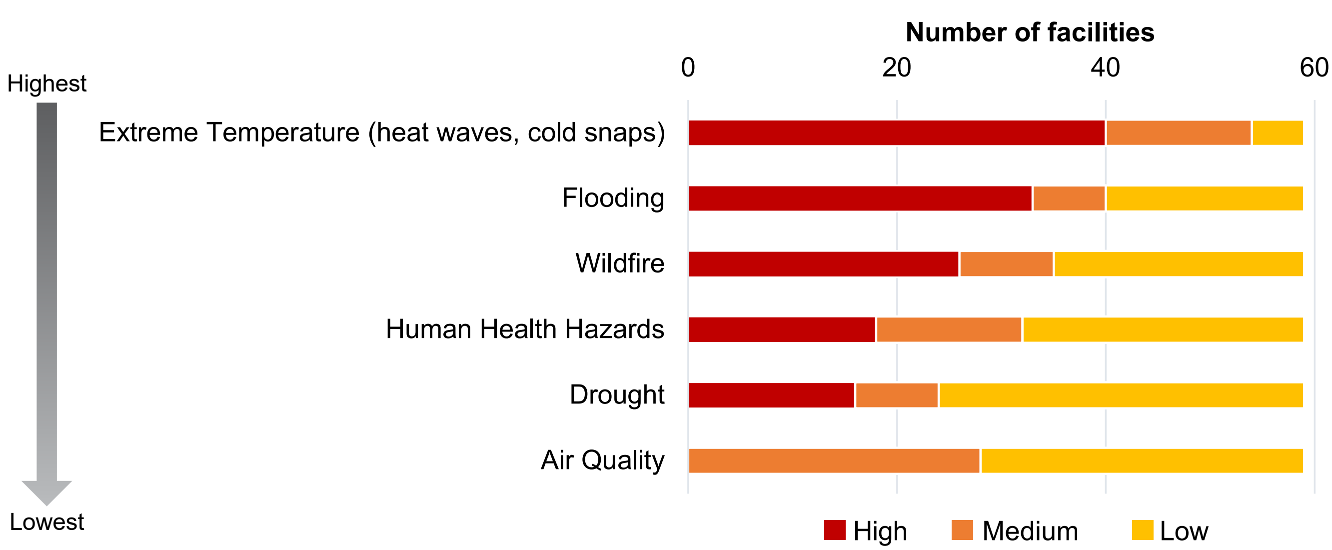
Figure 2.14 shows the hazard sensitivity of critical facilities in Western Riverside County to various climate hazards.

The hazard sensitivity evaluation takes into consideration the location of the facility and that location's sensitivity to a particular hazard (e.g., Is the facility located in a high wildfire severity zone?) as well as the likelihood of a hazard to disrupt energy supply to the facility.

During the development of this Plan, a workshop was held with WRCOG member agencies' emergency management personnel and public works departments to discuss which climate hazards were affecting their cities and how facilities and communities were being impacted.

Key stakeholders to engage at this step in the process include:

- **Municipal and/or regional emergency management personnel**
- **Public safety departments including Fire and Police**
- **Public and critical facilities managers**



Note: Additional threats include PSPS and earthquakes. The latter is specifically applicable to Riverside.

Figure 2.14. Physical Threats to Critical Facilities

2.4.5. Existing Infrastructure

The criteria in this component of the prioritization analysis address the physical attributes of the facility that are related to providing continuous energy supply or supporting the needs that are reliant on electricity, such as lighting, heating and cooling, refrigeration of medicines, or telecommunications.

The criteria include fundamental attributes such as the age of the building, the age and condition of the energy equipment, and the overall capacity of the electricity system. Older buildings are more likely to have less efficient systems or need energy upgrades and may have capacity constraints on electrical service or the addition of new systems. Older buildings may also present opportunities to integrate energy resilience measures into planned facility upgrades. Other infrastructure factors include the age and condition of the energy equipment and the presence and capacity of heating and cooling systems. Capacity is a critical concern if the facility is to be place of refuge or assembly.

The next cluster of criteria address methods of maintaining power to provide basic services. These include backup generation, fuel storage tanks, battery storage, and on-site energy generation. Photovoltaic systems designed to operate autonomously from the power grid can serve this need during daylight hours but need to be combined with other methods to provide energy for longer periods.

Typical backup generations systems are designed to maintain building energy services for relatively short periods. If the facilities are considered for a longer period of use to provide resilience services, which is likely, the existing backup systems may need to be increased to provide energy for 12 to 24 hours or be augmented by on-site generation to extend the time period. Other factors include whether there are multiple ways to feed energy to the property or if the property is able to switch from one source, such as a diesel generator, to another energy source, such as PV or batteries, without major disruption to services.

The energy infrastructure components and services at a given facility are compared to an ideal list of systems and services to determine the score in each category. The analysis is then used to determine the gap between a specific facility and an ideal situation. Facilities with a greater diversity of services and existing capacity, and thus a smaller gap, receive a higher score in this section of the prioritization analysis.

Similar to the operational needs factor, a request for information was sent to facility managers to collect data about critical facilities and was followed up with stakeholder interviews to provide more detail and confirm information.

Key stakeholders to engage at this step in the process to provide insight into the details of facilities include:

- **Municipal and/or regional emergency management personnel**
- **Public and critical facilities managers**
- **Public works departments**

3. Framework for Designing for Energy Resilience

The WRCOG Energy Resilience Plan serves as a guide for decision-making related to the identification of and investment in critical facilities and other community assets, which occurs in two stages:

1. Identification and Prioritization of Critical Facilities
2. Evaluation of Design and Implementation Options for Energy Resilience Solutions

Once the critical facilities are identified and prioritized, the framework for designing for energy resilience focuses on developing a technical solution. This includes determining what hazards to mitigate or protect against, what level of reliability and resilience to design to, what technologies and design elements could be part of the solution, and what resources can be mapped to the selected technologies to help with implementation.

3.1. Evaluating Energy Resilience

This section describes the process for defining the design objectives of a resilient energy system for critical WRCOG facilities. It is an attempt to answer the question:

"How resilient is resilient enough?"

There are many levels of resilience and many layers of backups and redundancies that could be applied to a given situation. The challenge for any prudent engineer or emergency planner is how to put boundaries on that decision-making process. One approach is summarized below:

$$\textit{Resilience} = \frac{\textit{[Capabilities]}}{\textit{[Requirements]}}$$

In other words, designing a facility to be "resilient enough" means designing it to have resilience capabilities that are appropriately aligned with the resilience requirements. Designing capabilities that far exceed the requirements appropriate for that facility, i.e., achieving ">100%" (conceptually) would constitute overinvestment in infrastructure.

3.1.1. Defining the Energy Resilience Requirements

When the resilience requirements are successfully identified for a given facility, the result is a "desired end-state" to aim for when selecting design solutions. This desired end-state should be built up from a holistic understanding of the **mission needs** of a facility, i.e., what is/are the function(s) and purpose of the facility being evaluated and what systems must be operational in order for the mission to be successful. Missions for a facility can include emergency response, water treatment and water distribution, critical life safety, and community cooling hubs. Mission needs can include lighting, computers and network connectivity for communications; heating, ventilation, and air conditioning (HVAC) systems; and specialized equipment such as garage bay doors, medical equipment, and pumps. This top-down approach for defining resilience requirements is summarized in Figure 3.1.

A resilience evaluation informs the **resources** required to support successful operation, as shown in Figure 3.1. Most critical missions require some degree of **power** supply to assure mission success, either for the whole facility or for critical circuits. Depending on the mission, **heating** and **cooling** may be critical to maintain sensitive climate control requirements. Reliable **water** supply may also be a requirement for mission success, although in some cases reliable water supply is the outcome of mission success (such as for water/wastewater treatment and distribution systems).[17]

Resource requirements for describing all possible scenarios for mission needs can be defined in three tiers of availability, as shown in Table 3.1.

To determine the availability requirements for each resource at a given facility, starting with an understanding of the facility by engaging the following stakeholders who know the facility well is recommended:

- The **facility manager** can speak to what systems are in place, what they are used for, and where are the chronic issues that have historically caused mission disruptions.
- The **site director** can speak to the broader functions of the facility, the implications to community resilience if utilities are disrupted, and what kind of contingency plans are in place (or lacking) to mitigate mission interruption due to facility degradation (such as whether the mission can be relocated).

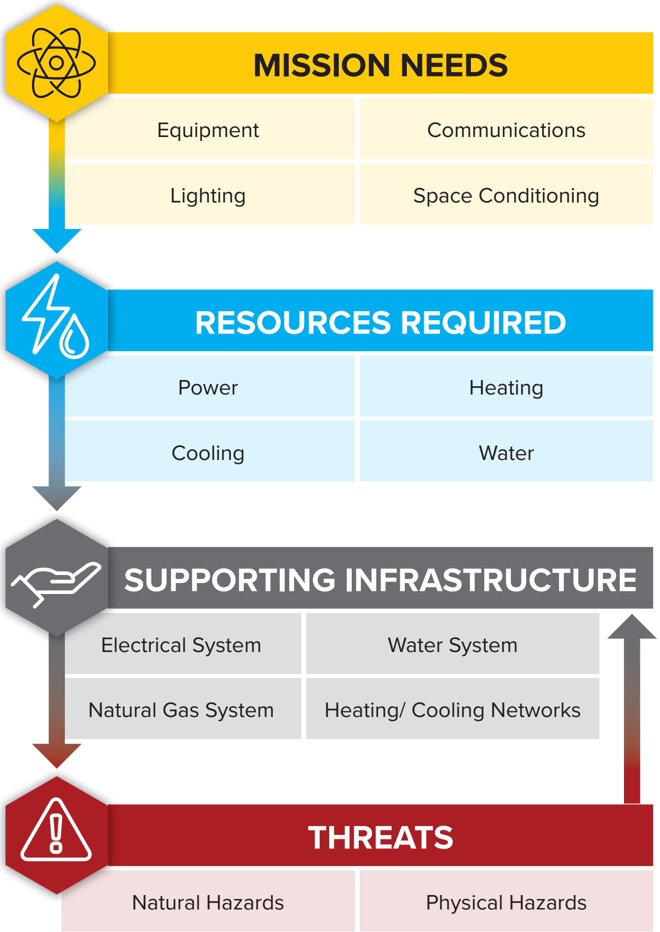


Figure 3.1. Top-down Approach to Defining Energy Resilience Requirements

Through interviewing the facility manager and site director of the critical facility being assessed, each end-use for each resource can be categorized as uninterruptible, essential, or non-essential. For the case studies, this was achieved by sending a facility questionnaire to the key stakeholders to gain an initial understanding and then following up with a phone interview. The result is a complete knowledge base for the resource requirements of the facility. For most facilities, such as the **Menifee Senior Center** and **Jurupa Valley Fire Station**, the resource end-uses that are categorized as uninterruptible or essential will be a focused

17 Water and wastewater systems at a facility are important elements of resilient infrastructure but have not been the focus of this effort.

Table 3.1. Tiers of Resource Availability Requirements

Tier	Description
Uninterruptible	Resource must be continuously available and cannot experience even momentary disruptions in supply or quality.
Essential	Resource must be available during a specific activity for a given duration. Minor variations in resource quality can be tolerated without significant disruption.
Non-Essential	Resource can be lost or quality can be degraded for extended periods without severe consequence.

subset of the total resource use at the facility. This can be a very helpful discovery because it means that the facility's resilience strategy can hone in on that subset of more critical end-uses instead of building a strategy for the entirety of all resources used. When resources are scarce in an austere environment, such as the aftermath of a natural disaster, having a clear understanding of which end-uses are most critical will help ensure that those scarce resources are allocated appropriately.

Once the resource requirements have been identified, an understanding of the supporting infrastructure is a natural next step. The supporting infrastructure represents not just the physical, engineered systems in a facility but also the management systems applied to a facility, such as maintenance plans and emergency protocol exercises. When a mission needs resources to ensure success, it is the **supporting infrastructure** that provides those resources. This includes the power distribution system (transformers, panels, circuits), the HVAC system (mechanical equipment, pipes, ducts, natural gas supply), the water and wastewater systems (pipes, pumps, valves), and management systems.

Similarly, it is the supporting infrastructure that must survive the **threats** present in a given community or geographic location. Threats include the natural hazards in the area (heat waves, earthquakes, heavy rains and flooding, strong winds) as well as the social vulnerabilities and physical threats that a community may face (socioeconomic factors, social unrest, public health challenges). Revisit Chapter 2 for information on how to assess the threats in a given location.

To summarize, when designing a facility for energy resilience, it is the supporting infrastructure that provides the resources required for the mission, and it is the supporting infrastructure that must survive the threats facing the community. The level of risk mitigation pursued (the resilience requirement) is informed both by the degree to which the critical resources are required for mission success and the magnitude of the threats that may cause resource disruption. The supporting infrastructure, therefore, is the entry point into making changes at a facility that will enhance its ability to achieve mission success amid a range of threats. Supporting infrastructure is the focus of the rest of this chapter. See Figure 3.2 for a conceptual summary.

3.1.2. Defining the Energy Resilience Capabilities

An effective energy resilience strategy involves more than simply installing a backup diesel generator with some fuel storage and calling it a day. Resilience includes **preventing** utility service disruptions from ever occurring, **mitigating** the impact of utility service disruptions when they do occur, and **recovering** to full operations in the aftermath of a disruption event.

The capability of a facility to prevent, mitigate, and recover from a disruption event is informed by the

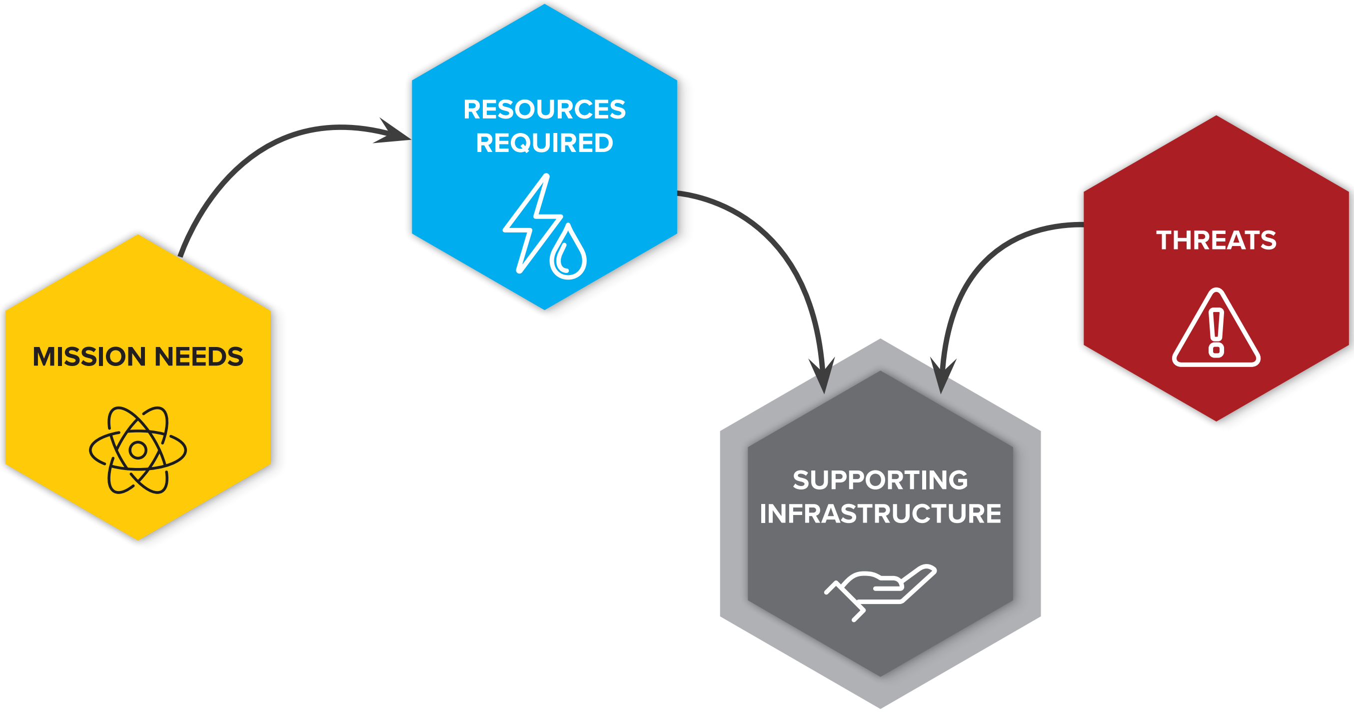


Figure 3.2. Supporting Infrastructure Is the Entry Point for Addressing Threats and Providing Resources for Mission Success at a Facility

supporting infrastructure defined in the previous section. To assess the energy resilience capability of the supporting infrastructure, the three qualities of resilient infrastructure (prevention, mitigation, recovery) can be subdivided into 10 energy resilience attributes (see Table 3.2). When evaluating the resilience capability of a facility, taking into account each of these attributes helps make sure that energy resilience is being addressed from all angles.

3.1.3. Defining the Energy Resilience Gaps

When compared against the energy resilience *requirements*, the existing energy resilience *capabilities* provide insight into how well the facility can meet the needs of the mission that the facility is charged to perform. If the capabilities fall short of the requirements, then a **resilience gap** is identified. The essential goal of an energy resilience plan is to fill these gaps by selecting and implementing energy resilience strategies.

For guidance on how to assess the existing infrastructure serving a critical facility, see Section 2.4.5.

As the gaps are identified, the areas that need more attention may become clearer. The resilience attributes can help provide a more focused direction for that attention. Once that direction is clear, resilience strategies come into play.

For example, the **Menifee Senior Center** was identified as a critical facility with an essential power requirement to serve as a cooling and heating emergency shelter and food distribution location for residents of the community. The existing infrastructure assessment found that this essential power supply requirement was not

Table 3.2. Energy Resilience Attributes

Resilience Attributes	Attribute Qualities
Cybersecurity of Energy Systems	Protection in place for energy systems (e.g., HVAC controls, centralized monitoring) to resist a cyber attack
Physical Hardening	Protection of energy infrastructure (e.g., electrical supply lines and switch stations, district heating plants and pipes) from threats, such as flooding, fire, and strong winds
Redundant Supply Paths	Separated supply paths to minimize the system infrastructure's vulnerability to the same local threat. (e.g., having multiple electrical supply lines from same source routed through the north and south of the campus, respectively)
Energy Source Diversity	Alternative sources of energy available to supply critical loads (e.g., utility connection, on-site renewable energy, and emergency backup diesel generator)
Energy Demand Reduction	Conservation and management of energy use to reduce the requirement for critical backup capacity and increase outage sustainment time
Load Sustainment Capacity	Ability to maintain energy supply to critical demand from on-site sources; includes generation, fuel storage, controls, and infrastructure
Emergency Management Protocols	Level of emergency response plan and personnel training
Islanding Capabilities, Analytics, & Controls	Automation of backup systems, threat prediction, and performance indicators to support response efforts
Personnel Availability for Assessment & Repair	Ability to access staff (be it university, contractor, or local specialists) of appropriate expertise for damage assessment and repair
Equipment, Parts & Procurement	Ensuring replacement critical equipment and parts are available; also includes standardization of components and secured procurement practices

being met. The utility power supply capacity was sufficient when the grid was operational, but in response to a threat such as a wildfire-caused PSPS event, no alternative power source would be available. In other words, the resilience gap of insufficient energy source diversity was identified. When a gap is thus identified, strategies can be considered that are designed to close that gap.

3.2. Selecting Energy Resilience Strategies

To close a resilience gap, start thinking about the nature of the gap and the different strategies that are available. Is the resource supply susceptible to physical damage? Does the facility consume excessive energy relative to its needs? Is the ability to phase down non-critical loads lacking? Based on the kind of gap, the next step is to look at the relevant menu of strategies and narrow it down to the strategy that best fits the need.

A list of the energy resilience strategies considered in this Energy Resilience Plan is provided in **Appendix D**. Although the list is not exhaustive and does not cover all possible design approaches to energy resilience, it does capture the majority of desired end-states or capabilities that would apply to the WRCOG community. The more agnostic take which is to focus on desired end-states and capabilities instead of focusing on specific technical solutions, allows the project engineer to identify the best solution for a specific site in the context of rapidly evolving energy technology. However, a selection of specific technical solutions that are more commonly deployed are also included in this list.

Besides addressing resilience gaps, the strategy selection takes into account the site **constraints** and **opportunities**, and these considerations inform the kinds of strategies that make sense for the facility. The strategy selection period is an appropriate time to re-engage the facility manager and site director because their knowledge of the site may exceed any information that can be gleaned from utility bills or as-built drawings. That said, data from utility bills (including interval data) and as-built drawings can be used to verify and support information provided by the facility manager and site director, and will be needed when forming the basis of design for a technical solution.

Appendix D provides a complete list of strategies considered in this Energy Resilience Plan. To help with identifying resilience strategies that can be applied to fill a resilience gap, each strategy is tagged with a category, the resource(s) the strategy supports, and the resilience attribute(s) the strategy addresses. Also included are some key considerations that help in determining whether the strategy is worth further evaluation. Table 3.3 provides a sample of what is included in **Appendix D**.

Categories that each energy resilience strategy will fall under are as follows:

- Backup Power
- Energy Supply
- Energy Storage
- Energy Conservation
- Energy Management and Controls
- Power Distribution
- Mechanical Systems
- Maintenance

Table 3.3. Sample of Energy Resilience Strategies

Strategy	Category	Resource	Resilience Attribute	Key Considerations
On-site Solar	Energy Supply	Power	Energy Source Diversity	• Rooftop/parking area • Circuit capacity • Structural support • Shading/glare
Battery Energy Storage System	Energy Storage	Power	Energy Source Diversity; Energy Demand Reduction	• Outdoor space with clearances • Circuit capacity • Advanced controls
Dispatchable Power (Backup Generator)*	Backup Power	Power	Load Sustainment Capacity	• Outdoor space with clearances • Ventilation requirements • Air quality requirements • Noise requirements • Fuel storage capacity • Dedicated emergency circuits

* The energy industry is currently developing alternatives to using diesel generators to support air quality improvements and reduce greenhouse gas emissions associated with backup power supplies.

Resource(s) that each energy resilience strategy may support are as follows:

- Power
- Heating
- Cooling

For resilience attribute(s) that each energy resilience strategy may address, see Table 3.2.

To arrive at a short-list of strategies to pursue, make use of this dataset of energy resilience strategies and keep in mind the resilience gaps and key considerations.

3.3. Implementing Selected Strategies

When the engineers and facility stakeholders have worked out which energy resilience strategies are appropriate to move forward with, it is time to develop the technical designs and financing plans for implementation.

Note that some of the strategies that may be selected for implementation are programmatic. Other strategies are more technological in nature and can be generally described as "strategies that require projects to implement." This section focuses on those strategies that require projects to implement (see Figure 3.3).

For the **technical design**, the case studies in **Appendix A** provide insight into the design process for arriving at an energy resilience solution. After the appropriate energy resilience strategies have been identified by working with the facility manager and site director to define the resilience requirements and opportunities or constraints of the existing conditions, the design team leverages a multi-variable optimization model to arrive at a recommended preliminary design architecture.

Inputs to the optimization model include the energy load profile, utility tariff structure (e.g., consumption rate, demand charges, time-of-use rates, ratchet charges), on-site energy generation profiles, PV overproduction net metering tariffs, new equipment capital costs, equipment maintenance costs, and equipment replacement costs or end-of-life demolition costs and equipment values (depending on project life cycle). Utility outage trends are also considered, namely, historical average outage frequency and duration in the site's utility service area.

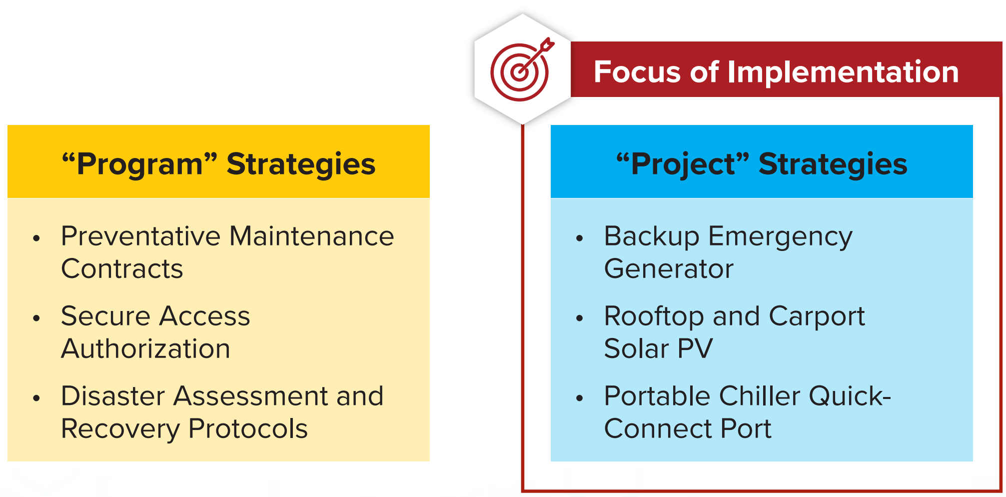


Figure 3.3. Program-oriented vs Project-oriented Energy Resilience Strategies

To arrive at a recommended preliminary design architecture, the optimization model essentially minimizes the net present cost of design scenarios. This begins with defining multiple design scenarios (i.e., design alternatives with different equipment capacities) for comparison. The model simulates how each scenario may operate in a manner that minimizes the operational costs (e.g., minimize purchased electricity or diesel consumption) and then ranks each scenario based on its overarching net present cost. Net present cost combines the upfront capital costs, ongoing operations and maintenance costs, and end-of-life costs and values into a single cost variable by applying a discount factor to future savings and expenses. For an energy resilience focus, the design team can rank each scenario by additional factors, such as reduction in annual diesel generator runtime. Multiple simulations were modeled per design scenario to capture typical and atypical utility outage conditions at varying times of day and year.

To choose a preferred alternative among the different design scenarios, a system that provides the right balance of minimum net present cost and minimum diesel generator runtime was selected for each case study. Once the recommended balance of equipment capacities has been selected, a preliminary architecture for the proposed solution can be drafted. To move forward from conceptual to detailed design and implementation, choosing a funding and financing strategy for the site is the next step.

A range of **funding and financing strategies** were identified to support project implementation, particularly to support the electrification and resilience planning of critical facilities in the WRCOG region, with an emphasis on including energy storage for emergency response. Funding strategies include federal and state grants, demand-side rebates and incentive programs, local revenue-generating mechanisms like new measures, and financing tools like public-private partnerships, state loan programs, and climate resilience-focused bonds. These strategies were also identified to inform and prepare the WRCOG for the development of new partnerships, the potential environmental review and technical analysis, and the tracking of federal and state funding opportunities as guidance is released. Refer to **Appendix E** for more details on the full list of funding and financing strategies identified as a part of this review.

4. Conclusion

The WRCOG Energy Resilience Plan serves two primary functions. First, the Plan is a decision-making guide for WRCOG members regarding implementation of energy resilience projects to increase facility and community resilience against regional power interruptions. Second, the Plan is a more general guide for governance organizations outside of Western Riverside County to begin to untangle the complex topic of community resilience through energy resilience. This conclusion addresses both elements.

4.1. Impact for WRCOG and Its Members

This Energy Resilience Plan will have a lasting impact on WRCOG and its member agencies by enhancing the day-to-day health and well-being of communities through reducing the negative impacts of natural disasters and power interruptions. The Plan achieves this by outlining a pathway for equitable and reliable access to electricity at all critical facilities across WRCOG member agencies, ensuring fundamental access to health and public safety services for all members of the Western Riverside community. Figure 4.1 shows the scope of the critical services covered in the Plan.

Through the Plan's framework, WRCOG will realize its goal of ensuring that its member communities can withstand and adapt to current and future climate-related threats. Because it is modeled around a replicable framework, the Plan can benefit other communities and jurisdictions beyond Western Riverside County.

