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Case Studies - Water-Related Flexible Electric Resources

Water and wastewater systems can help integrate renewable electric resources at both the transmission and distribution levels "today" but new programs and pricing strategies are needed to address barriers in existing programs that inhibit development and implementation of water sector flexible electric resources.

Additional submitted attachment is included below.




Water Sector Over-Generation Mitigation and Flexible Demand Response

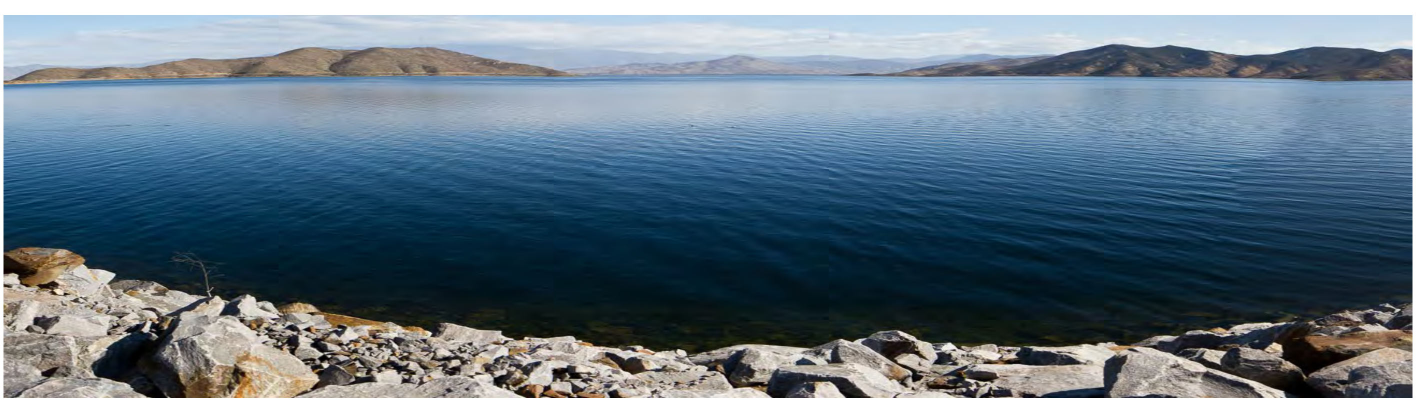
Phase 2 Program Recommendations

Prepared by:

waterenergy INNOVATIONS

for Southern California Edison

October 25, 2019



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*****

Conducting technical review is not an endorsement of this report's recommendations.

Those, as well as any remaining errors or inconsistencies, are solely those of the authors.

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Abstract

California has invested billions of dollars to put the State on a path to 100% carbon-free electricity. Curtailments of renewable energy are antithetical to State policy. More electric storage could substantially reduce and eventually eliminate the need for curtailments. However, current electric storage technologies cannot cost-effectively store all of the surplus solar and other types of variable electricity being produced. As solar continues to grow at a rapid pace, near-term solutions are needed to bridge the technology gap. Fortunately, cost-effective remedies exist today in the State's water and wastewater systems that can, when properly configured and operated, become virtual electric batteries.

Multiple water and wastewater utilities within SCE's service area were interviewed to understand the types of changes that would be needed to water sector infrastructure and operations in order to leverage the flexibility inherent in water systems to increase or shed load when needed to maintain electric reliability. The primary finding was that Flexible Electric Resources exist now in water and wastewater systems and can be used to support electric reliability, but new programs are needed to address barriers in existing programs that inhibit water sector participation. With solar PV projected to more than double within 5 years, the search for water and wastewater electric reliability partners should begin now with the aim of influencing the billions of dollars invested by the water sector in new and retrofit infrastructure every year.

Keywords: electric reliability, over-generation, over-supply, under-generation, under-supply, carbon-free energy, renewable energy, curtailments, electric storage, water storage, demand response, flexible demand response, Flex DR, Flexible Electric Resources, solar, wind, pumped storage hydro, water, wastewater, stormwater, recycled water, groundwater, groundwater banks, surface water reservoirs, conjunctive use

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Preface

California's phenomenal success in spurring development of clean, renewable energy resources has created a situation in which electricity production sometimes exceeds real-time electric demand. Battery energy storage has proven effective in helping to mitigate these so-called periods of "over-generation"; however battery technologies are not yet able to store very large quantities of electricity for long durations of time. Consequently, when over-generation causes voltage instability, variable energy resources such as solar, wind, and as-delivered hydropower may need to be curtailed.

The California Independent System Operator that manages 80% of the State's high voltage electric system recently advised that over-generation is growing much faster than forecasted. Since grid-scale solar PV alone is expected to more than double within 5 years, additional curtailments of carbon-free renewable resources are highly likely. Near-term solutions are needed while electric storage research and development proceeds in parallel.

The water sector is the perfect electric reliability partner. Not only does water depend on reliable electric service to meet its mission critical goals - water and wastewater utilities' service areas span hundreds of miles, usually contiguous with electric transmission and distribution infrastructure. It is not a coincidence that water and wastewater utilities' service areas overlay areas in which SCE's electric distribution system is already at or near capacity – where there are people and businesses that need electricity, those same people and businesses need water and wastewater services. Importantly, water-related Flexible Electric Resources exist today and there is a substantial opportunity to develop more Flexible Electric Resources by influencing the billions of dollars in upgrades and expansions being invested by the water sector and the State every year to build drought resilience.

Through case studies, meetings, and interviews with water and wastewater utilities, principles for a Water Sector Electric Reliability Program were developed to leverage the flexibility inherent in California's water systems for near-term cost-effective electric reliability support. Key to this program's success is the recognition that California's water sector is not merely an electric customer - it is a natural and inevitable electric reliability partner with substantial capabilities to provide over-generation mitigation as easily as it has historically provided relief during periods of under-generation (aka "under-supply"). When design, development and operations of water and wastewater systems are synchronized with the needs of the electric grid, cost-effective benefits accrue to both water and electric ratepayers.

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Executive Summary

By any benchmark, California's visionary low carbon and renewable energy resource policies have been successful. Backed not just by ambitious goals but also by substantial investment, both public and private, California achieved a 34% Renewable Portfolio Standard in 2018 – two years ahead of the statutory goal of 33% by 2020.[i,ii] Of this amount, solar photovoltaics (PV) accounted for 31% of California's renewable generation capacity and 14% of the State's total electricity production.[iii]

California leads the nation in solar, with 37% of the total installed solar PV capacity in the U.S. (4.6 times the next largest solar PV state).[iv] The combination of:

- ***Falling Prices*** - The installed cost of solar has decreased 70% over the past 10 years;[v] and
- ***Solar Mandates*** - California is the first state to require solar PV on new homes),[vi]

means that much more solar is in California's future. This has created a circumstance in which real-time solar PV generation is dominating the State's current electric profile. Given the State's goal of 100% renewable and zero carbon electricity by 2045, it is likely to continue to do so for the indefinite future.

With success comes challenges – in this case, the challenge is to find the means to effectively and cost-effectively integrate the very large quantities of solar PV and other variable energy resources anticipated in California's future electricity portfolio.

What is Over-generation?

Figure ES-1 on the next page illustrates the challenge: solar PV is produced when the sun shines. In most parts of the State, that typically occurs between 9am and 6pm. Since 2015, as solar PV began to grow at a rapid pace, real-time electric supplies began to exceed real-time electric demand during some hours of the day, including the historical Noon to 6pm peak electric time-of-use period. Studies conducted by the California Independent System Operator (CAISO) and the California Energy Commission (CEC) showed that solar PV's success will increase both the quantity and the frequency of over-generation during daylight hours, especially during spring months when solar production is high relative to electric demand.

Keeping power flowing reliably throughout the State requires careful choreography of supplies and demand, and a diverse portfolio of "ancillary" products and services. To remedy real-time imbalances, the CAISO performs grid balancing – dispatching additional electric resources or calling for reductions in demand - every few seconds. When over-generation occurs due to much more solar PV power flowing on the grid than there is demand to use it or batteries to store it, the CAISO has two primary options: increase demand or reduce supply. The grid balancing challenge is made more complex by the fact that electric reliability is locational: imbalances need to be solved at the locations on the grid at which they occur.

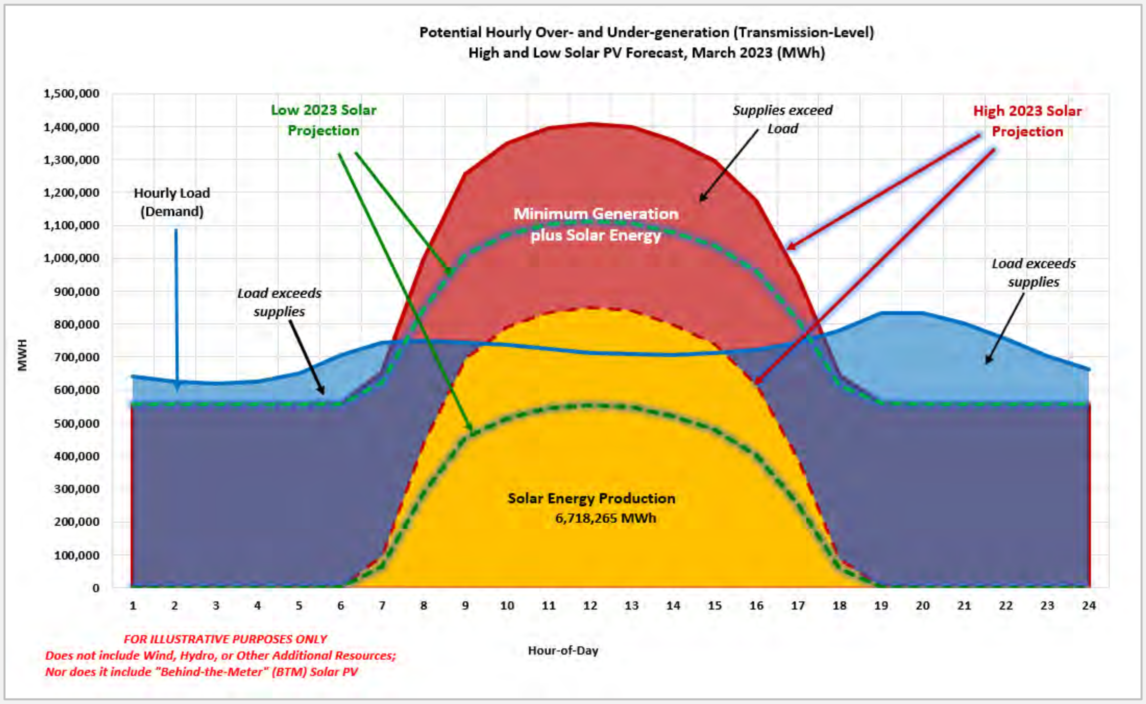

Figure ES-1. Projected Hourly Over- and Under-Generation during March 2023 (MWh)

Utility-scale (transmission level) solar PV is on a trajectory to more than double within 5 years. If all of the solar PV presently in queue for transmission interconnection is placed in-service, solar PV could triple. Figure ES-1 shows that as solar PV capacity increases, solar electricity plus "Minimum Generation" is expected to exceed real-time electric demand ("Load") during the middle of the day during some months, especially Spring when solar production is high relative to electric demand.

> *"Minimum Generation" is the amount of electric generation resources that cannot be dispatched – turned on or off – either because they are required to be operated ("regulatory must-run") or because they are needed for electric reliability purposes (e.g., natural gas turbines that provide emergency backup power, load following, and other important grid balancing services).*

Figure ES-1 shows that by March 2023, even the low solar PV forecast is likely to result in over-generation from 8am to 6pm. This graph does not show the impact of other grid-level renewable energy resources such as wind, nor "behind-the meter" (BTM) generation.

The CAISO recently advised that the phenomenon of over-generation is growing at a much faster rate than originally forecast, in part due to the fact that no one knows exactly how much BTM solar PV has been installed,[vii] but there is substantial evidence that both transmission-level and BTM solar PV will increase significantly over a fairly short timeframe. Absent other intervention, many more curtailments of carbon-free renewable resources are likely. Near-term solutions are needed while electric storage research and development proceeds in parallel.

Water Sector "Virtual Electric Batteries"

Today, as it has been for nearly 90 years, pumped storage hydropower (PSH) is the largest source of electric storage, accounting for 97% of all electric storage capacity in the U.S.[viii] It is the most mature and proven technology; and since most PSH facilities have by now been fully depreciated, it is also the most cost-effective. However, due to its large scale and siting within areas with sensitive ecosystems, conventional PSH requires extensive and long-lead time environmental studies, permits, and approvals. For this reason, very little PSH capacity has been added since the 1990s. Recently, however, since pumped storage remains by far the most effective means for integrating large quantities of utility scale variable energy resources such as solar and wind, new innovative pumped storage configurations are being explored. In California, five proposed projects could increase the amount of in-State pumped storage capacity by 84%.[ix]

Although conventional pumped storage hydropower is well suited for integrating bulk wholesale power, energy storage needs to be electrically proximate to the variable energy generation resources it is trying to integrate. In California, 99% of the State's pumped storage hydropower capacity resides within only four counties (Los Angeles, Fresno, Butte, and Merced).

The exciting news is that pumped storage opportunities, with or without hydropower, span the entire State. Wherever there is pumping of water, wastewater, or recycled water to storage tanks or reservoirs, a virtual electric battery exists. Substantial opportunities also exist to increase storage at water, wastewater, and recycled water treatment systems, thereby increasing the potential quantity of water sector Flexible Electric Resources. Solids handling and biogas production can also function as virtual batteries when combined with biosolids and biogas storage. Further, many water and wastewater utilities have substantial self-generation facilities that convert solar, wind, biogas, and flowing water to electricity. Combined with electric batteries and/or fuel storage (e.g., for biogas), these self-generation assets could potentially be operated to increase water sector grid purchases during periods of over-generation (9am to 4pm), and to reduce water sector grid purchases during periods of under-generation (also known as "under-supply" or "peak" electric time-of-use periods, currently 4pm to 9pm).

The Water Sector as an Electric Reliability Partner

The key to harnessing the considerable flexibility in water and wastewater systems is to create a new business model – one that recognizes that water and wastewater utilities have substantial capabilities to provide over-generation mitigation as easily as they have been able to provide relief during the legacy Noon to 6pm summer on-peak period.

The water sector is a natural and inevitable electric reliability partner: the water and electric sectors' service areas overlap, they are customers of each other, they serve many of the same customers, and they are both essential to public health and safety. As providers of vital utility services to the State, both the water and electric sectors are subject to the same types of State policies that require cost-effective and environmentally responsible operations. Both require substantial investments in infrastructure, with a need to prepare 2-3 decades in advance to assure they can reliably meet their customers' needs over the long-term. Both are responsible for assuring long term reliability ("resilience") of the valuable water and energy resources with which they have been entrusted, and the success of each in achieving long-term resilience and reliability depends in part on the other.

Water and wastewater utilities' service areas span hundreds of miles, usually contiguous with electric transmission and distribution infrastructure. It is not a coincidence that water and wastewater utilities' service areas overlay areas in which SCE's electric distribution system is already at or near capacity – people and businesses that need electricity also need water and wastewater services, and vice versa. Importantly, the water sector can help "now".

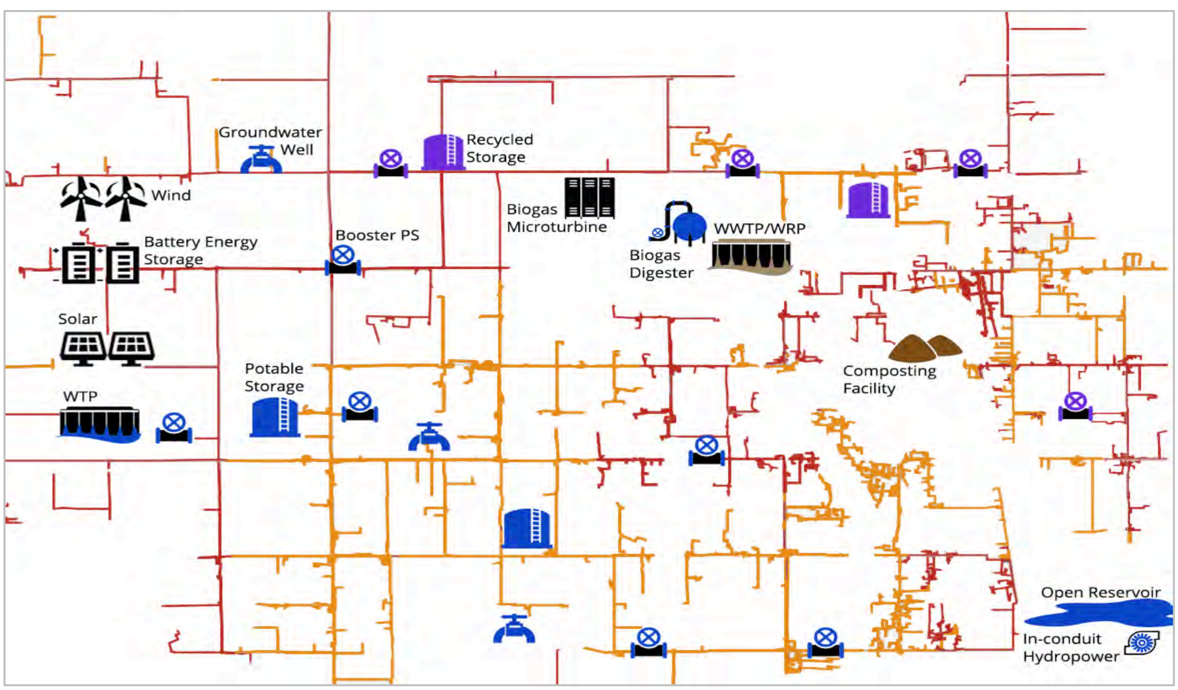

Figure ES-2. ***ILLUSTRATIVE*** **Relationship of Water and Wastewater Systems to Electric System**

Summary of Key Findings

Table ES-1 below summarizes the insights that were provided by water and wastewater utilities that participated in this Pilot Project. Table ES-2 on the following page describes key barriers.

Table ES-1. Summary of Key Findings

1. California's Water Sector is Replete with Flexibility	Water sector *Flexible Electric Resources* tend to flourish at points of Flexible Capacity but can be developed at other sites with some capital investment and/or operational changes.
2. Existing Demand Response (DR) Programs need revision	▪ Meter-specific DR programs ignore the network design of water and wastewater utilities. Operational changes made at one location may result in electric system impacts upstream, downstream, and/or laterally from a DR action taken at one particular site. As a consequence, responding to DR events at the individual meter level may not achieve the desired electric impact at the targeted location. ▪ Other aspects of conventional DR and other energy programs' design (e.g., the punitive nature of demand charges in context of Flexible DR) create barriers to water sector participation and sub-optimal DR program results.
3. Water and wastewater utilities can do much more	Water and wastewater utilities emphasized an urgent need to clearly understand the electric system impacts that are being targeted. With unambiguous information, water sector engineers, planners, operators, and their technical service providers can help identify opportunities to provide electric reliability support, both on near- and long-term bases.
4. The water sector is driving development of "SWEMS"	Of their own accord, many water and wastewater utilities are integrating real-time electric data into their SCADA systems and decision-making tools to further improve their ability to manage the time and cost of their energy use. These tools will be valuable in helping them determine how, when and where they can provide electric reliability support.
5. Building a culture of change and innovation requires training and buy-in	First-line operators have a pivotal role in energy management but they need appropriate tools and training, and they need a supportive organizational culture that values and recognizes initiative and results. Acknowledging the considerable value that water sector operators can bring to the State through improved real-time decision making will help to build the needed organizational buy-in and support.
6. The appropriate relationship is that of an Electric Reliability Partner	To fully leverage the flexibility inherent in water and wastewater utilities' systems and to influence the billions of dollars in ongoing investment in water sector infrastructure, an open and collaborative dialogue between the water and electric sectors is urgently needed.
7. The path forward is a new "BAU"	Water and wastewater utilities emphasized that they are not interested in shifting a few megawatts a few hours a year – they are interested in playing a major role in defining a new, electric reliability operations protocol that will define the water sector's new "Business As Usual" (BAU).

Table ES-2. Barriers to Water Sector Participation in Existing Demand Response Programs

Challenge	Issues	Opportunities
Demand Charges are inconsistent with the goals of Flexible Electric Resources.	Water and wastewater (W-WW) utilities often schedule systems to run during all non-peak hours to minimize electric demand charges.	Eliminating demand charges would enable W-WW utilities to provide over-generation mitigation support (i.e., increase electric demand when needed for electric reliability support).
Some customer electric programs are not in sync with over-generation mitigation.	Some metered loads that receive bill credits for "behind-the-meter" solar PV investments have been "grandfathered" under the old time-of-use (TOU) time periods for purposes of both revenue (valuation of solar PV output) and electric use (billed charges), creating a deterrent to providing over-generation mitigation support during Noon to 4pm.	Bifurcate Revenues (Bill Credits) and Expenses (Billed Electric Charges) in a manner that continues recovery of customer solar PV investments at the levels that were in effect at the time solar investments were made but that also allows W-WW utilities to schedule their electric loads using the price signals embedded in the new TOU time periods.
Meter-specific Demand Response programs do not necessarily achieve the targeted electric reliability results.	W-WW utilities are comprised of multiple systems and facilities, many of which are networked. An action taken at one site may impact electric use at other sites, potentially negating the targeted electric impact on any specific SCE circuit.	Refocusing water sector electric reliability responses on the specific electric impacts needed by circuit, feeder, and/or substation would enable W-WW utilities to help SCE achieve the locational real-time electrical impacts needed.
Electric pricing and tariff options are extremely complex.	Electric price complexity makes it difficult to train and enable W-WW operators to make cost-effective real-time changes that support electric reliability.	A simple blended price that can be easily translated to cost per unit of water, wastewater, or recycled water pumped or treated would enable wider water sector participation.
Most W-WW utilities do not have access to real-time electric data (usage and costs).	The time and costs needed to procure and install real-time electric metering equipment and integrate that data into W-WW SCADA systems exceed many W-WW utilities' staff and financial resources.	Accessing real-time SCE AMI and other electric data could enhance the ability of W-WW utilities to integrate energy information into their real-time operational decision-making.
Lead-time for notifications about DR events is insufficient.	Lack of sufficient notice reduces water sector participation.	Electric utilities need a diverse portfolio of electric reliability resources, distributed throughout their service areas. The water sector has the unique ability to commit in advance to provide Flexible Electric Resources that can operate for fairly long durations of time (e.g, 15 minutes to hours, instead of a few minutes at a time).
With few exceptions, W-WW utilities are not good candidates for Auto DR.	W-WW utilities must assure their mission-critical goals and objectives are met before opting-in to Demand Response or other discretionary revenue earning (or cost reduction) opportunities.	