12 Member Jurisdictions Represented

72 Critical Facilities Identified

178 Energy Loads Identified as Uninterruptible

141 Energy Loads Identified as Essential

27 Emergency Response Facilities

27 Critical Infrastructure Nodes

18 Community Resilience Hubs

Figure 4.1. Energy Resilience Scale of Impact

4.2. Next Steps

The main priority for achieving the full potential of this Energy Resilience Plan is to scale the findings from the case studies and apply them to the remaining critical facilities across WRCOG member agencies.

4.2.1. Technical Implementation Next Steps

The Plan describes an approach for identifying critical facilities and potential energy resilience strategies to be considered. At the subregional level, the next step is to apply the strategies outlined in this Plan across the critical facilities, developing bespoke concept designs for each. These designs will provide the basis for project financing, detailed design, and subsequent installation. This workflow is shown in Figure 4.2.

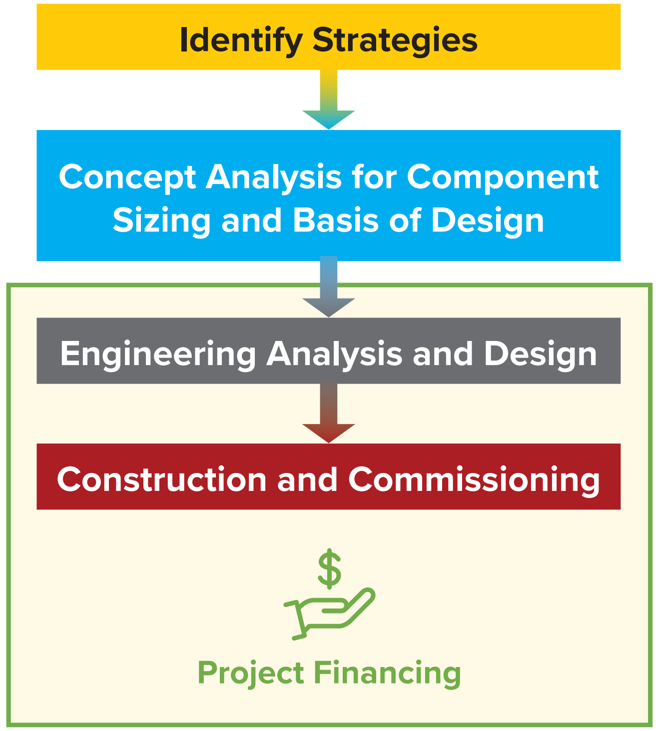


Figure 4.2. Project Implementation Life Cycle

In the development of this Plan, four facilities were selected as case studies for strategy analysis and subsequent preliminary concept design (provided in **Appendix A**). The facilities were chosen based both upon their score from using the prioritization methodology and how representative they are of other common critical facilities in the WRCOG subregion. The concept designs for the four facilities have informed the approach to energy resilience projects at the remaining critical facilities.

The following are general recommendations for the concept design process at any critical facility:

- **Confirm with stakeholders the age, condition, and future plans for a building to make sure that energy investments make sense for the site.** This information supports the relevance and urgency of seeking energy resilience improvements to the site; if a site is scheduled for demolition then energy projects may not be appropriate but if the site is due for major renovation then it may be perfect timing for energy upgrades.

- **Confirm with stakeholders all the critical loads at the site, and use this information as the basis for estimating the percentage of interval data to be carried by the alternative power system.** In rare cases, critical-load interval data may be available, but in general critical load information allows approximations of real-world outage scenarios to be modeled for energy supply optimization (compared, for example, with designing a microgrid at full load capacity that may require greater reliance on diesel generation).

- **Plan to install as much solar PV as can fit on the site, up to the capacity that would yield annual net zero energy.** Solar PV is typically the most cost-effective alternative energy resource. Thus, identifying as much area on-site for solar PV as possible (i.e., roofs and parking areas that are flat, unobstructed, unshaded, and generally southward facing) is likely to yield the greatest energy resilience benefits.

- **Unless limited by space availability at the site, optimize the on-site battery energy storage capacity for minimum net present cost and minimum generator runtime during grid outages.** When paired with enough solar PV, battery energy storage will unlock the ability to operate the site in islanding mode without a backup generator, which can significantly improve energy resilience even if just for a few hours during peak daylight.

- **Size the backup power source (i.e., diesel generator unless alternative technologies are identified) to cover all critical loads.** This is not only required where building codes dictate a backup power source but also guarantees the reliability requirements for a site will be met even if the solar PV array fails or if weather conditions yield a significantly less than average PV power output.

- **For community resilience hubs that serve a critical response function for heat waves and wildfires, evaluate the facility HVAC system and identify opportunities for greater redundancy in the cooling supply and intake air filtration.** For sites that serve this function, reliable and resilient power is only part of the energy resilience solution; reliable and resilient mechanical systems are equally important to ensure cooling and indoor air quality services are provided when they are most critical for the community.

4.2.2. Financial Implementation Next Steps

The Plan details a regional transition to renewable energy in critical infrastructure, including the ability to quickly adapt to drought, extreme heat, and other climate changes. Implementation will be most effective and efficient if multiple actions are pursued simultaneously, which may include using funding and financing sources to support multiple or bundled projects. Near-term next steps (within 1 to 2 years) for beginning implementation of priority actions may include the following:

- **Identify partnership opportunities to plan, fund, and implement climate actions.** WRCOG convened agencies from across Western Riverside County to participate in the development of this Plan, which has opened up opportunities to continue these partnerships as agencies begin to pursue funding. Partnerships between public agencies can increase the competitive edge of grant applications. Other civic institutions, notably UC Riverside, may also offer partnership opportunities.

- **Determine which strategies will require environmental review, technical analysis, and/or complex partnerships and permitting.** Some of the priority actions will have longer implementation timelines due to environmental review or financing coordination requirements (e.g., new sales tax, bond issuance). To meet WRCOG electrification goals in a timely manner, WRCOG member agencies will need to start the first phase of work on these longer-term projects.

- **Track new federal funding opportunities as guidance is released.** The Infrastructure Investment and Jobs Act (IIJA) and Inflation Reduction Act present enormous opportunities. While the available details on known programs are summarized in this chapter, the federal government regularly releases new program announcements related to funding eligibility and availability.

- **Begin preparing application materials for the state grants that have been allocated additional funding in the Governor's 2022-2023 budget.** Some funding for these grants may already be or will soon be available and will have short application deadlines. An early start on application materials will give WRCOG member agencies more time to match actions to grant opportunities, define strong proposal narratives, and identify potential partnerships Through this Energy Resilience Plan, WRCOG has advanced its mission to "facilitate, plan, and identify funding opportunities for critical infrastructure projects and programs that benefit its member agencies and the communities they serve" by providing a decision-making framework for identifying and prioritizing energy resilience projects for critical facilities and essential community assets.[18] The general next steps particularly benefit WRCOG member agencies by delivering an action plan that can be applied to all the critical facilities that were not analyzed in case studies. The benefits of the Plan extend beyond WRCOG by providing a replicable framework for energy resilience planning that may be used by other jurisdictions across California.

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18 Western Riverside Council of Governments Strategic Plan 2022-2027. Available: https://wrcog.us/DocumentCenter/View/9317/Strategic-Plan-2022- . Accessed November 2022.

Appendix A.
Case Studies

A1. Case Study 1 - Banning Wastewater Treatment Plant

Facility Overview

The Banning Wastewater Treatment Plant (WWTP) plant located at 2242 Charles Street, Banning, CA 92220 treats wastewater from approximately 30,000 people, including 12,800 dwellings and the surrounding community.

The Banning WWTP is currently connected to the Southern California Edison (SCE) utility on the TOU-GS-2-D-CPP tariff. As a critical infrastructure system, the WWTP has an existing backup power system consisting of two diesel generators, each dedicated to half of the plant, with a total capacity of 900 gallons of diesel storage.

Figure A.1. City of Banning Wastewater Treatment Plant Site Location

Past Disruptions

The WWTP has experienced seven SCE grid outages over the past several months, and the longest one lasted 5 hours. However, such outages have not yet led to any operational disruptions or degradations, as the backup generators have been able to cover the full plant electrical loads. However, given the importance of the WWTP to the community and the fact that no redundant diesel generator exists, additional backup power systems may be warranted for these reasons:

- If either of the existing diesel generators fails, no other alternative exists to power that section of the plant.
- In case of major disasters that may cause prolonged outages, the diesel storage may not be sufficient and fuel re-supply may be compromised.
- Air quality regulations limit the run hours of fossil-based generators, and alternatives are being promoted at the regional and state level for environmental benefits.

Therefore, to prevent such cascading effects of power outage to other utility functions, it is proposed that multiple on-site power sources be incorporated into the plant infrastructure to provide enough flexibility and redundancy to enhance system resilience against power outages.

Resilience enhancement against grid outages requires technical and financial analyses to develop a viable solution that includes a recommended size and combination of power generation and energy storage assets. These analyses, along with detailed simulations of the microgrid system, are further discussed in the section below.

Analysis and Simulations

To assess how the current and proposed system would response to prolonged utility power outages, a comprehensive microgrid modeling and analysis were carried out. For this purpose, the HOMER Grid software tool was used. HOMER Grid is a microgrid modeling software that is being widely used in the research and utility industry communities to design and optimize microgrids, to size different components of the system, and to perform a technical and financial feasibility assessment. This tool can also help with resilience and reliability assessments of various microgrid combinations, which are the main focus of the current study.

To develop the baseline model (i.e., the business-as-usual case), the annual load of the WWTP was collected and input to the model. AECOM received a partial load profile for August 22, 2021 to March 2, 2022. Estimates were then used to fill in missing data based on known load profiles in order to have a complete year for analysis. The existing diesel generators were also modeled to reflect the current status as the baseline of the model.

Based on utility bill analysis, the utility charges were $74,447 for the period from June 2020 to May 2021. The tariff is not Time of Use and energy costs were determined by a flat rate of $0.0923 per kWh used.

During the period from June 2020 to May 2021, the total energy consumption was 784,000 kWh. Peak demand of 120 kW was measured on November 14 and December 24, 2020, and on February 23, 2021.

Figure A.2 shows the monthly variations in monthly energy consumption and the breakdown of billing charges. Figure A.3 is the electrical load heatmap for the Banning WWTP.

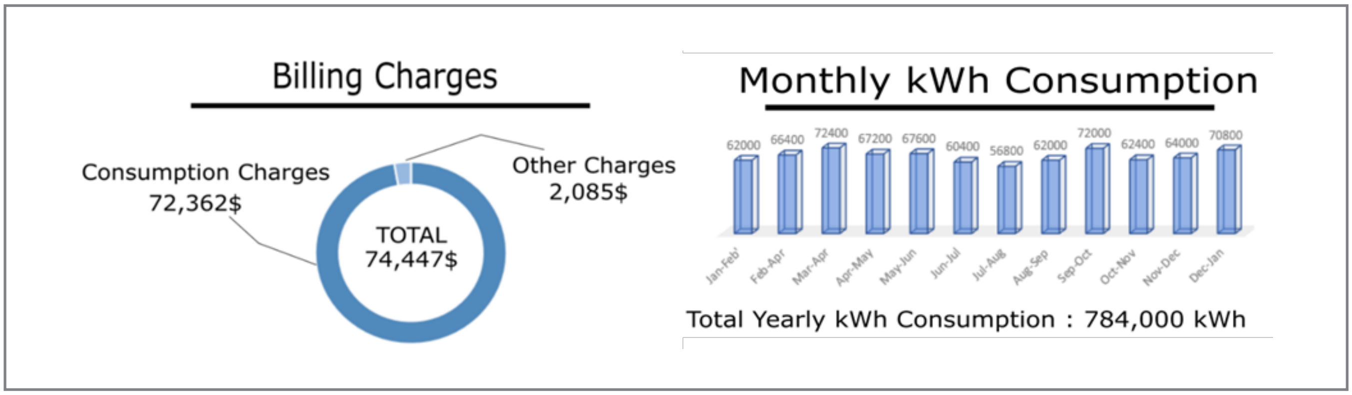

Figure A.2. System Annual Electricity Consumption and Billing Charges

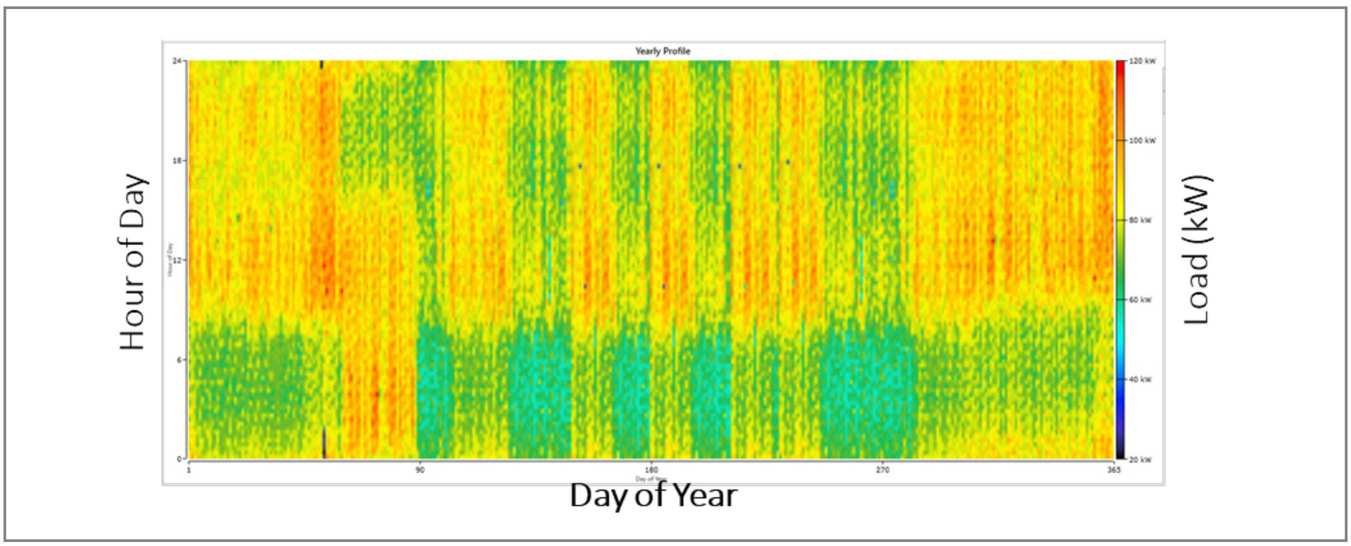

Figure A.3. Heat Map of the Banning WWTP Electrical Load

Improving the WWTP's resilience to utility power outages can be enhanced through implementation of diverse power sources. To achieve this goal, it is proposed that on-site solar photovoltaics (PVs be used as an additional source of power along with battery energy storage systems (BESS) and that various combinations and sizes be evaluated. The capacity of the existing diesel generators totals 130 kW; PV array size was dictated by the available space on land at the southwest corner of the site, resulting in a 123 kW system.

For the purpose of this analysis, it is assumed that 100% of the plant load is critical and that no downtime is acceptable. The schematic in Figure A.4 shows the main components and connections of the developed microgrid for the Banning WWTP.

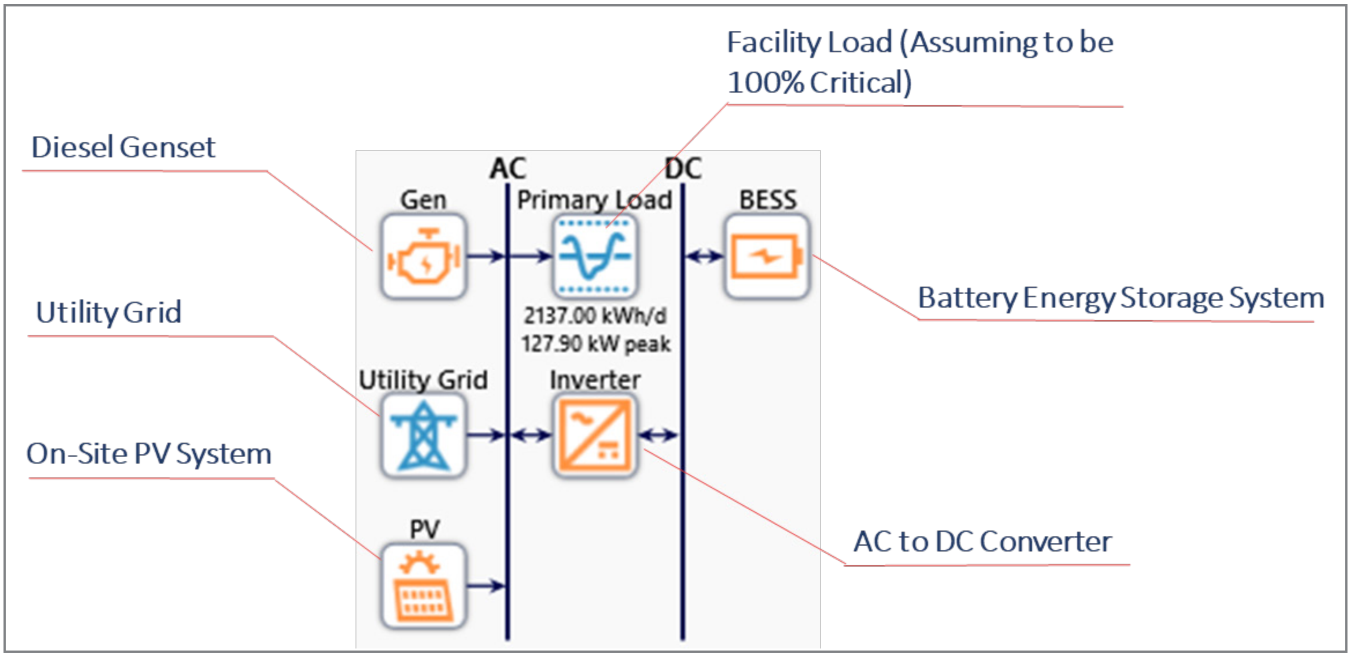

Figure A.4. Microgrid Architecture and Components

The analysis considered the numbers and duration of historical power outages sourced from SCE reliability reports.[1] System Average Interruption Frequency (SAIFI) and System Average Interruption Duration (SAIDI) numbers, which represent the average frequency of sustained interruptions and average duration of sustained interruptions respectively, were used in this study. According to the historical reliability of SCE circuits serving the City of Banning for 2021, the SAIDI has been 772 minutes and the SAIFI has been 2.9 outages per year. Therefore, it was assumed that the system would have to endure three outages per year, each of which would be 4.5 hours long.

$$SAIDI = \frac{\text{sum of all sustained customer interruption durations}}{\text{total number of customers served}}$$

$$SAIFI = \frac{\text{sum of total quantity of “sustained” customer interruptions}}{\text{total number of customers served}}$$

The distribution of these outages will be randomly selected by the software, depending on the reliability requirements set for the facility; one example is shown in Figure A.5. In this case study, we assumed that 100% of the plant load is critical and should be covered throughout the year; that is, no downtime or degradation of performance is allowed.

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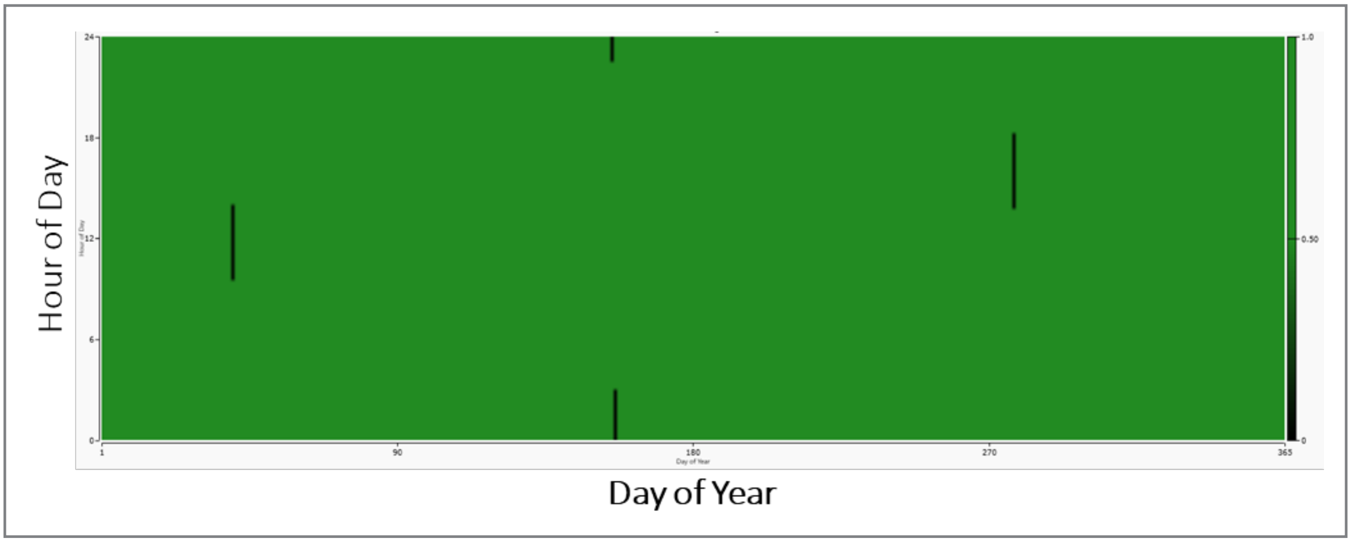

Figure A.5. Random Distribution of Outages Throughout the Year

Results and Recommendations

Feasible solutions for the Banning WWTP are summarized in Table A.1. These solutions essentially include those system sizes and combinations, referred to as system architecture, that are capable of meeting the loads during the defined outage scenarios. Each battery pack has the rated capacity of 85 kWh/185 kW, and the software will come up with the optimum number of packs for each system architecture. Also considered are scenarios without diesel generators (i.e., Scenarios 5 and 6) to see if there will be any benefits to replacing the existing ones if they are nearing their end of life.

Table A.1. Banning WWTP Microgrid Modeling Results

Architecture				Cost				System		
Scn.	PV (kW)	Generator (kW)	BESS (kWh/kW)	NPC ($)	LCOE ($/kWh)	Capital Expense ($)	Simple Payback (year)	Renewable Fraction (%)	Generator Hours	BESS Autonomy (hour)
1	123	130	-	$920 k	0.091	$194 K	11.2	27.5	10	-
2	-	130	-	$950 k	0.094	$0.0 K	-	0	14	-
3	**123**	**130**	**85/185**	**$1.00 M**	**0.099**	**$243 K**	**17.3**	**27.5**	**4**	**0.95**
4	-	130	85/185	$1.03 M	0.102	$48 K	-	0	10	0.95
5	123	-	425/925	$1.33 M	0.131	$435 K	-	27.5	-	4.77
6	-	-	510/1110	$1.43 M	0.142	$289 K	-	0	-	5.73

These scenarios are ranked based on their net present cost (NPC).[2] Scenario 2, which is the baseline scenario, has the second-best NPC; however, the renewable fraction (defined as annual renewable energy generation divided by annual energy consumption) is zero and the generator runtime is 14 hours per year. Scenario 3 consists of solar PVs, BESS, and diesel generators; this combination provides

2 Analysis was undertaken based upon equipment cost only. To take into consideration the total project cost, a premium of 30%-40% should be added.

multiple benefits in terms of resilience performance and integration of renewable energy. Availability of multiple power sources improves the system flexibility and thereby enhance resilience against power outages. If future outages become longer and more frequent, the system would be able to sustain the plant operations for longer periods compared to other scenarios investigated here; see the reduced generator runtime for Scenario 3 compared to other scenarios, which means less reliance on diesel fuel, less maintenance, and longer lifetime for the diesel generators. For these reasons and taking into account the only slightly higher NPC compared with the baseline case, Scenario 3 is the proposed option for improving the system's resilience posture while also reducing greenhouse gas (GHG) emissions and maintaining an economic performance close to that of the existing situation. Figure A.6 is a single-line diagram of the proposed system.

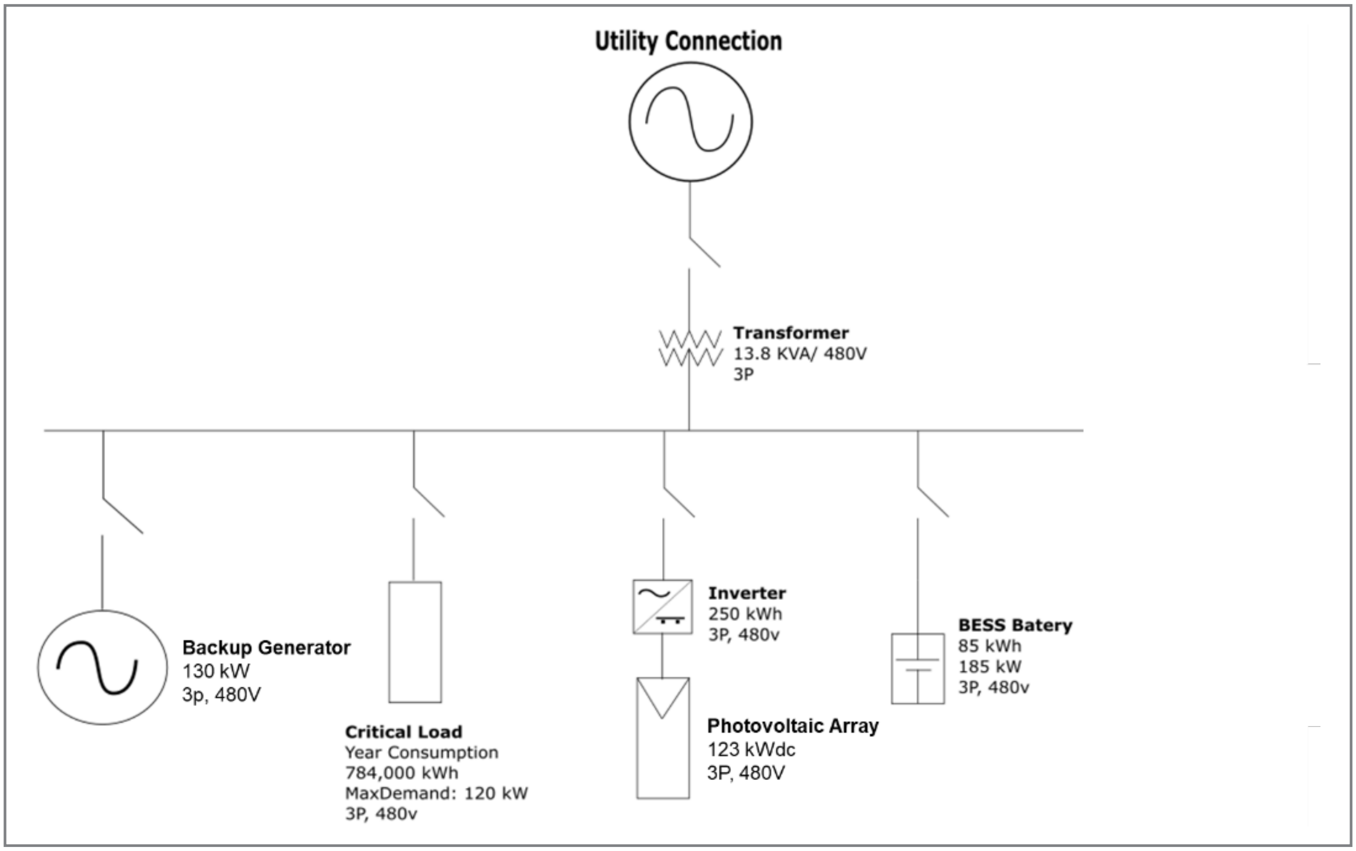

Figure A.6. Single-line Diagram of the Proposed System for Banning WWTP

A2. Case Study 2 - Menifee Senior Center

Facility Overview

The Menifee Senior Center is located at 29844 Haun Road, Menifee, CA 92586, and serves more than 100 seniors. The Menifee Senior Center is also being used as a cooling and heating emergency shelter and food distribution location for residents of the community.

The facility is currently connected to the Southern California Edison (SCE) utility on the TOU-GS-2-D-CPP tariff. The backup system includes a 36 kW diesel generator. The site location is shown in Figure A.7 below.

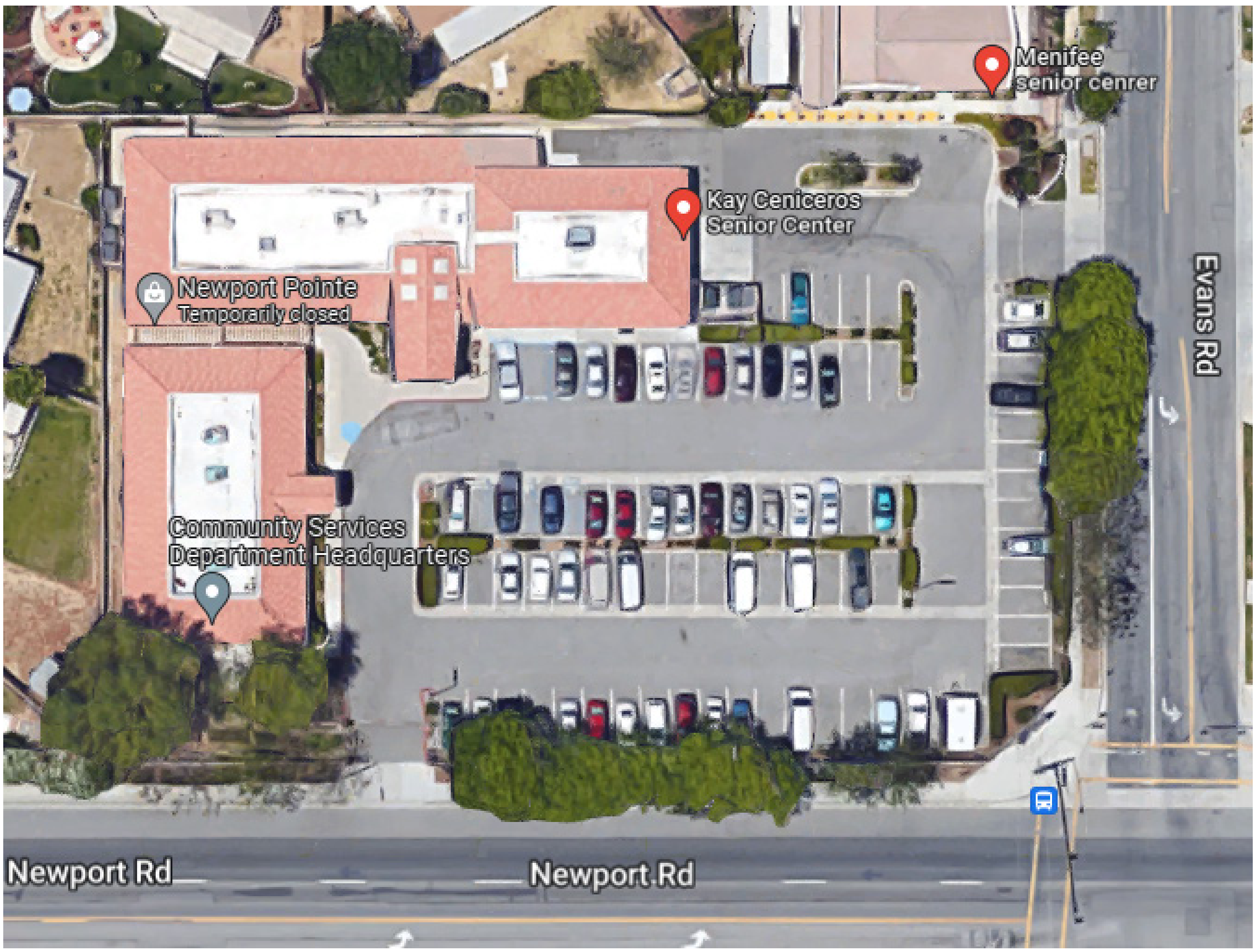

Figure A.7. Menifee Senior Center Site Location

Past Disruptions

The hazard sensitivity assessment revealed that flooding and human health risks caused by extreme temperatures are among the highest threats. The latter threat can be alleviated by enhancing the reliability of the senior center's heating and cooling systems. In addition to regular scheduled maintenance to ensure reliable operation of the heating and cooling systems, reliable power sources are required. As grid outages are becoming more frequent, improving the resilience of the energy systems against them is critical and has been the focus of this study. Analyses along with detailed simulation of the plant system are further discussed below.

Analysis and Simulations

To assess how the current and proposed system would response to prolonged utility power outages, a comprehensive microgrid modeling and analysis was carried out. For this purpose, the HOMER Grid software tool was used. HOMER Grid is a microgrid modeling software that is being widely used in the research and utility industry communities to design and optimize microgrids, to size different components of the system, and to perform a technical and financial feasibility assessment. This tool can also help with resilience and reliability assessment of various microgrid combinations, which are the main focus of this study.

In 2021, the total cost of electricity charges was $31,110, which includes energy charges, demand charges, and fixed charges. The annual electricity consumption during 2021 was 133,590 kWh, with peak demand of 58 kW occurring on August 1, 2021. Figure A.8 depicts the monthly variations in monthly energy consumption and the breakdown of billing charges. Figure A.9 is an electrical load heatmap for the Menifee Senior Center.

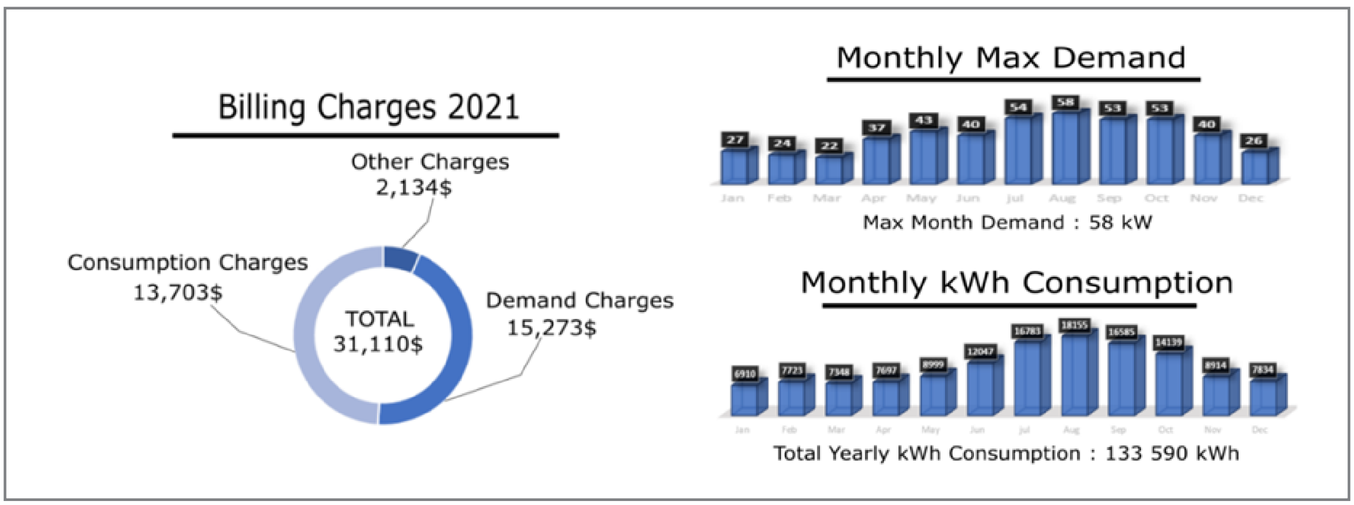

Figure A.8. System Annual Electricity Consumption and Billing Charges

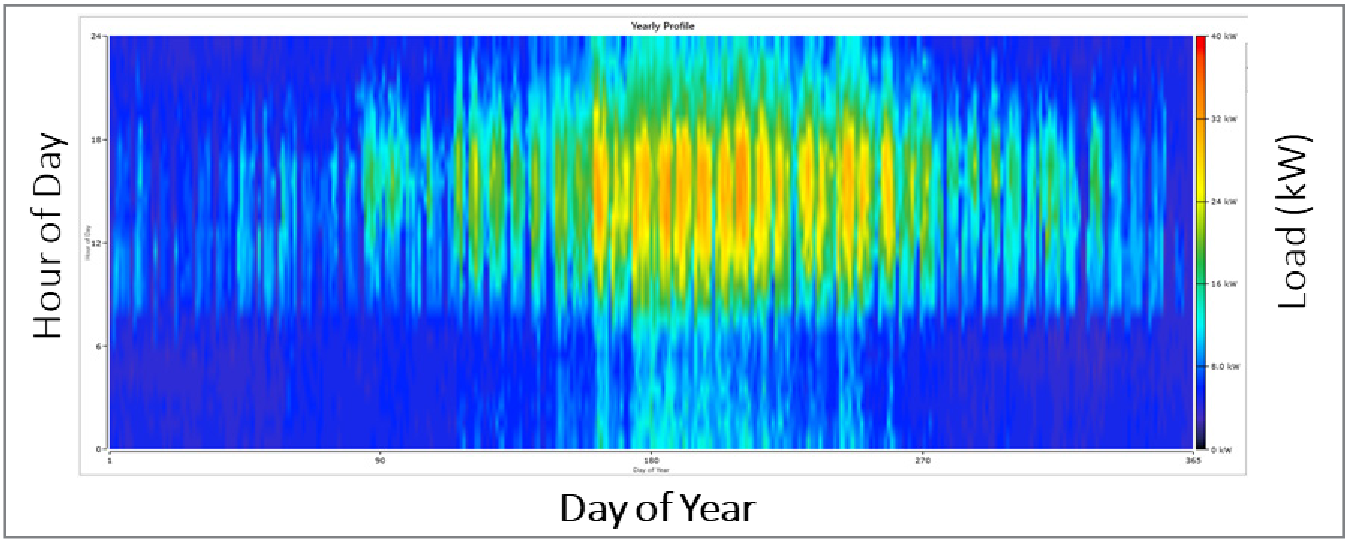

Figure A.9. Heat Map of the Menifee Senior Center Electrical Load

As mentioned earlier, the resilience performance of the Menifee Senior Center against utility power outages can be enhanced through implementation of diverse power sources. To achieve this goal, it is proposed that on-site solar photovoltaics (PVs) be used as an additional source of power along with battery energy storage systems (BESS) and that various combinations and sizes be evaluated. The capacity of the planned diesel generator is 36 kW.

Figure A.10 shows the proposed location for the solar PV arrays, which can accommodate a 62 kW PV system and also provide a shaded parking area for staff and customers.

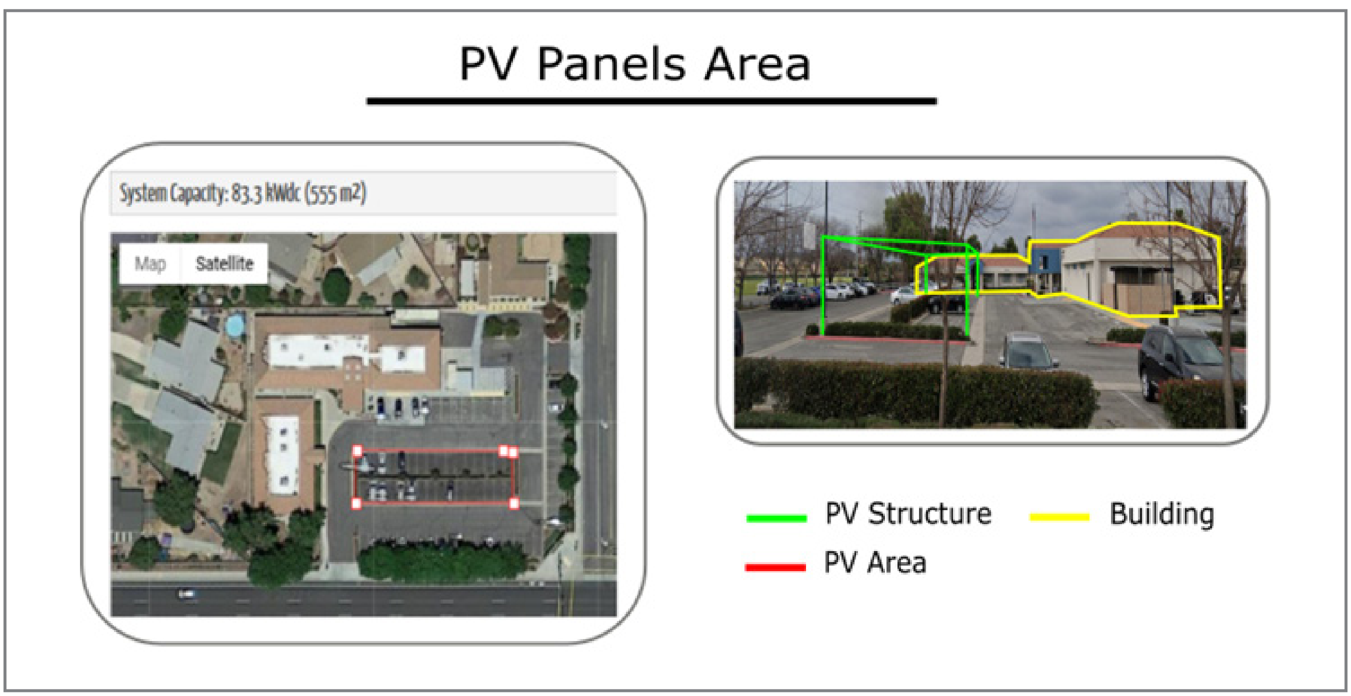

Figure A.10. Menifee Senior Center - PV System Location

For this analysis, it is assumed that 70% of the facility load associated with the non-office building is critical. That is particularly important in how the HOMER tools will treat the load in terms of resilience requirements, which would directly impact how the microgrid components are sized and operated. In this case study, no downtime is allowed, and the tool will develop the system such that all the loads are met all the time throughout the year, even in the case of prolonged grid outages. The schematic in Figure A.11 shows the main components and connections of the developed microgrid for the Menifee Senior Center.

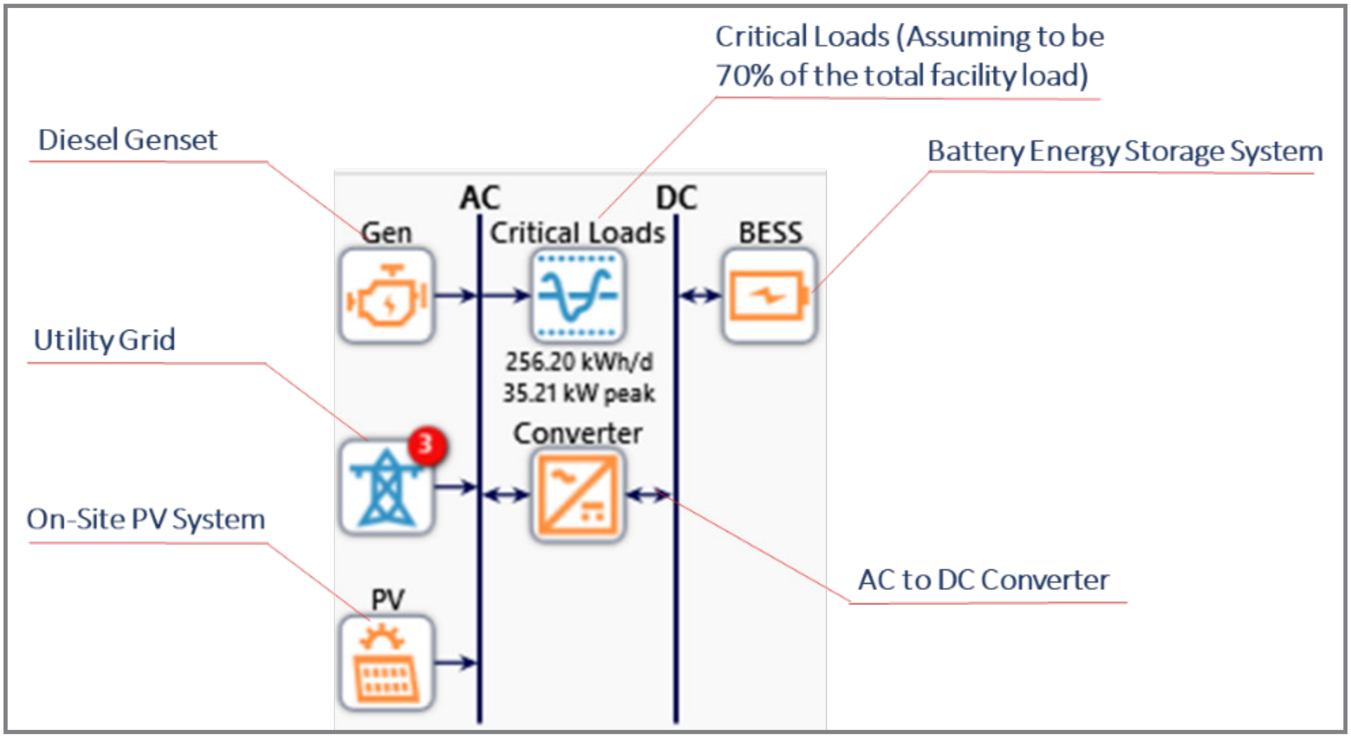

Figure A.11. Menifee Senior Center - Microgrid Architecture and Components

To evaluate the reliability and resilience of the facility, grid outages should be modeled, and the system's response to such outages should be evaluated. Therefore, data on the frequency and duration of power outages are needed as inputs to the software model. Statistics of the past grid outages are available at the city level through SCE reliability reports.[3] System Average Interruption Frequency (SAIFI) and System Average Interruption Duration (SAIDI) numbers, which represent the average frequency of sustained interruptions and average duration of sustained interruptions respectively, were used in this study. According to the historical reliability of SCE circuits serving the city of Menifee for 2021, the SAIDI has been 175 minutes and the SAIFI has been 1.2 outages. Therefore, it was assumed that the system would have to endure 1.2 outages per year, each of which would be 2.5 hours long.

The distribution of these outages will be randomly selected by the software; one example is shown in Figure A.12. Depending on the reliability requirements set for the facility, the software will size the solar and battery system such that those requirements are met at all times. In this case study, 70% of the facility load was assumed to be critical and should be covered throughout the year; that is, no downtime or degradation of performance is allowed for that portion of the load.

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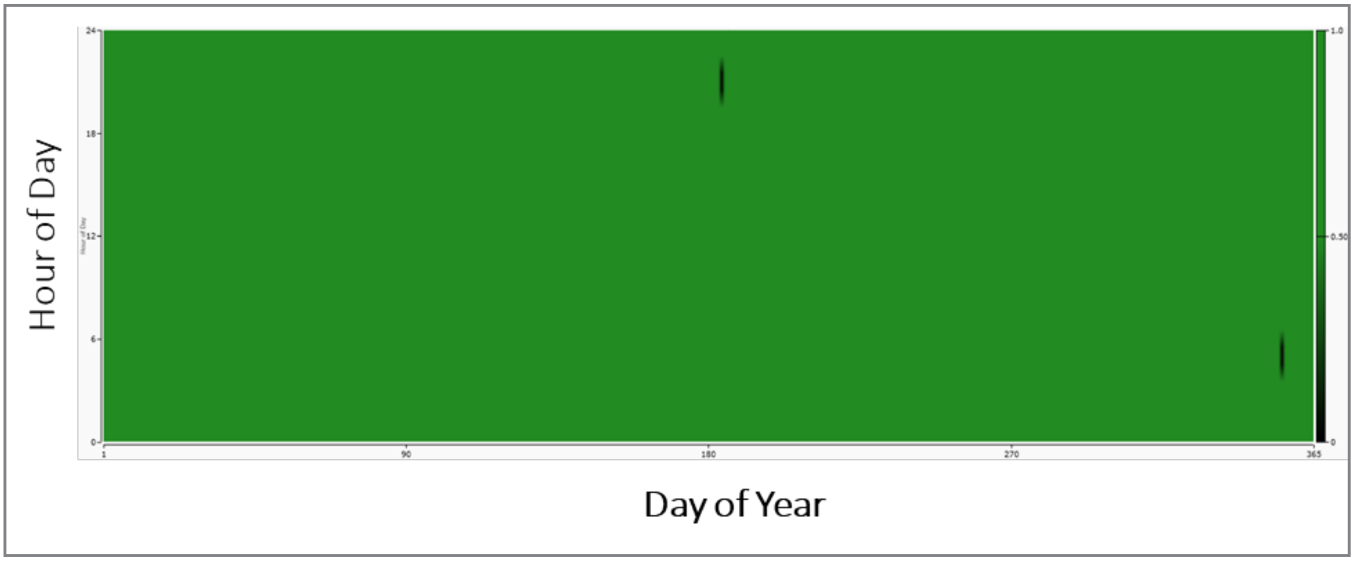

Figure A.12. Menifee Senior Center - Random Distribution of Outages Throughout the Year

Results and Recommendations

Feasible solutions for the Menifee Senior Center are summarized in Table A.2. These solutions include those system sizes and combinations, referred to as system architectures, that are capable of meeting the critical loads during the defined outage scenarios. Each battery pack has the rated capacity of 85 kWh/185 kW, and the software will come up with the optimum number of packs for each system architecture.

Table A.2. Menifee Senior Center- Microgrid Modeling Results

Architecture				Cost				System		
Scn.	PV (kW)	Generator (kW)	BESS (kWh/kW)	NPC ($)	LCOE ($/kWh)	Capital Expense ($)	Simple Payback (year)	Renewable Fraction (%)	Generator Hours	BESS Autonomy (hour)
1	62	36	-	$124 k	0.082	$149,450	9.5	75.8	4	-
2	-	36	-	$131.5 k	0.172	$27,000	-	0.0	4	-
3	**62**	**36**	**85/185**	**$146.4 k**	**0.108**	**$190,950**	**9.7**	**82.9**	**3**	**8**
4	-	36	85/185	$161.6 k	0.201	$68,500	-	0.0	4	8

These feasible scenarios are ranked based on their net present cost (NPC).[4] Scenario 2 represents the baseline scenario and has the second-best NPC; however, the renewable fraction for this scenario is zero. Additionally, the generator runtime is 4 hours per year, which is the highest time among all feasible scenarios. Scenario 3 consists of solar PVs, BESS, and diesel generators; this combination provides multiple benefits in terms of resilience performance and integration of renewable energy. Availability of multiple power sources improves the system flexibility and thereby enhances resilience against power outages. If future outages become longer and more frequent, the system would be able to sustain

4 Analysis was undertaken based upon equipment cost only. To take into consideration the total project cost, a premium of 30%-40% should be added.

critical operations for longer periods compared to other scenarios investigated here; in other words, the reduced generator runtime for Scenario 3 compared with other scenarios can be translated to less reliance on diesel fuel, less maintenance, and longer lifetime for the diesel generators. For these reasons and because the NPC of this scenario is only slightly higher than that of the other scenarios, Scenario 3 is the proposed option for improving the resilience posture of the system while also reducing greenhouse gas (GHG) emissions and maintaining an economic performance close to that of the existing situation. Implementation of BESS would provide more flexibility in demand management and could reduce demand charges on utility bills. Figure A.13 is a single-line diagram of the proposed system.

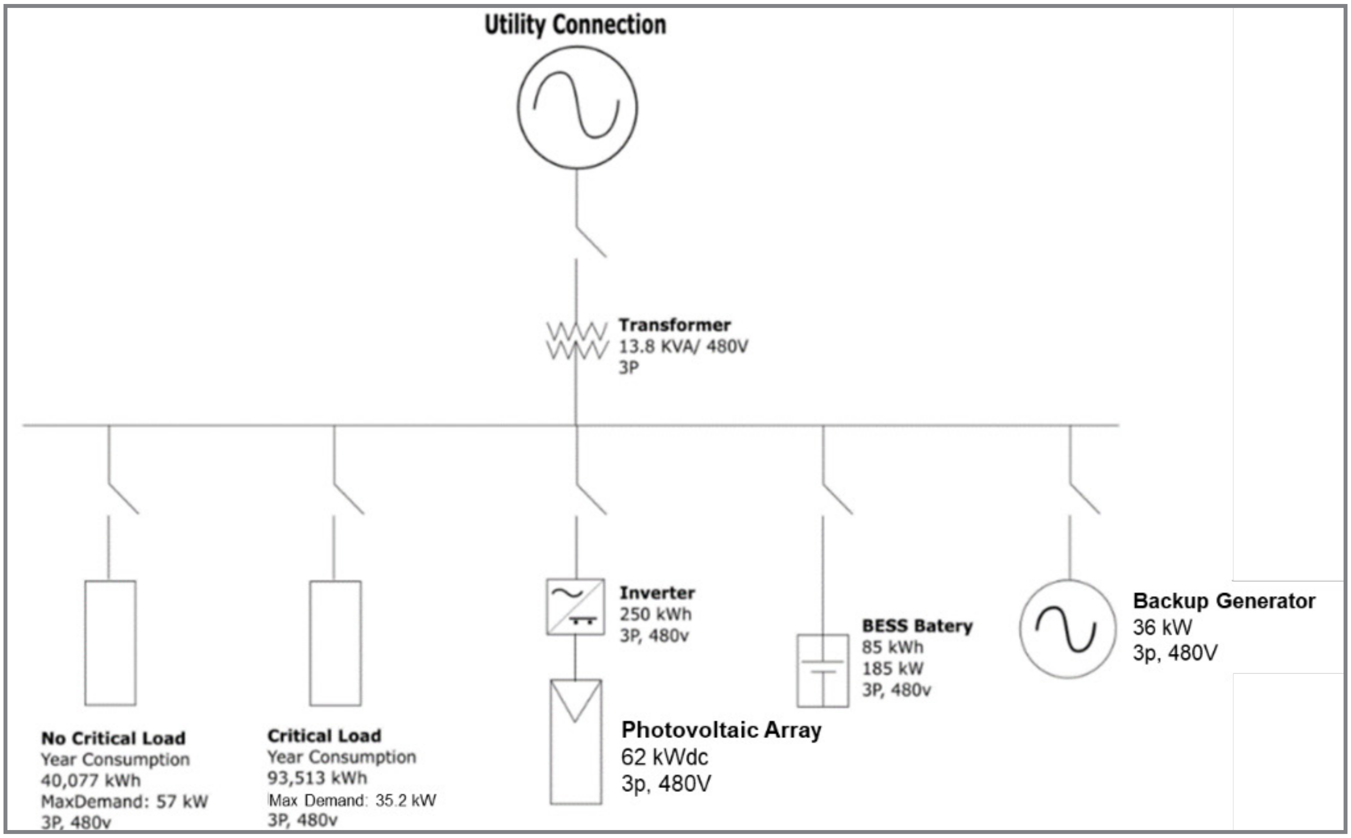

Figure A.13. Single-line Diagram of the Proposed System for the Menifee Senior Center

A3. Case Study 3 - Jurupa Valley Fire Station 16

Facility Overview

The Jurupa Valley Fire Station 16 is located at 9270 Limonite Avenue, Jurupa Valley, CA. The facility is more than 40 years old and serves around 10,000 people. The facility team has recently acquired a 12 kW backup generator.

The facility is currently connected to the Southern California Edison (SCE) utility on the TOU-GS-1-B tariff. The site location is shown in Figure A.14 below.

Figure A.14. Jurupa Valley Fire Station 16 Site Location

Analysis and Simulations

To assess how the current and proposed system would response to prolonged utility power outages, a comprehensive microgrid modeling and analysis was carried out. For this purpose, the HOMER Grid software tool was used. HOMER Grid is a microgrid modeling software that is being widely used in the research and utility industry communities to design and optimize microgrids, to size different components of the system, and to perform a technical and financial feasibility assessment. This tool can also help with resilience and reliability assessment of various microgrid combinations, which are the main focus of this study.

In 2021, the total utility charges were $5,256, which includes energy charges, demand charges, and fixed charges. The total energy consumption during 2021 was 26,923 kWh, with the peak demand reaching 11.28 kW on July 11, 2021. Figure A.15 shows the monthly variations in monthly energy consumption and peak demand. The electrical load heatmap for this facility is shown in Figure A.16.