A New Water Sector "Business As Usual" (BAU)

Building and inculcating a new industry-wide "BAU" is not a trivial undertaking. It would be even more daunting if the water and electric sectors' needs and interests were not aligned. However, the 2000/01 California power crisis and recent Public Safety Power Shutoffs (PSPS) are stark reminders of the need for the water sector to build its own reliability while concurrently supporting local and regional electric reliability.

Since "time is of the essence" for both the water and electric sectors, a three-pronged approach would be prudent:

1. ***Expedite Near-Term Development of Water Sector Flexible Electric Resources***. Water and wastewater utilities identified several key challenges in existing programs that inhibit their ability to provide electric reliability support. The decision as to which of these challenges to alleviate, and how, is a matter of policy.
2. ***Integrate Flexible Electric Resources into Future Water Sector Resources, Infrastructure, and Operations***. The State's water and wastewater utilities expend billions of dollars in new, expanded, and retrofit infrastructure every year. Long-term capital planning is an on-going process but there typically is a fairly small window for influencing infrastructure design. Two factors are vitally needed to integrate Flexible Electric Resources into water sector capital and operational planning:

> "Water IOUs have substantial potential to invest in upgrades that can provide Flexible Electric Resources for over-generation mitigation and other types of electric reliability support.
>
> ***"Under our financial model:***
>
> ***$1 million in operational cost reductions***
>
> ***= $8 million in infrastructure investments without impacting customers' bills."***
>
> - *Richard C. Svindland, President, California American Water*

- ***Clearly articulate the types, quantities, and locations of electric reliability support needed***. Water and wastewater utilities are confident that if they understand the electric system impacts that are needed, they will be able to determine how to structure their systems and operations to achieve those impacts.
- ***The mechanism for providing electric reliability must be simple to understand and implement, provide as much lead time as possible, and be absolutely unambiguous***. Meter-specific DR programs are not well suited to large, complex networked systems such as water and wastewater. One water utility noted that it may have 10 or more meters connected to a single SCE circuit. In order to assure that SCE receives the targeted electric impacts, a water sector Flexible Electric Resources program needs to specify the type of impact needed, at which circuit, the quantity and timing of the

impact, and the duration. The water utility can then deploy its portfolio of water and energy resources and adjust its operations in a manner that provides the targeted locational electric reliability result.

3. ***Develop a simple Partnership Agreement***. A "Standard Offer" similar in structure to the pre-approved regulatory agreements that were made available to "Qualifying Facilities" under The Public Utility Regulatory Policies Act of 1978 (PURPA)[x] would be helpful in facilitating a near-term dialogue about the types of electric reliability services a Water/ Wastewater Partner can provide now and in the future.

> California's "Standard Offers" expedited contracting and development of qualified renewable energy generation facilities by creating a "checklist" type of agreement with pre-approved "standard" terms and conditions, but with the ability to self-select some terms (e.g., the type of project – fixed or as-delivered capacity; the basis of compensation – fixed or variable, short- or long-run avoided cost, nominal dollars or levelized; etc.).[x] Similarly:
>
> - Term sheets documenting the level, types, and locations of electric reliability support that will be provided by individual water and wastewater utilities to electric utilities could be simply documented and appended to a Water Sector "Standard Offer" for Flexible Electric Resources.
> - The term sheet could provide a list of different compensation options for the proposed electric reliability services that the Water/Wastewater Partner could self-select.

Through case studies, meetings, and interviews with water and wastewater utilities, the foregoing principles for a Water Sector Electric Reliability Program were developed with the aim of leveraging the flexibility in California's water systems to provide near-term, cost-effective electric reliability support. Expedience is needed to influence the billions of dollars being expended by water and wastewater utilities today for upgrades and expansions that build drought resilience while meeting load growth. When design, development, and operations of water and wastewater systems are synchronized with the needs of the electric grid, cost-effective benefits accrue to both water and electric ratepayers.

There is no "one size fits all" – each water and wastewater utility has a unique mix of resources, infrastructure, and service area characteristics (demand, topography, hydrology/climate) that need to be considered when providing electric reliability services. Ideally, each Water/Wastewater Partner will identify synergistic opportunities that enable it to provide electric reliability support while concurrently increasing the reliability of its own systems and services. A "win-win" will assure that electric reliability becomes fully integrated into the new Water "BAU".

End Notes

[i] "Tracking Progress: Renewable Highlights." *California Energy Commission (CEC)*. June 2019. Retrieved at https://www.energy.ca.gov/sites/default/files/2019-06/renewable_highlights.pdf.
[ii] "The 100 Percent Clean Energy Act of 2018." Senate Bill 100 [*SB100, De León*]. September 10, 2018.
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[iv] "U.S. Solar Market Insight." *Solar Energy Industries Association (SEIA)* website: https://www.seia.org/us-solar-market-insight.
[v] Id.
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[vii] Loutan, Clyde, Hong Zhou, and Amber Motley. "Flexible Capacity Needs and Availability Assessment Hours Technical Study for 2020." *California Independent System Operator (CAISO)* presentation. April 4, 2019.
[viii] "Global Energy Storage Database." *Office of Electricity Delivery and Energy Reliability, U.S. Department of Energy* website: https://www.energystorageexchange.org/.
[ix] Park, Laurene and Caroline Minasian. "Water Sector Over-Generation Mitigation and Flexible Demand Response". *Water Energy Innovations for Southern California Edison*. May 7, 2019.
[x] "Opinion on Future Policy and Pricing for Qualifying Facilities." *California Public Utilities Commission* Decision 07-09-040 [Rulemaking 04-04-003 "to Promote Policy and Program Coordination and Integration in Electric Utility Resource Planning" and Rulemaking 04-04-025 "to Promote Consistency in Methodology and Input Assumptions in Commission Applications of Short-Run and Long-Run Avoided Costs, Including Pricing for Qualifying Facilities."] September 20, 2007.

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I The Challenge

SCE's Over-generation Pilot Project

Goal

Continue building knowledge and understanding about water sector opportunities for developing flexible resources that enhance grid reliability and mitigate both regional and local distribution over-generation impacts. For purposes of this report, "water sector" includes water and wastewater utilities, agricultural water purveyors, groundwater bankers, wholesale water suppliers, and other types of water purveyors and water service providers, both publicly and investor-owned.

Objectives

- Identify strategies for California's water sector to increase flexibility in their systems and operations where beneficial for mitigation of electric voltage instability, physical and economic curtailments of renewable electric resources, and other undesired impacts of over-generation.
- Develop analytical models and tools to assist the water sector in identifying and evaluating opportunities to provide over-generation mitigation support.
- Evaluate the costs/benefits of water sector over-generation opportunities from the perspectives of the water sector and their ratepayers, SCE and its ratepayers, and the State.
- Develop a proposed framework, rate model, and tariff for providing incentives to water sector entities to mitigate over-generation.

Approach

- Leverage prior work and existing relationships, resources, and assets to achieve the project goals and objectives as efficiently and cost-effectively as possible.
- Obtain input and insights from leading water and wastewater utilities that have already commenced identifying and evaluating strategies for minimizing energy costs and risks in the anticipated new electric markets.
- Capture stakeholders' insights in case studies that document best-in-class over-generation mitigation programs, projects, and practices.
- Convert data and information about water sector opportunities for mitigating over-generation into training materials, analytical and predictive models, and other tools that can help water and wastewater utilities increase their flexible load capabilities.

Background and Context

On September 19, 2013, the California Public Utilities Commission (CPUC) opened Rulemaking No. 13-09-011 "To Enhance the Role of Demand Response in Meeting the State's Resource Planning Needs and Operational Requirements" (R.13-09-011). One activity conducted under this rulemaking was review and approval of the State's electric investor-owned utilities' (IOUs) proposed Demand Response Programs which include new demand response research activities to meet the future grid needs envisioned by the State.

On June 9, 2016, the CPUC issued Decision 16-06-029 approving SCE's proposed pilot to evaluate the potential of pumped water storage as a means of addressing periods of over-supply (over-generation) on California's electric grid.

For purposes of this project, "water sector" includes water and wastewater utilities, agricultural water purveyors, groundwater bankers, wholesale water suppliers, and other types of water purveyors and water service providers, both publicly and investor-owned.

Phase 1

The Pilot commenced with establishing a baseline understanding of "over-generation" and the potential role of the water sector in providing over-generation mitigation and related types of electric reliability support.

Summary of Phase 1 Findings

Over-generation occurs at times and in places where real-time electric supplies exceed real-time electric demand, causing electric system instability.

1. ***Over-generation is real, and it will increase substantially over the next 5 years***. Over-generation due to surplus variable energy resources, especially solar photovoltaics (PV) and wind, has been observed since 2015. California policymakers and regulators have been tracking the rate of growth in over-generation events and impacts which, due to insufficient battery energy storage, requires intervention from the California Independent System Operator (CAISO) that is charged with managing 80% of California's wholesale electric grid. "Intervention" resulted in "curtailments": turning off some of the State's valuable clean and renewable energy resources, mostly utility-scale solar PV, during some hours. Given the State's commitment to achieving a portfolio of 100% carbon free and renewable electric resources by the year 2045, curtailments are antithetical to State policy.

2. ***California's water sector has unique opportunities to provide over-generation mitigation and related electric reliability services***. It has long been known that water and wastewater utilities have the unique ability to substantially change the quantity, time, and location of their electric use. Many water and wastewater utilities routinely minimize use of electricity

during summer on-peak (high electric price) periods. The same types of changes to water and wastewater systems and operations that enable avoiding high cost summer on-peak electricity can be readily adapted to increase electric use during periods of over-generation, provided there is sufficient financial compensation and any potential risks to mission-critical operations can be appropriately mitigated.

3. ***The water sector is interested in participating in design of an over-generation mitigation and "Flexible Demand Response" program***. Water and wastewater utilities that participated in Phase 1 of this Pilot Project stated that they could do more Demand Response and expressed a desire to participate in designing a "Flexible Demand Response" program tailored to the special needs and capabilities of the water sector.

The results of the Phase 1 opportunity assessment were documented on May 7, 2019 in a report: "Water Sector Over-Generation Mitigation and Flexible Demand Response". The Phase 1 report is available for download.[1].

Phase 2

Phase 2 was structured to build upon the Phase 1 findings through meetings, site visits, interviews, and workshops with a variety of water and wastewater utilities.

Goal

Advance development of an SCE Flexible Electric Resources Program that helps the water sector and other SCE customers develop Flexible Electric Resources that can support electric reliability at both the transmission and distribution system levels.

Objectives

1. Identify strategies for water and wastewater utilities to increase flexibility in their systems and operations where beneficial for mitigation of electric instability, physical and economic curtailments of renewable electric resources, and other electric reliability challenges at both the transmission and distribution system levels.
2. Evaluate the costs/benefits of water sector Flexible Electric Resources opportunities from the perspectives of water and wastewater utilities and their ratepayers, SCE and its ratepayers, and the State.
3. Develop a proposed framework for engaging the assistance of the water sector in providing electric reliability support through development and provision of Flexible Electric Resources.

[1] The Phase 1 report can be accessed on *Water Energy Innovations* website via the below link: https://www.waterenergyinnovations.com/wp-content/uploads/2019/05/20190507-FINAL-Overgen-T1-Assess-HIGH_RES.pdf.

Time is of the Essence

The Phase 1 report showed that as of March 25, 2019, 23,832 MW of new utility-scale solar photovoltaic (PV) generation had applied for transmission interconnection with the CAISO between the five year period 2019-2023. Of that amount, projects totaling 8,933 MW (37.5%) had already executed transmission interconnection agreements.[2]

Over the 6 month period following the Phase 1 report, the queue for new utility-scale solar PV increased by 6.8%, to 25,458 MW as of October 8, 2019. Of that amount, 10,682 MW (41%) have now executed transmission interconnection agreements.[3]

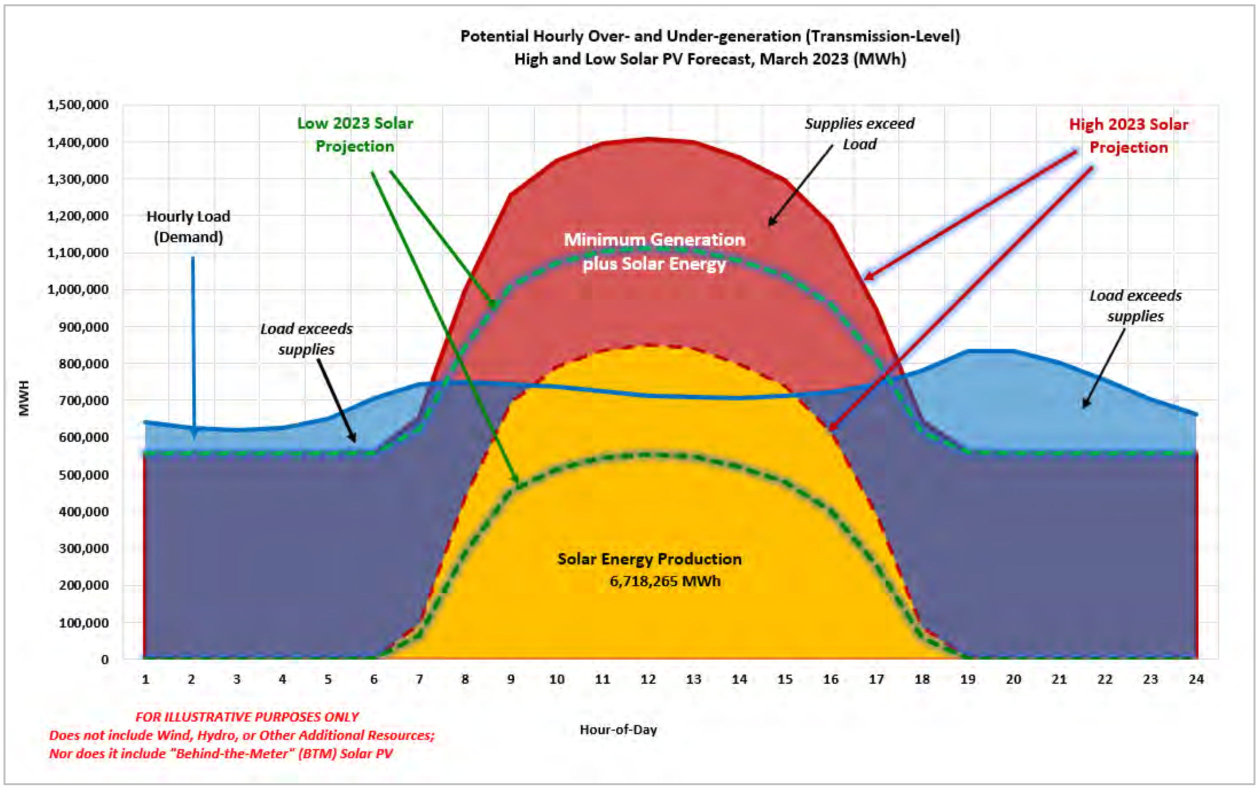

Figure 1. Potential Range of Over-generation by March 2023 [High and Low Solar PV Projections]

<u>Note</u>: Utility-scale (transmission level) solar PV is on a trajectory to more than double within 5 years. If all of the solar PV presently in queue for transmission interconnection is placed in-service, solar PV could triple. Figure 1 shows that as solar PV capacity increases, solar electricity plus “Minimum Generation” is expected to exceed real-time electric demand (Load) during the

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[2] Source: CAISO data about the number and capacity of projects requesting generation interconnection as of March 25, 2019.

[3] “A streamlined process for interconnecting generating facilities.” *CAISO* website: http://www.caiso.com/planning/Pages/GeneratorInterconnection/Default.aspx. ISO Generator Interconnection Queue, Excel spreadsheet, “Active” Projects only. Data downloaded on September 27, 2019.

middle of the day. [“Minimum Generation” is the amount of other electric generation resources that cannot be dispatched – turned on or off – either because they are required to be operated (“regulatory must-run”) or because they are needed for electric reliability purposes (e.g., natural gas turbines that provide emergency backup power, load following, and other important grid balancing services).]

Figure 1 on the preceding page shows that by March 2023, even the low solar PV forecast is likely to result in over-generation from 8am to 6pm. This graph does not show the impact of other grid-level renewable energy resources or “behind-the meter” (BTM) Solar.

Note that utility-scale solar PV is just one part of the equation. Over-generation also has a distribution system counterpart: mini-duck curves created by distribution level variable energy resources (primarily solar PV), most of which is “behind-the-meter” (BTM) customer-side electric generation. Figure 2 below shows that as of April 4, 2019, the CEC expected BTM solar PV capacity alone to exceed 12,000 MW by 2022.

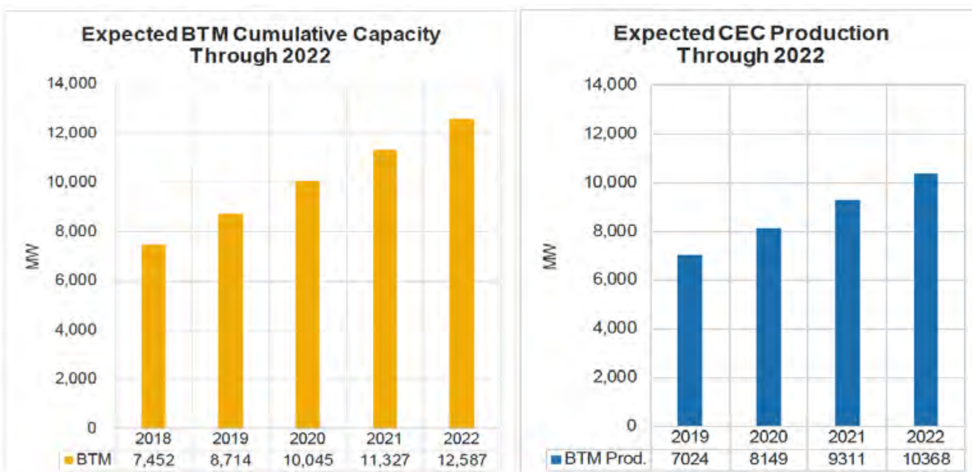


Figure 2. Projected 2020 BTM Solar PV Capacity and Production[4]

[4] Estimated BTM Solar PV Capacity was projected by Load Serving Entities (LSEs); estimated BTM Solar PV Production was projected by the California Energy Commission (CEC). Source: Loutan, Clyde, Hong Zhou, and Amber Motley. “Flexible Capacity Needs and Availability Assessment Hours Technical Study for 2020.” *California Independent System Operator (CAISO)* presentation. April 4, 2019.

On April 4, 2019, the CAISO reported that its “Duck” (Net Load) was four years ahead of schedule due to under-forecasting rooftop (BTM) solar PV (see Figure 3 below).