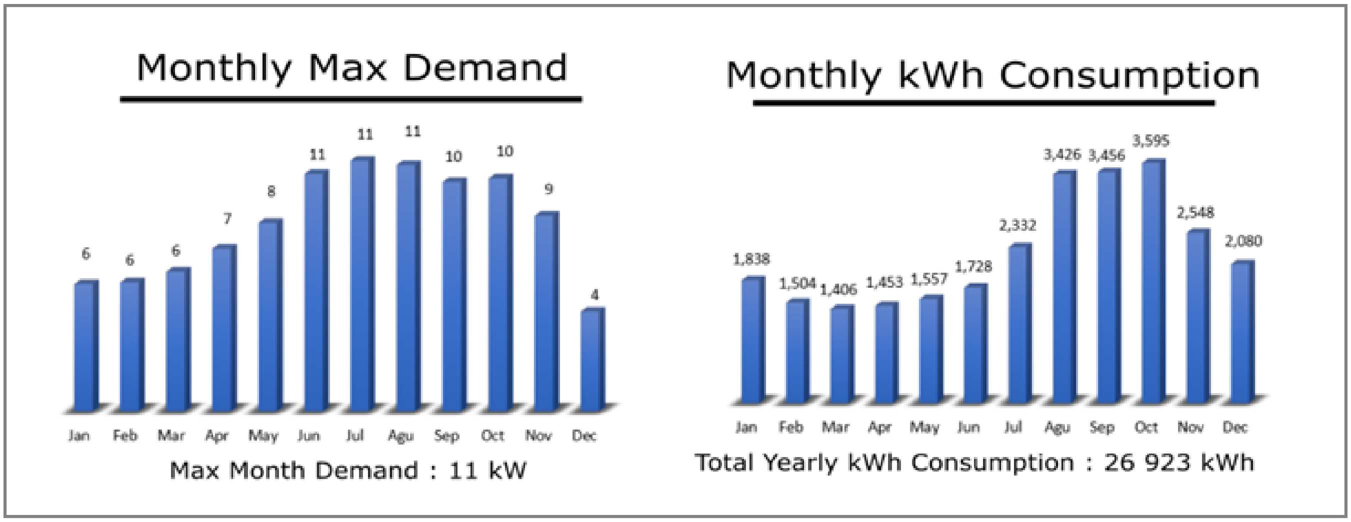

Figure A.15. Monthly Electricity Consumption and Peak Demand

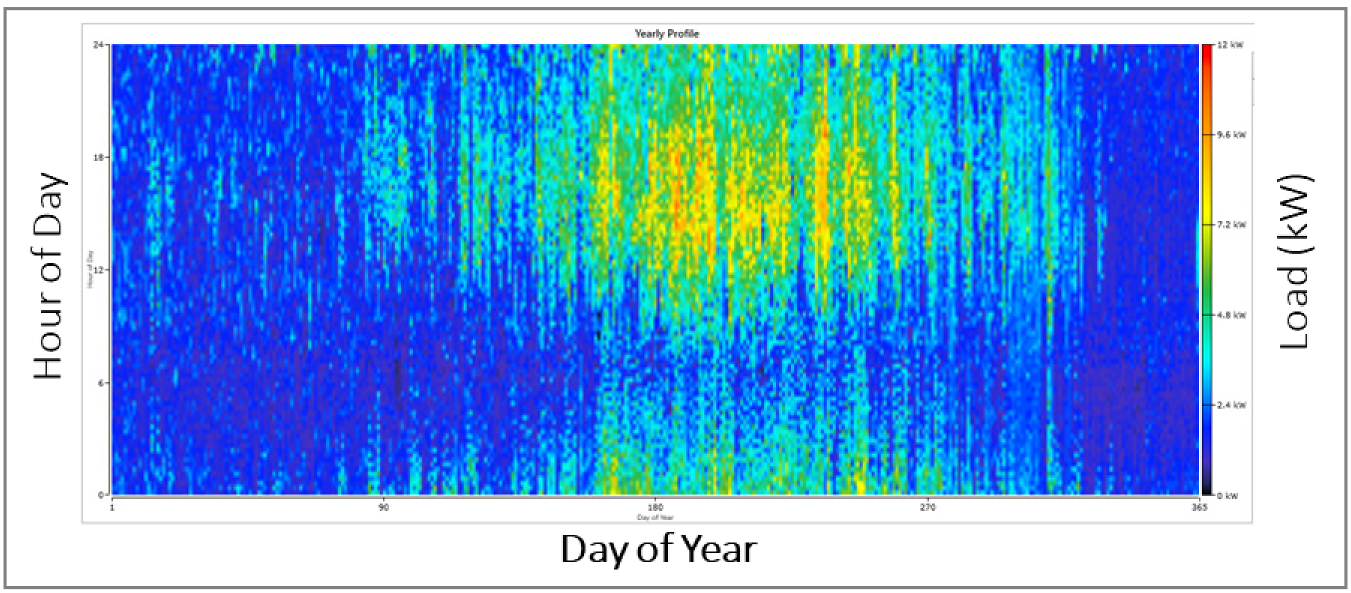

Figure A.16. Heat Map of the Jurupa Valley Fire Station 16 Electrical Load

To improve the resilience performance of the facility, it is proposed that on-site solar photovoltaics (PVs) be used as an additional source of power along with battery energy storage systems (BESS) and that various combinations and sizes be evaluated. The capacity of the existing (or planned) diesel generator is 12 kW. Figure A.17 shows the proposed location for the solar PV arrays, which can accommodate a 14 kW PV system and also provides a shaded parking area for the staff.

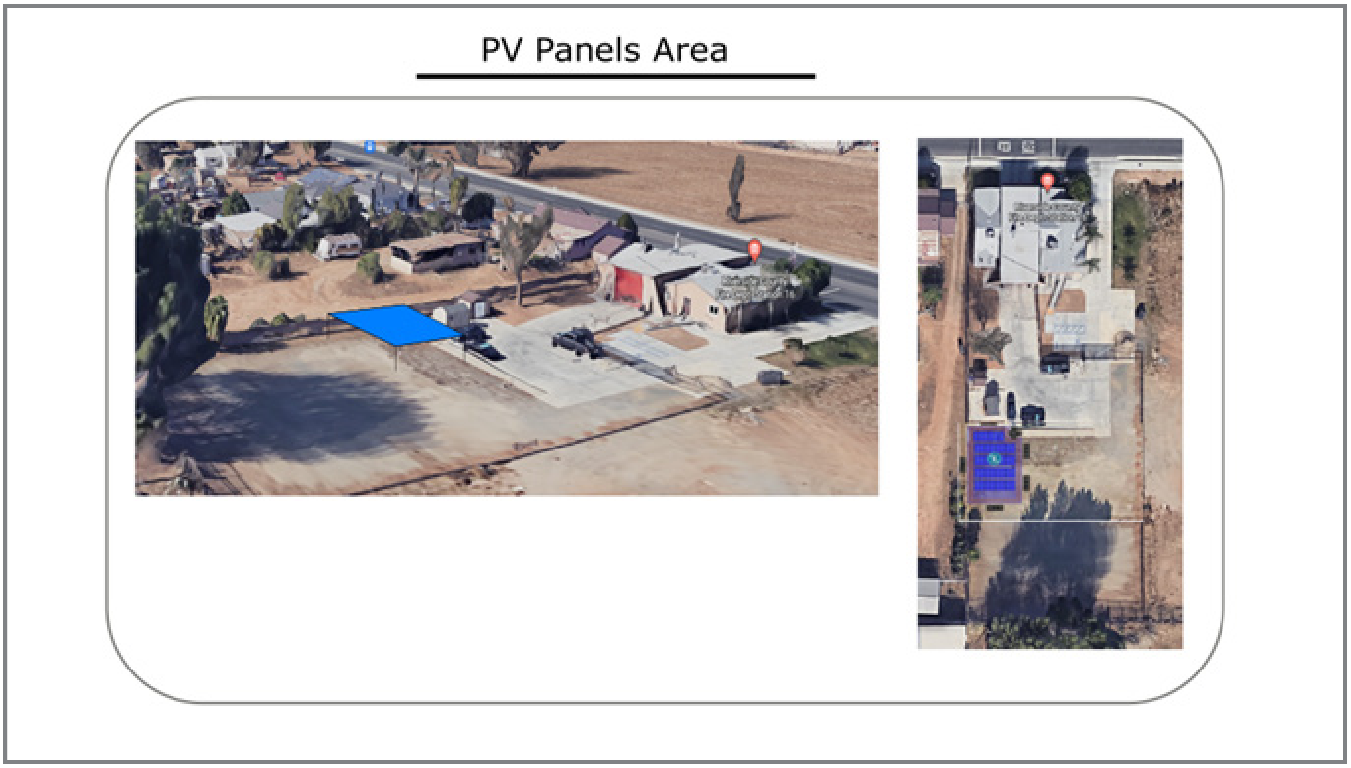

Figure A.17. Jurupa Valley Fire Station 16 - PV System Location

For the purpose of this analysis, 100% of the facility load is assumed to be critical. That is particularly important with respect to how the HOMER tools will treat the load in terms of resilience requirements, which would directly impact how the microgrid components are sized and operated. In this case study, no downtime is allowed, and the tool will develop the system such that all the loads are met all the time throughout the year, even in the case of prolonged grid outages. The schematic in Figure A.18 shows the main components and connections of the developed microgrid for Jurupa Valley Fire Station 16.

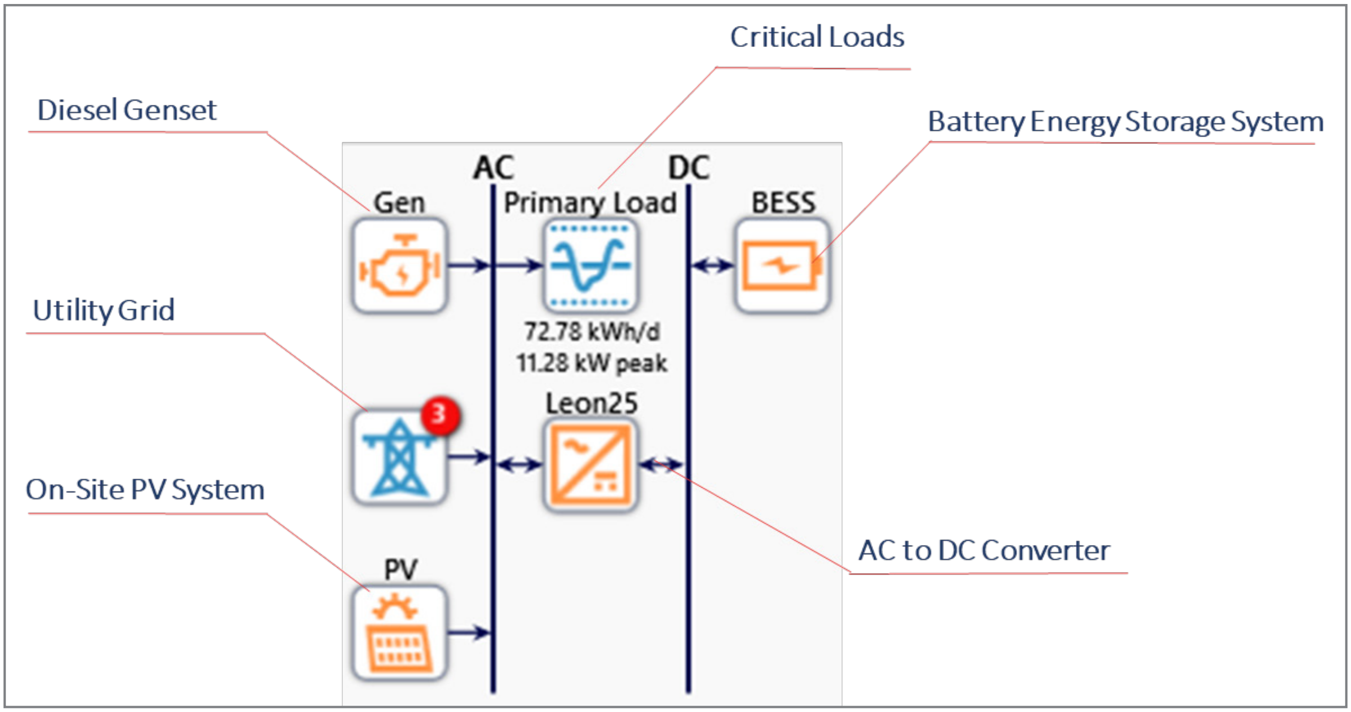

Figure A.18. Jurupa Valley Fire Station 16 - Microgrid Architecture and Components

To evaluate the reliability and resilience of the facility, grid outages should be modeled and the system's response to such outages should be evaluated. Towards that end, frequency and duration of power outages are needed as input to the software model. Statistics of the past grid outages is available at city level through SCE reliability reports.[5] SAIFI and SAIDI numbers, representing average frequency of sustained interruptions and average duration of sustained interruptions respectively, were used in this study.

According to the historical reliability of SCE circuits serving the city of Jurupa Valley for 2021, the SAIDI has been 891 minutes and the SAIFI has been 2.7 outages. Therefore, it was assumed that the system would have to endure 2.7 outages per year, each of which would be 5.5 hours long.

The distribution of these outages will be randomly selected by the software; one example is shown in Figure A.19. Depending on the reliability requirements set for the facility, the software will size the solar and battery system such that those requirements are met at all times. In this case study, we assumed that 100% of the plant load is critical and should be covered throughout the year, i.e., no down time or degradation of performance is allowed.

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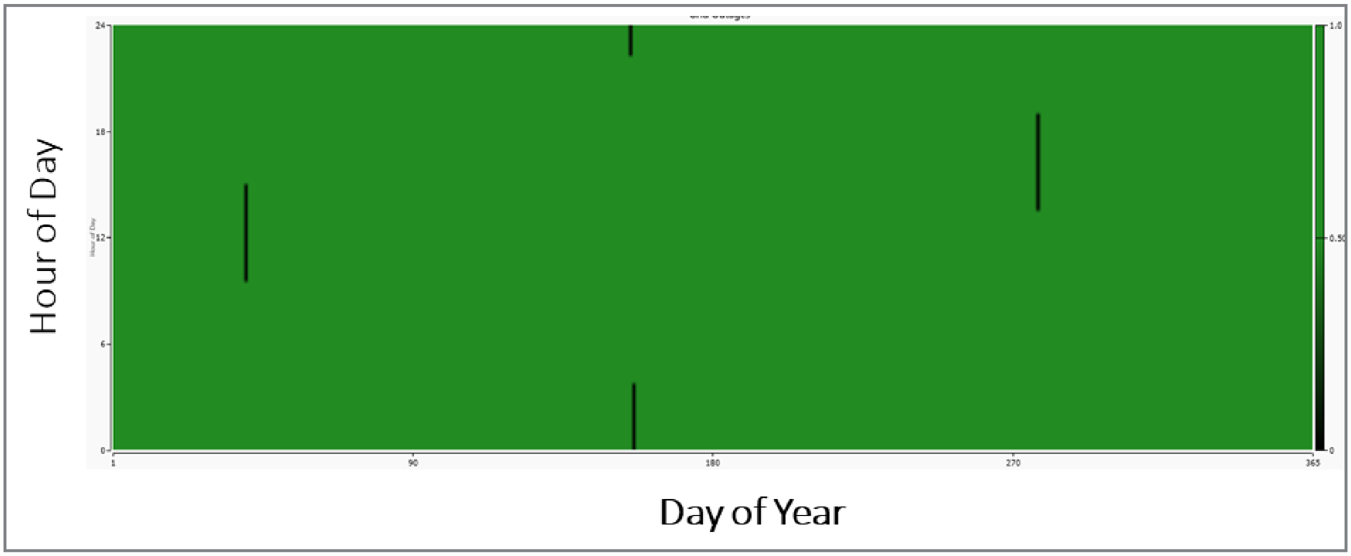

Figure A.19. Jurupa Valley Fire Station 16 - Random Distribution of Outages Throughout the Year

Results and Recommendations

Feasible solutions for the Jurupa Valley Fire Station 16 are summarized in Table A 3. These solutions essentially include those system sizes and combinations, referred to as system Architectures, that are capable of meeting the critical loads during the defined outage scenarios. Each battery pack has the rated capacity of 10.5 kWh/10.5 kW, and the software will come up with the optimum number of packs for each system architecture.

Table A.3. Jurupa Valley Fire Station 16 - Microgrid Modeling Results

Architecture				Cost				System		
Scn.	PV (kW)	Generator (kW)	BESS (kWh/kW)	NPC ($)	LCOE ($/kWh)	Capital Expense ($)	Simple Payback (year)	Renewable Fraction (%)	Generator Hours	BESS Autonomy (hour)
1	14	12	-	$27.8 k	0.066	$27.6 k	7.7	66.2	8	-
2	**14**	**12**	**10.5/10.5**	**$37.2 k**	**0.089**	**$33.6 k**	**10**	**67.1**	**3**	**2.8**
3	-	12	-	$41.4 k	0.159	$0	-	0	7	-
4	-	12	10.5/10.5	$50.1 k	0.193	$5.9 k	-	0	19	2.8

These feasible scenarios are ranked based on the net present costs (NPC).[6] Scenario 3 represents the baseline scenario and has the third-best NPC. Scenario 2 consists of solar PVs, BESS, and diesel generators; this combination provides multiple benefits in terms of resilience performance and integration of renewable energy. Availability of multiple power sources improves the system flexibility and thereby enhance resilience against power outages. In case of future outages become longer and more frequent, the system would be able to sustain critical operations for longer periods compared to other scenarios investigated here; in other words, reduced generators runtime for scenario 2 compared

6 Analysis was undertaken based upon equipment cost only. To take into consideration the total project cost, a premium of 30%-40% should be added.

with other scenarios can be translated to less reliance on diesel fuel, less maintenance, and longer lifetime for the diesel generators. Scenario 2 will also result in a better economic performance compared to the baseline case; for those reasons, and considering that it has lower GHG emissions, Scenario 2 is the proposed option for improving resilience posture of the system. Implementation of BESS would provide more flexibility in demand management and could reduce demand charges on utility bills. The single-line diagram of the proposed system is shown in Figure A.20.

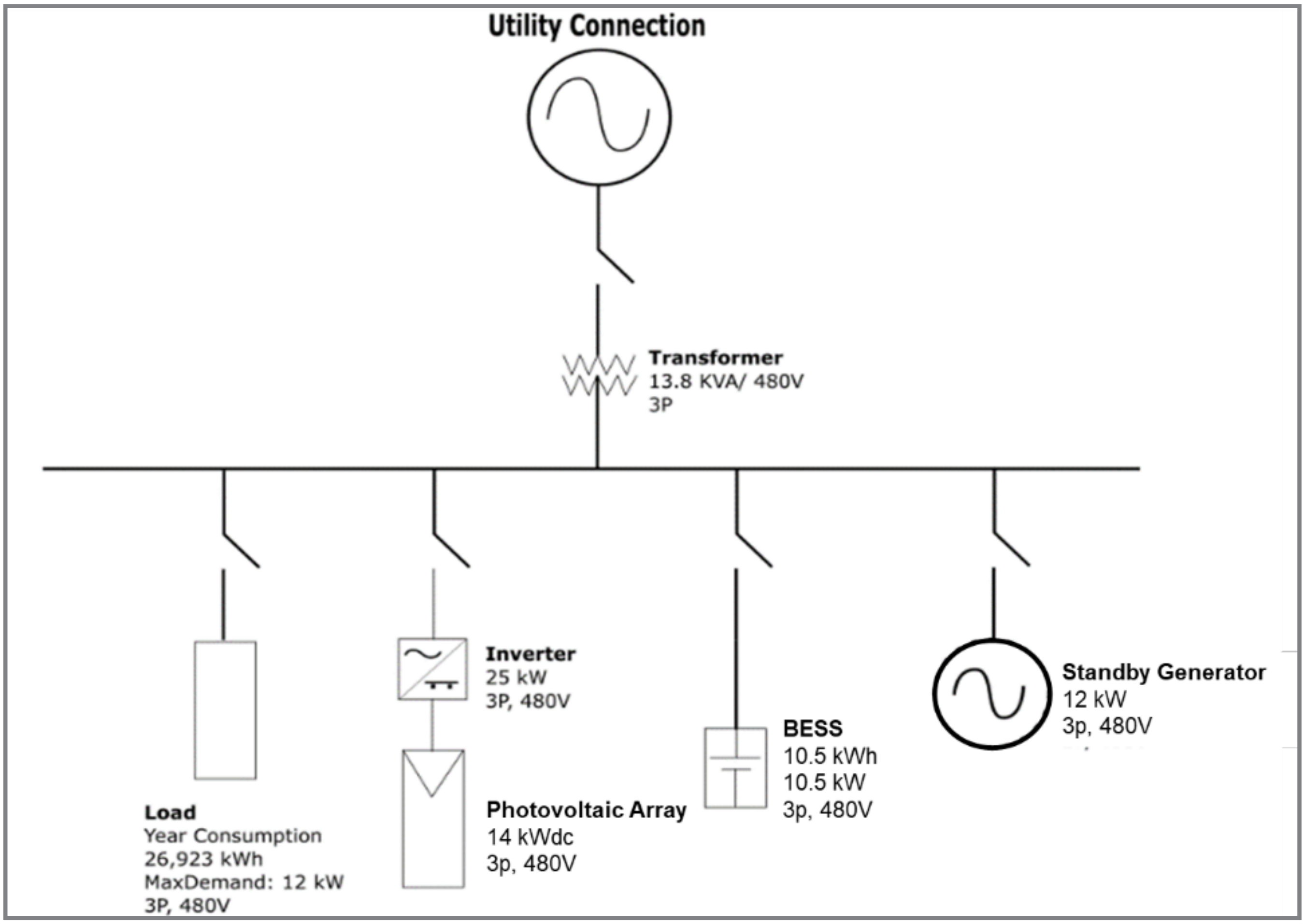

Figure A.20. Single-line Diagram of the Proposed System for Jurupa Valley Fire Station 16

A4. Case Study 4 - Jurupa Valley Fire Station 17

Facility Overview

Similar analysis was carried out on Jurupa Valley Fire Station 17 as was completed for the Jurupa Valley Fire Station 16. Jurupa Valley Fire Station 17 is a larger and newer facility located at 10400 San Sevaine Way, Mira Loma, CA 91752.

The facility is currently connected to the Southern California Edison (SCE) utility on the TOU-GS-1-B tariff. The site location is shown in Figure A.21.

Figure A.21. Jurupa Valley Fire Station 17 Site Location

Analysis and Simulations

To assess how the current and proposed system would response to prolonged utility power outages, a comprehensive microgrid modeling and analysis was carried out. For this purpose, HOMER Grid software tool was used. HOMER Grid is a microgrid modeling software that is being widely used in the research and industry communities to design and optimization of microgrids, size different components of the system, and also to perform a technical and financial feasibility assessment. This tool can also help with resilience and reliability assessment of various microgrid combinations, which has been the main focus of this study.

In 2021, the total energy consumption of the facility was 73,600 kWh, with the peak demand reaching 24 kW multiple times throughout the year in June, July, and August. Figure A.22 depicts the monthly variations in monthly energy consumption and peak demand. The electrical load heatmap for this facility is shown in Figure A.23.

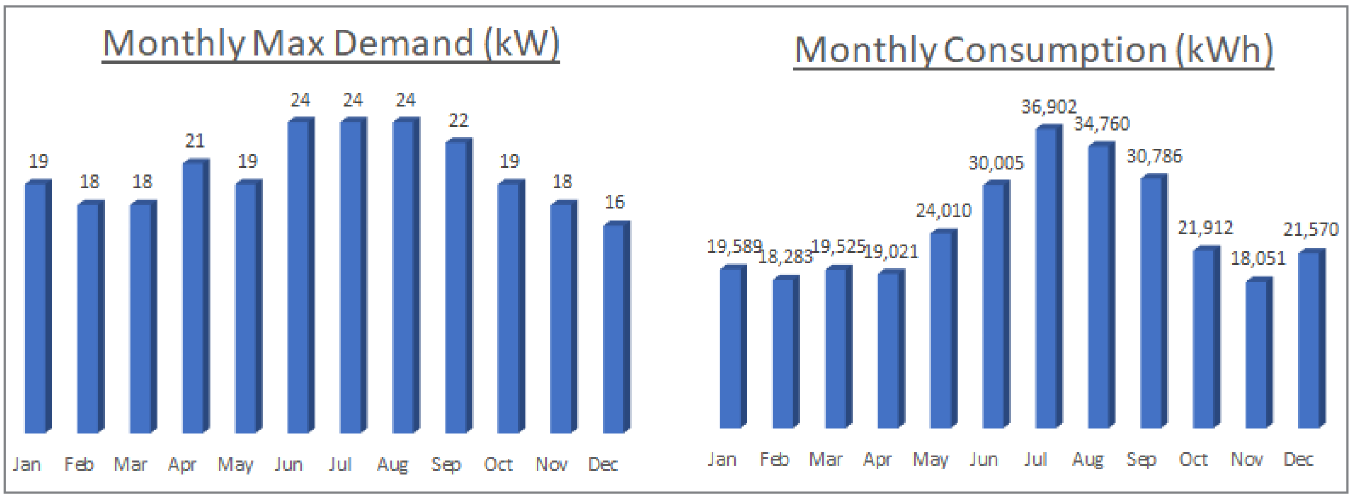

Figure A.22. Monthly Electricity Consumption and Peak Demands

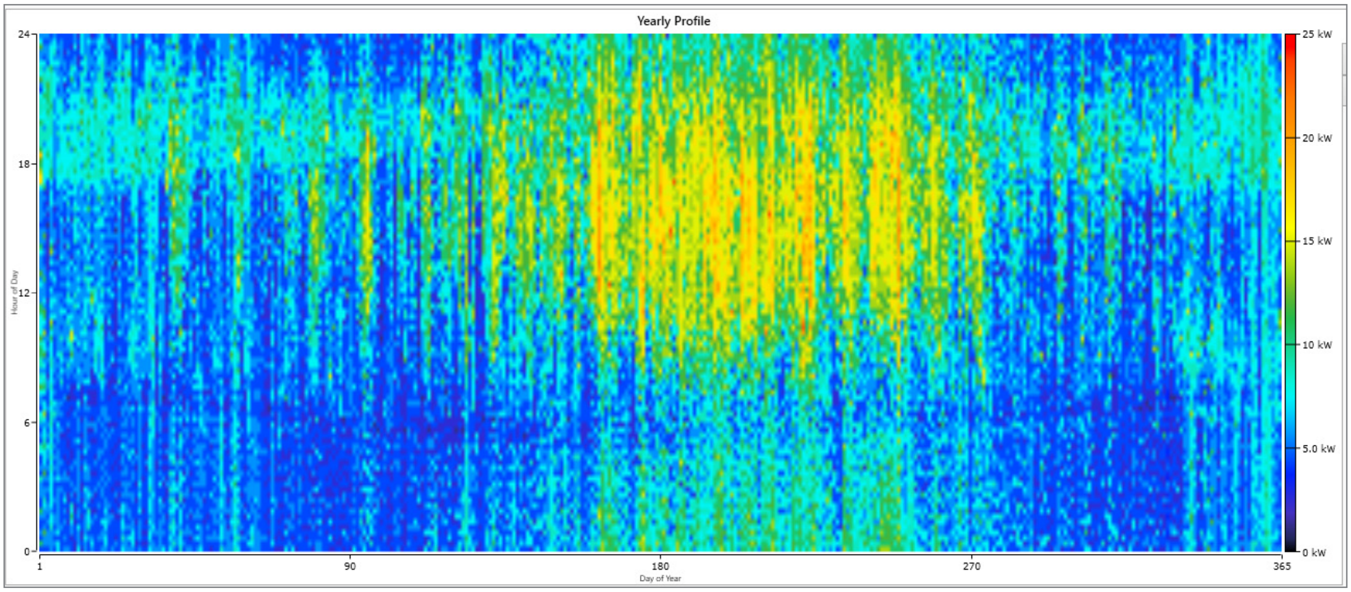

Figure A.23. Heat Map of the Jurupa Valley Fire Station 17 Electrical Load

To improve the resilience performance of the facility, it is proposed that on-site solar photovoltaics (PVs) be used as an additional source of power along with battery energy storage systems (BESS) and that various combinations and sizes be evaluated. The capacity of the existing (or planned) diesel generator is 24 kW. Figure A.24 shows the proposed locations for the solar PV arrays, which can accommodate a 55 kW PV system combined and also provide shaded parking areas for the staff.