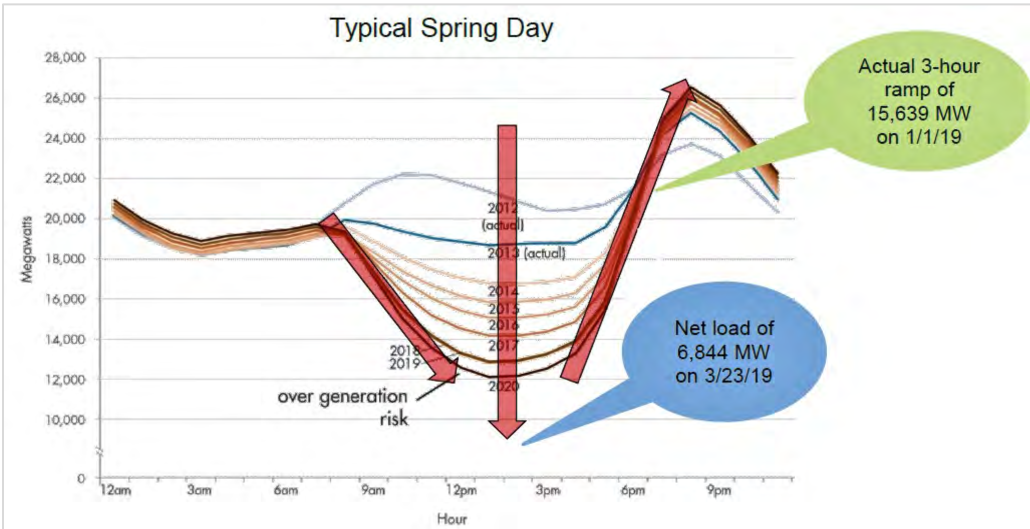
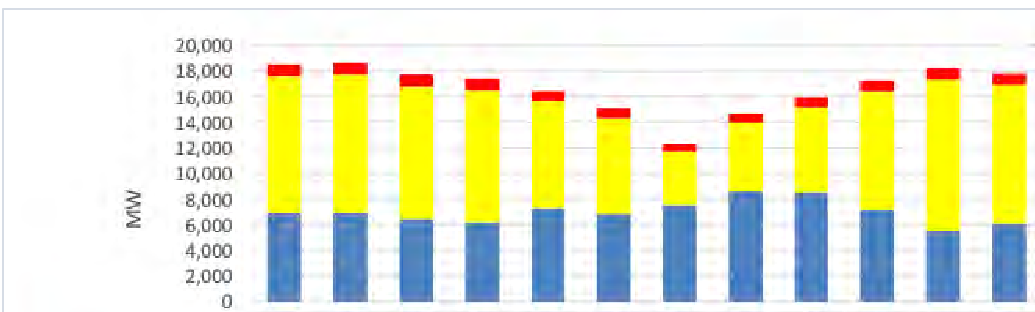


Figure 3. CAISO Duck is 4 Years Ahead of Schedule[5]

Significant quantities of flexible capacity will be needed in 2020 to effectively integrate high volumes of both transmission- and distribution-level variable energy resources, most of which is solar PV. Figure 4 below shows the monthly amount of flexible resources that the CAISO estimates will be needed by 2020 by type of resource (Base, Peak, and Super-Peak).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Super-Peak Flexibility	925	931	885	869	822	756	617	733	798	863	913	890
Peak Flexibility	10,691	10,778	10,326	10,303	8,343	7,499	4,175	5,323	6,618	9,249	11,826	10,832
Base Flexibility	6,885	6,916	6,489	6,208	7,279	6,858	7,546	8,612	8,547	7,156	5,521	6,088

Figure 4. Preliminary System-Wide Flexible Capacity Monthly Calculation by Category for 2020[6]

[5] Loutan, Clyde, Hong Zhou, and Amber Motley. “Flexible Capacity Needs and Availability Assessment Hours Technical Study for 2020.” *California Independent System Operator (CAISO)* presentation. April 4, 2019.

[6] “Flexible Capacity Needs Assessment for 2020.” *California Independent System Operator (CAISO)* presentation. May 15, 2019.

CAISO Flexible Capacity Categories

Base Flexibility: Operational needs determined by the magnitude of the largest three-hour secondary net load ramp

Peak Flexibility: Operational need determined by the difference between 95 percent of the maximum three-hour net load ramp and the largest three-hour secondary net load ramp

Super-Peak Flexibility: Operational need determined by five percent of the maximum three-hour net load ramp of the month

Source: Loutan, Clyde, Hong Zhou, and Amber Motley. "Flexible Capacity Needs and Availability Assessment Hours Technical Study for 2020." *California Independent System Operator (CAISO)*. May 15, 2019.

Solar and Wind Energy Curtailments

Table 1 below and Figure 5 on the next page show the amount of solar and wind energy curtailed by the CAISO during 2015-2019. (Note that curtailments during 2019 cover the period through July 31, 2019.)

Table 1. Quantity of Solar and Wind Curtailments (MWh) [2015-2019][7]

Year	Solar	Wind	Total Curtailments
2015	137,182	50,588	**187,770**
2016	228,418	73,744	**302,162**
2017	345,545	33,873	**379,418**
2018	432,357	28,686	**461,043**
2019	671,220	32,971	**704,191**

Clearly, curtailments during 2019 have increased substantially, especially solar. The gap between electric supplies and demand will continue to grow as more utility-scale renewable generation such as solar and wind are brought on-line to meet California's ambitious goal of 100% carbon-free energy by 2045.

[7] Compiled from California Independent System Operator (CAISO) historical wind and solar production and curtailment data through July 31, 2019 in the California Independent System Operator. "Managing Oversupply." *CAISO* website: http://www.caiso.com/informed/Pages/ManagingOversupply.aspx.

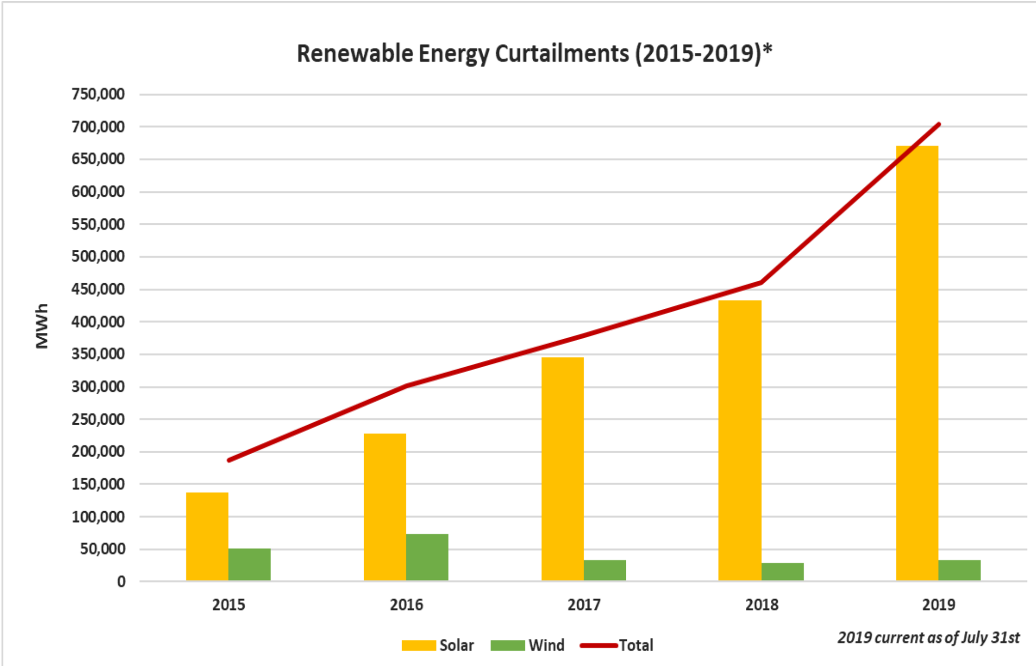


Figure 5. Annual Solar and Wind Energy Curtailments (2015-2019)[8]

The largest curtailments during 2019 occurred during May. This is a substantial change from prior years wherein curtailments have been highest during spring months, especially February and March. Figure 6 below shows the quantity of renewable energy curtailments by month during CY2019 (as of September 30, 2019).

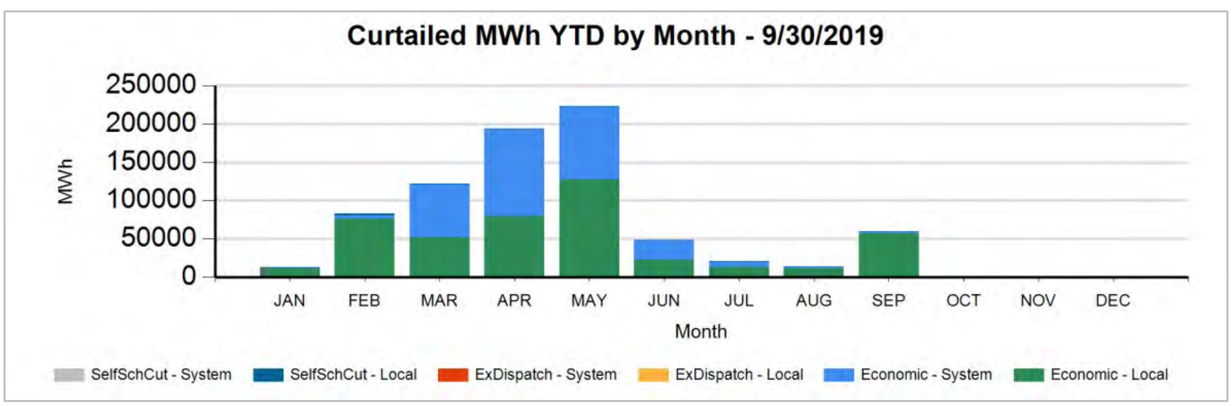


Figure 6. Monthly Renewable Energy Curtailments During CY2019 (as of September 30, 2019)[9]

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[8] Compiled from California Independent System Operator (CAISO) historical wind and solar production and curtailment data through July 31, 2019 in the California Independent System Operator. "Managing Oversupply." *CAISO* website: http://www.caiso.com/informed/Pages/ManagingOversupply.aspx.

[9] California ISO Wind and Solar Curtailment September 25, 2019. *CAISO* website: http://caiso.com/Documents/Wind_SolarReal-TimeDispatchCurtailmentReportSep30_2019.pdf.

Figure 7 below shows the hourly pattern of renewable energy curtailments during 2019 as of September 25th. The diurnal pattern tracks with hourly solar PV production.

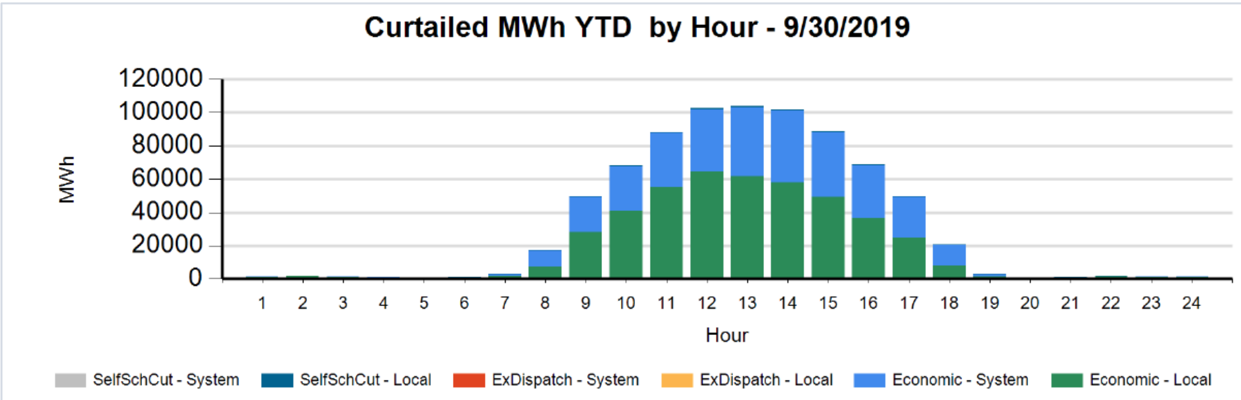

Figure 7. Hourly Curtailments by Type During CY2019 (as of September 30, 2019)[10]

Figure 8 below was prepared by the CAISO to illustrate the deep curtailments (39 GWh depicted as red bars) that were needed on May 27, 2019.

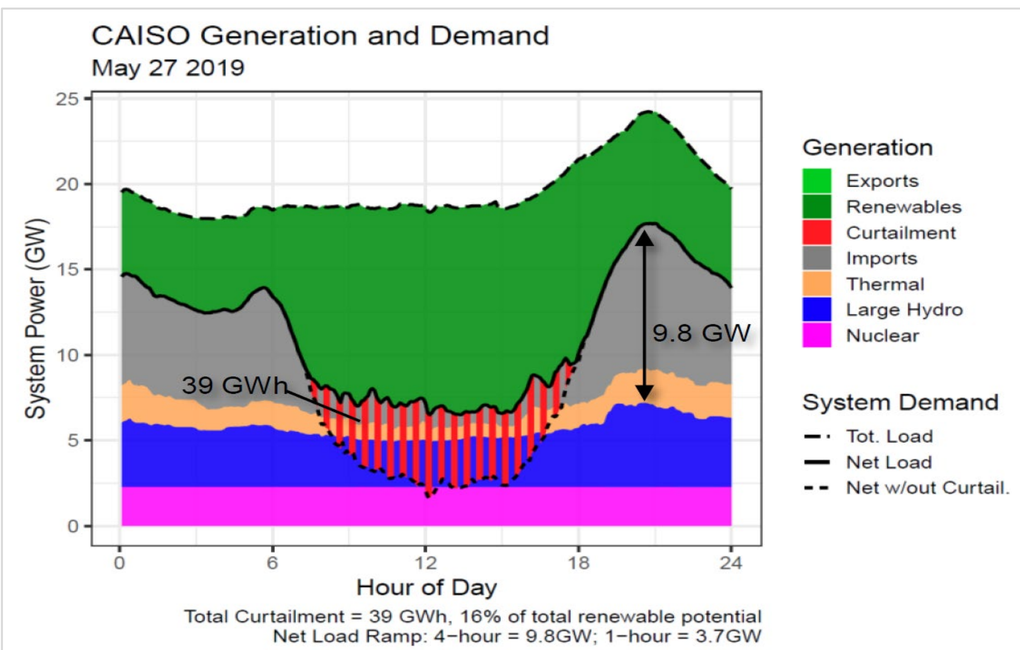

Figure 8. CAISO Renewable Energy Curtailments on May 27, 2019[11]

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[10] California ISO Wind and Solar Curtailment September 25, 2019. *CAISO* website: http://caiso.com/Documents/Wind_SolarReal-TimeDispatchCurtailmentReportSep30_2019.pdf.

[11] Gerke, Dr. Brian, et. al. "California Demand Response Potential Study Phase 3: The Potential for Shift Demand Response." *Lawrence Berkeley National Laboratory, Energy Technologies Area*. Powerpoint dated July 24, 2019.

Particularly given the need for near-term measures to reduce curtailments, the water sector – with substantial flexible capacity already in place that could shift electric demand to periods of over-generation "today" – should be a high priority for California.

What's in this Report

Chapter II Demand Response describes the State policies, legislation, and regulations that drive the search for over-generation mitigation and electric reliability support from customers. It will also briefly describe the evolution of California's demand response programs and what will be needed in order to inculcate "Flexible Electric Resources" into water sector planning and operations as the new "business as usual" (BAU).

Chapter III Water Sector Flexible Electric Resources describes the types of cost-effective Flexible Electric Resources that exist now in California's water and wastewater systems, and what will be needed to develop and rapidly deploy these valuable electric reliability resources.

Chapter IV Water-Energy Management Tools describes some of the technologies, innovations, tools, and techniques that have been initiated by water and wastewater utilities for development in-house, with vendors, with academia, and/or a wide variety of other partners, to improve the quality of water sector real-time decision-making.

Chapter V Valuing Flexible Electric Resources describes the efforts currently underway pursuant to CPUC regulatory proceedings that require investor-owned electric utilities to develop avoided costs for distributed energy resources (DERs) that include avoided upgrades to electric transmission and distribution infrastructure.

Chapter VI A New "BAU" describes the primary insights gained during Phase 2 of this Pilot and summarize the project team and case study participants' insights and observations with respect to opportunities for accelerating development and implementation of Water Sector Flexible Electric Resources.

Chapter VII A Flexible Electric Resources Partnership presents a potential Partnership framework that could productively and expeditiously engage electric reliability support from the State's water and wastewater utilities.

II Demand Response

The Evolution of Demand Response

Demand Response (DR) has been used as an electric reliability resource in the U.S. for decades. The concept of DR emerged from crisis: the 1973-74 oil embargo that created critical energy supply shortages throughout the U.S. in all sectors. This widespread energy emergency focused the nation's attention on the need to build energy independence and reduce reliance on politically volatile energy imports.[1]

On November 7, 1973, President Nixon announced a new initiative, "Project Independence." Although the long-term vision focused on nuclear power, the President also proposed raising thermostats to reduce air conditioning load, reducing driving speeds, and eliminating all unnecessary lighting. The President also called on Americans to unite around development of domestic energy sources in order to eliminate dependence on foreign energy supplies. [2]

The U.S. Department of Energy was established in 1977 under President Carter to replace several interim federal organizations that had been created to address the 1973-74 oil embargo. Over a three year period (1978-1980), multiple federal legislation were enacted that were intended to work together in concert to build national energy self-sufficiency. Their creation was timely since another oil crisis struck in 1979.[3]

- 1978 – President Carter signed the National Energy Act that includes the National Energy Conservation Policy Act, the Power Plant and Industrial Fuel Use Act, the Public Utility Regulatory Policy Act, the Energy Tax Act, and the Natural Gas Policy Act.
- 1980 – President Carter signed the Energy Security Act comprised of six major pieces of federal legislation: U.S. Synthetic Fuels Corporation Act, Biomass Energy and Alcohol Fuels Act, Renewable Energy Resources Act, Solar Energy and Energy Conservation Act and Solar Energy and Energy Conservation Bank Act, Geothermal Energy Act, and Ocean Thermal Energy Conversion Act.

The Regulatory Assistance Project (RAP) attributes the roots of Demand Response "in part due to the spread of central air conditioning" during the 1970s and the call to turn up thermostats during the oil crises that drew attention to the high fuel demand and system costs of meeting these peak electric loads. These events encouraged electric utilities to seek load management alternatives.[4]

Sources:

[1] "Oil Embargo, 1973-1974". *U.S. Department of State* Office of the Historian website: https://history.state.gov/milestones/1969-1976/oil-embargo.

[2] "The Energy Emergency." The President's Address to the Nation Outlining Steps To Deal With the Emergency. November 7, 1973. Retrieved from *University of Luxembourg* website: https://www.cvce.eu/obj/address_given_by_richard_nixon_7_november_1973-en-1158015d-8cf9-4fae-8128-0f1ee8a8d292.html.

[3] "Timeline of Events: 1971 to 1980." *U.S. Department of Energy* website: https://www.energy.gov/management/office-management/operational-management/history/doe-history-timeline/timeline-events-1.

[4] Cappers, Peter, Charles Goldman, and David Kathan. "Demand Response in U.S. Electricity Markets: Empirical Evidence." *Ernest Orlando Lawrence Berkeley National Laboratory*. 2009.

Demand Response as a Reliability Resource

> *"Demand response refers to the intentional modification of electricity usage by end-use customers during system imbalances or in response to market prices."*
>
> - Hurley, Doug, Paul Peterson and Melissa Whited. "Demand Response as a Power System Resource." *The Regulatory Assistance Project and Synapse Energy Economics, Inc.* May 2013.

Over the past several decades, the nation's electric utilities became increasingly aware of the value of reducing peak electric demands and implemented a wide variety of customer demand-side management programs aimed at shifting the time of electric use as a valuable electric system management tool. The Regulatory Assistance Project (RAP) noted, however, that although interruptible and curtailable programs were popular during the 1980s and 1990s, customers were seldom called upon to reduce load.[12]

Following the Energy Policy Act of 1992[13] that allowed independent power generators to participate in wholesale markets and FERC Order 888 (1996) implementing "open access" to high voltage transmission systems, the electric market transitioned from predominantly vertically integrated utilities to competitive wholesale markets in which electric generation, transmission, and distribution were disaggregated. In this new marketplace, the responsibility for assuring grid reliability was assumed by new organizations (independent system operators (ISOs) or regional transmission organizations (RTOs)) that were charged with managing newly competitive wholesale power markets and assuring open access to transmission assets.[14]

The 2000/01 California Power Crisis

On the heels of California's electric restructuring (1995-1999), the State was pitched into a power crisis of proportions heretofore unknown in the U.S.

- On May 22, 2000, the California Independent System Operator (CAISO) charged with managing 80% of the State's high voltage transmission system announced its first Stage 2 power alert when high electric use and low supplies resulted in power reserves falling to 5%. (At that time, reserves of 23% were typical.)
- On June 14, 2000, temperatures in San Francisco reached 103 degrees, triggering a series of localized rolling blackouts by Pacific Gas & Electric (PG&E) in the Bay Area.

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[12] Hurley, Doug, Paul Peterson and Melissa Whited. "Demand Response as a Power System Resource." *The Regulatory Assistance Project (RAP)* and Synapse Energy Economics, Inc. May 2013. Page 9.

[13] "The Energy Policy Act (EPAct)." *Public Law* 102-486, 106 Stat. 2776. October 24, 1992.

[14] Id at page 10.

- On August 2, 2000, Governor Davis called for an investigation into "possible price manipulation in the wholesale electricity marketplace."[15]

Over a frantic 12 month period, the State's policymakers and regulators scrambled to help electric utilities and the CAISO create and deploy emergency measures that could reduce the costs and adverse public health, safety, and economic impacts of the power crisis. Key among these strategies was "load management" – asking customers to take actions to reduce their electric use to avoid power outages. Voluntary load reductions (turning thermostats up and lights off) were made by responsible customers in all segments throughout the State. The CPUC rushed implementation of emergency rate programs such as the 20/20 Rebate program.

California's Emergency 20/20 Rebate Program

Governor Davis exercised his emergency powers to establish the 20/20 Rebate Program that offered a 20% rebate on electricity bills from June through September 2001 for customers of the State's regulated electric utilities. The rationale for the 20/20 program was that qualifying customers could dampen higher electric costs through rebates, and the program might lower the overall cost of electricity by reducing spot market volumes and prices. Under the program:

- Residential and small commercial/industrial customers received a 20% rebate off the electricity commodity portion of their bill if they reduced their total monthly electricity use by at least 20% compared to the same month in the previous year.
- Large commercial/industrial customers with time-of-use (TOU) meters received a 20% rebate off their summer on-peak demand and energy charges (weekdays, Noon to 6 PM) if they reduced on-peak electricity use by 20% or more.

To assure participation, the program was structured very simply. Ultimately, the State's investor-owned utilities reported participation rates of 33% Residential and 26% Non-Residential.

Although analysts differ as to whether the program was cost-effective, both electric use and electric demand did decrease during the Summer of 2001, under extraordinary power market conditions. The program was thus proclaimed "successful".

Sources:

- Goldman, Charles, Joseph Eto, Galen Barose. "California customer load reductions during the electricity crisis: Did they help to keep the lights on?" *Lawrence Berkeley National Laboratory*. May 1, 2002.
- Bachrach, Devra, Matt Ardema, Alex Leupp. "Energy Efficiency Leadership in California, Preventing the Next Crisis." *Natural Resources Defense Council with the Silicon Valley Manufacturing Group*. April 2003.

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[15] "The California Crisis, California Timeline." *KVIE* website: https://www.pbs.org/wgbh/pages/frontline/shows/blackout/california/timeline.html.

The Evolving California Definition

"Demand Response" (DR) has morphed from its early versions during the 1970s oil crises (turning thermostats up and lights off) to an essential electric balancing resource. In its earliest iterations, the concept of DR – encouraging customers to reduce their electric use during periods of high electric demand relative to available electric generation and transmission capacity – was simple to understand and to implement.

Everything became much more complex when the federal Energy Policy Act of 1992 (EPAct)[16] mandated establishing a competitive market for electric supplies. Under "deregulation" (or more correctly, "re-regulation" or "restructuring" of the nation's electricity markets), owners of high voltage transmission assets were required to provide access for all electric generators to their transmission lines ("open access") to support development of a competitive market for electric supplies. While not specifically required by EPAct 1992 or the subsequent EPAct 2005, California encouraged the State's electric IOUs to divest at least 50% of their fossil-fueled generation.[17] As a result, with few exceptions, California's electric IOUs divested most of their non-nuclear generation assets,[18] substantially changing the regulated electric utilities' resource portfolios and virtually eliminating the historical linkage between customer DR programs and IOU electric generation capacity. The electric capacity to be avoided was now being provided primarily through purchases of wholesale power from independent power producers under a wide variety of contract mechanisms. The nature of fixed vs. variable costs associated with Generation also changed significantly but the historical regulatory framework for cost-of-service ratemaking and associated valuation of Demand-Side Management (DSM) programs such as Energy Efficiency and Demand Response changed little.

The 2000/01 California Power Crisis

California's charge to implement near-instantaneous competitive markets required extraordinary changes to the ownership and management of virtually all of the State's electric resources and infrastructure, practically "overnight." The rush to implement sweeping changes was met with a catastrophic power crisis (2000/01) that required extraordinary measures to maintain electric reliability. Throughout the power crisis, both Energy Efficiency and Demand Response were relied on to an unprecedented extent as a means to keep power flowing throughout the State.

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[16] "The Energy Policy Act (EPAct)." Public Law 102-486, 106 Stat. 2776. October 24, 1992.

[17] "California Electric and Gas Utility Cost Report, AB67 Annual Report to the Governor and Legislature. *California Public Utilities Commission* Energy Division. April 2019. Page 25.

[18] "Report to Congress on Competition in Wholesale and Retail Markets for Electric Energy, Pursuant to Section 1815 of the Energy Policy Act of 2005." *The Electric Market Competition Task Force (federal agencies)*. April 5, 2007.

Post 2000/01 California Power Crisis

Demand response programs reduce peak demand in 2 ways:

[1] Incentives and metering technology enable customers to reduce electric loads when prices and electricity demand are high.

[2] Reliability programs provide customers with a non-price signal that shows when DR would be beneficial.

- "Integrated Energy Policy Report." *California Energy Commission*. 2004.

The evolution of customer energy programs in California post 2000/01 power crisis shows that while the basic characteristics of "Demand Response" have remained fairly constant:

- The ***voluntary reduction of electric demand*** by customers,
- ***At certain times and on certain days***,
- When needed ***to support electric reliability***;

The State's DR policies and programs morphed over time as needed to support California's evolving policy priorities.

The following key policies have affected the nature and valuation of Demand Response resources and programs post 2000/01 power crisis.

Demand response sometimes, not always, reduces energy use; but the primary purpose of demand response is to shift the time of electric use to reduce demand on the electric system at times of electricity shortages.

1. ***Energy Loading Order***. In 2003, State policymakers developed the concept of prioritizing California's investments in energy resources. The resultant "Energy Loading Order" reflected energy resource investment priorities that were established by the Joint Energy Agencies and implemented by adoption of the State's first Energy Action Plan. The Loading Order designated Energy Efficiency as the State's highest priority energy resource. Although they are very different in character, "Demand Response" was included in "Energy Efficiency".[19]

[19] "Energy Action Plan." Adopted May 8, 2003 by the Joint Agencies: Consumer Power and Conservation Financing Authority (*California Power Authority*), Energy Resources Conservation and Development Commission (*California Energy Commission*), and the *California Public Utilities Commission*.

2. ***Integrated Demand Side Management (IDSM)***. CPUC Decision 07-10-032[20] directed the State's energy IOUs to "Integrate customer demand-side programs, such as energy efficiency, self-generation, advanced metering, and demand response, in a coherent and efficient manner" to increase both the effectiveness and cost-effectiveness of energy efficiency programs." The concept of IDSM was reinforced in the CPUC's California Long-Term Energy Efficiency Strategic Plan adopted on September 18, 2008.[21] Specifically, the Plan emphasized a need to integrate program design; delivery of energy programs and services; marketing, education, and outreach; and even resources on a comprehensive basis - both in context of integration of all energy resources (energy efficiency, demand response, distributed generation, and energy storage), and across multiple State agencies and goals including water and climate.

   In 2009, the CPUC approved IDSM energy efficiency programs proposed by the energy IOUs. The IOUs' demand response IDSM program budgets were included with a requirement that "Integration Teams" be established that include staff from energy efficiency, demand response, distributed generation, marketing, and delivery channels.[22]

3. ***Flexible Capacity for System and Local Electric Reliability***. In 2013, the CPUC opened Rulemaking 13-09-011 To Enhance the Role of Demand Response in Meeting the State's Resource Planning Needs and Operational Requirements. This rulemaking was initiated to determine whether and how to bifurcate utility-administered, ratepayer-funded DR programs into demand-side and supply-side resources with the intent of prioritizing DR as a utility-procured resource, competitively bid into the CAISO wholesale electricity market to meet the State's long-term clean energy goals while maintaining system and local reliability.[23]

> *"The ISO envisions demand response and energy efficiency becoming integral, dependable and predictable resources that support a reliable, environmentally sustainable electric power system."*
>
> - "Demand Response and Energy Efficiency Roadmap: Maximizing Preferred Resources." *California Independent System Operator (CAISO)*. December 2013.

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[20] "Interim Opinion on Issues Relating to Future Savings Goals and Program Planning for 2009-2011 Energy Efficiency and Beyond." *California Public Utilities Commission* Decision 07-10-32. October 18, 2007.

[21] "California Long-Term Energy Efficiency Strategic Plan." *California Public Utilities Commission*. September 18, 2008.

[22] "Decision Approving 2010 to 2012 Energy Efficiency Portfolios and Budgets." *California Public Utilities Commission* Decision 09-09-047. September 24, 2009. Ordering Paragraph 33.

[23] "Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Demand-Side Resource Programs." *California Public Utilities Commission* OIR 14-10-003. October 2, 2014. Page 2.

The rulemaking revised the CPUC's definition of "Demand Response":

> "*Demand response is defined as changes in electricity use by customers from their normal consumption pattern in response to changes in the price of electricity, financial incentives to reduce consumption, changes in wholesale market prices, or changes in grid conditions*."[24]

Through this rulemaking, the concept of Flexible Capacity –demand response resources capable of providing grid level operational flexibility to the CAISO in order to support integration of increasing quantities of intermittent renewable energy resources – was introduced.[25] This rulemaking also raised the possibility of tapping into electric IOUs' Resource Adequacy capacity payments as a means to procure demand response resources. (Resource adequacy procurements do not employ traditional utility avoided cost compensation mechanisms.)[26]

4. ***Integrated Distributed Energy Resources (IDER)***. In 2015, the CPUC changed the scope of its Rulemaking 14-10-003 "to focus on the integration of distributed energy resources in a holistic way that includes not only what the utilities offer customers (integrated demand-side management) but also what customers offer the utility (integrated distributed energy resources)."[27] In this decision, the CPUC noted the close relationship between Rulemaking 14-10-003 (IDSM/IDER) and Rulemaking 14-08-013 Regarding Policies, Procedures and Rules for Development of Distribution Resources Plans Pursuant to Public Utilities Code Section 769.[28] The scope of the rulemaking included determining the "optimal location(s) for deployment of DERs, and then identifying specific locational values for DERs."[29] Public Utilities Code Section 769 states "For purposes of this section, 'distributed resources' means distributed renewable generation resources, energy efficiency, energy storage, electric vehicles, <u>and demand response technologies</u>."[30] [<u>emphasis added</u>]

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[24] "Order Instituting Rulemaking to Create a Consistent Regulatory Framework for the Guidance, Planning, and Evaluation of Integrated Demand-Side Resource Programs." *California Public Utilities Commission* R.14-10-003. October 2, 2014. Page 3.

[25] Id. at pages 10-12.

[26] Id. at pages 12-13.

[27] "Decision Adopting an Expanded Scope, a Definition, and a Goal for the Integration of Distributed Energy Resources." *California Public Utilities Commission* Decision 15-09-022. September 17, 2015. Ordering Paragraph 2.

[28] "Order Instituting Rulemaking 14-08-013 Regarding Policies, Procedures and Rules for Development of Distribution Resources Plans Pursuant to Public Utilities Code Section 769." *California Public Utilities Commission* R.14-08-013. August 14, 2014.

[29] Id. at page 4.

[30] Id. at Appendix A.

5. ***Over-generation Mitigation***. On June 9, 2016, the CPUC issued Decision 16-06-029 that approved bridge funding for 2017 demand response programs and activities. Among other things, this decision provided funding for pilots to address California's over-generation situation.[31] Over-generation mitigation requires two-way Demand Response: shedding (reducing) electric use during times of electric supply shortages and increasing electric use during times of electric supply surpluses ("over-generation").

Four 'Ss'

A study conducted by Lawrence Berkeley National Laboratory (LBNL) on behalf of the CPUC developed a new way of viewing Demand Response: in terms of four "Ss" (see Figure 9 below).

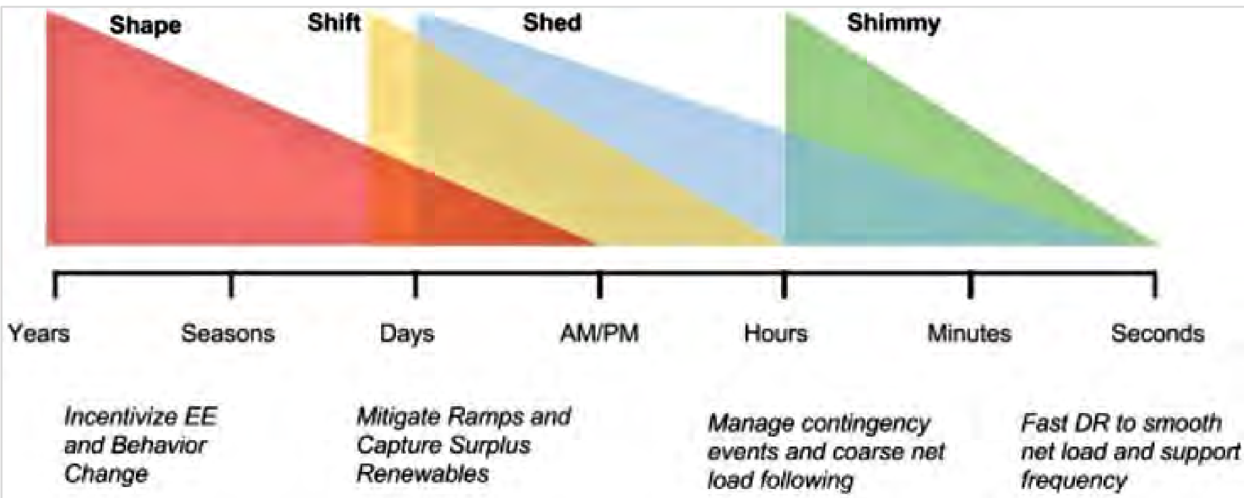

Figure 9. Four Types of Demand Response[32]

The four Ss represent four types of Demand Response:

- **Shape**: Persistent daily load modifications (Shed & Shift combinations) arising from changes in behavior.
- **Shift**: Acts like a storage resource.
- **Shed**: Acts like a generation capacity resource.
- **Shimmy**: Acts like a regulation/ancillary services resource.

These four Ss drive today's dialogues about the State's demand response potential and the types of DR services and products that are needed to support statewide electric reliability.

[31] "Decision Adopting Bridge Funding for 2017 Demand Response Programs and Activities." *California Public Utilities Commission* D.16-06-029. June 9, 2016. [This Decision was issued pursuant to R.13-09-011 To Enhance the Role of Demand Response in Meeting the State's Resource Planning Needs and Operational Requirements.]

[32] Gerke, Dr. Brian, et. al. "California Demand Response Potential Study Phase 3: The Potential for Shift Demand Response." *Lawrence Berkeley National Laboratory*, Energy Technologies Area. Powerpoint dated July 24, 2019.

Looking Forward

Demand response has been viewed as an important system reliability balancing resource since the early 1970s when the U.S. realized that it needed to substantially reduce or completely end dependence on politically volatile imported fuels. Major changes occurred in U.S. energy policies and markets over the next three decades aimed at increasing energy self-sufficiency. These policies were the progenitors of California's core integrated distributed energy resources: energy efficiency, demand response, distributed generation, and energy storage (in that order).

In one of its earliest iterations, demand response consisted primarily of turning up thermostats to reduce air conditioning loads during times of peak electric demand. Then, as now, reducing peak demand was a means to optimize the value of installed electric system capacity.

Although the nature of demand response programs has changed over the past five decades, the fundamental characteristics have remained.

From the perspective of electric service, "Demand Response":

- Occurs when an electricity user voluntarily changes the time of his or her electric use.
- May or may not reduce electricity consumption.

The types of electric system benefits sought through demand response programs have, however, changed over time.

- Until recently, the primary purpose of Demand Response was to provide cost-effective and reliable electric service by reducing the amount of electricity and electric capacity (generation, transmission, and/or distribution) needed to serve customers.
- Then, as now, the need for Demand Response was time- and location-specific, related to the amount of electricity required at any particular location at any point in time to serve customers' loads vs. the amount of electricity resources and electric capacity available to serve them.

California's successful renewable energy and climate action policies, however, have created an urgent need to quickly identify and deploy large quantities of Demand Response capacity capable of integrating variable energy resources that have increased substantially, and are continuing to increase at an unexpectedly rapid rate, to meet California's vision for a 100% clean and renewable energy future.

Renewable "variable energy resources" produce electricity when the sun shines, when the wind blows, and when water flows.

Where the focus was once on encouraging customers to shed relatively small quantities of electric load during a few hours of the year, California now needs as much "Flexible Load" as possible – customer electric demand can that both increase and decrease during some hours of the day - to reliably integrate the huge quantities of "variable energy resources", mostly solar PV, that are producing more electricity than needed during some hours of the day.

"Flexible Load"

The capability of increasing or increasing electric demand as needed to provide electric reliability support is referred to as "Flexible Load."

Where customers were once passive users of electricity, largely unaware and indifferent with respect to how electricity is produced and how it is delivered to them, customers are now viewed as integral to providing cost-effective energy efficiency and demand response to support continued reliable electric service. Not only are many customers now electricity producers as well as users – every Californian has a stake in assuring the success of the State's ambitious clean and renewable energy goals and its climate action plans, and they can do that merely by changing the quantity of their electric use during some hours of the day. With education, training, new tools and techniques, and some new technologies, the potential to avoid future investments in electric infrastructure through customer-side strategies is substantial.

California is poised to transition from a utility-centric electric service model to one in which customers become integral parts of the power system – generating some power, storing some power, and shifting their time of electric use to times when electricity is available. The transition has begun, but there is still much to do. Efficient and cost-effective battery storage will eventually make the transition much simpler, but those technologies are still relatively immature. In the meantime, in order to protect its substantial investments in clean and renewable energy resources and infrastructure, California needs as much Flexible Load as possible, "today."

Sophisticated large electric users can bridge some of the gap while also providing important insights into the technologies and tools that will be needed to successfully transition the electric service model for all customers. Water and wastewater systems and infrastructure have unique characteristics that can increase the State's ability to reliably integrate a significant portion of these additional variable energy resources. It is appropriate that they, the water sector, should lead the State's transition to the "Customer of the Future."

Flexible Electric Resources

For purposes of this study, we use the term "Flexible Electric Resources" to describe the types of electric reliability support that can be provided by water and wastewater utilities.

The term "***Flexible Electric Resources***" integrates multiple complementary concepts:

Flexible Capacity	Electric resources, whether demand-side or supply-side, that can provide grid-level operational flexibility for 3 continuous hours.[1]
Flexible Load	Although "load" can be both supply- or demand-side, we use it here to refer to electric use (demand-side) that can vary up and down when needed to support electric reliability.
Flexible Demand Response	The ability to change the time and quantity of electric use up or down in response to price, policy, and other signals.
Flexible Demand Side Management	Any demand-side resource that can be operated in a flexible manner to either increase or decrease electric load.

Simply put, the term "Flexible Electric Resources" includes all types of electric resources and strategies that enable customers to change the time and amount of their electric use to provide electric reliability support at both the Transmission and Distribution system levels.

[1] "Qualifying Capacity and Effective Flexible Capacity Calculation Methodologies for Energy Storage and Supply-Side Demand Response Resources." Revised Staff Proposal for Resource Adequacy Proceeding R.11-10-023. *California Public Utilities Commission* Energy Division. April 9, 2014.

The interconnected nature of water and wastewater systems that are designed with Flexible Capacity and redundant systems to assure their ability to reliably meet their customers' needs creates many opportunities for Flexible Electric Resources.

Types of water sector Flexible Electric Resources are described in the next chapter.

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III Water Sector Flexible Electric Resources

Water and wastewater systems can often shape, shift, and shed electric loads within their systems by changing operating protocols and schedules

The extent to which a water or wastewater utility can change its operations in a manner that produces Flexible Electric Resources depends on multiple factors.

- ***System design constraints***
  - **Water Pumping**. Pump capacity may be sufficient to increase pumping during some hours, but the quantity of increased pumping is limited to:
    - The capacity of the pipeline to deliver increased quantities of water pumped,
    - The amount of storage available to hold additional pumped groundwater, imported water, recycled water, or other water supplies until needed to meet demand, and/or
    - The amount of storage available to defer processing of wastewater to future hours.

    Alleviating these types of constraints can increase flexible capacity.
  - **Treatment Plants**. Wastewater and water reclamation (recycled water) treatment plants are typically designed for 24/7 operations and are either "on" or "off" for two reasons: (1) Storage of raw wastewater creates odors and can present health challenges, and (2) Biological and chemical treatment processes require careful balancing for effective treatment.
    - Some operational flexibility can be gained through integration of interim storage of partially-treated effluent and recycled water.
    - Since many wastewater treatment facilities have some type of on-site distributed generation, one of the most promising strategies may be to coordinate operations of on-site generation in a manner that results in the targeted real-time electric system impacts on SCE's distribution system (i.e., reduce or store on-site generation and purchase more grid electricity during periods of over-generation, and reduce reliance on grid electricity during periods of under-supply).
- ***Regulatory and legal constraints*** – The water or wastewater utility may lack regulatory or legal rights to increase pumping at a particular time and location, such as an adjudicated groundwater basin or water contract that governs when and how much water can be withdrawn.
- ***Water quality*** – Increasing the rate of pumping from a particular water resource can sometimes impair water quality (e.g., by increasing turbidity or groundwater contaminants). Furthermore, increased storage volumes and the resulting increased storage time can impair water quality within the distribution system.

Over-generation impacts to-date have been responsibly managed by the CAISO and market participants in accordance with the market mechanisms for addressing these types of electric reliability challenges. Nevertheless, given the aggressive outlook for new variable electric generation resources, especially new utility-scale solar PV, there is a critical need to develop near-term interim strategies that can reduce the frequency, costs, and risks of over-generation.

SCE's over-generation pilot was approved in CPUC Decision 16-06-029 as part of the Demand Response rulemaking. In accordance with the scope approved by the CPUC, the Pilot was structured to identify and evaluate the potential for over-generation mitigation by pumped water storage systems.

During the course of this Pilot Project, SCE learned that the greatest potential for harnessing water sector operational flexibility as an electric resource lies beyond traditional "pumped storage", to leveraging Flexible Capacity within all water and wastewater systems and functions now and in the future.

The initial focus of the Pilot was on water distribution systems: pumps, pipelines, tanks, and reservoirs. Through discussions with SCE's water sector customers that include both water and wastewater utilities, it became clear that Flexible Electric Resources can be found in wastewater systems as well. Further, at least one groundwater bank has been exploring opportunities to operate "conjunctively" with surface reservoirs to create a "Water-Energy Bank".

These three types of systems – water, wastewater, and groundwater – have distinctly different design and operating characteristics in context of Flexible Electric Resources.

Water

The keys to identifying and evaluating the potential for Flexible Electric Resources within water distribution systems, both potable and non-potable, are Flexible Capacity and hydraulics.