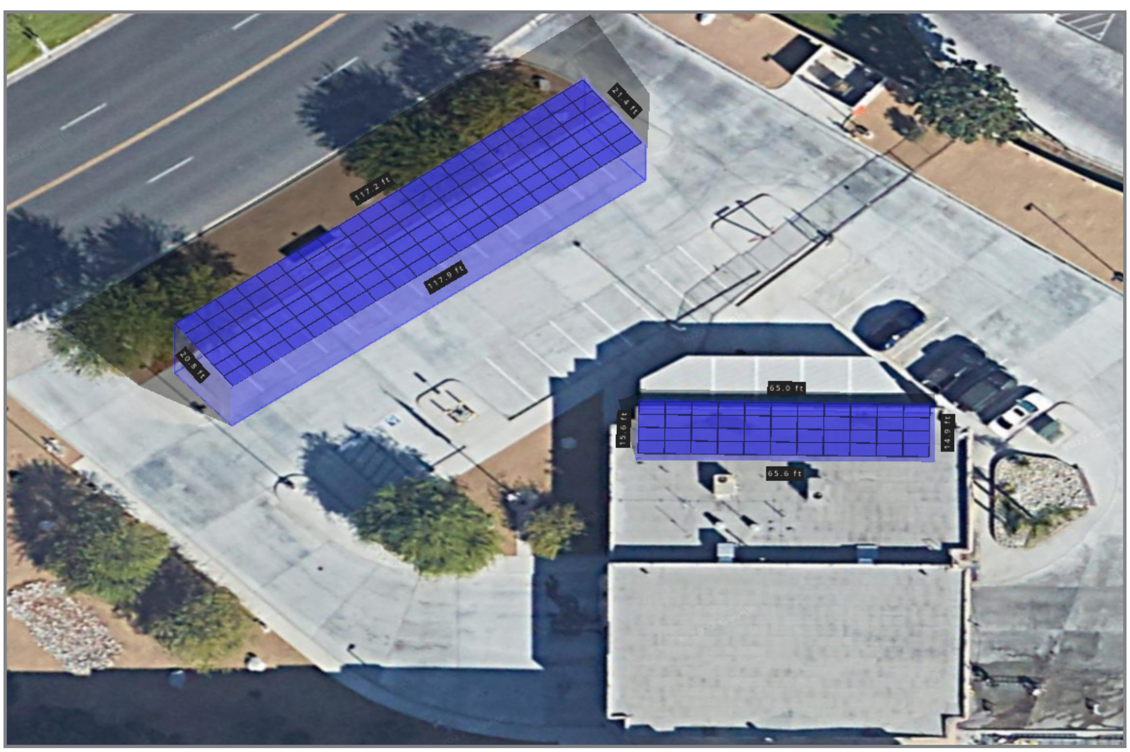

Figure A.24. Jurupa Valley Fire Station 17 - PV System Location

For the purpose of this analysis, 100% of the facility load is assumed to be critical. That is particularly important in how the HOMER tools will treat the load in terms of resilience requirements, which would directly impact how the microgrid components are sized and operated. In this case study, no down time is allowed, and the tool will develop the system such that all the loads are met at all the time throughout the year even in case of prolonged grid outages. Figure A.25 schematically shows the main components and connections of the developed microgrid for Jurupa Valley Fire Station 17.

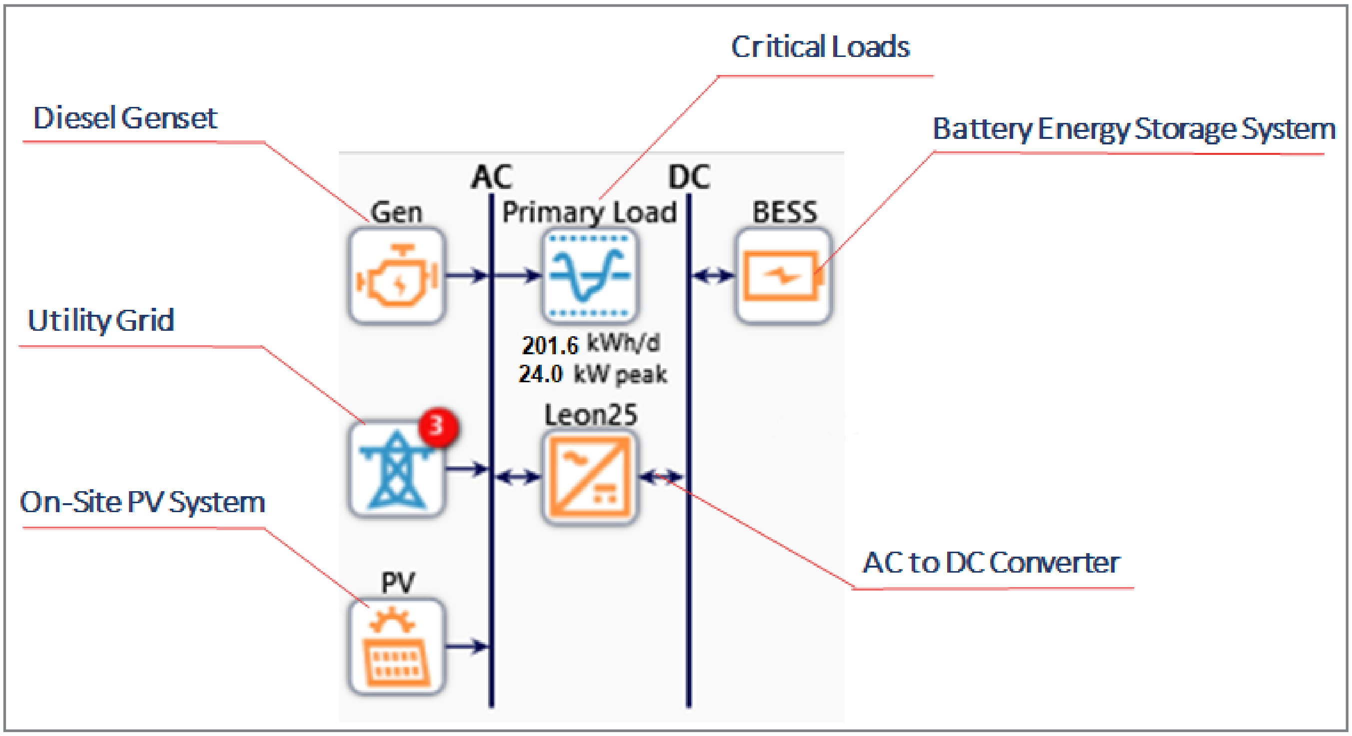

Figure A.25. Jurupa Valley Fire Station 17 - Microgrid Architecture and Components

To evaluate reliability and resilience of the facility, grid outages should be modeled, and the system respond to such outages to be evaluated. Towards that end, frequency and duration of power outages are needed as input to the software model. Statistics of the past grid outages is available at city level through SEC reliability reports.[7] SAIFI and SAIDI numbers, representing average frequency of sustained interruptions and average duration of sustained interruptions respectively, were used in this study According to the historical reliability of SEC circuits serving the Jurupa Valley for 2021, the SAIDI has been 891 minutes and the SAIFI has been 2.7 outages. Therefore, it was assumed that the system would have to endure 2.7 outages per year, each of which would be 5.5 hours long.

The distribution of these outages will be randomly selected by the software; one example is shown in Figure A.26. Depending on the reliability requirements set for the facility, the software will size the solar and battery system such that those requirements are met at all times. In this case study, we assumed that 100% of the plant load is critical and should be covered throughout the year, i.e., no down time or degradation of performance is allowed.

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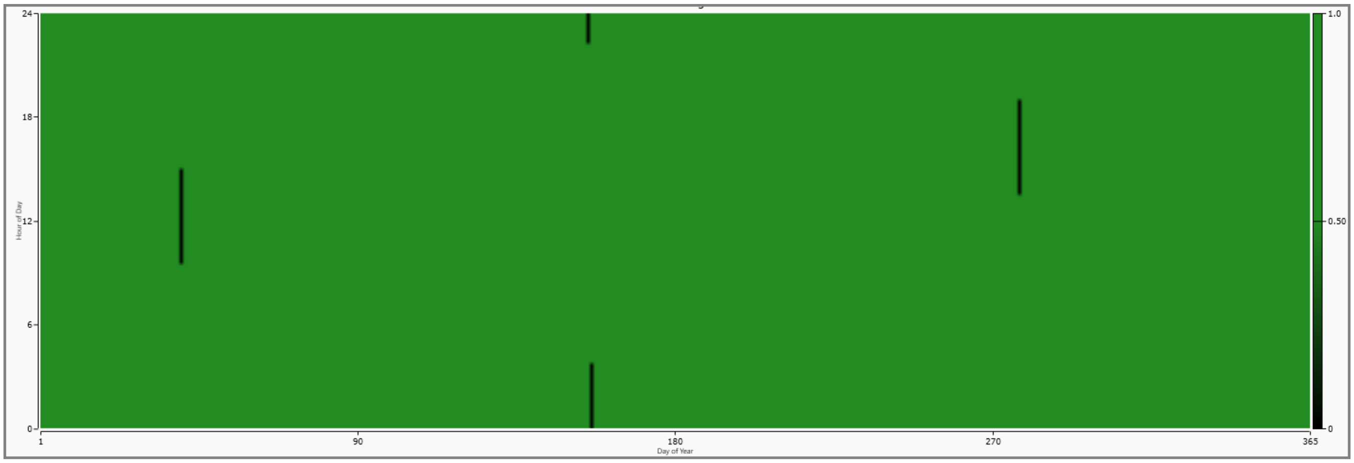

Figure A.26. Jurupa Valley Fire Station 17 - Random Distribution of Outages Throughout the Year

Results and Recommendations

Feasible solutions for the Jurupa Valley Fire Station 17 are summarized in Table A 4. These solutions essentially include those system sizes and combinations, referred to as system Architectures, that are capable of meeting the critical loads during the defined outage scenarios. Each battery pack has the rated capacity of 10.5 kWh/10.5 kW, and the software will come up with the optimum number of packs for each system architecture.

Table A.4. Jurupa Valley Fire Station 17 - Microgrid Modeling Results

Architecture				Cost				System		
Scn.	PV (kW)	Generator (kW)	BESS (kWh/kW)	NPC ($)	LCOE ($/kWh)	Capital Expense ($)	Simple Payback (year)	Renewable Fraction (%)	Generator Hours	BESS Autonomy (hour)
1	55	24	-	$62.5 k	0.042	$108.6 k	8.1	74.5	17	-
2	**55**	**24**	**10.5/10.5**	**$98.6 k**	**0.067**	**$131.4 k**	**10.9**	**74.9**	**16**	**1**
3	-	24	-	$107.7 k	0.150	$0	-	0	31	-
4	-	24	10.5/10.5	$143.6 k	0.199	$22.8 k	-	0	33	1

These feasible scenarios are ranked based on the net present costs (NPC).[8] Scenario 3 represents the baseline scenario and has the third-best NPC. Scenario 2 consists of solar PVs, BESS, and diesel generators; this combination provides multiple benefits in terms of resilience performance and integration of renewable energy. Availability of multiple power sources improves the system flexibility and thereby enhance resilience against power outages. In case of future outages become longer and more frequent, the system would be able to sustain critical operations for longer periods compared to other scenarios investigated here; in other words, reduced generators runtime for scenario 2 compared with other scenarios can be translated to less reliance on diesel fuel, less maintenance, and longer lifetime for the diesel generators. Scenario 2 will also result in a better economic performance compared to the baseline case; for those reasons, and considering that it has lower GHG emissions, Scenario 2

8 Analysis was undertaken based upon equipment cost only. To take into consideration the total project cost, a premium of 30%-40% should be added

is the proposed option for improving resilience posture of the system. Implementation of BESS would provide more flexibility in demand management and could reduce demand charges on utility bills. The single-line diagram of the proposed system is shown in Figure A.27.

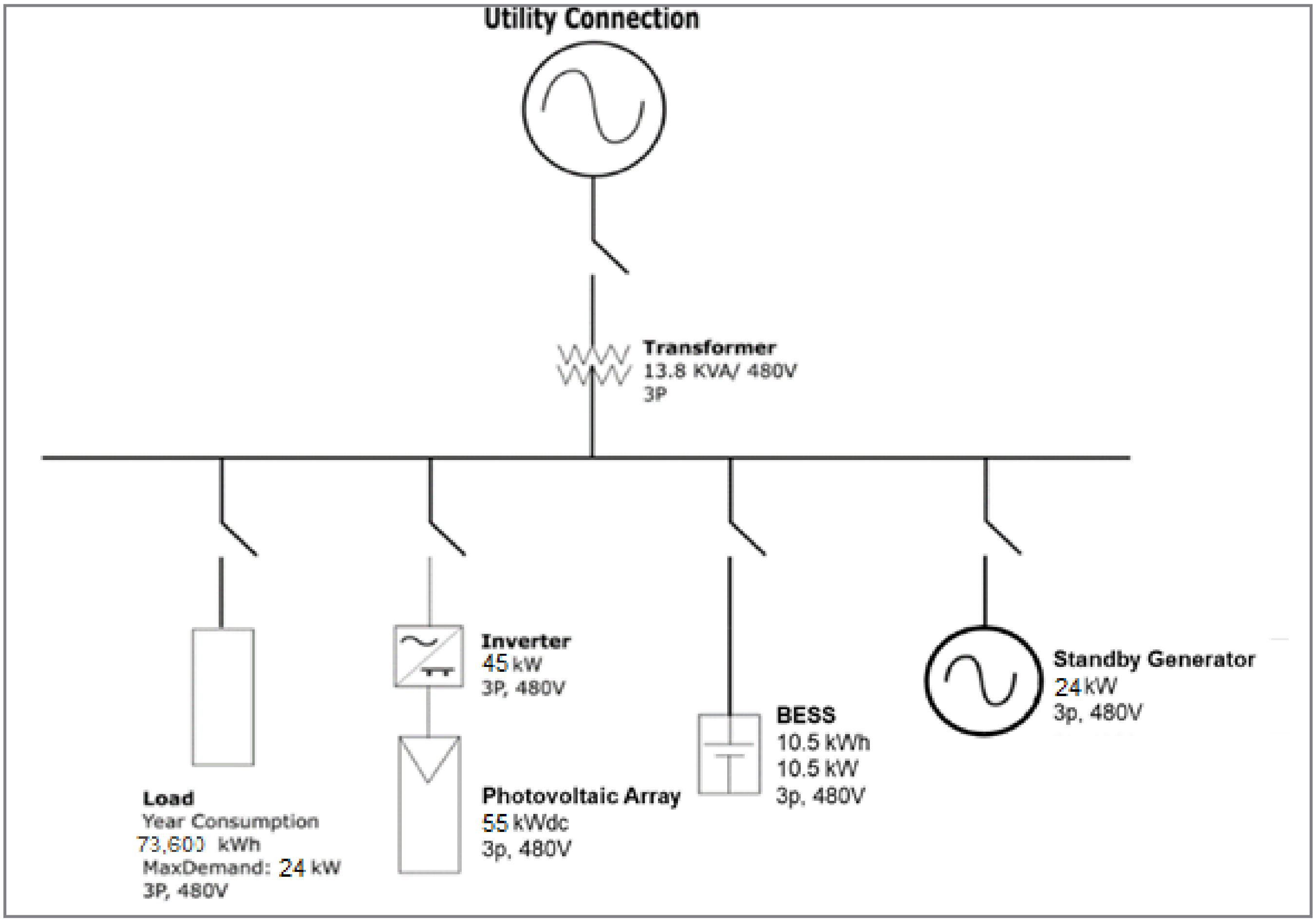

Figure A.27. Single-line Diagram of the Proposed System for Jurupa Valley Fire Station 17

Appendix B.
Critical Facility Questionnaire

WRCOG Critical Assets- Questionnaire

[NAME OF JURISDICTION]

	Guidance	Facility 1	Facility 2	Facility 3	Facility 4
Facility Name	*As extracted from the WRCOG Regional Facility List spreadsheet circulated earlier; add/modify list as needed.*	**[FACILITY NAME]**	**[FACILITY NAME]**	**[FACILITY NAME]**	**[FACILITY NAME]**
FACILITY OVERVIEW					
Facility Type	*As extracted from the WRCOG Regional Facility List spreadsheet circulated earlier; add/modify list as needed.*				
Services Provided	*As extracted from the WRCOG Regional Facility List spreadsheet circulated earlier; add/modify list as needed.*				
No. of people served	*On average, how many people does this facility serve under normal operations? Select range from dropdown menu.*				
Facility Age	*Select from dropdown menu.*				
HAZARD SENSITIVITY					
Air Quality	*Identify degree of sensitivity against each threat, by selecting one of the following options from the dropdown menu:* ***Low*** ***Medium*** ***High***				
Drought					
Flooding					
Human Health Hazards					
Extreme Temperature (heat waves, cold snaps)					
Wildfire					
Other?	*Note any additional remarks on threat probability and consequence*				

	Guidance	*Facility 1*	*Facility 2*	*Facility 3*	*Facility 4*
Facility Name	*As extracted from the WRCOG Regional Facility List spreadsheet circulated earlier; add/modify list as needed.*	**[FACILITY NAME]**	**[FACILITY NAME]**	**[FACILITY NAME]**	**[FACILITY NAME]**
MOST CRITICAL ENERGY NEEDS					
Computers/ Other Equipment	*Identify most prioritized energy needs for the facility by selecting "X" where applicable. Leave other fields blank.*				
Space conditioning (heating/cooling)					
Lighting					
Communications/ Server Rooms (including ltg, clg etc)					
Security					
Other?	*Note any additional remarks on critical energy needs here*				
AVAILABILITY REQUIREMENTS					
Computers/ Other Equipment	*Identify availability requirements to meet the most critical energy needs by selecting one of the following options from the dropdown menu:* ***Uninterruptible :*** *Eg-24x7, no downtime at all; Eg- 911 call center comms* ***Essential*** *: Eg- can afford minor downtime, Eg- fire station* ***Non-Essential*** *: Eg: can afford downtime, can stay offline for a few hours without major impact, Eg- Contracting office* ***Not Applicable***				
Space conditioning (heating/cooling)					
Lighting					
Communications/ Server Rooms (including ltg, clg etc)					
Security					
Additional remarks	*Note any additional remarks on availability requirements can be entered here*				

	Guidance	Facility 1	Facility 2	Facility 3	Facility 4
Facility Name	*As extracted from the WRCOG Regional Facility List spreadsheet circulated earlier; add/modify list as needed.*	**[FACILITY NAME]**	**[FACILITY NAME]**	**[FACILITY NAME]**	**[FACILITY NAME]**
EXISTING INFRASTRUCTURE					
Electrical/Power System Condition	*Select from dropdown menu*				
HVAC System Condition	*Select from dropdown menu*				
Backup Generators	*Identify if facility has backup generators that support facility load, in part or in full, from dropdown selection*				
Fuel storage tanks	*Identify if facility has fuel storage tank, from dropdown selection*				
Power conditioning systems (UPS)	*Identify if facility has UPS supporting critical loads of the concerned facility, from dropdown selection*				
Renewable energy supply	*Identify if facility has solar PV or other forms of renewable energy, from dropdown selection*				
Battery energy storage	*Identify if facility has battery energy storage systems, from dropdown selection*				
Multiple power feeds	*Identify if facility has multiple power feeds, from dropdown selection*				
Opportunity for alternative technologies	*Identify if alternate energy on site can be an option, or if there is room to expand current alternative systems. Enter response in words.*				
Additional remarks	*Any additional remarks on current infrastructure or on any of the above can be entered here. Note any issues related to backup power, power outages, or power quality*				
What are the key challenges you anticipate in implementing resilience measures on this site ?	*Enter response in words. Mention any key pain points, if they exist, specific to the facility or region.*				

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Appendix C.
Asset Prioritization Matrix

WRCOG Facility Prioritization Matrix

All responses translated from questionnaire and coded per category as highlighted in this row (Low → High)

Category	Attribute	Coding	Attribute weight
Community Value (Social Vulnerability) — The scale and vulnerability of the community served by the asset/facility.	People served	<100=1, 100-1k=2, 1k-10k=3, >10k=4	1.25
	Socioeconomic Status	4 percentiles [highest (4) to lowest (1)]	
	Household Composition & Disability		
	Minority Status & Language		
	Housing & Transportation		
	Overall Social Vulnerability		1.25
Operational Needs (Energy Needs & Availability Requirements) — The requirements for energy at the at the facility to maintain function.	Relocatability	Y=1, N=3	1.4
	Computers/ Other Equipment	Uninterruptible=3, Essential=2, Non-essential=1, N/A= 0	1.4
	Space conditioning (heating/cooling)		1.4
	Lighting		1.4
	Communications/ Server Rooms (including		1.4
	Security		1.4
Physical Hazard Sensitivity — The scale and nature of the physical threats to the asset/facility.	Air Quality	High=3, Medium=2, Low=1, N/A=0	2.0
	Drought		2.0
	Human Health Hazards		2.0
	Flooding		2.0
	Extreme Temperature (heat waves, cold		3
	Wildfire		2.3
Existing Infrastructure — The asset's/facility's existing systems which influence its ability to operate	Facility age- Old /Avg/New	<10 yrs=1, 10-40yrs	0.5
	Electrical/Power system condition	Poor=3, Avg/Fair=2, Good=1	1
	HVAC systems		1
	Backup Generators	No=3, Yes-P=2, Yes-	1
	Fuel storage tanks	Yes=1, Yes w/gap=2, No=3, Not needed= blank/0	0.81
	Power conditioning systems (UPS)		0.81
	Renewable energy supply		0.81
	Battery energy storage		0.81
	Multiple power feeds		0.81
	Opportunity for alternative technologies		0.81
TOTAL SCORE		Max=100	

Facility Overview

Agency	Facility name	Building Type	Services Provided	TOTAL SCORE
CORONA	Wells 7, 8, 9A, 11, 12, 13, 14, 15, 17, 1	Water Wells	Groundwater pumped for treatment used as potable wat	86
BEAUMONT	Beaumont Fire Station	Fire Station	Emergency ops	83
CORONA	Desalter	Potable WTP	Potable water treatment for distribution	82
CORONA	Sierra del Oro Treatment Plant	Potable WTP	Potable water treatment for distribution	81
CORONA	Garretson Blending Station	Blending station	Blend multiple sources of potable water for distribution	81
CORONA	Water Reclamation Facility 1	Water Reclamation	WWT to be used as reclaimed water	81
CORONA	Lester Water Treatment Plant	Potable WTP	Potable water treatment for distribution	80
CORONA	15 Wastewater Lift Stations	Lift station	Lift station	80
CORONA	Water Reclamation Facility 2	Water Reclamation	WWT to be used as reclaimed water	80
BEAUMONT	Beaumont Police Station	Police Station	Emergency ops	80
JURUPA VALLEY	County Sheriff's Station	Police Station	Emergency ops	79
CORONA	Mangular Blending Station	Blending station	Blend multiple sources of potable water for distribution	79
CORONA	Water Reclamation Facility 3	Water Reclamation	WWT to be used as reclaimed water	79
BEAUMONT	City of Beaumont WWTP	WWTP	24/7 WWT	78
JURUPA VALLEY	County Fire Station 18	Fire Station	Emergency ops	77
JURUPA VALLEY	County Fire Station 16	Fire Station	Emergency ops	77
JURUPA VALLEY	County Fire Station 38	Fire Station	Emergency ops	75
BANNING	Water Canyon Production Wells	Water production well	Wells in water canyon to provide city water	74
BEAUMONT	Four Seasons Lift Station	WW Pump Station	Lift station	73
JURUPA VALLEY	County Fire Station 17	Fire Station	Emergency ops	73
BEAUMONT	Beaumont Mesa Lift Station	WW Pump Station	Lift station	73
RIVERSIDE	Riverside Water Quality Control Plant	Sewer treatment plant	Sewer treatment plant for potable use	72
BEAUMONT	Noble Creek Lift Station	WW Pump Station	Lift station	71
BEAUMONT	Marshall Creek Lift Station	WW Pump Station	Lift station	71
MURRIETA	Murrieta Fire Station 5	Fire Station	Emergency ops	70
MENIFEE	Fire Station #68	Fire Station	Emergency response	70
MENIFEE	Kay Ceniceros Senior Center	Senior Center	Senior center and shelter	69
MURRIETA	Murrieta Fire Station 2	Fire Station	Emergency ops	69
MENIFEE	City Hall	City Hall	City service hall	69
RIVERSIDE	Wood Rd Swer Lift Station	Lift station	Lift station	69
BEAUMONT	Upper Oak Valley Lift Station	WW Pump Station	Lift station	69
BEAUMONT	San Timoteo Repeater	Comms	Control/Comm for sewer conveyance	68
RIVERSIDE	Emergency Operation Center (EOC)	EOC	Emergency ops	68
BANNING	Wastewater Treatment Plant	WWTP	WWT for percolation ponds	68
TEMECULA	CalFIRE Station 12	Fire Station	Emergency ops	68
MURRIETA	Murrieta Fire Station 1/Admin	Fire Station	Back-up EOC	68
MENIFEE	Maintenance and Operations Center	Department ops center (D	DOC location during rainstrom/flooding	68
BEAUMONT	Fairway Canyon Lift Station	WW Pump Station	Lift station	68
MURRIETA	Murrieta Fire Station 3	Fire Station	Emergency ops	68
BEAUMONT	Albert A. Chatigny, Sr. Community Re	Community Center	Emergency center, heat/cool center, children/senior serv	67
MURRIETA	Murrieta Fire Station 4	Fire Station	Emergency ops	67
BEAUMONT	Seneca Springs Lift Station	WW Pump Station	Lift station	67
MURRIETA	Murrieta Senior Center	Senior Center	Senior center and cool/heat center	67
MURRIETA	Murrieta Community Center	Community Center	Services for children/adults	66

WRCOG Facility Prioritization Matrix

Agency	Facility name	Building Type	Services Provided	People served	Socioeconomic Status	Household Composition & Disability	Minority Status & Language	Housing & Transportation	Overall Social Vulnerability	Relocatability	Computers/ Other Equipment	Space conditioning (heating/cooling)	Lighting	Communications/ Server Rooms (including	Security	Air Quality	Drought	Human Health Hazards	Flooding	Extreme Temperature (heat waves, cold	Wildfire	Facility age- Old /Avg/New	Electrical/Power system condition	HVAC systems	Backup Generators	Fuel storage tanks	Power conditioning systems (UPS)	Renewable energy supply	Battery energy storage	Multiple power feeds	Opportunity for alternative technologies	TOTAL SCORE
Facility Overview				Community Value (Social Vulnerability) *The scale and vulnerability of the community served by the asset/facility.*						Operational Needs (Energy Needs & Availability Requirements) *The requirements for energy at the at the facility to maintain function.*						Physical Hazard Sensitivity *The scale and nature of the physical threats to the asset/facility.*						Existing Infrastructure *The asset's/facility's existing systems which influence its ability to operate*										
All responses translated from questionnaire and coded per category as highlighted in this row (Low – High)				<100=1 100-1k=2 1k-10k=3 >10k=4	4 percentiles [highest (4) to lowest (1)]					Y=1 N=3	Uninterruptible=3 Essential=2 Non-essential=1 N/A= 0					High=3 Medium=2 Low=1 N/A=0						<10 yrs=1 10-40yrs	Poor=3 Avg/Fair=2 Good=1		No=3 Yes-P=2 Yes-	Yes=1 Yes w/gap=2 No=3 Not needed= blank/0						Max=100
			Attribute weights listed in this row	1.25					1.25	1.4	1.4	1.4	1.4	1.4	1.4	2.0	2.0	2.0	2.0	3	2.3	0.5	1	1	1	0.81	0.81	0.81	0.81	0.81	0.81	
BEAUMONT	Lower Oak Valley Lift Station	WW Pump Station	Lift station																													66
JURUPA VALLEY	Jurupa Valley City Hall	Admin	City service hall																													66
RIVERSIDE	Janet Goeske Senior Center	Senior Center	Senior center																													65
RIVERSIDE	Ysmael Villegas Community Center	Community Center	Service for children/adults																													65
MURRIETA	Murrieta Police Department	Police Station	Emergency ops																													65
WILDOMAR	Fire Station #61	Fire Station	Emergency ops																													64
MURRIETA	Murrieta Youth Center	Youth Center	Services for children																													63
TEMECULA	Temecula Field Operations Center	Field ops	Response ops, response equipment location																													63
TEMECULA	Mary Phillips Senior Center	Senior Center	Cool/heat center																													62
TEMECULA	Temecula City Hall	EOC	Emergency ops																													62
BANNING	Westward Lift Station	Lift station	Lift station																													61
WILDOMAR	City Hall	City Hall	EOC																													61
JURUPA VALLEY	City of Jurupa Valley, Fleet Maintenar	Maintenance	Field/Maintenance/Facilities Maintenance staff use																													61
EASTVALE	Fire Station 27	Fire Station	Fire Service																													61
EASTVALE	Fire Station 31	Fire Station	Fire Service																													60
JURUPA VALLEY	City of Jurupa Valley, Eddie D. Smith S	Senior Center	Senior center and shelter																													60
BANNING	Community Center	Community and senior cen	Cool center, services for seniors																													59
MENIFEE	Lazy Creek Recreational Center	Rec Center	Service for children																													58
WILDOMAR	Facility #4	Cooling center	Cool center																													57
BANNING	Banning Police Station	Police Station	Emergency ops																													57
TEMECULA	Temecula Community Recreation Cen	Community Center	Services for children/adults and emergency shelter																													57
MORENO	City of Moreno Valley Senior Center	Senior center	daily access and services for seniors, cooling center																													53
MORENO	City of Moreno Valley EOC	Emergency Operations Cer	emergency response central command																													51
MORENO	City of Moreno Valley CRC	Community center /emerg	emergency shelter for disasters, COOL center																													50
LAKE ELSINORE	Senior Center	cooling center	lunch service, cooling center																													45
LAKE ELSINORE	Planet Youth/ Tiny Tots	child care, school	child care, school																													44
LAKE ELSINORE	Neighborhood Center	child care, cooling center	child care, activities for kids																													44
WILDOMAR	Facility #3	Traffic Signals-citywide																														37

Appendix D.
Energy Resilience Strategies

Table D.1. Energy Resilience Strategies

Strategy	Category	Resource	Resilience Attribute	Considerations
Dispatchable Power (Backup Generator)	Backup Power	• Power	• Energy Source Diversity • Load Sustainment Capacity	• Outdoor space with clearances • Ventilation requirements • Air quality requirements • Noise requirements • Fuel storage capacity (runtime requirement) • Critical loads (for generation capacity) • Dedicated emergency circuits • Weatherproofing requirements • Generator testing
Critical Load Uninterruptible Power Supply (UPS) System	Backup Power	• Power	• Load Sustainment Capacity • Islanding Capabilities, Analytics, and Controls	• Space availability • Runtime requirement • Dedicated emergency circuits • Maintenance
Portable Generator Quick-Connect	Backup Power	• Power	• Energy Source Diversity • Load Sustainment Capacity	• Dedicated emergency circuits • Space availability • Electrical panel capacity
On-site Solar Photovoltaics (PVs)	Energy Supply	• Power	• Energy Source Diversity	• Rooftop/Parking Area • Circuit capacity • Structural support • Shading/glare • Solar rate riders and net-metering tariffs • Ability to operate in island-mode
Other Alternative Energy Generation	Energy Supply	• Power	• Energy Source Diversity	• Alternative energy opportunity assessment required
Battery Energy Storage System	Energy Storage	• Power	• Energy Demand Reduction • Load Sustainment Capacity • Energy Source Diversity • Islanding Capabilities, Analytics, and Controls	• Space availability • Circuit capacity • Advanced controls • Utility tariff structure • Battery storage sizing • Ability to operate in island-mode
Fuel Storage for Dispatchable Power	Energy Storage	• Power	• Load Sustainment Capacity	• Space availability • Secondary containment • Surface or subsurface storage requirements • Fire/explosives safety requirements (for alternative fuels)

Strategy	Category	Resource	Resilience Attribute	Considerations
Thermal Energy Storage	Energy Storage	• Heating • Cooling	• Energy Demand Reduction • Thermal Load Sustainment Capacity	• Space availability • Heating or cooling demand profiles • Utility tariff structure • Critical thermal loads • Thermal storage sizing
Building Envelope Sealing	Energy Conservation	• Heating • Cooling	• Energy Demand Reduction	• Energy savings payback • Expected useful life (EUL) remaining for envelope
Heating, Ventilation, and Air Conditioning (HVAC Performance Upgrades	Energy Conservation	• Heating • Cooling	• Energy Demand Reduction	• Energy savings payback • Expected useful life (EUL) remaining of mechanical system • Building system controls capability
Lighting Performance Upgrades	Energy Conservation	• Power	• Energy Demand Reduction	• Type of existing lighting fixtures • Energy savings payback • Building system controls capability
System Recommissioning and Rebalancing	Energy Conservation	• Heating • Cooling	• Energy Demand Reduction	• Energy savings payback • Age of existing mechanical system • Building system controls capability
Energy Demand Forecasting	Energy Conservation	• Power • Heating • Cooling	• Energy Demand Reduction • Islanding Capabilities, Analytics, and Controls	• Building system monitoring capability • Building system controls capability
Building System Monitoring and Controls	Energy Management and Controls	• Power • Heating • Cooling	• Cybersecurity of Energy Systems • Islanding Capabilities, Analytics, and Controls	• Age of existing mechanical system • Existing communications network
Energy Management Personnel	Energy Management and Controls	• Power • Heating • Cooling	• Energy Demand Reduction • Personnel Availability for Assessment and Repair	• Complexity of building energy systems • Energy savings potential • Difference in critical and non-critical loads
Microgrid Controls System	Energy Management and Controls	• Power	• Islanding Capabilities, Analytics, and Controls	• On-site energy generation opportunity • On-site energy storage opportunity • On-site dispatchable power capacity • Building system controls capability • Difference in critical and non-critical loads

Strategy	Category	Resource	Resilience Attribute	Considerations
Priority Load-Shedding Protocol	Energy Management and Controls	• Power • Heating • Cooling	• Emergency Management Protocols	• Building system controls capability • Difference in critical and non-critical loads
Graceful Shutdown Procedures	Energy Management and Controls	• Power	• Emergency Management Protocols	• Difference in critical and non-critical loads • Uninterruptible power requirement • Ability to relocate critical functions to another location
Energy Communications Network Encryption	Energy Management and Controls	• Power • Heating • Cooling	• Cybersecurity of Energy Systems	• Existing communications network • Desired building monitoring and controls capability
Isolated Energy Communication Strands	Energy Management and Controls	• Power • Heating • Cooling	• Cybersecurity of Energy Systems	• Existing communications network • Desired building monitoring and controls capability
Cybersecurity Authorization Protocol	Energy Management and Controls	• Power • Heating • Cooling	• Cybersecurity of Energy Systems	• Existing communications network • Typology of new equipment to be installed on site
Remote Alerts for Building Systems	Energy Management and Controls	• Power • Heating • Cooling	• Cybersecurity of Energy Systems • Personnel Availability for Assessment and Repair	• Existing communications network • Desired building monitoring and controls capability • Maintenance personnel location (on- or off-site)
Dedicated Emergency Circuits	Power Distribution	• Power	• Load Sustainment Capacity	• Difference in critical and non-critical loads • On-site energy generation opportunity • On-site dispatchable power capacity
Sufficient Power Circuit Capacity	Power Distribution	• Power	• Load Sustainment Capacity	• Facility age and condition • History of change in facility use
Adequate Power Circuit Condition	Power Distribution	• Power	• Equipment, Parts and Procurement	• Facility age and condition • Preventative maintenance on power systems
Redundant Power Supply Paths	Power Distribution	• Power	• Redundant Supply Paths	• Uninterruptible power requirement • Power utility relationship
Hardened Power Supply Paths	Power Distribution	• Power	• Physical Hardening	• Power utility relationship • Hazard threat profile
Critical Cooling Capacity	Mechanical Systems	• Cooling	• Thermal Load Sustainment Capacity	• Criticality of cooling loads • Facility age and condition • History of change in facility use

Strategy	Category	Resource	Resilience Attribute	Considerations
Critical Heating Capacity	Mechanical Systems	• Heating	• Thermal Load Sustainment Capacity	• Criticality of heating loads • Facility age and condition • History of change in facility use
Adequate HVAC System Condition	Mechanical Systems	• Heating • Cooling	• Equipment, Parts and Procurement	• Facility age and condition • Preventative maintenance on HVAC systems
Simplified HVAC Systems	Mechanical Systems	• Heating • Cooling	• Equipment, Parts and Procurement	• Facility age and condition • History of change in facility use • Expected useful life (EUL) remaining of mechanical system
HVAC System Redundancies	Mechanical Systems	• Heating • Cooling	• Redundant Supply Paths • Equipment, Parts and Procurement	• Criticality of heating and cooling loads • Existing mechanical system layout (e.g., ducting)
Portable HVAC System Tie-in Connection	Mechanical Systems	• Heating • Cooling	• Energy Source Diversity • Equipment, Parts and Procurement	• Mechanical system type (e.g., hydronic) • Mechanical room location
Regular Generator Testing	Maintenance	• Power	• Energy Management Protocols • Equipment, Parts and Procurement	• Availability of maintenance personnel
Regular UPS Maintenance and Testing	Maintenance	• Power	• Emergency Management Protocols • Equipment, Parts and Procurement	• Availability of maintenance personnel • Existing contracts with vendor
Preventative Maintenance on Power Systems	Maintenance	• Power	• Personnel Availability for Assessment and Repair • Equipment, Parts and Procurement	• Availability of maintenance personnel • Power system ownership demarcation point
Preventative Maintenance on HVAC Systems	Maintenance	• Heating • Cooling	• Personnel Availability for Assessment and Repair • Equipment, Parts and Procurement	• Availability of maintenance personnel
Critical Spare Parts Supply	Maintenance	• Power • Heating • Cooling	• Equipment, Parts and Procurement	• Space availability • Price and lead time of replacement parts
Contractor Emergency Availability Protocol	Maintenance	• Power • Heating • Cooling	• Personnel Availability for Assessment and Repair	• Ownership structure of electrical and mechanical systems
Defined Repair and Recovery Response Protocols	Maintenance	• Power • Heating • Cooling	• Personnel Availability for Assessment and Repair	• Disaster recovery exercises • Coordinated response team personnel
Defined Generator Refueling Protocols	Maintenance	• Power • Heating • Cooling	• Personnel Availability for Assessment and Repair	• Ownership structure of backup power system • Off-site fuel resupply source • Refueling assets

Appendix E.
Funding and Financing Strategies

The available funding and financing strategies identified in this chapter support the electrification of and resilience planning for critical facilities in the WRCOG region, with an emphasis on inclusion of energy storage for emergency response. This chapter summarizes key considerations for developing funding strategies for resiliency efforts, as well as grants and other funding and financing tools that are currently available to fund capital-intensive energy resiliency projects and ongoing policies and programs.

E1. Key Considerations for Developing Funding and Financing Strategies

The following section will contain high-level descriptions of the difference between funding and financing types, revenue-generating tools, and the potential role of local and regional stakeholders in the implementation process.

Funding versus Financing

Energy resiliency projects often require a combination of funding and financing strategies. Funding includes revenue generated by a project (e.g., from electricity generated by a renewable energy project), taxes, and grants or incentives that do not need to be paid back. While many grants are very competitive and require a multiple-stage application process, some are allocated through state or federal formulas that consider factors such as population size, demographics, and various other forms of census data.

Financing, often accessed in the form of loans or bonds, is the incurrence of indebtedness to cover the initial costs of a project. Financing must be paid back with revenue, for example, from the sale of electricity back to the grid, incentives, or tax credits. A common example of financing for a renewable energy project is a solar power purchase agreement (PPA). Solar PPAs are a type of public-private partnership in which a developer covers most, if not all, of the cost associated with design, permitting, financing, and installation of a solar energy system on a customer's property. The developer will then provide the energy generated on-site to the customer at a cost lower than the typical utility's rate. The developer of the solar energy system will benefit from the income associated with the sale of electricity as well as any related tax credits and other incentives generated from the system. In addition to public-private partnerships, other financing opportunities may include revolving loan funds operated by the state and/or bond issuances.

Implementation and Governance

The facilities evaluated in this planning process are operated by a wide range of city and county agencies, including local Police (or County Sheriff), Fire, Wastewater, and Community Services Departments. Some of the fire stations evaluated are operated by the state (CalFIRE). In general, the agencies that own and operate facilities are likely to be the primary implementers of energy measures. Local governments are eligible to apply for most of the grants and incentives described below, to enter into PPAs or other public-private partnerships, and to access the other funding and financing tools described below.

However, the process for applying for competitive grants in particular is onerous. Larger cities and local governments that operate their municipal utilities are most likely to have the capacity to pursue state and federal grants independently. By partnering together, cities may help share the administrative burden and increase the competitiveness of grant applications. WRCOG can continue to play a valuable role in convening cross-agency partnerships, providing information about upcoming grant opportunities, and even serving as a co-applicant for specific grants that have a regional focus. Other important local partners include Southern California Edison (SCE), which (as discussed below) offers some incentive and financing programs for energy efficiency improvements.

E2. Funding and Financing Tools

Common funding and financing sources for energy resiliency projects and programs can be broadly categorized as (1) grants from local, state, and federal agencies, (2) financing tools and 3) local revenue sources. This section summarizes key funding and financing sources that are currently available to support implementation of WRCOG's regional resilience plan.

Grants and Incentives

In response to the COVID-19 pandemic and the increasing impacts of climate change, an unprecedented amount of federal and state funding is being made available to local governments for energy and resilience related projects, creating a once-in-a-generation opportunity to implement projects and programs that mitigate and adapt to climate change. At the same time, local agencies across the country are largely underfunded, which creates substantial competition for grant funding. The increasing frequency and intensity of extreme weather events have also increased local agency demand for grant dollars to mitigate climate change, prepare for future events, and support recovery from these events.

The grants summarized below are those that have the potential to fund WRCOG and member agencies' resiliency efforts. These efforts include improving resiliency to regional vulnerabilities, such as wildfire, drought, flooding, and extreme heat, and supporting the goal of long-term decarbonization.

State and Regional Grants

The State of California offers an array of mitigation and resilience-related grants for which WRCOG's Energy Resiliency Plan may be well-suited. In May 2022, Governor Newsom announced a record-breaking $32 billion increase in state funding over the next four years to address climate change, including emissions reduction, drought resilience and response, extreme heat, natural carbon sequestration, renewable energy, and energy resilience (Office of Governor Gavin Newsom, 2022). State grant programs that are earmarked to receive increased funding allocations because of this increased budget allocation are indicated with an asterisk.

Table E.1. State and Regional Grants Most Applicable to WRCOG Energy Resiliency Plan

Administering Organization	Program/Grant Name	Eligible Receiving Entities	Description	Eligible Uses	Funding Range	Type of Funding
California Governor's Office of Planning and Research (Cal OPR)	Adaptation Planning Grant Program*	Local, Regional, and Tribal Governments	Adaptation Planning Grant Program provides funding to help fill planning needs, provides communities the resources to identify climate resilience priorities, and support the development of a pipeline of climate resilient infrastructure projects across the state.	• Build community planning and capacity by supporting peer to peer learning/info sharing. • Multisector/issue planning. • Support communities faced with cascading and compound impacts of climate change.	$25 million (M) released in total through multiple rounds of funding.	Competitive
California Governor's Office of Planning and Research (Cal OPR)	Regional Resilience Planning and Implementation Grant Program*	Local, Regional, and Tribal Governments	This Program will support regions in advancing resilience through capacity-building, planning, and project implementation.	• Support regional projects that improve climate resilience and reduce risk from climate impacts. Including: wildfire, sea level rise, drought, flood, increasing temperatures, and extreme heat events.	$255M in federal funding (federal cost share) 25% local cost share ($85M set aside by FEMA to cover).	Reimbursement based; advanced funding on a case-by-case basis.
California Energy Commission (CEC)	Energy Partnership Program	Cities, Counties, County offices of Education, Special Districts, Public Hospitals, Public Care Facilities, Public Colleges or Universities	This Program offers services to help identify the most cost-effective, energy-saving opportunities for existing buildings and new construction. These funds may be used to conduct energy audits, prepare feasibility studies, and develop equipment performance specifications, among other construction related plans.	• Assist with contractor selection • Review commissioning plans. • Review equipment bid specifications. • Develop equipment performance specifications. • Review existing proposals and designs.	Up to $20,000 available per grantee.	Available, continuously open with final filing date. Closed once funding is expended.
California Governor's Office of Emergency Services (Cal OES)	PrepareCA Jumpstart	Local, Regional, and Tribal Governments	Provides technical assistance to develop local initiatives that primarily benefit eligible socially vulnerable and high hazard risk communities; and create resiliency through capacity building, mitigation, preparedness activities, education, response and recovery planning, and/or future project scoping.	• Evacuation planning – community education on mitigation. • Strengthening building codes. • Implementing a Community Emergency Response Team. • Establishing a data/fiscal management system.	$15M in state funding. Applications may not receive more than $1m in state funds.	Reimbursement based; advanced funding on a case-by-case basis.
California Resilience Challenge	California Resilience Challenge 2022 Grant Program	State communities	A statewide effort inviting local communities across CA to apply for funding for a project that addresses a unique climate threat: drought, fire, flood, or extreme heat.	• Differs case-by-case. • Santa Barbara County received an award to design two pilot climate resilience hubs that will provide safe refuge and critical services during emergencies.	$2M released in 2021, 2022 TBD.	Competitive
California Governor's Office of Emergency Services (Cal OES)	PrepareCA Match	Local, Regional, and Tribal Governments	Provides scoping/sub-application technical assistance to develop FEMA HMGP projects and activities that directly and primarily benefit socially vulnerable and high hazard risk communities.	• Address effects of future conditions such as climate change, demographics changes, population changes, and land-use changes. • Advance whole community risk reduction, including protecting access and functional needs.	$255M in federal funding (federal cost share) 25% local cost share ($85M set aside by FEMA to cover).	Reimbursement based; advanced funding on a case-by-case basis.
California Governor's Office of Planning and Research (Cal OPR)	Extreme Heat and Community Resilience Grant Program*	TBD. More information coming soon.	TBD. More information coming soon.	• TBD. More information coming soon.	TBD. More information coming soon.	TBD. More information coming soon.
Coachella Valley Mountains Conservancy	Climate Resilience and Community Access Grant Program	Nonprofit, Public Agency, Tribal Government	Seeks to invest in local conservation community by creating new programs or developing organizational or agency capacity to enhance desert resilience to climate change and foster conservation of the desert as a carbon sink.	• Enhance desert resilience to climate change. • Improve natural resources management.	Grants requests may range from $100-400,000 per grantee.	No minimum match, but applicants leveraging other funds will be preferred.
State Energy Resource Conservation and Development Commission	Community Energy Resilience Act of 2022 (Senate Bill 833)	TBD. More information coming soon.	Seeks to support local governments in developing community energy resilience plans that help achieve energy resilience objectives and state clean energy and air quality goals.	• TBD. More information coming soon.	TBD. More information coming soon.	TBD. More information coming soon.
California Department of Food and Agriculture (CDFA)	Fairground and Community Resilience Centers Program	Tribes, Community-based organizations, Nonprofits, Foundations, Public agencies, Financial institutions, small businesses, Private sector	The Fairground and Community Resilience Centers Program focuses on improving both local fairground and other community facilities to enhance the state's emergency preparedness capabilities, particularly in response to climate change.	• Infrastructure for emergency evacuation, shelter, base camps during emergency events, and critical deferred maintenance. (I.e., cooling and heating centers, clean air centers, and extended emergency evacuation response centers with kitchens, shower facilities, broadband, back-up power, etc.)	$38M of available funding.	TBD. Draft guidelines and details are currently being developed.

*These grants have been allocated funding through the 2022 California State Budget.

Administering Organization	Program/Grant Name	Eligible Receiving Entities	Description	Eligible Uses	Funding Range	Type of Funding
California Strategic Growth Council	Community Resilience Centers (CRC) Program	California Native American Tribes, Community-based organizations, Community development financial institutions, Faith-based organizations, Foundations, Joint powers authorities, Nonprofits, Libraries, Local government agencies, Schools, Small businesses	The CRC program funds new construction and upgrades of neighborhood-level resilience centers across the state that will support communities during climate and other disasters, as well as build long-term resilience, preparedness, and recovery operations for local communities.	• Comprehensive retrofits that support the resilience center's ability to provide shelter during an emergency (I.e., solar installation, energy and water efficiency appliances, etc.). • Upgrades to surrounding area that support accessibility and function of the center (I.e., community gardens, shade trees, low-carbon transportation, etc.) • Distribution of community services and resources such as food, clean water, and personal protective equipment. • Local workforce development and job force training programming.	$25M will be available in 2022-2023 fiscal year and $75M will be available in 2023-2024 fiscal year.	TBD. Draft guidelines and details are currently being developed.

Federal Grants

Federal grants tend to offer larger dollar amounts per grantee than state and local grants but often have more requirements and lengthier application processes, which can be resource-intensive for the applicant. Given this, federal grants are generally better suited for projects with a higher price tag, including regional projects, for which the grant can cover a significant portion. The federal grants that are most relevant to WRCOG's Energy Resiliency Plan are summarized in Table E.2. Many new and legacy federal grants have received an injection of funding through President Biden's Infrastructure Investment and Jobs Act (IIJA). These funding opportunities must be used in accordance with IIJA rules, such as domestically sourced construction materials and Justice 40 Initiative requirements.

In addition to pursuing competitive funding, WRCOG member agencies may also consider allocating federal formula funding to improve energy resilience. For example, funds already allocated to cities and counties from the American Rescue Plan Act (ARPA) through the Coronavirus State and Local Fiscal Recovery Fund could potentially be used to fund portions of energy resiliency projects, particularly projects related to water infrastructure or replacement of lost public sector revenue streams.[1] Other potential formula funding sources include the Energy Efficiency and Conservation Block Grant Program, which specifically calls out as an eligible use the development, implementation, and installation of renewable energy technologies on government buildings.

1 For example, the City of Riverside received $73,535,189 in ARPA funding, which the City had already allocated to various uses at the time of this publication. Any remaining funding, however, could be considered for this purpose.

Table E.2. Federal Grants Most Applicable to WRCOG Energy Resiliency Plan

Administering Organization	Program/Grant Name	Eligible Receiving Entities	Description	Eligible Uses	Funding Range	Type of Funding
Federal Emergency Management Agency (FEMA)	Building Resilient Infrastructure and Communities (BRIC)*	State, Tribal Government/ Organization, Local Government, For-Profit Entity, Public Agency/ Authority, Other, Utilities, Cooperative Organization	The BRIC program makes federal funds available to states, US territories, federally recognized Tribal governments, and local communities for hazard mitigation activities.	• Capability and capacity-building. (knowledge sharing, etc.) • Mitigation projects. (projects to increases resilience and public safety) • Management costs (indirect, direct, administrative expenses.)	State allocations - $56M. National competition for mitigation projects - $919M.	Competitive
United States Department of Energy (US DOE)	Program Updating our Electric Grid and Ensuring Reliability and Resiliency*	State, Tribal Government/ Organization, Local Government, US Territory	Provides federal financial assistance to demonstrate innovative approaches to transmission, storage, and distribution infrastructure to harden and enhance resilience and reliability.	• Innovative approaches for hardening efforts that enhance resilience and reliability. • Promotion of grid resilience by region.	$5B available in total with $1B appropriated annually for FY 2022-2026. Opens 3rd QTR, 2022.	Competitive, Cooperative Agreement, Other
Federal Emergency Management Agency (FEMA)	Hazard Mitigation Grant Program (HMGP)*	State, Tribal Government/ Organization	Hazard mitigation includes long-term efforts to reduce risk and the potential impact of future disasters. HMGP assists communities in rebuilding in a better, stronger, and safer way to become more resilient overall.	• Development and adoption of hazard mitigation plans (required to receive federal funding). • Structural resilience retrofits for buildings and utilities for resistance against hazards.	$3.46B available until expended.	Competitive. 75% federal and 25% local/state match requirement.
Energy Efficiency and Renewable Energy (EERE)	Energy Efficiency and Conservation Block Grant Program*	State, Tribal Government/ Organization, Local Government, County	This program assists states, local governments, and Tribes to reduce energy use, reduce fossil fuel emissions, and improve energy efficiency.	• Energy distribution technologies; distributed resource, district heating and cooling systems. • On-site renewables; solar energy, wind energy, fuel cells.	$550M available until expended. Applications 4th QTR, 2022.	Mix of competitive and formula grants.
Department of Agriculture, Forest Service	Community Wildfire Defense Grant Program for At-Risk Communities*	State, Tribal Government/ Organization, Local Government, Public Agency/Authority, Non-Profit	Provides grants to communities at risk from wildfire to develop or revise their community wildfire protection plans and carry out projects described within those plans.	• Under development. • Eligible to plan and implement fuels reduction strategies and drought mitigation.	Not to exceed $250,000 for planning or $10M for implementation per grantee.	Mix of competitive and formula grants.
Federal Grant, disbursed through State	Building Codes Implementation for Efficiency and Resilience*	States and State Partnerships	Enables sustained, cost-effective implementation of updated building energy codes to save customers money on their energy bills.	• Meeting updated building energy codes in a cost-effective manner. • Address implementation needs in both urban and suburban areas. • See sources for all eligible uses.	$225M available until expended.	Competitive
US Department of Housing and Urban Development (HUD)	Community Development Block Grant (CDBG)	Metropolitan Statistical Areas (MSAs), Cities with a Minimum Population of 50,000, Urban Counties with a Minimum Population of 200,000	To develop viable urban communities by providing decent housing and a suitable living environment, and by expanding economic opportunities, principally for low- and moderate-income persons.	• Flexible funding to meet multi-sector/issue planning needs that intersect with climate risks. • Planning and responding to cascading and compound impacts of climate change.	$8.7B allocated for FY 2022. Minimum request of $100,000 and has no ceiling limit.	Mix of competitive and formula grants. 70% of funds must be used to benefit low- and moderate-income persons.

*These grants have been allocated additional funding through IIJA.

Utility and Tax Incentives

The state and federal government currently have programs in place to incentivize an equitable transition to clean energy. Incentive programs and rebates are funding sources open to all applicable projects until the program budget is expended. To reap the benefits of incentives and rebates, the costs of planning and implementation must first be covered to establish a functioning renewable energy system.

Note that the federal Inflation Reduction Act, which was passed in August 2022, extended the solar investment tax credit and advanced energy project credit, and created new tax credits and deductions to incentivize investments in energy efficient commercial buildings, clean vehicles, alternative fuels, and clean electricity production and storage. Guidance on the details of these new programs can be expected over the coming months and years.

Table E.3 summarizes the existing utility and tax incentives that are most applicable to the WRCOG Plan.

Table E.3. Existing Utility and Tax Incentives Most Applicable to WRCOG Energy Resiliency Plan

Administering Organization	Program Name	Description	Eligible Uses
California Public Utilities Commission (CPUC)	Microgrid Incentive Program (MIP)	The MIP, with $200M budget, will fund clean energy microgrids to support the critical needs of vulnerable communities impacted by grid outages and to test new technologies or regulatory approaches to inform future action.	• Increased electricity and resiliency in communities at risk of electrical outages. • Increased reliability for critical infrastructure such as fire stations, schools, nursing homes, etc. • Reduced impacts of power outages and minimized disruptions for low-income households.
Southern California Edison (SCE)	Self-Generation Incentive Program (SGIP)	The SGIP is a CPUC program administered by California's Investor-Owned Utilities (IOUs) that offers rebates for installing energy storage technology at an IOU facility. These storage technologies include battery storage systems that can function in the event of a power outage.	• Self-generated energy in a storage system (i.e., a battery).
United States Department of Energy (US DOE)	Solar Investment Tax Credit (ITC)	The solar ITC is a federal tax credit for those who purchase solar energy systems for commercial-scale properties. The credit is equal to a percentage of the cost of eligible equipment. Tax exempt entities may not collect the credit themselves, but the benefits may be useful in securing a power purchase agreement (PPA).	• Solar photovoltaic (PV) system that is placed in service during the tax year.