Flexible Capacity

The typical Flexible Electric Resource strategies applicable to water systems primarily relate to having Flexible Capacity in pumping, pipelines, and storage. The combination of these three types of facilities enable water utilities to increase pumping to the maximum installed capacity during some hours of the day, provided there are no constraints in connected facilities that might limit pumping to less than the installed capacity. Potential constraints include:

- Pipeline capacity is not sufficient to deliver water at the increased rate of pumping.
- Demand for water being pumped at that location is not sufficient to accept delivery of higher volumes of water during the periods targeted for increased pumping.

- Diurnal and/or seasonal storage capacity is not sufficient to capture and store the water being pumped at a higher rate.
- The water utility does not have legal or regulatory rights to pump the volume of water at the targeted rate.
- Pumping at higher rates during the targeted hours could impair water quality to levels requiring additional treatment, and the additional treatment is not deemed acceptable (existing treatment methods cannot restore the impaired water resource to the water quality level required by regulations, customer needs, or policy; and/or the type(s) of additional treatment required to achieve the targeted water quality are too expensive).

Hydraulics

Water managers view their systems in context of its hydraulics – the pressures and flows of water throughout the distribution system. Energy managers view water distribution systems as batteries – the ability to store or dispatch energy at various points and at various times in water systems.

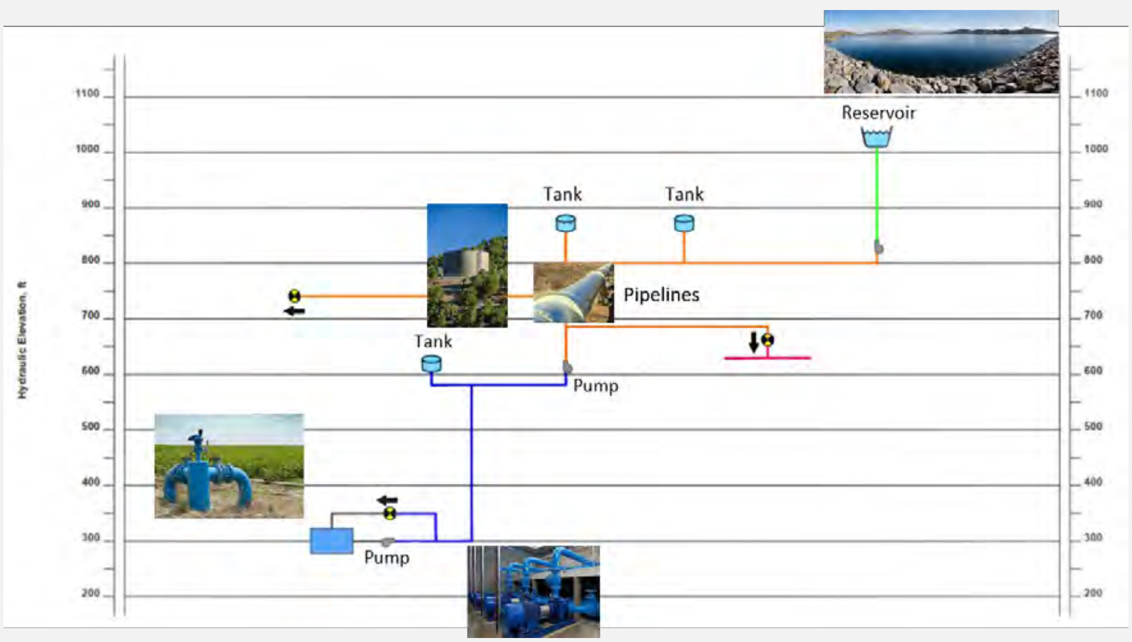

Figure 10. Illustration of a Hydraulic "Battery" *(diagram courtesy of West Yost Associates)*

Figure 10 above illustrates a simple recycled water system with a water recycling plant at the lowest elevation that pumps water uphill to serve customers at higher elevations. At the highest elevation, there is an open recycled water reservoir. There are also recycled water tanks at two different elevations to store water to serve diurnal recycled water demand when needed.

In addition to pumping and storage of potable and recycled water, wastewater utilities have unique opportunities for load shifting and Flexible Electric Resources (see Table 2 below).

Table 2. Flexible Electric Resources Related to Pumping and Storage Operations

Type of Pumped Water Storage	Types of Flexible Electric Resource Opportunities	System Design & Operational Considerations
Diurnal Storage Facilities	Usually associated with municipal water, wastewater, and recycled water; best suited to electric distribution system balancing	▪ Flex DR capabilities exist now at thousands of water, wastewater, and recycled water facilities (surface and groundwater pumps, water and wastewater treatment facilities), most of which are proximate to electric utility distribution systems. ▪ This is the highest potential near-term water sector Flex DR opportunity: many water and wastewater utilities could begin providing support with existing diurnal storage facilities; few infrastructure changes would be needed.
Seasonal Recycled Water Reservoir	Usually associated with municipal wastewater treatment facilities, best suited to electric distribution system balancing	▪ Seasonal recycled water storage enables producing recycled water all year long, reducing discharges to ocean outfalls and maximizing water supplies. ▪ Seasonal and diurnal electric time-of-use patterns change markedly under this scenario: electric use increases during fall, winter, and early spring to produce and store additional recycled water; electric use decreases during summer due to higher availability of local recycled water (and less need to pump or treat surface or groundwater resources). ▪ Increased recycled water production coincides with over-generation season; may also be able to pump to storage during over-generation hours.
Groundwater Banks	Large capacity storage potentially operated for conjunctive use; could support both bulk power (transmission) and electric distribution system balancing	▪ Electricity used to deliver water supplies for recharge and to deliver withdrawals to customers. ▪ Time of electric use depends on many factors (e.g., legal and regulatory) that may not be within the groundwater bank's sole control. ▪ Conjunctive use requires coordinating with surface water operations, complicating scheduling but creating additional Flex DR opportunities. ▪ Opportunities increase with some surface storage at or near the site.
Modular Pumped Storage Hydropower (m-PSH)	Much smaller in size, best suited to distribution system balancing	▪ "Closed loop" by definition. ▪ Comprised of man-made structures and replenished from water supplies (surface, groundwater, and/or recycled water). ▪ Design could be as simple as connecting two water tanks and cycling water between the two (beneficial for water quality). ▪ May or may not include hydropower production.

Type of Pumped Water Storage	Types of Flexible Electric Resource Opportunities	System Design & Operational Considerations
Flood Managed Aquifer Recharge (Flood-MAR)	Although highly variable in size and complexity, from single site to regional, best suited to electric distribution system balancing	▪ Flood management uses electricity for pumping: "*Flood control is provided by a system of levees, canals, and pump stations. All stormwater runoff is conveyed by gravity through a system of drainage lines and canals into the suction bays of various pump stations then pumped to a higher elevation into larger levees or the ocean*."[33] ▪ Pumping facilities are typically dispersed over a large geographic area so individual pump loads may not be very high; but the coincidence of flood events with over-generation during spring months is beneficial for electric distribution system balancing.
Pumped Storage Hydropower (PSH)	Best suited for bulk power (transmission voltage level)	▪ Capable of providing substantial electric balancing services if schedules for hydropower production and pumping uphill can be synchronized with needs for electric reliability support. ▪ "Closed loop" facilities have highest value for electric reliability because they can control their own schedules for water deliveries and releases.

Most water utilities have some amount of Flexible Capacity at various points in their systems. For example, most water utilities have redundant pumps, both for groundwater wells and booster pumps, that enable water utilities to perform maintenance on one group of pumps while others continue to provide water to customers. It also assures that water utilities can continue to operate during an unplanned outage (e.g., due to equipment failure).

Examples of Flexible Electric Resource opportunities in potable and recycled water distribution systems and the types of issues and constraints that need to be considered are provided below and on subsequent pages.

[33] "Flood Control." Orange County Public Works website: http://occom.ocpublicworks.com/sections/flood.

Rancho California Water District (RCWD)

Substantial changes to agricultural and urban water use created Flexible Capacity in RCWD's potable and recycled water distribution and storage systems. Recognizing the opportunity to leverage underutilized capacity to optimize water resource management and reduce operating costs, RCWD adopted an operating philosophy that specifically considered optimization of energy resources to reduce operating costs without impairing the District's mission critical goals and objectives – that of delivering "reliable, high-quality water, and reclamation services to its customers and communities in a prudent and sustainable manner."

A conscious decision to optimize both water and energy resources precipitated innovations in data, tools, and techniques that have significantly improved the District's ability to efficiently manage its water resources and infrastructure. With the aim of integrating energy cost-effectiveness into its operational decisions, the District initiated market-leading SCADA system enhancements and partnered with vendors on development of improved decision-making tools.

RCWD estimates that it can provide up to 17 megawatts (MW) of flexible electric resources - 85% of its annual peak electric demand of 20 MW – to support local and regional electric reliability while also reducing its net energy costs and reducing future energy cost risks.

RCWD's ability to shift pumping and electric demand to SCE's over-generation time period depends on the amount of capacity available in three types of distribution system infrastructure:

1. ***Pumping capacity*** (groundwater, imported water, recycled water),
2. ***Storage capacity*** (reservoirs and tanks for both potable and recycled water), and
3. ***Conveyance capacity*** between pumping and storage.

Presently, to minimize electric demand charges, RCWD utilizes only a portion of the available pump capacity and pumps over a longer timeframe. RCWD operations staff stated that the District has adequate capacity in all three infrastructure types ***today*** to focus pumping to the overgeneration window, provided no demand charges or other financial disincentives are incurred.

Moulton Niguel Water District (MNWD)

Since there are few natural water resources within its service area, MNWD imports most of its water. To build water reliability, MNWD has operated a very successful Recycled Water Program for the last 50 years. The Program began with a couple of golf course customers but now includes over 1,300 customers using 7 million gallons per day. This Program has helped to diversify supplies to increase system reliability.

In addition to building a successful Recycled Water Program, MNWD focused on managing its energy costs. Since MNWD spans the border between Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E), District operations staff have had to develop strategies that avoid pumping during TOU peak periods for two different electric utilities.

Some pump stations are not operated at their maximum capacity. The rate of pumping could be increased at these sites, provided electric demand charges are waived. The amount that pumping could be increased before pipeline constraints dominate would need to be confirmed by hydraulic modeling.

MNWD staff stated that some water resources brought into its potable water distribution system could be pumped into another (lower elevation) zone before being pumped into higher zones if desired to increase energy demand and consumption during some hours of the day. In this case, the District's overall energy consumption would not change; only the time of electricity use would change.

Opportunity	Challenge(s)
Increase ("shift") pumping to SCE over-generation periods (9am to 4pm).	▪ Increasing the rate of pumping during some hours could increase the District's electric costs through increased demand (kW) charges. ▪ If a higher rate of pumping causes pumps to operate outside the optimal range of pump efficiency, additional energy (kWh) costs may also be incurred.
Pumps presently grandfathered under the old TOU time periods continue to shut down during Noon to 6pm, despite the fact that 4 of those hours (Noon to 4pm) coincide with periods of over-generation.	Electric loads presently grandfathered under the old TOU time periods are in direct opposition with the goals of over-generation mitigation. Multiple parties were involved in the solar PV Settlement Agreements. Unless MNWD can negotiate a separate agreement without undoing the CPUC adopted Settlement Agreement(s), all of the parties involved in those Settlement Agreements would need to be reconvened to renegotiate and the CPUC would need to adopt the revised Settlement Agreements.

Wastewater

From an energy perspective, water, wastewater, and recycled water plants tend to have fairly consistent diurnal electric load profiles and relatively high average load factors (often in the 70-90% range, reflecting their 24/7 operations). Integrating flexibility into a 24/7 electric load with a high average load factor usually requires additional infrastructure and/or technologies.

The primary types of Flexible Electric Resource strategies for wastewater and water recycling plants that operate 24/7 at high average load factors are very different than those within potable and recycled water distribution systems. There are usually not as many opportunities to increase pumping and pipelines. Further, storage of influent, effluent, biogas, and biosolids, while technically possible, may have adverse impacts on treatment processes, the environment, and public health and safety.

The challenges and opportunities for Flexible Electric Resources in wastewater and recycled water treatment systems are summarized below and in Table 3 on the following page.

Challenges

- ***Pumping*** within a treatment plant is typically driven by factors related to the treatment technology(s). Storage between the various treatment functions may enable changing rates of pumping in some parts of the plant; however
- ***Storage*** of untreated wastewater is challenging because the biological solids in wastewater decay and produce odors and noxious chemicals. Further, the wastewater treatment process generally has biological components that require relative stability in the process rate. For these reasons, it is difficult to start and stop wastewater treatment processes to focus energy consumption during an overgeneration period.

Opportunities

- ***Solids handling*** at the end of the wastewater treatment process could potentially be started and stopped relatively easily.
- ***Biogas storage***. Similarly, biogas is produced at the end of the process and could be compressed and stored in the pipeline for renewable LNG production. Biogas storage could also be constructed on-site to enable utilizing grid electricity during periods of over-generation and producing and using bio-electricity during periods of under-generation.
- ***Battery Energy Storage (BES)***. Wastewater utilities that participated in this Pilot noted that the obvious method for increasing operating flexibility within their wastewater treatment and recycled water plants is Battery Energy Storage (BES). Although it is not the focus of this Pilot Project which seeks to identify means for water and wastewater utilities to provide the equivalent of battery energy storage, or superior capabilities, by harnessing Flexible Capacity within water and wastewater systems, BES is a technically viable means to provide

Flexible Electric Resources. Participating wastewater utilities stated their belief that BES should be considered an integral part of any water sector Flexible Electric Resources portfolio. All also stated that when BES becomes more affordable, they plan to include more of it in their own energy resource portfolios.

- ***Coordinated dispatch of on-site distributed generation facilities***. Many wastewater utilities have some type of on-site distributed generation. Instead of operating these units in a manner that optimizes the utilities' net electric costs, electric production could be coordinated with on-site electric use to produce the net real-time electric impacts desired by SCE at various points on its electric distribution system.
- ***Partially treated wastewater storage***. As described above, raw wastewater contains biological solids whose decay produces noxious odor and health challenges. Wastewater that has gone through primary treatment has had the solids removed, although further treatment is necessary for the resulting liquid. Primary-treated wastewater can be stored for longer periods with fewer challenges than raw wastewater. Such storage could allow the subsequent secondary and tertiary storage processes, which are each energy intensive, to be aligned with over-generation requirements.

Table 3. Flexible Electric Resources in Wastewater and Biosolids Management Systems

Wastewater Systems	Types of Flexible Electric Resource Opportunities
Battery Energy Storage (BES)	Given the typical 24/7 operations of wastewater treatment and water reclamation facilities, BES is a viable and potentially economic strategy for load shifting. (BES is currently more cost-effective than water, wastewater, and/or recycled water storage facilities, both closed tanks and open reservoirs. However, BES storage durations are currently measured in hours, while water and wastewater storage facilities can store water, wastewater, and recycled water for days or even months.)
Solids handling	Solids handling (sludge dewatering) is an energy intense function that can be started and stopped relatively easily without impairing the end product (dried sewage sludge that can be used for compost and other materials).
Coordinated Dispatch of Distributed Generation	Through a combination of BES and coordinated operations and dispatch of water sector distributed generation, electric uses (wastewater treatment and recycled water reclamation and distribution systems) and electricity production (self-generation) could be coordinated in a manner that provides some of the locational real-time electric impacts needed by SCE and the CAISO for electric reliability purposes - whether a net electric draw (purchases) or a net electric push (exports) - to SCE or the grid.

Inland Empire Utilities Agency (IEUA)

IEUA operates four regional water recycled plants (RWRPs) that produce Title 22 recycled water for indirect reuse and for groundwater recharge. All have primary, secondary, and tertiary treatment and recycled water pumping facilities that are interconnected in a regional network. Sewage bypass and diversion facilities enable IEUA's operations staff to optimize flows and capacity utilization among the four RWRPs. Flows are typically routed between RWRPs to maximize recycled water deliveries while minimizing overall pumping and treatment costs.

The network configuration of IEUA's facilities provides substantial flexibility for effective mitigation of equipment outages and other types of emergencies. This capability served the Agency and its customers well during the 2000/01 California power crisis.

Grid Independence During Peak Periods

IEUA adopted a goal of achieving grid independence during highest priced electricity peak periods by 2020. During Summer 2019, peak electric production was low because 3.0 MW of biogas internal combustion engines were taken out of service. Consequently, the Agency was able to meet only 33% of its peak electric demand and 9% of its electric requirements with self-generated resources. When the biogas engines units are restored to service and operation of IEUA's 4.0 MW of Battery Energy Storage is coordinated with its self-generation resources, IEUA will be able to meet 100% of its summer on-peak electric demand with self -produced power.

Flexible Electric Resource Opportunities

IEUA staff identified the following potential types of Flexible Electric Resource opportunities in its systems:

- ***Pumps*** – Addition of higher head pumps and pipeline improvements to connect these pumps to higher pressure zones could increase the flexibility of the recycled water system.
- ***Sludge Dewatering*** – IEUA staff are exploring up-sizing dewatering equipment so that the process can be completed within an 8-hour shift. Dewatering could be scheduled to coincide with SCE's over-generation period.
- ***Centrifuges*** – It may be possible to increase the number and installed capacity of large, high energy-consuming equipment and operate these units during fewer (over-generation) hours.
- ***Storage, Liquids*** – Storing raw influent is typically not done due to concerns about odor and septicity; however, under some conditions, there may be opportunities to store treated primary water for accelerated advanced treatment during over-generation periods. Similarly, there may be opportunities to increase storage for secondary and tertiary effluent, and advance treated recycled water.
- ***Stormwater Retention Basins*** – Injection wells could enable recycled water to be captured and injected into stormwater basins even during wet weather, but system upgrades would be needed.

County Sanitation Districts of Los Angeles (LACSD)

LACSD is a public agency consisting of 24 independent special districts in Los Angeles County. Its service area spans about 850 square miles and serves 5.6 million people in 78 cities and unincorporated areas of the County. The scope of LACSD's services encompasses operation of sanitary landfills and recycling centers, wastewater treatment, and recycled water production.

Eleven (11) Water Recycling Plants with a combined treatment capacity of 456 MGD provide wastewater treatment and recycled water production. These facilities require large quantities of power – during 2018, LACSD's total electric requirements were 309,000 MWh with a peak electric demand of 35 MW (non-coincident).

As responsible stewards of the resources to which it has been entrusted, LACSD has been on the leading edge of renewable energy technologies for decades. In addition to producing CNG and LNG transportation fuels, the District produces substantial quantities of electricity from methane produced at its largest wastewater treatment plant and three landfills.

130 MW of Self-Generation Capacity

- ***Digester Gas-to-Energy***: 3 x 9.9 MW Gas Turbines with HRSG heat digesters and produce 29.7 MW of electricity at LACSD's Joint Water Pollution Control Plant, 95% of the Plant's power needs.
- ***Landfill Gas-to-Energy (electric production limited by availability of landfill gas)***:
  - 3 x 4.6 MW Gas Turbine-Generators produce 4.0 MW of electricity at LACSD's Calabasas Landfill (all of this power is exported).
  - 1 x 50 MW Steam Turbine Generator at LACSD's Puente Hills Landfill produces 25 MW of electricity.
- ***Refuse-to-Energy***: 36 MW municipal solid waste-to-energy cogeneration project at LACSD's Southeast Resource Recovery Facility in Long Beach.

Flexible Electric Resources

Wastewater and recycled water production facilities typically operate 24/7. Unlike water distribution utilities, opportunities to vary pumping rates and pump water to storage are few.

LACSD and other regional wastewater utilities can potentially provide electric reliability support in the following ways:

- Utilize batteries to change the quantity and time-of-use of grid electricity purchases for 24/7 facilities;
- Increase recycled water, biogas, and biosolids storage to enable changing the quantity and time-of-use of electric requirements for these systems; and/or
- Add battery energy storage to electric generation facilities to enable changing the quantity and time of electric exports.

Groundwater

Groundwater facilities can create Flexible Electric Resources when operated conjunctively – i.e., in coordination with surface water storage (reservoirs, tanks, pipelines, aqueducts, ponds). The key goal is to enable shifting pumping on a diurnal and/or seasonal basis to achieve the targeted electric time-of-use needed to support local and regional electric reliability.

Given the State's high policy priority on replenishing over-pumped ("critical") groundwater basins,[34] water agencies are seeking ways to optimize recharge and replenishment activities.

- One intriguing possibility raised by Willow Springs Water Bank (WSWB) is to coordinate the water operations of multiple parties to optimize the energy impacts of groundwater recharge and withdrawals with surface water supplies (aka "conjunctive use") to create "Water-Energy Banks."
- Palmdale Water District (PWD) is developing a new 80-acre recharge basin to bank its water allocations from the State Water Project (SWP) when available. A blend of untreated SWP water and tertiary-treated recycled water from Palmdale Recycled Water Authority, a joint venture between City of Palmdale and PWD, would be delivered to four spreading basins. When complete, both banking and recovery operations could potentially be scheduled during over-generation periods.

[34] Sustainable Groundwater Management. [Source: "SGMA Groundwater Management." DWR website: https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management.]

Willow Springs Water Bank (WSWB)

WSWB, formerly known as the Antelope Valley Water Bank, is located in Kern and Los Angeles counties near Rosamond, California in the adjudicated Antelope Valley Groundwater Basin. WSWB has embarked upon a phased plan to develop up to 1 MAF (million acre-feet) of groundwater recharge, recovery, and banking.

Three major aqueducts – the California Aqueduct, the Los Angeles Aqueduct, and the Antelope Valley-East Kern Water Agency – are nearby, providing an opportunity to optimize surface and groundwater resources "conjunctively." WSWB and its technical consultants conducted extensive modeling to estimate the incremental water, energy, climate, ecosystem, and other benefits that might be achievable through optimization of the State's water and energy resources in Antelope Valley.

A Water-Energy Bank

WSWB has developed a concept for a "Water-Energy Bank" that would maximize statewide water, energy, climate, environmental, and other benefits: instead of focusing on the economic performance of WSWB's operations alone, WSWB is investigating the net benefits that could be achieved through coordinated ("conjunctive") operations of WSWB and another entity such as the State Water Project (SWP).

WSWB proposes operating its groundwater aquifer in a pumped-storage configuration that utilizes the SWP's San Luis Reservoir as the upper reservoir, and WSWB as the lower reservoir. (See Figure 11 on the next page.) When operated conjunctively in this pumped-storage configuration, WSWB anticipates being able to help SWP shift a significant portion of its summer electric requirements to fall and spring with no adverse impacts on SWP's contractual water deliveries. A seasonal shift of electric use from summer to fall and spring could increase statewide electric reliability by:

- Reducing electric demand during periods when the State is short on electric supplies (summer on-peak periods), and
- Increasing electric demand during periods when the State has substantial quantities of surplus electricity (during fall and spring days when real-time electric supplies exceed real-time electric demand, known as "over-generation" or "over-supply").

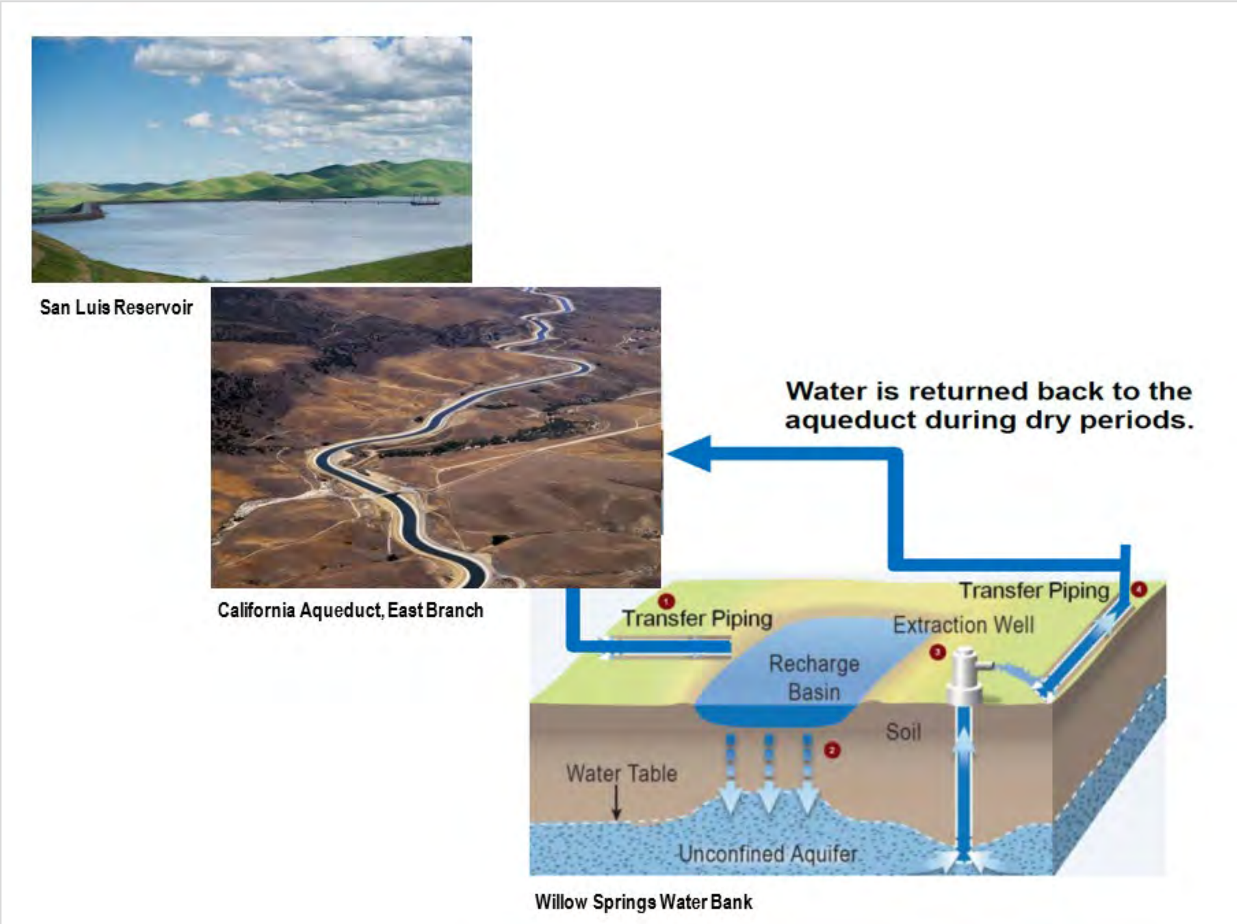

Figure 11. Willow Springs Water Bank's Proposed Water-Energy Bank[35]

Note that the SWP already optimizes pumping operations to minimize electric use during summer peak periods. They do this by pumping at maximum capacity during off-peak hours and reducing pumping to zero during on-peak hours. The SWP's ability to optimize its operations from an energy perspective is constrained by its contractual obligations to deliver water supplies to the State Water Contractors (SWC).[36]

[35] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank for California Energy Commission* Grant No. EPC 16-029. See Figure 2-7. Schematic of WSWB Aquifer Recharge, Storage and Recovery Operations on p.26; added photos of San Luis Reservoir and East Branch of the California Aqueduct. Graphic image and photos courtesy of DWR.

[36] "Water-Energy Bank 'Proof-of-Concept'." Powerpoint presentation by Mark Beuhler, General Manager of *Willow Springs Water Bank* to Southern California Edison. June 19, 2019. Slide 13.

Palmdale Water District (PWD) Recharge & Recovery Project

PWD 's largest opportunity for future over-generation mitigation support can likely be found in its proposed groundwater banking and recovery program. Phased construction of pipelines, recovery wells, and additional recharge basins are planned. When complete, both groundwater banking and recovery operations could potentially be scheduled during over-generation periods. This program would also enable using groundwater during periods of over-generation while water from the State Water Project (SWP) is banked, enabling the District to maximize its water supplies.

Project Description	New 80-acre recharge basin on 160-acre site. This project would construct recharge basins to bank PWD's SWP allocation when available. A blend of untreated SWP water and tertiary recycled water from the Palmdale Recycled Water Authority would be delivered to 4 spreading basins to recharge the Antelope Valley groundwater aquifer with up to 52,000 acre-feet per year (AFY). Targeted recovery is 15-30 Thousand Acre-Feet (TAF) per year (8-16 wells) that will either be chlorinated prior to delivery to customers or returned via the California Aqueduct to other State Water Contractors.
Phased Development	▪ **Phase 1a**: Construct conveyance pipelines, 4 recovery wells and a well collection pipeline that connects to the potable water distribution system. ▪ **Phase 1b**: Expand facilities and construct a third recharge basin, up to 4 additional recovery wells, a water storage tank to meet chlorine contact time requirements, and a potable water pump station and distribution system that includes chlorine generation. ▪ **Phase 2**: Build-out all remaining facilities including a 4th recharge basin, up to 8 additional recovery wells, and a potential return water pump station that would bypass the storage tank to pump non-chlorinated return water to the East Branch of the California Aqueduct.
Project Location	Northeastern portion of the City of Palmdale in portions of Alpine Butte, Lancaster East, Littlerock, and Palmdale.
Environmental Impact Report	Finalized June 2016.
Estimated Project Cost	$103,730,000
Benefits	• Diversify PWD's portfolio of ground and surface water; • Increase supply reliability; • Replenish groundwater supplies; • Save for future droughts; • Cost-effective drought resilient supply.
Current Status	• On June 24, 2019, PWD's Board of Directors approved a WaterSMART grant application for $1.1 million in federal funds for final design phase. • PWD is continuing groundwater tests to determine project feasibility.

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IV Water-Energy Management Tools

California's water and wastewater utilities are leading development of technologies, tools, and techniques for managing energy use and costs

California's water and wastewater utilities directly advance development of technologies, tools and techniques for managing their energy costs and use. In addition to state-of-the art upgrades to both hardware and software, notable water sector innovations include:

- ***Integration of Energy Data with SCADA Systems*** – Bring information about historical and/or real-time energy use and price data into water and wastewater SCADA dashboards so that operators can understand the potential energy and cost impacts of their decisions.
    - ***Energy Use Data*** – Use submeters and/or CT equipment to measure and display real-time electric use by individual equipment unit so that operators can understand how much energy of what type (gas or electric) is being used at any point in time.
    - ***Energy Cost Data*** – Whether real-time and fully integrated, or input from historical data for display, some water sector SCADA operators now have the ability to view energy cost data on their SCADA dashboards.
- ***Automated Real-Time Pump Efficiency Tests*** - Use real-time SCADA data from flow meters, suction pressure, discharge pressure, and CT equipment to measure pump efficiency. In this manner, pump efficiency tests can be conducted weekly, rather than annually or biannually, resulting in more timely identification of pump performance or efficiency degradation.
- ***Bill Analysis Tools*** – Usually residing on a dashboard separate from SCADA, many water and wastewater utilities have some type of tool for tracking and analyzing their energy bills for accuracy, to determine whether cost savings may be possible by using other tariffs or energy purchase options, and to identify opportunities for reducing energy costs by changing systems and/or operations. An important feature of many of these tools is that they disaggregate the complex components of an electrical bill into consumption, transmission, and peak demand charges so that operators can effectively target specific components for cost reduction.
- ***Economic Dispatch Models*** – Some water and wastewater utilities with multiple fuel choices (e.g., natural gas and/or electricity purchased, produced, and/or stored in batteries) have dual fuel capabilities and intelligent systems that dispatch the most economic fuel based on real-time or contractual prices or tariffs.

Water and wastewater utilities that participated in this study indicated interest in exploring means to directly interface SCE AMI data and real-time electric prices with their SCADA systems.

A conscious decision to optimize both water and energy resources precipitated innovations in data, tools, and techniques that have significantly improved Rancho California Water District's ability to efficiently manage its water resources and infrastructure. With the aim of integrating energy cost-effectiveness into its operational decisions, the District initiated market-leading SCADA system enhancements and partnered with vendors on development of improved decision-making tools.

One of the common themes that emerged through the over-generation case studies and workshop was a need for new tools and techniques to improve real-time water operations decision-making. In addition to assuring that operators have the best available information when making real-time operational changes, water and wastewater utilities interviewed for this project indicated a need to integrate real-time energy data and pricing into their SCADA dashboards to enable operators to consider the energy cost impacts of potential operational changes.

Three case study participants – Rancho California Water District (RCWD), Inland Empire Utilities Agency (IEUA), and Palmdale Water District (PWD) have made substantial progress towards integrating energy usage data into their SCADA systems. RCWD is also beta-testing integration of energy cost data (Figure 12 below). Two other case study participants - Moulton Niguel Water District (MNWD) and Cucamonga Valley Water District (CVWD) - partnered with academia to develop SCADA dashboards that bring in data about electricity use and costs.

Figure 12. Rancho California Water District (RCWD) SCADA-Based Electric-Gas Energy Cost Gauge[37]

[37] SCADA screenshot provided by *Rancho California Water District*.

The Evolution of SCADA

Technological advances since the 1950s enabled the evolution of SCADA (Supervisory Control and Data Acquisition) tools from initial stand-alone systems that monitored and controlled simple industrial processes ("Subject to certain criteria: This Unit is either 'OFF' or 'ON'), to networked intelligent systems that monitor and enable automated operation of hundreds or thousands of equipment units, systems, and processes via a centralized "supervisory" control center.

- ***Supervisory Computer***[1] is the control center comprised of both hardware (now typically PCs) and software that collect data from field connected devices that enables operators to monitor and automatically control thousands of individual processes via a dashboard (Human Machine Interface, or HMI, the SCADA graphical user interface).
- ***Data Acquisition***[2] occurs through distributed Program Logic Controllers (PLCs) and Remote Terminal Units (RTUs) installed at key points in industrial systems, processes, and facilities.
    - A PLC reads sensors but only holds the current set of readings. Its purpose is to make quick responses with a control output. (New Programmable Automation Controllers (PACs) have additional programming capabilities and can take the place of a SCADA PC.) There may be multiple PLCs on a single equipment unit – e.g., one to measure temperature, one to measure flow.
    - An RTU reads inputs from sensors or PLCs, has programmable logic to change outputs based on input algorithms, and can either execute simple logical processes without involvement of a master computer or can report back to a master computer. RTUs transmit data to the Supervisory Computer and receive messages about controlling the connected devices.
- ***Set Points***[3] establish the allowable ranges of operation (flow, temperature, level, etc.) at each individual point that is managed by PLCs and RTUs. Operations that fall outside of established set points trigger ***alarms*** that can be over-ridden by SCADA operators to establish a new (temporary) set point that will be executed by the PLC.

This basic configuration - a central command center (supervisory computer) with multiple remote points of data acquisition and logical controls (PLCs, RTUs, and alarms) – comprise the nuts and bolts of SCADA systems.

Over the past few decades, extraordinary advancements in both hardware and software - computing, sensors, programmable logic controllers, and communications - enabled SCADA systems to evolve to complex systems with increasing flexibility and intelligence. Importantly, however, SCADA is not a replacement for human judgment – it is a tool that enables knowledgeable operators to monitor multiple diverse systems, processes, and functions to assure that they operate safely, efficiently, and within the organization's policies, rules, and protocols.

[1] Abbey, Lester. "Evolution of SCADA Systems." Paper presented to the Inaugural *New Zealand SCADA Conference*. October 28-29, 2003.

[2] Davis, Jacob. "Understanding the Roles of Data Loggers, RTUs, PLCs, and PACs." *Campbell Scientific* Blog February 28, 2018.

[3] "SCADA: Systems Concept." *SCADAWorld* website: http://www.scadaworld.net/systems-concept.html.

Integration of Energy Data with SCADA Systems

Coined as "*SWEMS*" (*SCADA-integrated Water-Energy Management System*) by SCE's Emerging Products and Technologies Division, effective integration of real-time energy cost and use data into water and wastewater SCADA systems is the highest priority tool presently sought by water and wastewater utilities of all sizes throughout California.

SCADA and Energy Management Systems

The term "Energy Management System" (EMS) has been used for decades – initially to describe the system of hardware and software to manage energy utility systems; but over time, as customer energy programs evolved, it was used to describe the hardware and software that help customers manage their energy use. Direct integration of real-time electric use with SCADA is most prevalent in industrial processes where energy is a significant component of manufacturing and process costs. For these types of applications, monitoring and controls are geographically more compact – usually, within the footprint of a single industrial facility – than water and wastewater utilities whose facilities and systems span their entire service areas. The geographic distance that water and wastewater SCADA systems must cover – often referred to as "Wide Area SCADA" - increases the complexity of the communications systems needed to support them.[38]

Water and Wastewater SCADA Systems

Core SCADA functions for water and wastewater systems relate to monitoring and control of mission-critical operations. Depending on the type of water or wastewater utility, critical functions may include wholesale water conveyance, groundwater pumping, water quality, potable water distribution, wastewater collection and transport, wastewater treatment, recycled water production, advanced water treatment, biosolids collection (e.g., food waste, agricultural waste), biosolids processing, biogas collection, and renewable/distributed energy production. Very small water utilities have relatively few systems and processes that need to be monitored and controlled. In contrast, large regional utilities that provide comprehensive water, wastewater, and biosolids management functions need to monitor and control thousands of systems and processes being performed by diverse equipment, systems, and infrastructure over hundreds of miles.

The types of processes monitored and the quantity of monitoring points increase exponentially with the complexity of the water or wastewater utility's systems and functions.

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[38] Abbey, Lester. "Evolution of SCADA Systems." Paper presented to the *Inaugural New Zealand SCADA Conference*. October 28-29, 2003.

Table 4 below provides a partial list of the types of processes that need to be monitored by a municipal water utility's SCADA system. (This municipal water system provides wastewater collection but not wastewater treatment.)

Table 4. *SAMPLE* SCADA Specifications for a Municipal Water System[39]

<table>
<tr><th>Drinking Water Storage Facilities</th><th>Drinking Water Pump Stations</th><th>Wastewater Pump Stations</th></tr>
<tr><td>▪ Level Signals for reservoirs and tanks
▪ Distribution system pressure on the distribution system side of any storage facility isolation valves
▪ Inflow/Outflow data for storage facilities[40]
▪ Reservoir bypass flow data
▪ Overflow alarm (float switches) to calculate the overflow rate and total[41]
▪ Overflow Flow Rate measurement to evaluate storage facility piping
▪ Water Quality Monitoring:[42]
o Water Quality Analog Data
o High/Low Discrete Alarms
o Equipment Warning and Failure Discrete Alarms</td>
<td rowspan="3">▪ Suction Pressure measures pressure at upstream side of pump suction connections
▪ Discharge Flow enables tracking water transfer from zone to zone, calculate and monitor pump efficiency, and detect water leakage on a system-wide basis
▪ Discharge Pressure measures pump station discharge pressure and sends the signal to the PLC and then to the SCADA operator
▪ Electrical Power Consumption measures kW and kWh; sends data to the PLC and to the SCADA system. Data is used to check electric bills, monitor electrical problems, and diagnose individual motor/pump failures.
▪ Pump Running is monitored by a run contact in each pump motor starter.
▪ Local-Off-Remote Switch Status in remote position, allows a pump start command
▪ Start Signal sent by PLC to motor control center (MCC) when the pump is required to run
▪ Pump Available Status calculated by the PLC
▪ Pump Station Bypass Valve or other remote-controlled valves</td>
<td rowspan="3">▪ Wet Well/Dry Well and Submersible Pump Stations consist of a storage well for wastewater, and an adjacent dry vault for pumps, motors, valves, and electrical equipment. Setpoints are used to control the pumps based on wet well levels.
▪ Single and Double Pot Air-Left (Compressed Air) Pump Stations use compressed air in one or more air chambers to push wastewater to a higher elevation; are controlled by conductivity sensors in the wastewater container. When the level reaches "start", a lead pump will run on a timer based on the container size and effluent flow rate.
▪ Station Discharge Flow is measured by a flow meter between the pump discharge header and the discharge zone.
▪ Wet Well Level signals provided for non-air-lift wastewater wet well storage tanks.
▪ High Level Floats identify when the wet well level has reached a high point that could possibly cause an overflow condition.
▪ Electrical Power Fail Alarm detects a power fail relay.
▪ Pump Running or Pump Available Status – similar to that for Drinking Water Pump Stations.</td></tr>
<tr><td>Remote-Controlled Valve Stations</td></tr>
<tr><td>▪ Upstream Pressure monitoring at higher pressure zone side of valve
▪ Downstream Pressure monitoring at lower pressure side of valve
▪ Downstream Pressure High Alarm when a failure or calibration error occurs with the downstream pressure transmitter
▪ Valve Station Flow to Zone measures flow at remote controlled valve stations to track water flows, aid in detection of water leaks and losses, and reduce the cost of water delivery by finding the lowest cost delivery strategy</td></tr>
</table>

[39] "SPU Design Standards and Guidelines". *Seattle Public Utilities*. February 2017.

[40] Flow meter data are used to calculate water losses, zone transfer flows, and pump efficiencies.

[41] Calculated on basis of inflow rate, outflow rate, and bypass flow rate.

[42] Water quality sensors include chlorine residual, pH, turbidity, fluorine, temperature, ozone, ultraviolet transmittance (UVT), and other types of sensors.

Integration of Real-Time Electric Data

Integration of real-time electric data into water and wastewater SCADA systems is fairly new, primarily because of the time and cost of installing submeters or Current Transformers (CTs) at each point where data about real-time electric use would beneficial. This can create a need to separately meter hundreds of equipment units and processes within the water or wastewater utility. (For example, while a single pump station usually has one SCE electric meter, each pump within the station would need to be separately monitored to support real-time energy management.)

Over the past 7 years, ***Inland Empire Utilities Agency (IEUA)*** completed installation of over 180 submeters at its major facilities. Submetered loads > 200 kW are being integrated into the Agency's SCADA system, along with historical data about kW, kWh, amperes, and load factor. These data help the Agency understand operating patterns and efficiencies to help reduce energy demand charges and identify malfunctioning equipment. SCADA systems for two of IEUA's Regional Water Recycling Plants have already been upgraded; the other two are expected to be completed within 2-3 years.

The Relationship Between Hydraulic Models and SWEMS

The primary business of a water utility is to provide potable water to customers in the volumes required and at the pressures required by those customers. Water supplies must meet applicable water quality standards as well. The primary business of a wastewater utility is to collect, convey, treat, and dispose of sanitary sewage for protection of public health and safety. Optimizations to energy usage and costs cannot occur until these mission-critical objectives are met.

"Providing the right amount of water where it is needed is Priority 1a. Providing that water at suitable quality is Priority 1b. Managing energy usage and cost is priority 3."

Rancho California Water District (RCWD)

Hydraulic models of potable water distribution systems or wastewater collection systems are tools that can feed the SWEMS input data about the hydraulic constraints of the system being analyzed. For example, although the SWEMS optimization logic might indicate that the most energy cost-effective course of action is to fill a reservoir within a four hour window, the hydraulic model may indicate that pumping into a reservoir that quickly will raise system pressures at certain customer connections to unacceptable levels, and therefore the reservoir should be filled over six hours instead. Because individual customer connections are typically not monitored for pressure, the SWEMS logic would have no way of integrating this constraint without the hydraulic model results. The process that water and wastewater utilities use to establish “safe operating levels” is an example of using a hydraulic model to inform a SWEMS system of the relevant hydraulic constraints.