Financing Tools

Projects that generate their own revenue or cost savings create private investment opportunities. Public-private partnership (P3) agreements are cooperative agreements between one or more public and private entities that can take different forms, such as private entity financing or management of a project in return for a promised stream of payments from a government agency. In the context of limited public funding opportunities, P3 agreements may provide capital that allows a project to be delivered faster, since private operators may have more immediate access to capital and debt financing and fewer competing resource demands. Table E.4 summarizes some of the most common P3 opportunities to implement energy projects.

Table E.4. Public-Private Partnership Opportunities

Strategy	Description
Power Purchase Agreement (PPA)	A power purchase agreement (PPA), a type of P3, is a financial agreement in which a developer arranges for the design, permitting, financing, and installation of an energy system on a customer's property at little to no cost. The developer sells the power generated to the host customer at a fixed rate that is typically lower than the local utility's retail rate. The lower electricity price serves to offset the customer's purchase of electricity from the grid, while the developer receives the income from the sales of electricity as well as any tax credits and other incentives generated from the system. These may take the form of corporate PPAs, which involve corporate or industrial buyers purchasing renewable energy directly or virtually from developers. PPAs typically last 10 to 25 years, and the developer is responsible for the operation and maintenance of the system for the duration of the agreement. The Morris Model of a PPA is when a public entity issues a government bond at a low interest rate and transfers low-cost capital to a developer in exchange for a lower PPA price.
Energy Savings Performance Contracting (ESPC)	Budget-neutral approach to building improvements that provide renewable energy, reduce energy, and increase operational efficiency. In ESPC, a facility owner partners with an energy service company (ESPC) that provides design and installation of the energy improvements, arranges the financing, and in some cases provides ongoing operations and maintenance services. Similar to a PPA, a facility owner can use an ESPC to pay for today's facility upgrades with tomorrow's energy savings without tapping into capital budgets. State and local governments can implement ESPC projects in their own facilities as well as promote and support ESPC projects through ESPC programs. Ideal candidates for ESPC projects include any large building or group of buildings such as city, county, and state buildings; schools; hospitals; commercial office buildings; and multiple-family buildings.
Leasing Arrangements	Tax-exempt lease-purchase agreements provide state and local governments with the opportunity to finance upgrades and use energy savings to pay for financing costs. While leasing arrangements have higher rates compared to bond financing, they are often faster and more flexible revenue-generating mechanisms.
On-Bill Tariff Financing (SCE Program)	The On-Bill Financing Program provided by Southern California Edison (SCE) offers commercial and institutional customers with a monthly usage of 100 kW or less the opportunity to reduce operating expenses and finance retrofitting projects by covering the initial costs of installing the energy-saving measures. Commercial property owners pay back these costs on their monthly utility bills interest free for up to 60 months. The program includes energy assessment and includes a specific list of measures to reduce the cost of refrigeration, cooling, and lighting.

Table E-5 summarizes current loan opportunities that are relevant to WRCOG's resiliency framework. Notably, the California Infrastructure and Economic Development Bank's Infrastructure State Revolving Fund (ISRF) can be used as a source of matching funds for grants or other financing needs. Table E-6 summarizes the types of bonds that may be suitable for funding WRCOG's climate actions.

Table E.5. Relevant Loan Programs Offered by the California Infrastructure and Economic Development Bank

Program	Description
CLEEN (Green Loan) Program	The CLEEN Program provides public financing to help meet state goals for greenhouse gas reduction, water conservation, and environmental preservation. This program consists of two subprograms: (1) the Statewide Energy Efficiency Program (SWEEP), which helps local governments and nonprofit organizations make small-, medium-, and large-scale energy efficiency upgrades and projects, and (2) the Light Emitting Diode Street Lighting Program, which finances the installation of LED (Light Emitting Diode) streetlights for local governments.
Infrastructure State Revolving Fund (ISRF)	The ISRF Program (through IBank) is authorized to directly provide low-cost public financing to state and local government entities, including municipalities, universities, schools, and hospitals (MUSH borrowers) and to nonprofit organizations sponsored by public agencies for a wide variety of public infrastructure and economic expansion projects. In the past, WRCOG member agencies have received state revolving fund loans for the development of bike path and pedestrian path lights and investments in drinking water sources.

Table E.6. Bonds Relevant to WRCOG Energy Resiliency Plan

Strategy	Description
Environmental Impact Bond (EIB)	An EIB is an innovative financing tool that uses a pay-for-success approach to provide up-front capital from private investors for environmental projects, either to pilot an innovative approach whose performance is viewed as uncertain or to scale up a solution that has been tested in a pilot program.
Revenue or General Obligation Bonds	Revenue bonds are used to pay for projects, such as major improvements to an airport, water system, garage, or other large facilities, that generate revenue that is then used to repay the debt. General obligation (GO) bonds are issued to pay for projects that may not have a revenue stream. Debt is repaid through an increase in the ad valorem property tax. In California, GO bonds (and in some cases revenue bonds) are subject to voter approval.
Green or Climate Bonds	Green or climate bonds specifically finance climate change adaptation or mitigation projects. Eligible projects include those related to renewable energy and energy efficiency, sustainable waste management projects, sustainable land use and biodiversity conservation, clean transportation, and clean drinking water.
Utility Revenue Bonds	A utility revenue bond is a type of municipal bond issued to finance a public utility project that repays investors directly from project revenues. Utility revenue bonds are used to fund capital projects in areas considered essential to public services, including hospitals, fire services, water and waste treatment facilities, and improvements to the electrical grid.

Local Revenue Sources

Another key strategy for funding and financing the region's climate actions is to develop fiscal policies that support and reinforce the region's climate goals. Climate change creates a long-term financial obligation, and an obligation in terms of mitigating, adapting, and responding to a climate crisis, therefore requires long-term fiscal planning. WRCOG's member agencies may consider developing a Climate Action Fund that allocates a portion of the local General Fund to specifically fund climate mitigation and adaptation efforts.

WRCOG member agencies may also identify climate action and adaptation as priority criteria when determining how to allocate funding and prioritize programs and projects across all funds. For example, the City of Los Angeles Financial Policies identifies “resilience and sustainability” as a primary criterion for allocating funding and prioritizing capital projects (City Administrative Officer of Los Angeles, 2020). If WRCOG member agencies were to develop a similar criteria policy, it could have the effect of facilitating implementation of fund-specific or department-specific climate actions, such as prioritizing facility improvements that include energy resiliency improvements.

In some cases, government agencies in California have implemented local climate and resource specific taxes to offset the cost of natural hazard mitigation. The City of Santa Clara renewed the Safe, Clean Water and Natural Flood Protection Program in November of 2020, along with a parcel tax of $.006 per square foot, which protects drinking water supplies and dams from earthquakes and climate change; reduces pollution, toxins, and contaminants in waterways; and provides flood protection. Marin County also passed the Marin Wildfire Prevention Measure in 2020; this parcel tax of 10 cents per building square foot supports wildfire prevention, including early detection and improvements to critical infrastructure. WRCOG member agencies may consider a similar program or measure to fund regionally specific resilience efforts, which could include funds set aside for resilience improvements for critical facilities.

Next Steps

The Energy Resiliency Plan details a regional transition to renewable energy in critical infrastructure, including the ability to quickly adapt to drought, extreme heat, and other climate changes. Implementation will be most effective and efficient if multiple actions are pursued in tandem, which may include using funding and financing sources to support multiple or bundled projects. Near-term next steps (within 1 to 2 years) for beginning the implementation of priority actions may include the following:

- **Identify partnership opportunities to plan, fund, and implement climate actions.** WRCOG made efforts in this planning process to include representatives from member agencies across Western Riverside County, and now there are opportunities to continue these partnerships as agencies begin to pursue funding. Partnerships between public agencies can increase the competitive edge of grant applications. Other civic institutions, notably the University of California, Riverside, may also offer partnership opportunities.
- **Determine which strategies will require environmental review, technical analysis, and/or complex partnerships and permitting.** Some of the priority actions will have longer implementation timelines due to environmental review requirements or financing coordination (e.g., on a new sales tax or bond issuance). To meet its electrification goals in a timely manner, WRCOG and its member agencies will need to start the first phase of work on these longer-term projects.
- **Track new federal funding opportunities as guidance is released.** The IIJA and Inflation Reduction Act present enormous opportunities. While the available details on known programs are summarized in this chapter, the federal government is regularly releasing new program announcements related to funding eligibility and availability.
- **Begin preparing application materials for the state grants that have been allocated additional funding in the Governor’s 2022-2023 budget.** Some funding for these grants may already be or will soon be available and the grants will have short application deadlines. An early start on application materials will give WRCOG member agencies more time to match actions to grant opportunities, define strong proposal narratives, and identify potential partnerships.

Appendix F.
Resilient Design Resources and Guidelines (References)

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Relevant Websites and Organizations:

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- Better Buildings U.S. Department of Energy
- Building Forward LA
- California Association of Councils of Governments Planning for Resiliency
- HUD (US Department of Housing and Urban Development) Community Resilience Planning Resources
- Microgrid Resources Coalition
- National Renewable Energy Laboratory (NREL) – Resilient Energy Systems
- Resilient California
- Resilient Cities Catalyst
- Resilient Cities Network (formerly 100 Resilient Cities)
- Southern California Association of Governments (SCAG)
- Southern California Resilience Initiative (SCRI)
- Uptime Institute
- U.S. Green Building Council (USGBC)
- Urban Land Institute (ULI) Urban Resilience Program
- Whole Building Design Guide

Appendix 2 – Water Systems Resiliency Study for WRCOG

UCR | College of Engineering- Center for Environmental Research & Technology

UC RIVERSIDE UNIVERSITY OF CALIFORNIA

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

November 9, 2022

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WRCOG Western Riverside Council of Governments

CALIFORNIA RESILIENCE CHALLENGE

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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.

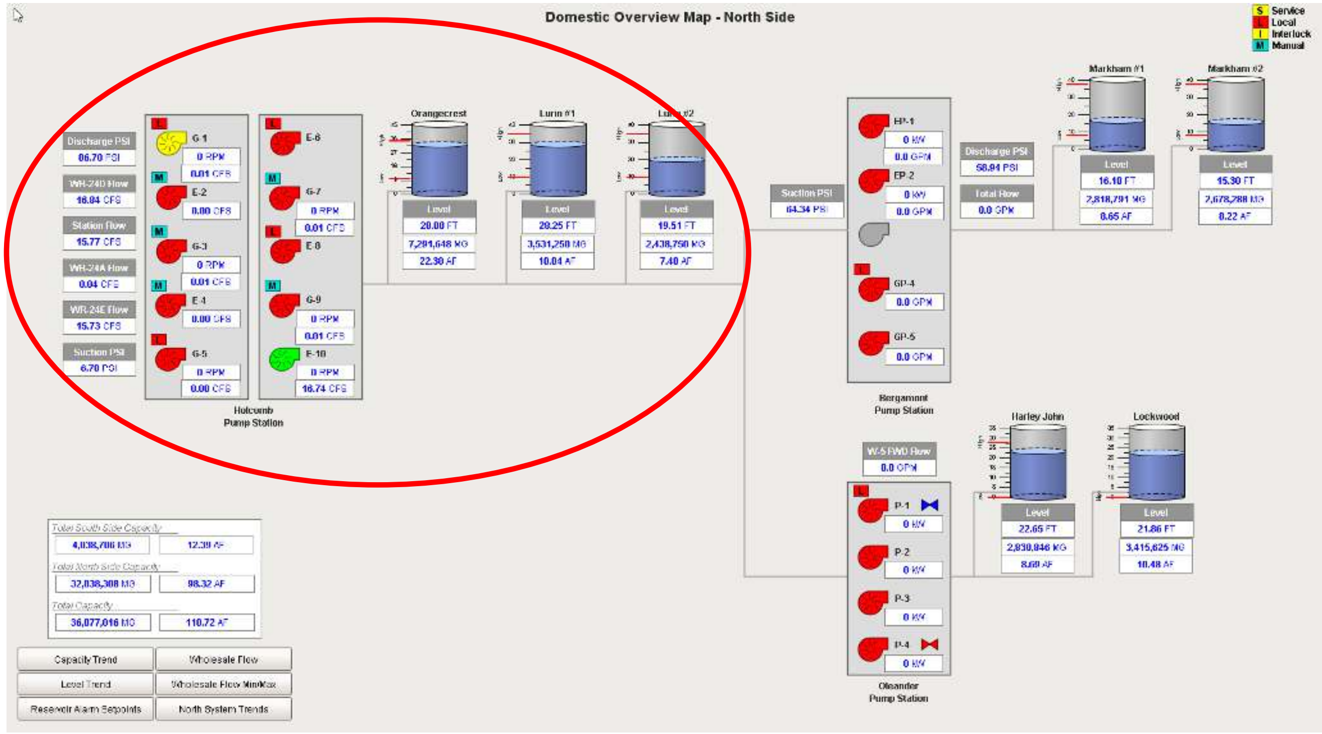


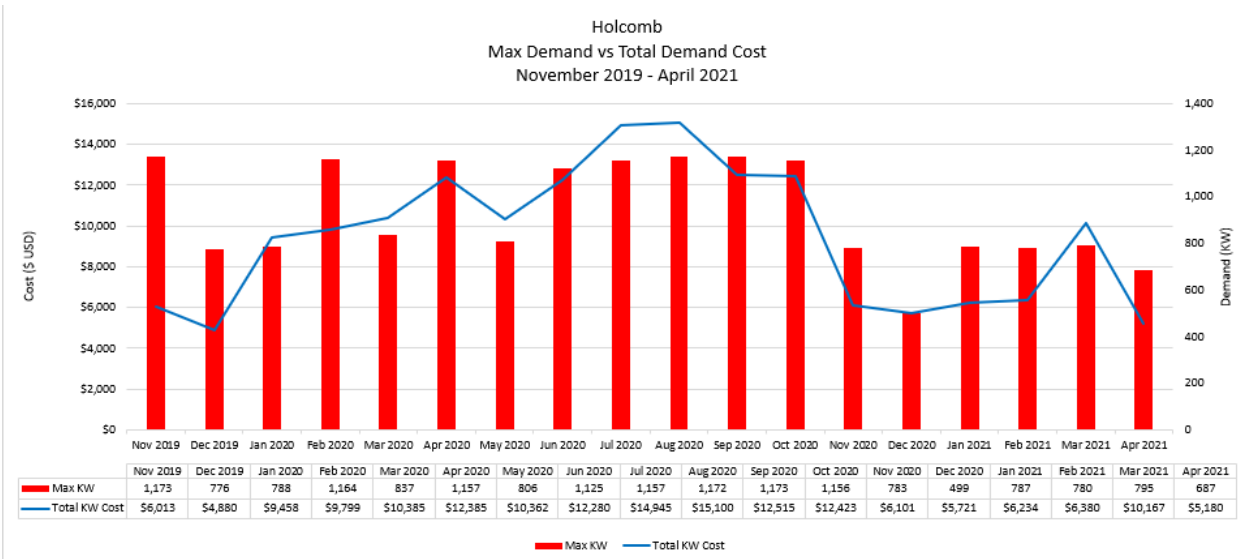
Figure 2.1: Holcomb Pump Station SCADA Overview

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

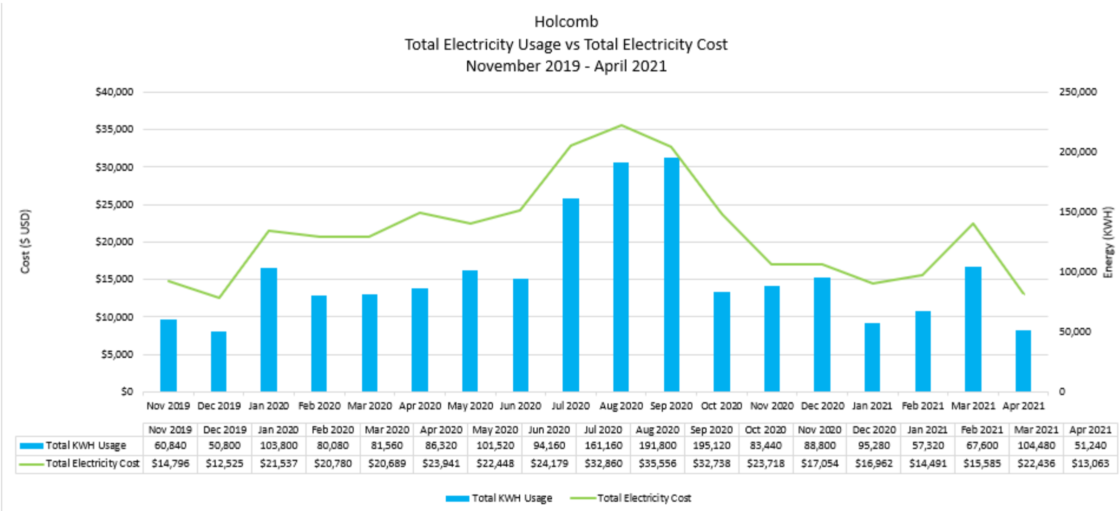
Figure 2.2: Holcomb Pump Station Total Bill Amount versus Max Demand and Demand Cost

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.

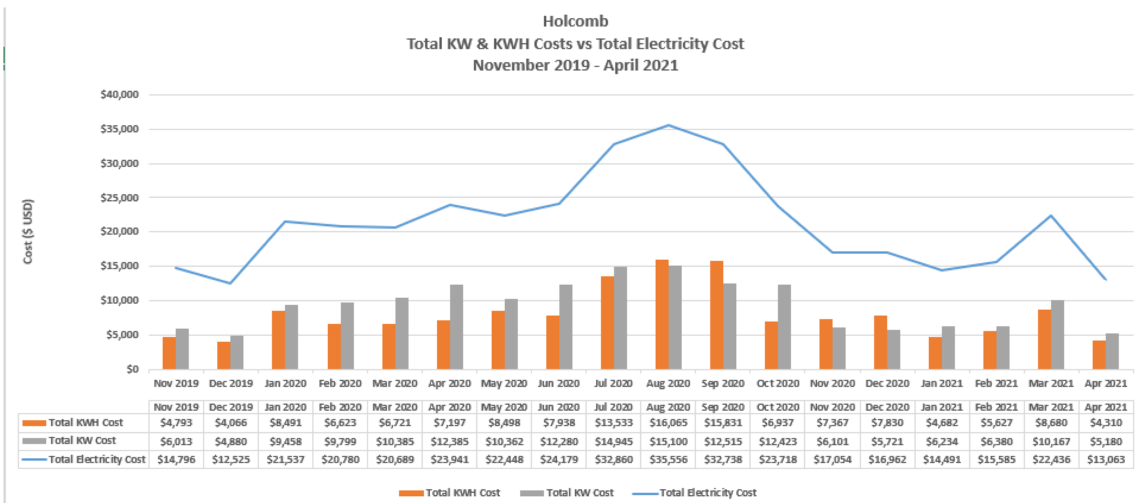
Figure 2.3 shows the monthly energy usage (kWh) as well as the total charge for electricity over the period from November 2019 to April 2021.

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.



	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	60,840	50,800	103,800	80,080	81,560	86,320	101,520	94,160	161,160	191,800	195,120	83,440	88,800	95,280	57,320	67,600	104,480	51,240
Total Electricity Cost	$14,796	$12,525	$21,537	$20,780	$20,689	$23,941	$22,448	$24,179	$32,860	$35,556	$32,738	$23,718	$17,054	$16,962	$14,491	$15,585	$22,436	$13,063

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



	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	$4,793	$4,066	$8,491	$6,623	$6,721	$7,197	$8,498	$7,938	$13,533	$16,065	$15,831	$6,937	$7,367	$7,830	$4,682	$5,627	$8,680	$4,310
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
Total Electricity Cost	$14,796	$12,525	$21,537	$20,780	$20,689	$23,941	$22,448	$24,179	$32,860	$35,556	$32,738	$23,718	$17,054	$16,962	$14,491	$15,585	$22,436	$13,063

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%.

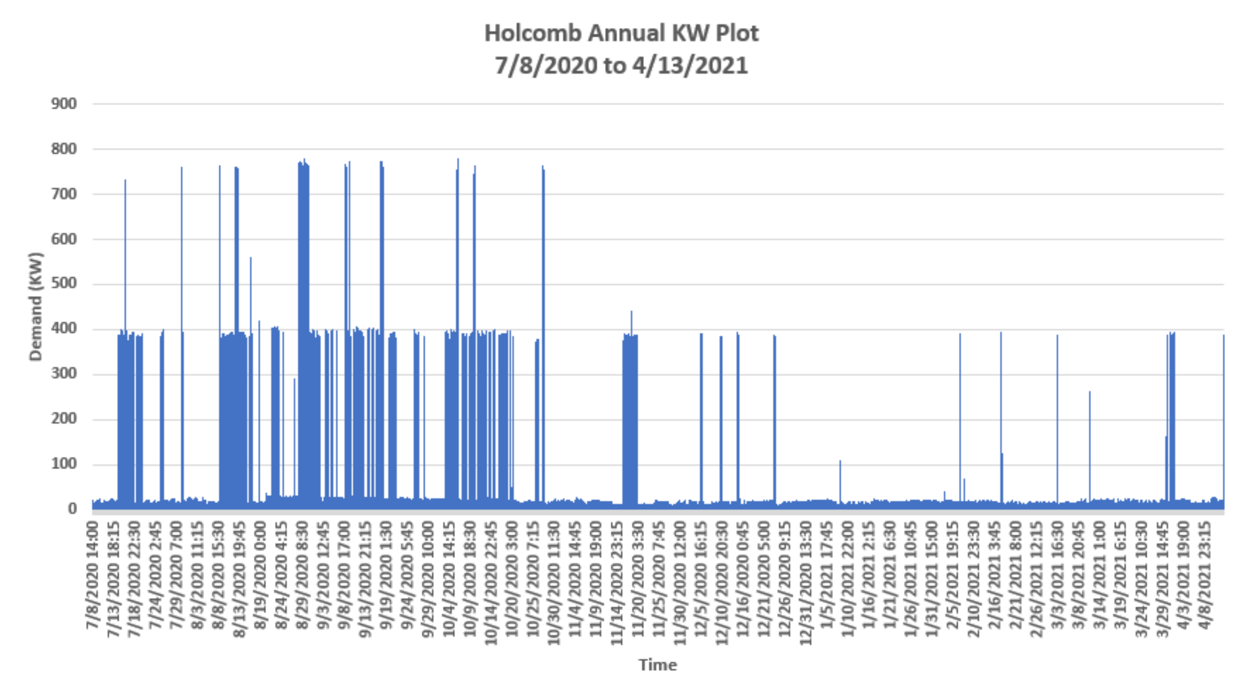


Figure 2.5: Holcomb PS 15-Minute Interval kW Demand Data for One Year

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.

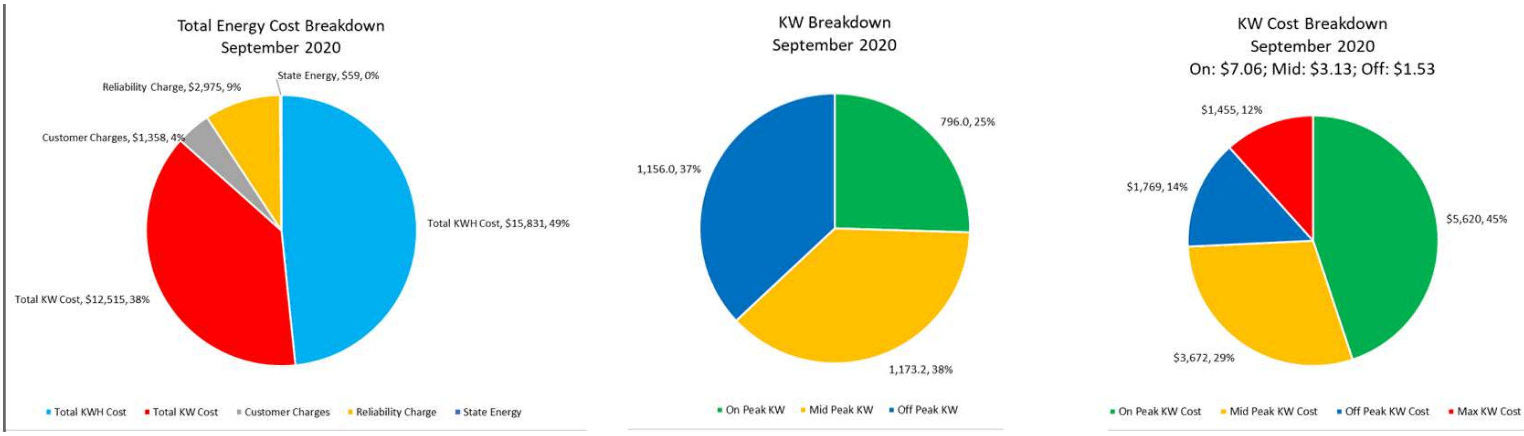


Figure 2.8: Holcomb Pump Station Cost Breakdown for September 2020

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.

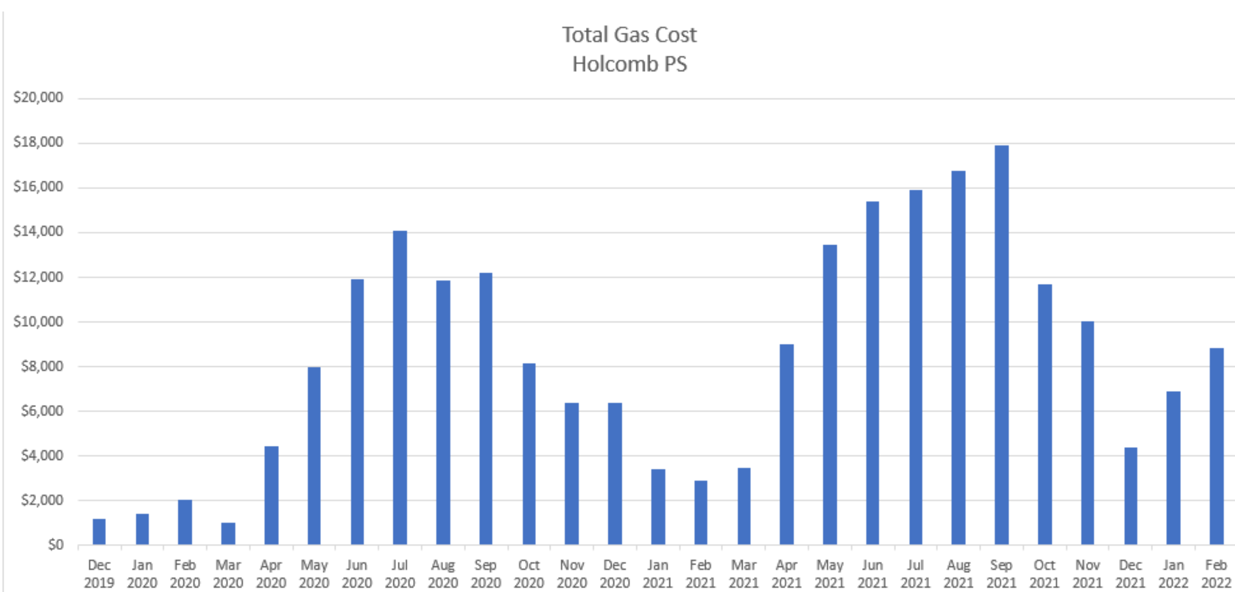


Figure 2.9: Holcomb PS Total Gas Cost Breakdown

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.