Very few water or wastewater utilities operate real-time operational hydraulic models. More typically, the hydraulic models will contain scenarios that represent “snapshots” of 24-hour to 240-hour operational conditions that represent significant hydraulic conditions in the system (for example, Maximum Day Demand in a potable water hydraulic model). As hydraulic model results are integrated into the SWEMS decision-making process, it is critical that system operators and engineers develop an understanding of what operational “snapshots” are important for the SWEMS.

Palmdale Water District’s Ten Year Journey to Build a Best-in-Class SCADA System

- Upgraded Programmable Logic Controllers (PLCs)
- Added Power CT and PT Instrumentation to wells and booster pumps for pump efficiency data
- Added emergency power generation and programming for various electric rate schedules
- Built new control panels in-house
- Replaced and reprogrammed SCADA Packs
- Visited other water districts to view functionality and ease-of-use of Master Station management software options
- Selected new Master Station software and sent several staff for training
- Integrated production and distribution functions into a single SCADA system (previously run on 2 separate systems)
- Upgraded communications system from 900 MHz to 4.9 GHz, substantially increasing speed to real time (also enabled communicating on the U.S. Public Safety Band recommended for water district use by the Department of Homeland Security)
- Installed SCADA Room and SCADA Development Servers
- Continuing testing and reprogramming SCADA Pulse Code Modulation (PCM)
- Calibrated and maintained distribution and treatment plant automation and control
- Purchased and working on deployment of SCADA Watch computer program
- Continuing enhancements of PWD’s Human Machine Interface (HMI) to improve operators’ ability to make informed real-time decisions.

Sources:

Jeters, Kelley P. “Customer Spotlight: Out with the Old.” *Palmdale Water District for The Sage Advisor*. Volume 24, Issue 2, Fall 2014 and Palmdale Water District Operating Budgets for Calendar Years 2018 and 2019.

Palmdale Water District (PWD)

INNOVATION: Integration of Real-Time Sub-metered Electric Use into SCADA

In the past, PWD used SCADA to set operational limits, upper and lower, with little ability to adjust to changed conditions. Now, operators can tweak the system whenever there is an opportunity to gain some efficiency, with the confidence that they will not be risking mission critical goals and objectives. This is key to increasing resource and operational efficiencies. Optimizing performance requires understanding pump curves, operational means, system demands – all key factors in operational optimization. Once all of this data is understood, the operators need the flexibility to turn each groundwater or booster pump on and off, and choose which ones to run at any point in time.

With the enhanced SCADA system:

- Operators can re-sequence pumps in the field on the basis of their relative efficiencies.
- Operators can also now measure "baseline" performance of groundwater wells and determine whether and when wells should be rehabilitated.

The enhanced SCADA system and tools also improved communication, collaboration, and confidence among operations, planning, engineering, and other departments. Operations can now confer with engineering about the potential costs and benefits of operating a part of the system at 60% instead of 90%. Engineering has a hydraulic model that enables simulations, which are very valuable for long-term planning. But, ultimately, the SCADA system enables testing of various operating strategies to calibrate output from the hydraulic model and other planning tools and assures that a proposed operating strategy is capable of achieving the targeted results without taking any undue risks.

Importantly, with real-time information, PWD has the ability to monitor performance degradation over time and identify pumps and wells that need attention before, rather than after, they fail.

Palmdale Water District's Leslie O. Carter Water Treatment Facility (*photo courtesy of Palmdale Water District*)

Water Sector Partnerships with Academia

Moulton Niguel Water District (MNWD)

MNWD is partnering with the University of California Davis' Center for Water and Energy Efficiency on a $3.1 million technology project funded by an Electric Program Investment Charge (EPIC) grant administered by the California Energy Commission (CEC) (see Figures 13 and 14 on this page). The purpose of the project is to develop tools to help a water utility reduce or shift energy demand loads, or ramp up energy demands, in response to different price signals.

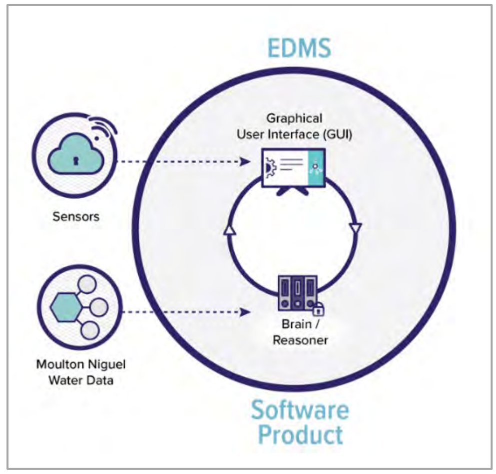

Figure 13. UC Davis and Moulton Niguel Water District Collaboration on an Energy Demand Management System (EDMS) for Water Utilities

The project focuses on understanding how to optimize a water distribution utility's energy usage and costs. The scope includes leveraging the water utility's hydraulic model and overlaying an energy model to determine the energy cost impacts of different operating strategies and scenarios. The initial phase involved documenting the design and capacity of MNWD's potable water distribution system and developing "safe operating ranges" for various parts of the system. The safe operating ranges sought to optimize pump schedules given water demands and regulatory and policy compliance. The final stage of the project will involve building a prototype model that integrates the intelligence inherent in both hydraulic models and energy management systems.

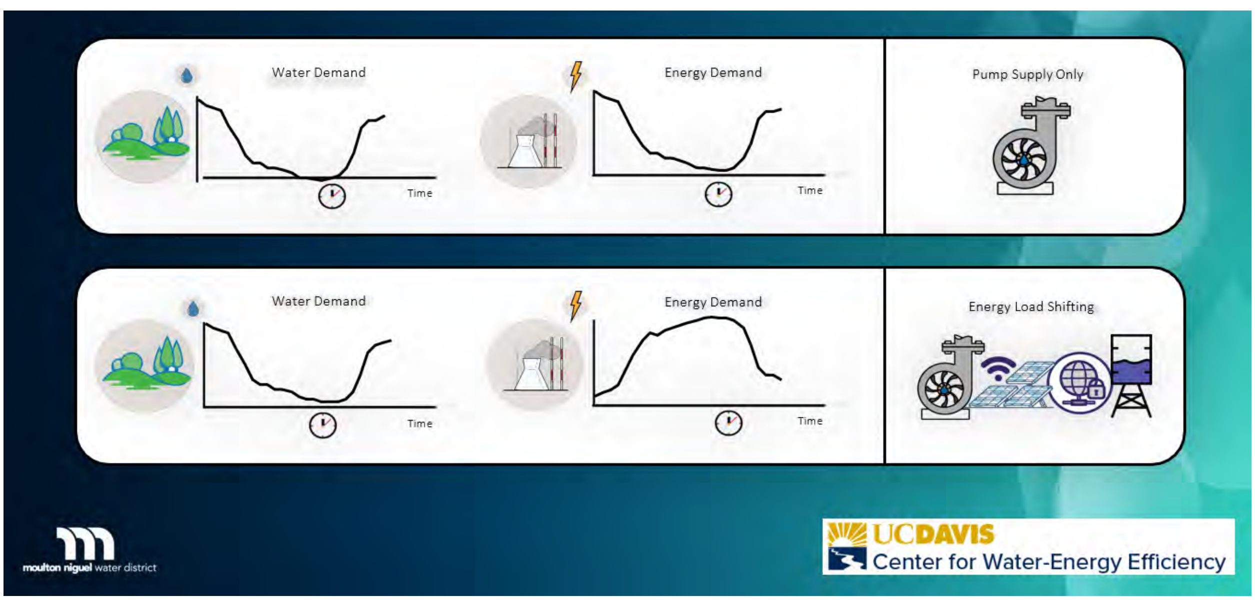

Figure 14. Conceptual Use of the UC Davis and Moulton Niguel Water District EDMS Tool to Evaluate Energy Load Shifting Strategies

Cucamonga Valley Water District (CVWD)

In 2015, the University of California Riverside was awarded a $3 million EPIC grant for “Bringing Energy Efficiency Solutions to California’s Water Sector With the use of Customized Energy Management Systems (EMS) and SCADA.” The goal of the project is to demonstrate that integrating EMS into water SCADA systems can create greater efficiencies while reducing peak loads and electricity costs of delivery and treatment of water. CVWD was one of several sites that UC Riverside researched for its project.

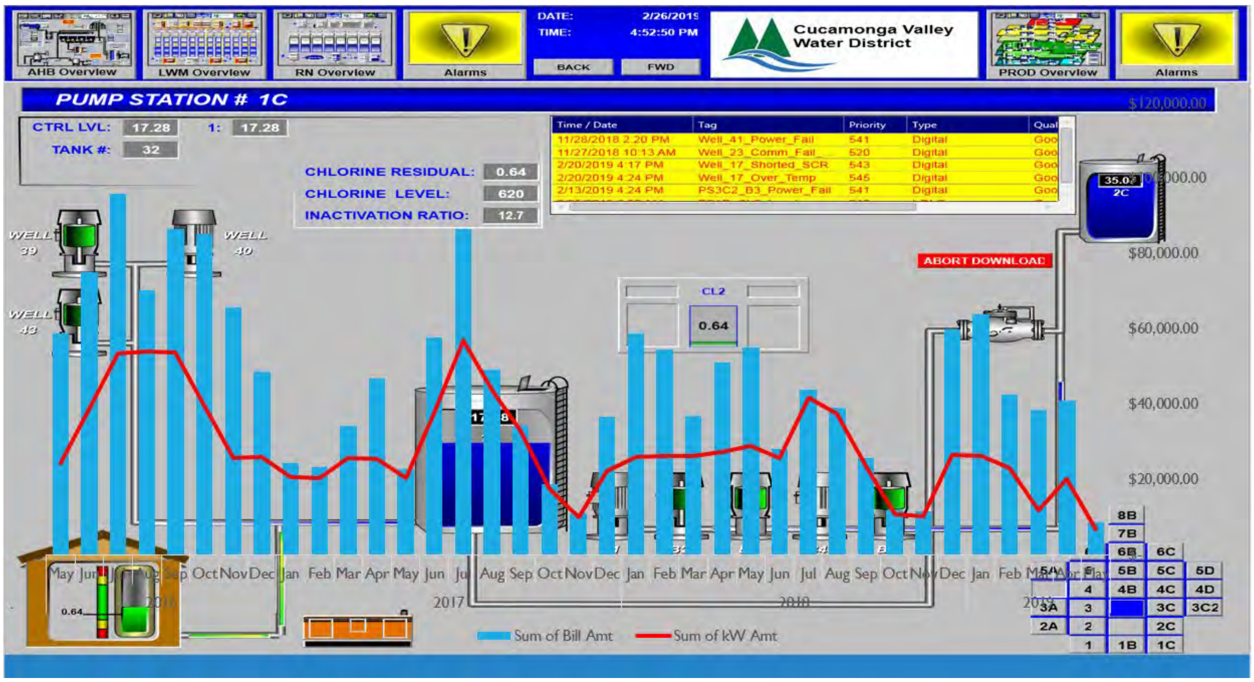

Figure 15. Cucamonga Valley Water District’s SCADA System with Energy Data[43]

Since implementation of the SCADA upgrade, CVWD has realized a 41% average reduction of monthly electric demand and related energy costs. The electric savings was achieved by the enabling CVWD’s SCADA operators to consider historical and real-time electric use and cost data before making operational changes.

[43] Maestas, Mike. “Production and Energy Management Strategies.” Cucamonga Valley Water District (CVWD). July 11, 2019.

V Valuing Flexible Electric Resources

Potential Over-generation Mitigation Services

There is not yet an over-generation mitigation program. To design a program, a wide variety of models for obtaining customer support during different types of electric reliability events – both “over-generation” and its opposite, “under-generation” or “under-supply” – are being contemplated by electric utilities, their regulators, and a wide variety of technical services providers, supply chain participants, and other key stakeholders throughout the U.S.

Most models anticipate that over-generation mitigation support is likely to mirror Demand Response programs with the primary difference being that over-generation will require “Flexible Demand Response”, the ability to increase or decrease real-time electric use at a particular site when called upon to provide electric reliability support.

Importantly, over-generation mitigation need not necessarily involve shifting substantial quantities of electricity to the over-generation period for the entire 9am to 4pm time frame. Just as existing Demand Response (DR) programs seek multiple types of support, the State’s electric utilities and the CAISO anticipate needing a portfolio of Flexible Electric Resources:

- <u>Notification/Commitment Lead Time</u>: Ten days, a week, a day-ahead; Day of a DR event; 1-2 hours or 30 minutes advance notice; real-time.
- <u>Type of Demand Response Commitment</u>:
    - *Discretionary* - The ability to either choose to participate or decline an opportunity to provide DR support during an event, or
    - *Automated Demand Response (aka “Auto DR” or “Direct Load Control”)* – Allowing the electric utility to install energy management controls systems (EMCs) on specific electric loads that can be automatically dispatched (turned on or off) by the electric utility when and as-needed during a DR event.
- <u>Dispatch Length</u>: One or several hours (although some requested products may involve commitments to support “shimmy” – a product comparable to wholesale electric services that can change magnitude at very short intervals to “follow” load).

Similarly, while providers of electric reliability support services may bid in various quantities of electric support (typically in kW), the electric utility may choose to access only a portion of the quantity of electric demand bid.

Typically, the highest value DR product is real-time, automated, and can follow load; however, other products also have substantial value, depending on the specific electric reliability needs at any particular location and at any particular point in time. A meaningful dialogue between SCE and its water and wastewater utility customers will help immeasurably to quickly identify the types of water sector over-generation mitigation support that SCE needs and that the water sector can provide.

Except in rare instances, water sector services are unlikely to provide "shimmy" or "load following" services because of potential damage to equipment and pipelines, and potential risks to water quality.

The water sector may, however, be able to reliably provide electric load shifts on a pre-scheduled basis for long durations of time (hours, not minutes). The water sector may also be able to reliably provide those types of load shifts over multiple days, months, and even seasons.

Few other electric users would be able to provide a comparable level of sustained electric load shifts with the high degree of advance operational certainty to which water and wastewater utilities could commit, provided their systems and operations have been properly configured and scheduled to operate in that manner.

The Role of Distribution Resource Plans

Pursuant to Public Utilities Code Section 769 and California Public Utilities Commission (CPUC) Regulatory Rulemaking 14-08-013 Distribution Resources Plan (DRP), Southern California Edison (SCE) and the State's other regulated electric investor-owned utilities (IOUs) were required to support customer development of Distributed Energy Resources (DERs). Among other things, SCE and the other electric IOUs were required to develop methodologies for the Integration Capacity Analysis (ICA) of their electric distribution systems, and then input the results of those analyses into maps that visually depict locations in which DERs were important to increasing local electric reliability and deferring or reducing costs of electric distribution system upgrades.[44]

The resultant maps[45] are comprised of the following layers:

- ***SCE ICA Circuit Segments**:* The Integration Capacity Analysis (ICA) layer displays the "maximum amount of power that can be injected to and drawn from the distribution system requiring minimal to no distribution upgrades or operational restrictions." Each color shown in the legend is representative of how many MW can be added. Red circuits are already at maximum capacity; orange circuits are approaching maximum capacity.
- ***Transmission Circuits**:* This layer provides the location for all of SCE's transmission circuits and provides the voltage rating for each ranging from less than 33 to greater than 500 volts.

The intent of the ICA map is to enable potential developers of DERs to identify locations in which DERs are likely to have high value from an avoided cost standpoint. In other words, if circuits are at or near capacity, some types of upgrades – generation, distribution, and/or transmission – would likely be needed at some point in time. The value of the electric system upgrades that could be avoided by development of DERs serves as a proxy for potential incentives.

To illustrate the concept, Figure 16 on page 50 overlays a variety of water, wastewater, biosolids, recycled water, and distributed energy projects onto a fictitious circuit map. Please note that the facilities and the layout of the facilities relative to each other do not depict any particular water or wastewater utility, nor are they intended to represent the hydraulics of any particular system - elevations, pressure, capacity, and other factors needed to evaluate hydraulics are not represented here. The sole purpose of this diagram is to illustrate the general concept: that by identifying the specific circuit(s) to which an electric load is connected,

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[44] "Application of Southern California Edison Company (U 338-E) for Approval of its Distribution Resources Plan." *Southern California Edison* A.15-07-007. July 1, 2015.

[45] Found at SCE's Distribution Resources Plan External Portal (DRPEP) website: https://ltmdrpep.sce.com/drpep/.

information about the relative value of connecting one or more DERs at that site may be determinable.

Also note that the colors of the circuits alone do not indicate the specific mix of DERs that may be needed or could be most beneficial at each location. The location of the Flexible Electric Resources relative to SCE's ICA Circuits will, however, be helpful in facilitating a dialogue about the types and mix of resources needed by SCE at these locations.

A detailed dialogue between SCE's Distribution System Planners and the water sector will be critical in determining the types and levels of capital investments and operational changes water and wastewater utilities may be willing to make in order to provide different types of electric reliability support to SCE. It will also be essential to helping SCE determine the value of potential water sector Flexible Electric Resources, and thereby, the approximate level of incentives and/or other compensation and technical support that SCE can convey to compensate water and wastewater utilities for making these types of water system investments and operational changes.

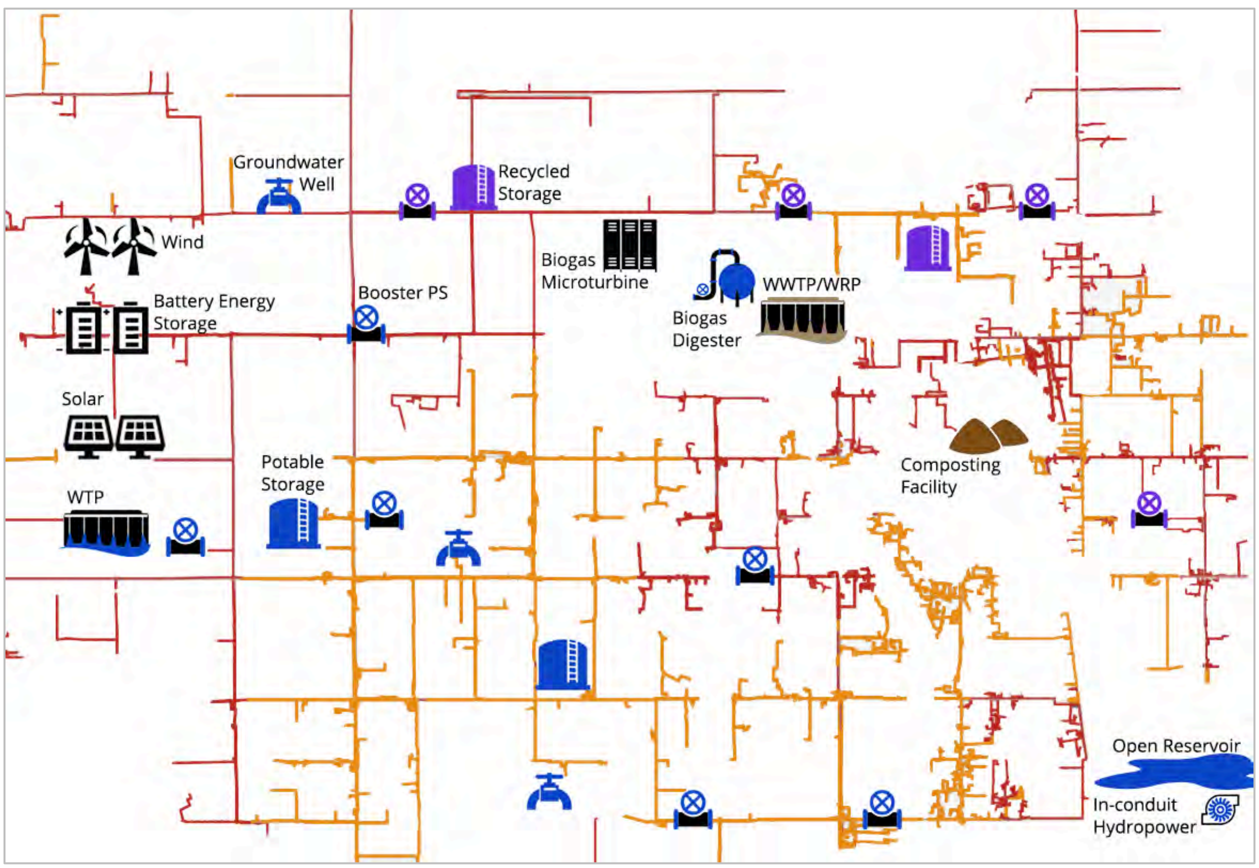

Figure 16. *ILLUSTRATIVE* Overlay of Water and Wastewater Systems and Facilities onto SCE's Integration Capacity Analysis (ICA) Map

Pricing Theories

California Public Utilities Code § 701.1 states that "*a principal goal of electric and natural gas utilities' resource planning and investment shall be to minimize the cost to society of the reliable energy services that are provided by natural gas and electricity …*" Section 701.1 also states that "*electrical and natural gas utilities should seek to exploit all practicable* ***and cost-effective*** *conservation and improvements in the efficiency of energy use and distribution that offer equivalent or better system reliability, and which are not being exploited by any other entity.*" [***emphasis added***]

The overarching guiding principle for valuing energy efficiency, therefore, as codified by California law and implemented for regulated energy utilities by the CPUC, is "cost-effectiveness". The CPUC's methodology for valuing energy efficient resources applies four tests to assess the costs and benefits of various demand-side programs from different stakeholder perspectives (see Table 5 below).