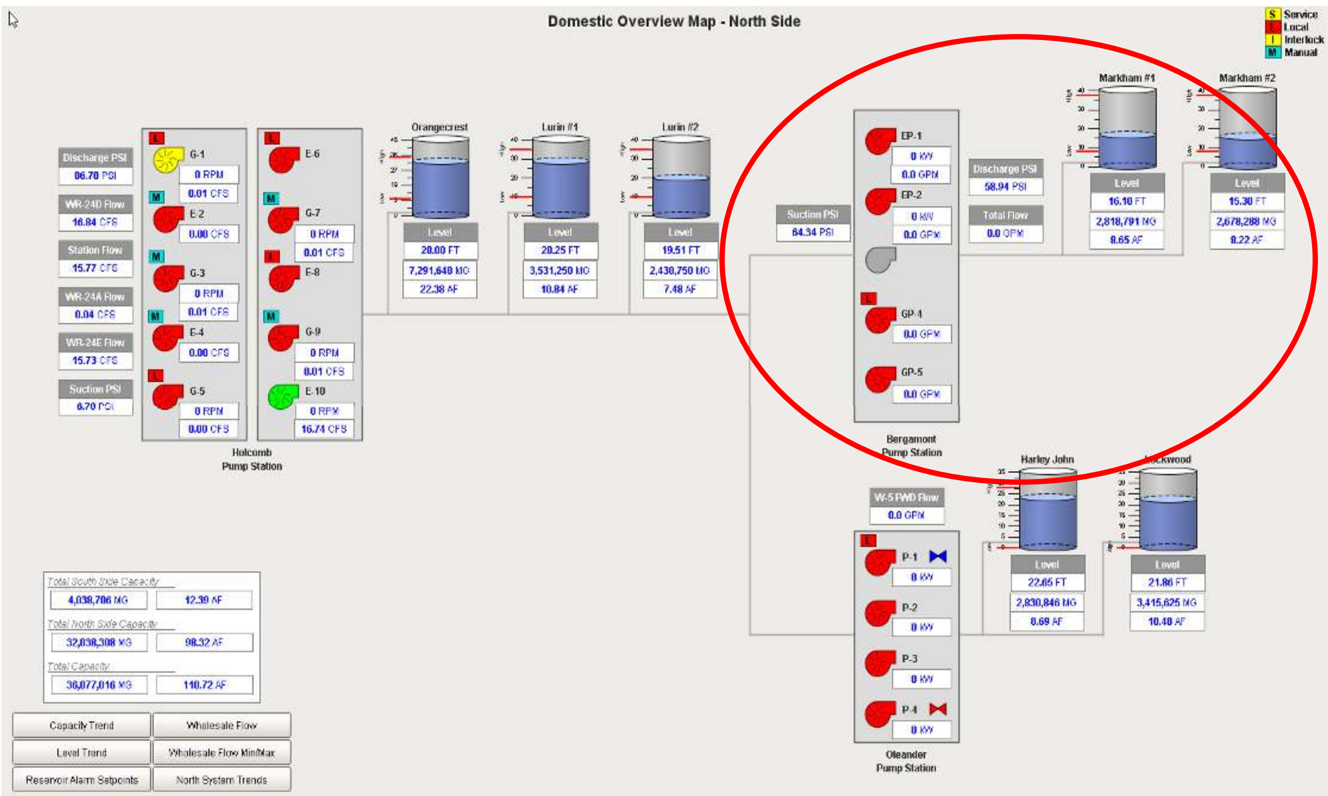
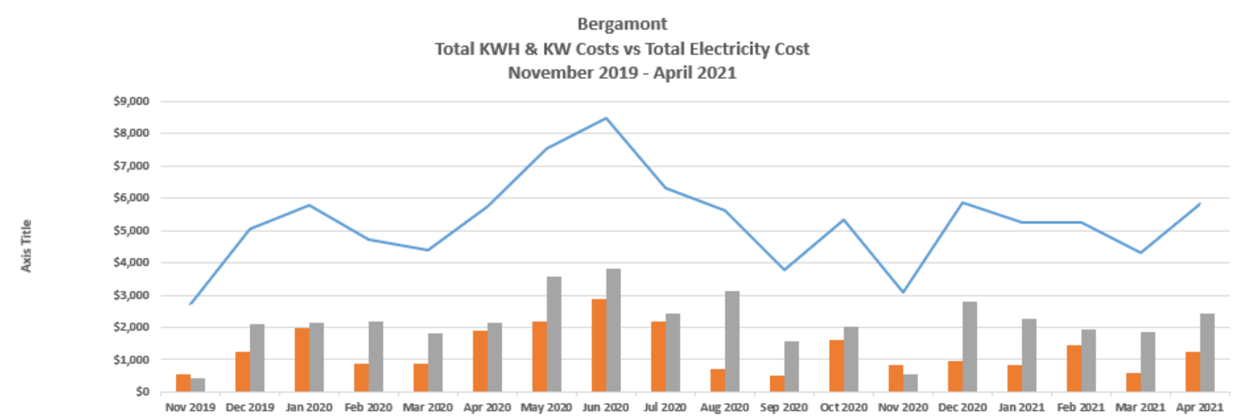


Figure 3.1: Bergamont Pump Station SCADA Overview

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.

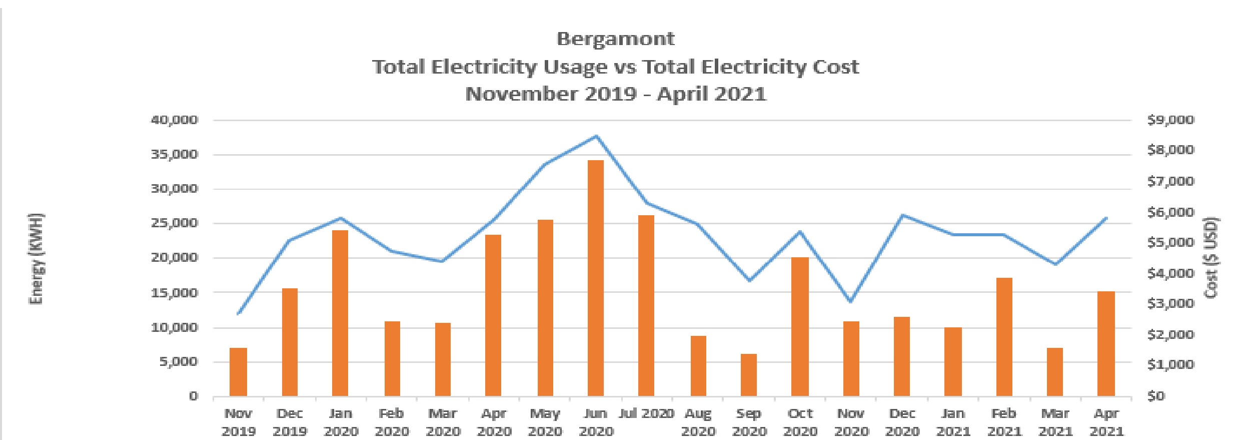


	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Sep 2020	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021
Total KWH Cost	$543	$1,255	$1,983	$870	$884	$1,901	$2,204	$2,873	$2,181	$711	$509	$1,627	$843	$971	$854	$1,443	$577	$1,252
Total KW Cost	$425	$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

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

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.

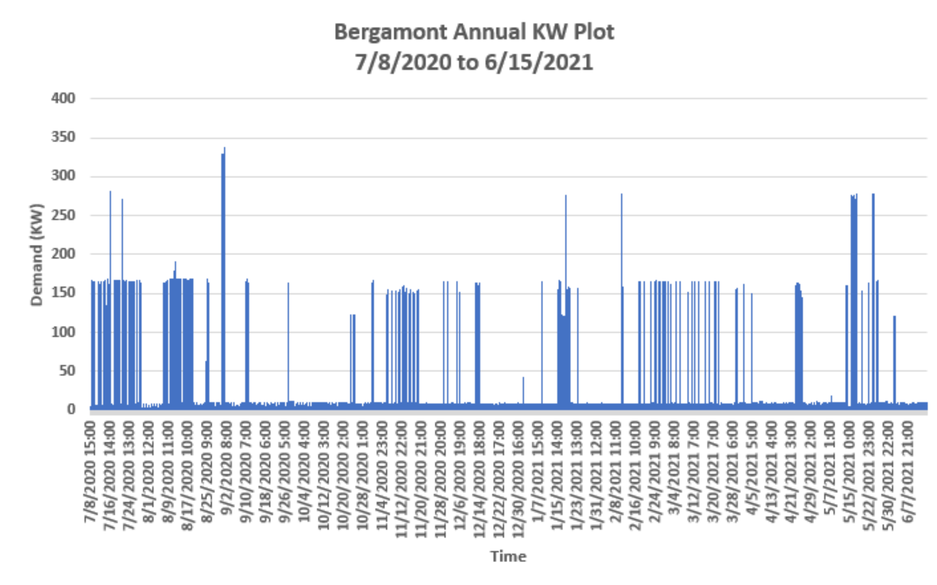


Figure 3.4: Bergamont 15-Minute Interval kW Demand Data for One Year

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.

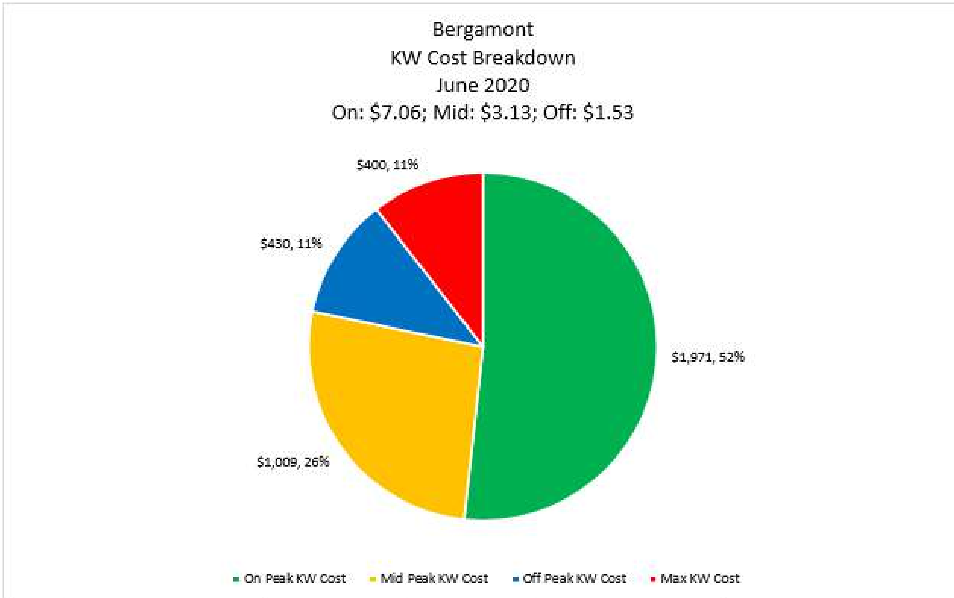


Figure 3.8: Bergamont kW Cost Breakdown for June 2020

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.

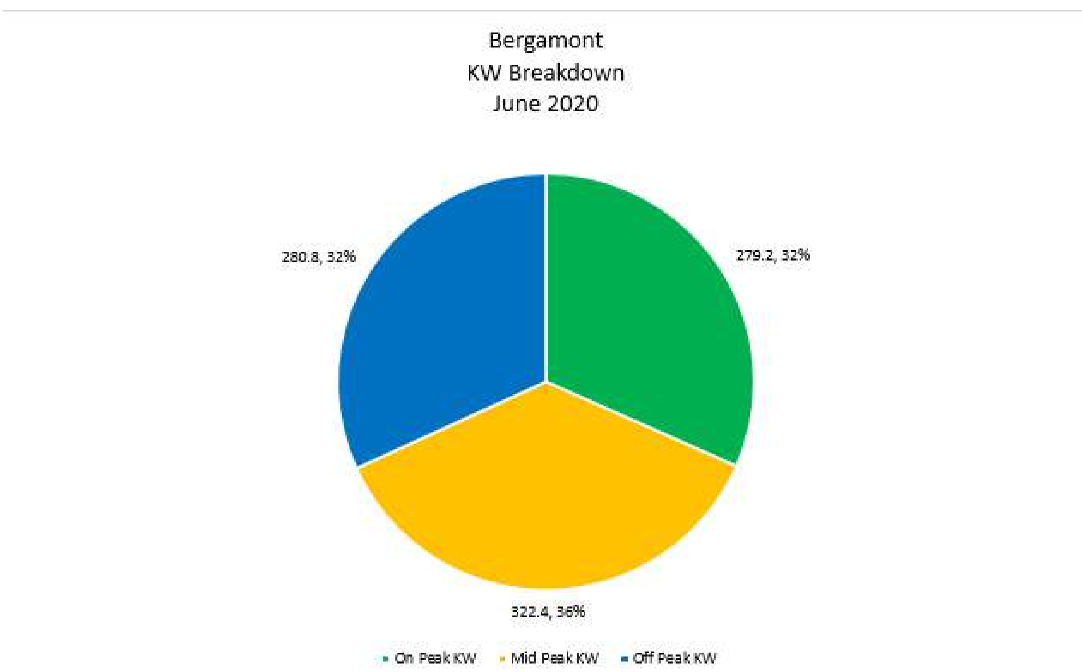


Figure 3.9: Bergamont kW Amount Breakdown for June 2020

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.

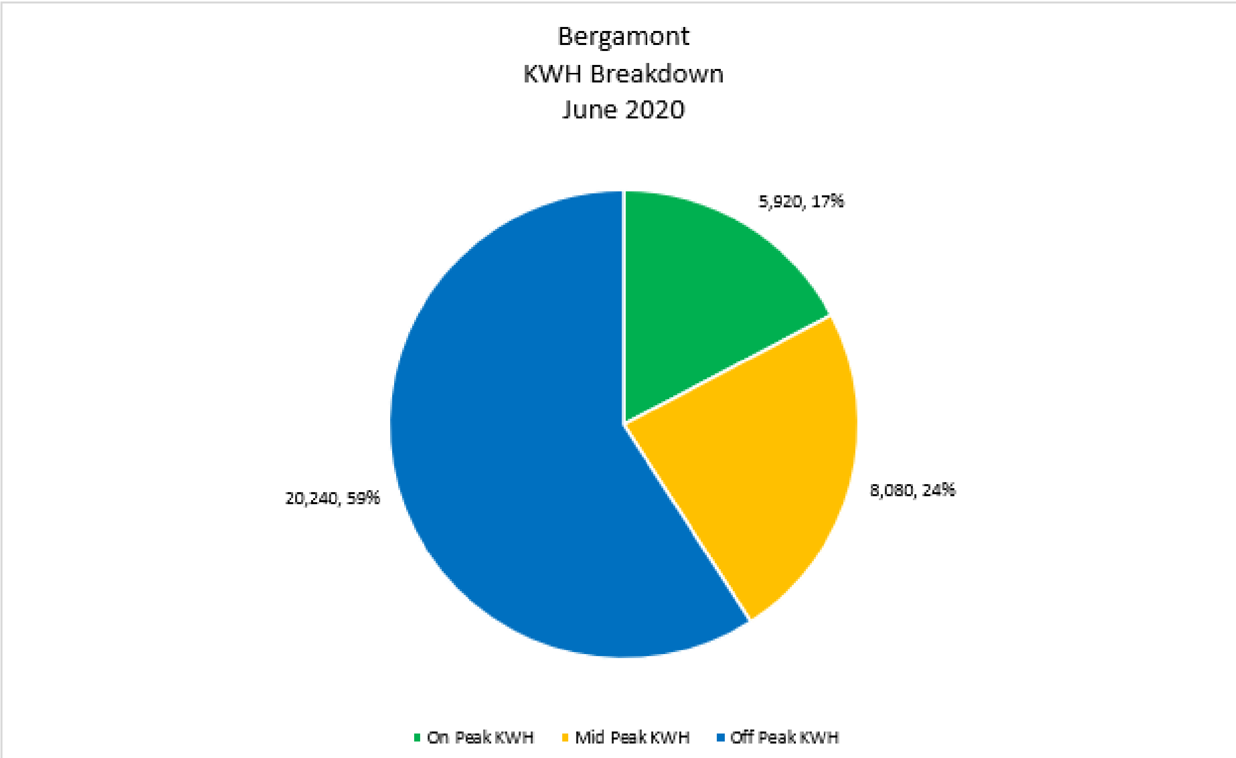


Figure 3.10: Bergamont kWh Amount Breakdown for June 2020

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.

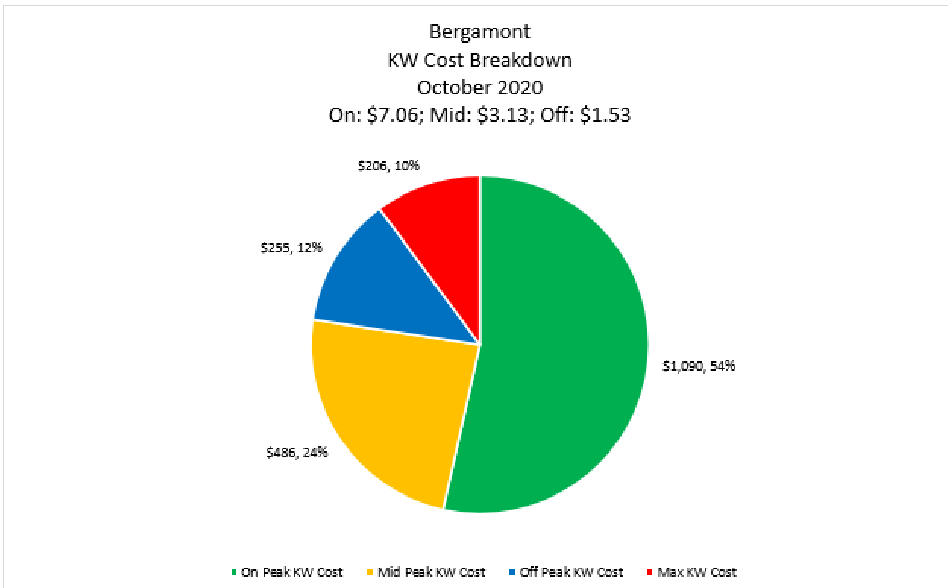


Figure 3.11: Bergamont kW Cost Breakdown for October 2020

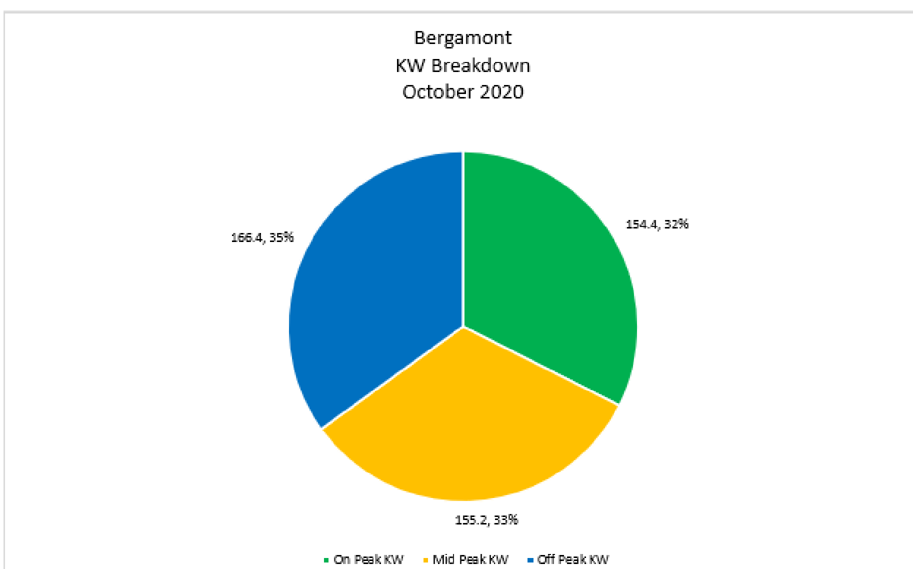


Figure 3.12: Bergamont kW Amount Breakdown for October 2020

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.

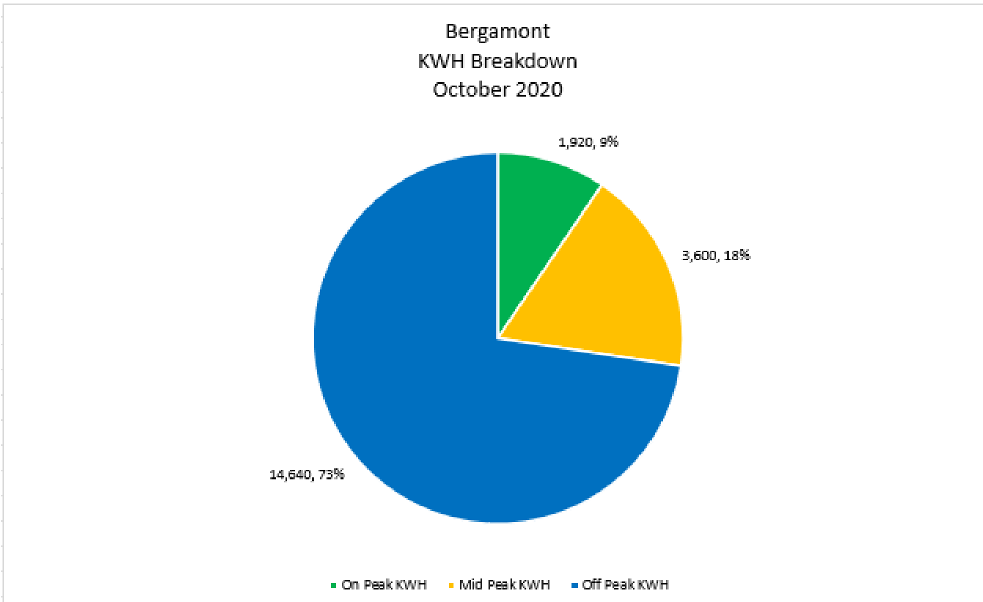


Figure 3.13: Bergamont kWh Amount Breakdown for October 2020

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.

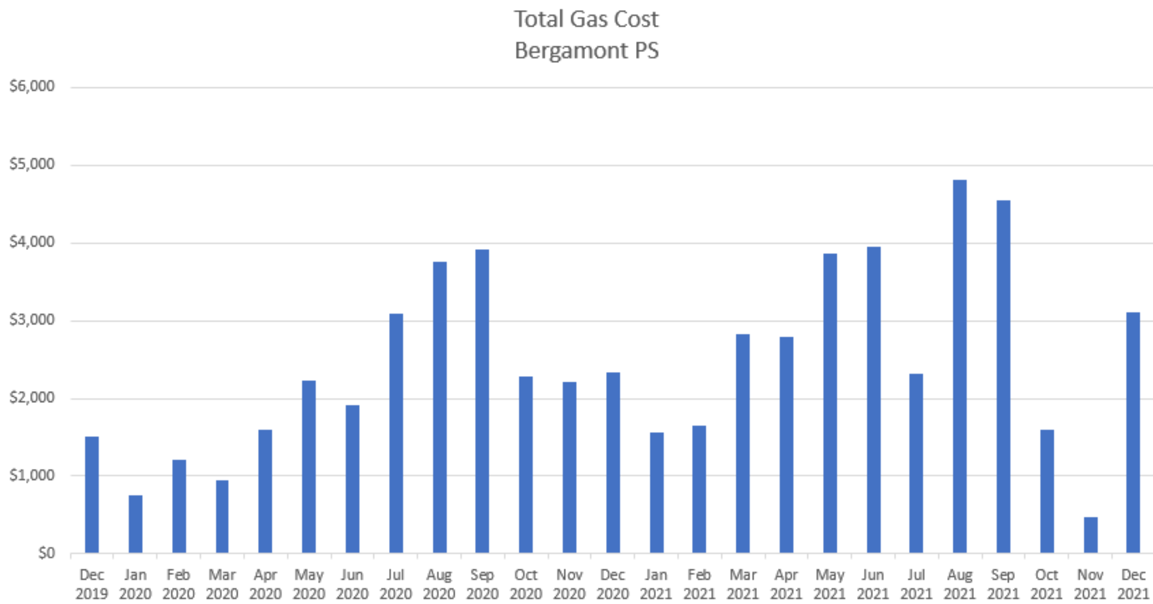
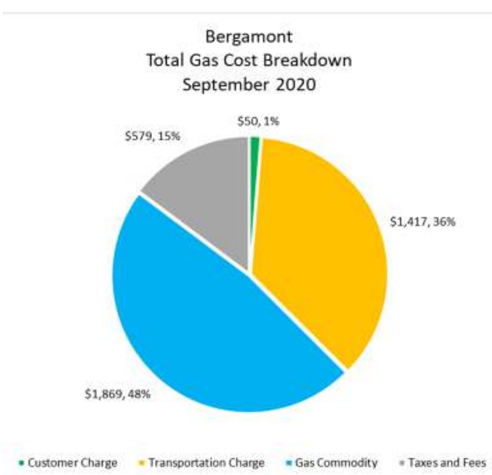


Figure 3.14: Bergamont PS Total Gas Cost Breakdown

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.



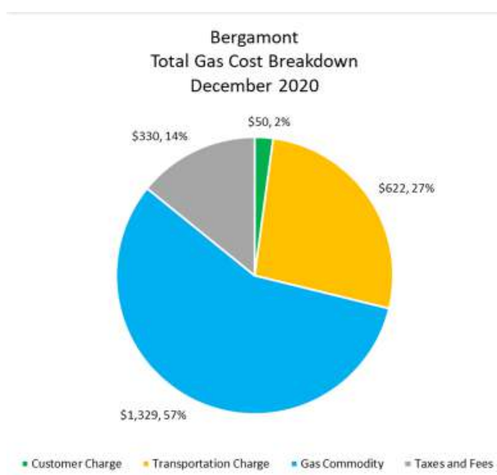


Figure 3.15: Bergamont Total Gas Cost Breakdown for July 2020 and December 2020

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.

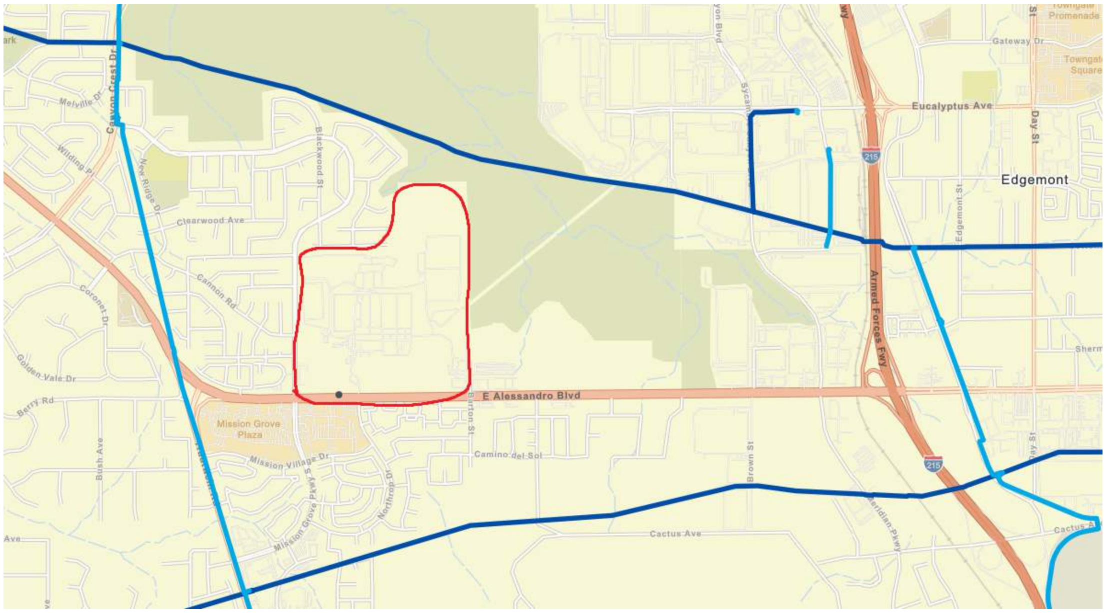
- La Colina Substation (North of facility) [Now Temporarily Closed]

    - 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:

Ground Mounted Solar Panels:

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

Raised Solar Panels:

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