Table 5. California Standard Practice Manual Energy Efficiency Cost-Effectiveness Tests[46]

CPUC Cost-Effectiveness Tests	Description
Participant Cost Test (PCT)	Measures costs and benefits from the perspective of the customer that participates in an energy efficiency program.
Ratepayer Impact Measure (RIM)	Estimates the impact of an energy efficiency project or measure on customer utility rates.
Program Administrator Cost (PAC)	Compares costs of energy efficiency program administration to the costs of avoided supply-side resources (i.e., what is the net benefit of avoided supply-side costs less the costs of administering the energy efficiency program?).
Total Resource Cost (TRC)	A comprehensive measurement of ***all costs and benefits*** deemed to have impacted ***all utility customers***, both program participants and non-participants. ▪ Costs include program administrator costs and all costs incurred by customers. ▪ Benefits include avoided utility costs and "other program impacts" on both program participants and non-participants. (Examples of other program impacts include avoided water costs, other fuel savings, reduced O&M costs, improved productivity, improved comfort levels, health and safety benefits).

[46] Woolf, Tim, William Steinhurst, Erin Malone, and Kenji Takahashi. "Energy Efficiency Cost-Effectiveness Screening." *Synapse Energy Economics, Inc. for The Regulatory Assistance Project*. November 2012.

Although these multi-part tests were initially designed to evaluate IOU Demand-Side Management (DSM) programs, both gas and electric, that helped customers reduce their energy, they have since been expanded – first, to include all DSM measures, and next, to include all DERs.[47,48]

While the basic cost-effectiveness tests have been adopted widely by other states and energy utilities throughout the U.S., including federal energy programs, there is general consensus that (a) there are many different variables that comprise the costs and benefits of each test and these have changed over time, and (b) as a result, these four tests alone no longer meet the needs of today's energy programs.

As described in Chapter II, the State's energy demand-side programs have evolved over time, and Demand Response (DR) in particular has changed markedly in character.

- Commencing in the 1970s and until fairly recently, DR was primarily utilized as a means to reduce peak system electric demands. In its early iterations, DR programs were simple to understand and implement – vertically integrated electric utilities asked customers to reduce electric use when electric demand began reducing operating reserves.[49]
- In response to State legislation implementing the California electric restructuring in 1996,[50] California electric utilities divested most of their non-nuclear generation assets to support the State's transition to a competitive electric market. Electric reliability became the shared responsibility of the electric utilities and the newly formed California Independent System Operator (CAISO).
- During the 2000/01 California power crisis, the role of DR was elevated on an emergency basis as a vital strategy for keeping power flowing throughout the State. During this period, the roles of DR and energy efficiency became intermingled, since fuel shortages and a high frequency of power plant outages reduced the quantity of available electric supplies.

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[47] IDSM and IDER include the same four energy resources: Energy Efficiency, Demand Response, Distributed Generation, and Energy Storage. The "I" for "Integrated" merely means that programs now target these resources in combination – at least two different resources that are produced or delivered on an "integrated" (combined) basis. Both IDSM and IDER refer to customer-focused energy resources. The primary distinction is that "IDER" has an expanded goal – that of "provide[ing] optimal customer and grid benefits, while enabling California to reach its climate objectives." [Source: "Decision Adopting an Expanded Scope, A Definition, and a Goal for the Integration of Distributed Energy Resources." *California Public Utilities Commission* Decision 15-09-022. September 17, 2015.]

[48] "Integrated Demand-Side Management (IDSM) Cost-Effectiveness Framework White Paper." *Black & Veatch for San Diego Gas and Electric* On Behalf of the IDSM Task Force. May 12, 2011.

[49] Operating reserves were established to assure that electric utilities would have enough power to meet electric demands even if an outage occurred that made one or more electric generation facilities unavailable.

[50] "The Electric Utility Industry Restructuring Act." *California Assembly* Bill 1890 [Brulte 1996].

- Post 2000/01 California power crisis, the State adopted an Energy Action Plan (in 2003, later updated in 2005 and again in 2008),[51] recognizing Demand Response as one of four distributed energy resources[52] but including DR for energy program purposes as an "Energy Efficiency" resource.
- Thereafter, several initiatives emerged that sought to bundle all four DERs into unified "Integrated" programs – first as DSM measures ("IDSM"), and then as DERs ("IDER").

The most recent iteration of DR was precipitated by the emergence and fast-growing "over-generation" situation that now seeks to identify two-way DR that can decrease electric demand during periods of electric supply shortage ***and increase electric demand*** during periods of electricity surpluses.

To further complicate matters, each of these DR versions resulted in different types of products and services, subject to different rules, regulations, and valuation protocols. The various cost-effectiveness benchmarks share a common principle, that of "avoided cost" - but the CPUC applies multiple variants on avoided cost values and assumptions to ascribe value to different types of DERs for various types of purposes. The most notable differences are between grid (transmission level) resources that utilize long-term electric production cost modeling (simulated future electricity markets and electric infrastructure) vs. the avoided costs of customer-side DERs that are typically determined on the basis of the avoided cost value of the avoided marginal resource(s). Notably, although DSM measures and DERs were bundled under "Integrated" programs intended to achieve incremental cost-efficiencies, the four DSM/DER resources (EE, DR, DG, and ES) are still being measured separately.[53]

The wide diversity of energy products and services, and the different data, assumptions, and methodologies applied to value them, mirrors the complexity of California's energy programs and markets. The intricacies of the multiple computations and assumptions are understood by only a handful of expert practitioners, and even they acknowledge that there are many imperfections in the data and the methods. It is therefore not surprising that although California's water sector has unique characteristics that make it a near-perfect partner for electric utilities, the understandably risk-averse water sector that must always first meet its own mission-critical goals and objectives is cautious about the energy programs in which it will participate.

Table 6 on the next page compares different types of Demand Response programs.

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[51] "Energy Action Plans." *California Public Utilities Commission* website: https://www.cpuc.ca.gov/eaps/.

[52] The four Distributed Energy Resources (DERs) are Energy Efficiency (EE), Demand Response (DR), Distributed Generation (DG), and Energy Storage (ES).

[53] "Integrated Demand-Side Management (IDSM) Cost-Effectiveness Framework White Paper." *Black & Veatch for San Diego Gas and Electric* On Behalf of the IDSM Task Force. May 12, 2011.

Table 6. The Many Dimensions of "Demand Response"

Demand Response Variations	Types of Products	Targeted Benefits	Valuation Methodology(s)
Energy Action Plan – Demand Response as an Energy Efficient Resource	▪ Voluntary curtailable load ▪ Behavioral-based response ▪ Price-based response ▪ Event-based response	▪ Cost of system capacity upgrades avoided through DR ▪ Net operational cost savings through DR deployment	Total Resource Cost (TRC): avoided costs of supply, transmission, distribution, generation and capacity costs attributable to a load reduction[54]
Flexible Capacity (Grid Level Balancing Resources)	Effective Flexible Capacity (EFC) capable of providing transmission-level balancing resources for the largest 3 consecutive hour ramps each month	Ability to provide grid capacity via grid-level energy storage, certain eligible distribution-level and BTM storage, and supply-side DR on short notice: ▪ Fast, dispatchable ramping services ▪ Load following capabilities	Resource Adequacy (RA) Local Capacity Requirements (LCR) solicitations and auctions for "least cost/best fit" resources[55]
Integrated Demand Side Management (IDSM)	Customer-side actions that integrate 2 or more of the 4 DSM resources (EE, DR, DG, ST)	Reduced costs of individual DSM resources and programs through integrated production &/or delivery of 2 or more DSM resources	Resources are still valued on the basis of individual avoided cost models (incremental values attributable to "integration" not yet recognized)[56]
Integrated Distributed Energy Resources (IDER)	Integration of DERs into Distribution Resource Plans (DRPs) [includes electric vehicles]	▪ Increased local and regional electric reliability for "optimal customer and grid benefits" ▪ Enabling California to reach its climate objectives	
Flexible (2-way) Demand Response	Electric Reliability by both shedding and increasing electric use on a time-of-use and locational basis	▪ Avoided cost of investments in electric distribution system upgrades ▪ Value of flexible resources provided to the CAISO for grid level reliability support	Locational Net Benefits Analysis (LNBA)[57]

[54] "California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects." *California Public Utilities Commission*. October 2001. Page 18.

[55] "Testimony of Southern California Edison Company (U 338-E) in Support of Its Application for Approval of the Results of Its 2018 Local Capacity Requirements Request for Proposals (LCR RFP)." *Southern California Edison*. Application 19-04-016, Exhibit SCD-01. April 22, 2019.

[56] "Integrated Demand-Side Management (IDSM) Cost-Effectiveness Framework White Paper." *Black & Veatch for San Diego Gas and Electric* On Behalf of the IDSM Task Force. May 12, 2011.

[57] LNBA estimates the value of distribution system investments that can be avoided by Distributed Energy Resources (DERs) over various time frames. Upon its completion, LNBA is intended to calculate an estimated value of DER solutions to locational electric reliability challenges.

Price Signals Work …

In March 2019, SCE implemented the much anticipated new time-of-use rates for its non-residential customers. Water and wastewater utilities readily shifted peak avoidance from the previous Noon to 6pm summer on-peak periods that had been in effect since the 2000/01 power crisis[58] to the new peak period of 4pm to 9pm. With sufficient rate incentives, most water and wastewater utilities would also likely shift as much of their electric use to the over-generation period (9am to 4pm daily, when solar PV is producing surplus electricity that exceeds real-time electric demand).

But More Could be Done.

Water and wastewater utilities can do much more to support electric reliability. Some Flexible Electric Resources are available now; but as described previously, not all of it is being bid into regulatory DR programs which are deemed too prescriptive. Much more could be developed with some investment, and other types of electric reliability support could be provided by reconfiguring existing water and wastewater systems and/or changing operating protocols.

Tell us what you need, where you need it, and what you'll be able to pay to get it – we'll figure it out!

[58] "In June 2001, the CPUC approved a 30% increase in average electricity rates by customer (CPUC, 2001a). … The new rates sent a strong price signal for large commercial/industrial customers to reduce electricity consumption, particularly during the summer peak periods (e.g., 12-6 PM)." [Source: Goldman, Charles A., Joseph H. Eto, and Galen L. Barbose. "California Customer Load Reductions during the Electricity Crisis: Did They Help To Keep the Lights On?" Lawrence Berkeley National Laboratory, Energy Analysis Department, Environmental Energy Technologies Division. May 2002. Page 9.]

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VI A New "Business As Usual" (BAU)

The Water Sector's Unique Capability to Provide Flexible Electric Resources

Water "batteries" are prolific and distributed throughout California, contiguous with electric distribution systems.	Every groundwater well; booster pump; water reservoir or tank; water, wastewater, or recycled water treatment plant; and even biosolids and biogas facilities are potential water batteries.
Water storage is superior to battery energy storage technologies with respect to their ability to reliably integrate large quantities of variable energy resources for long durations of time.	Water, wastewater, and recycled water storage can store large quantities of energy for long durations of time – in some configurations, for days, weeks, and months (instead of minutes and hours) – making them superior to electric batteries as a variable renewable energy integration resource.
The potential energy storage capacity of some water and wastewater systems can exceed their maximum electric demand.	Water and wastewater utilities schedule operations in a manner that reduces peak electric demand to reduce energy costs. Wherever flexible pumping, pipeline, and storage capacity exists, electric demand could be increased beyond existing electric load to provide over-generation mitigation support.

California's water and wastewater utilities understand "reliability" – not only is it one of the underpinnings of their own products and services; their ability to achieve their mission depends in large part on reliable energy services. For this reason, they have needed to become knowledgeable energy managers, continually seeking opportunities to assure long-term access to reliable and cost-effective energy resources.

Water and wastewater utilities also plan for the long-term. Like electric utilities, they routinely integrate redundancy into design of all critical systems and install on-site emergency power generation and fuels to enable them to continue to provide their mission-critical services during power outages.

Billions of dollars are invested by the water sector every year. Many more billions are planned to be invested over the next decade.

Water and wastewater utilities emphasized a new to establish a new "Business As Usual" (BAU) that will define how both the water and electric sectors operate hereafter: as reliability partners.

Key Findings

Table 7 below summarizes key findings from SCE's Over-generation Pilot Project.

Table 7. Key Findings from SCE's Over-generation Pilot Project

1. California's Water Sector is Replete with Flexibility	Water sector *Flexible Electric Resources* tend to flourish at points of Flexible Capacity but can be developed at other sites with some capital investment and/or operational changes.
2. Existing Demand Response (DR) Programs need revision	▪ Meter-specific DR programs ignore the network design of water and wastewater utilities. Operational changes made at one location may result in electric system impacts upstream, downstream, and/or laterally from a DR action taken at one particular site. As a consequence, responding to DR events at the individual meter level may not achieve the desired electric impact at the targeted location. ▪ Other aspects of conventional DR and other energy programs' design (e.g., the punitive nature of demand charges in context of Flexible DR) create barriers to water sector participation and sub-optimal program results.
3. Water and wastewater utilities can do much more	Water and wastewater utilities emphasized an urgent need to clearly understand the electric system impacts that are being targeted. With unambiguous information, water sector engineers, planners, operators, and their technical service providers can help identify opportunities to provide electric reliability support, both on short- and long-term bases.
4. The water sector is driving development of "SWEMS"	Of their own accord, many water and wastewater utilities are integrating real-time electric data into their SCADA systems and decision-making tools to further improve their ability to manage the time and cost of their energy use. These tools will be valuable in helping them determine how, when and where they can provide electric reliability support.
5. Building a culture of change and innovation requires training and buy-in	First-line operators have a pivotal role in energy management but they need appropriate tools and training, and they need a supportive organizational culture that values and recognizes initiative and results. Acknowledging the considerable value that water sector operators can bring to the State through improved real-time decision making will help to build the needed organizational buy-in and support.
6. The appropriate relationship is that of an Electric Reliability Partner	To fully leverage the flexibility inherent in water and wastewater utilities' systems and to influence the billions of dollars in ongoing investment in water sector infrastructure, an open and collaborative dialogue between the water and electric sectors is urgently needed.
7. The path forward is a new "BAU"	Water and wastewater utilities emphasized that they are not interested in shifting a few MW a few hours a year – they are interested in playing a major role in defining a new, electric reliability operations protocol that will define the water sector's new "Business As Usual" (BAU).

California's Water Sector is Replete with Flexibility

As described in Chapter III Water Sector Flexible Electric Resources, California's water and wastewater systems can provide many types of Flexible Electric Resources in large quantities and over long durations. The key to identifying and leveraging that flexibility is to first identify Flexible Capacity (for water utilities, it is pumps, pipelines, storage), and then to conduct hydraulic analyses to determine whether there are any design, capacity or other constraints that would prohibit increasing the rate of pumping at any particular location. If sufficient incentives are provided to alleviate such constraints (e.g., increase the number and/or capacity of pumps, increase the diameter of a pipeline, increase storage capacity), and provided there are no adverse impacts on the water or wastewater utility's mission-critical operations, the water or wastewater utility may be willing to make the investment(s) and the operational change(s) needed to increase their Flexible Electric Resources potential.

Additional constraints that could reduce a water or wastewater utility's Flexible Electric Resources potential need to also be considered. These include, but are not limited to:

- Public health and safety concerns (e.g., water supply and/or quality, wastewater influent and sewage sludge odors).
- Policy, regulatory, and/or legal compliance.
- Operational prudence (e.g., increasing the rate of pumping can cause stress and increase outages on pumps and pipelines).

However, water and wastewater utilities know their systems and know where (a) flexibility exists, and (b) the level and types of Flexible Electric Resources that they can provide.

Importantly, water and wastewater utilities are constantly maintaining and upgrading their systems and are aware of opportunities for leveraging capital investments to increase operational flexibility. Approved Capital Improvement Program (CIP) budgets for the 7 water and wastewater utilities that participated in case studies for this Pilot Project alone exceed $2 billion.

There is considerable opportunity to coordinate both operations and infrastructure investments to the mutual benefit of water and electric sector ratepayers.

Existing DR Programs Need Revision

Water and wastewater utilities interviewed for this Pilot Project described several characteristics of existing Demand Response programs that inhibit water sector participation. Key among these were the fact that existing programs are:

- ***Too prescriptive*** (need to bid in separate meters and then make specific commitments to respond to specific numbers and types of events);
- ***Too risky*** (reiterating the water sector's need to always first meet their mission-critical goals and objectives); and
- ***Uneconomic*** (demand charges were cited as the primary financial deterrent).

Water and wastewater utilities emphasized that they can do more to support electric reliability but major barriers in existing Demand Response programs must first be addressed.

> ***Rancho California Water District*** has identified 80 sites totaling 17 MW that can provide Flexible Electric Resources. Only 19 of these meters totaling 1 MW are presently enrolled in Demand Response programs.

Assuring that the targeted electric system benefits are achieved

Existing meter-specific DR programs ignore the network design of water and wastewater utilities. Operational changes made at one location may result in electric system impacts upstream, downstream, and/or laterally from a DR action taken at a particular site. Consequently, responding to DR at the individual meter level may not achieve the desired electric impact at the targeted location.

This challenge can be overcome if water sector programs are structured to instead achieve the targeted electric reliability benefit at each circuit, feeder, or substation (instead of the existing program structure that seeks participation by individual meters without regard for whether the actions taken at one meter may negate the targeted electric reliability benefit).

Removing barriers to water sector participation in existing DR programs

Water and wastewater utilities that participated in this Pilot Project cited many barriers to participation in existing Demand Response programs.

Table 8 below describes the major barriers that were identified.

Table 8. Barriers to Water Sector Participation in Existing Demand Response Programs

Challenge	Issues	Opportunity
Demand Charges are inconsistent with the goals of Flexible Electric Resources.	Demand charges can account for 30-40+% of a W-WW utility's energy bill. To reduce costs, some W-WW utilities schedule pumping as evenly as possible over all non-peak hours to avoid punitive on-peak charges (demand and energy) and to minimize demand charges during all other hours.	Historical goals of reducing peak demand have been replaced by today's need for Flexible Electric Resources that can vary time of electric use on a locational basis up and down as/when needed to support electric reliability.
Some customer electric programs are not in sync with over-generation mitigation.	▪ Solar PV output from eligible Net Energy Metering (NEM) and Renewable Energy Self-Generation Bill Credit Transfer Program (RES-BCT) projects have been "grandfathered" under the old TOU time periods, enabling these customers to continue to earn the highest value for their solar PV output during Noon to 6pm. However, associated electric usage (for NEM, the on-site electric load; for RES-BCT, designated "benefiting" meters) are also charged for electricity on the basis of the old TOU time periods, causing eligible customers to avoid using electricity during Noon to 4pm (periods of over-generation).[59] ▪ Some W-WW pumping loads were authorized to continue using Agricultural and Pumping rates under the old TOU time periods. These loads also have a disincentive to participate in over-generation mitigation or other Flexible Electric Resources programs.[60]	Continuing use of the old TOU rates is in direct opposition with the State's urgent need for over-generation mitigation and related electric reliability support. W-WW utilities indicated a willingness to participate in a modified program that continues to provide the economic benefits that were in place at the time Solar PV investment decisions were made but that also eliminates any rate penalties that may accrue by shifting electric use when needed to support electric reliability. Similarly, the economic benefits sought by opting to remain under the old Agricultural and Pumping rates and TOU periods would need to be maintained under any proposed alternative programs.

[59] The CPUC accepted a settlement agreement among the State's electric IOUs and electric customers with RES-BCT solar generating facilities allowing projects that were economically impaired by the change in TOU periods to remain on historical Noon to 6pm on-peak TOU tariffs for up to 10 years. [Sources: (1) "Decision on Southern California Edison Company's 2016 Rate Design Window Application." *CPUC* Decision 18-07-006 [SCE Application 16-09-003]. July 12, 2018. (2) "Motion of Southern California Edison Company (U 338-E) and Renewable Energy Water Districts for Adoption of Renewable Energy Self-Generation Bill Credit Transfer Indifference Mechanism Amended Settlement Agreement." *SCE* Application 17-06-030. Motion dated September 28, 2018.]

[60] Customers that participated in the "Super Off-Peak" option under Agricultural and Pumping tariffs were granted grandfathered TOU status. The grandfathered TOU time periods remain in effect until replaced with new Agricultural and Pumping rates in SCE's 2021 General Rate Case (GRC) Phase 2. [Source: CPUC Decision 18-11-027 "Decision on Southern California Edison Company's Proposed Rate Designs and Related Issues", November 29, 2018.]

Challenge	Issues	Opportunity
Meter-specific Demand Response programs do not necessarily achieve the targeted electric reliability results.	W-WW utilities are comprised of multiple systems and facilities, many of which are networked. An action taken at one site may impact electric use at other sites upstream, downstream, and/or lateral to the site of a meter-specific DR event, potentially negating the targeted electric impact on any specific SCE circuit.	Refocusing water sector electric reliability responses on the specific electric impacts needed by circuit, feeder, and/or substation would enable W-WW utilities to help SCE achieve the locational real-time electrical impacts needed.
Electric pricing and tariff options are extremely complex.	The complexity of pricing options makes it difficult to determine which is "best" for W-WW utilities at any particular point in time, creating a significant deterrent to training and enabling operators to make real-time changes to support electric reliability without incurring additional energy costs.	A simple blended price that can be easily translated to $/AF of water pumping or $/MG of water, wastewater, or recycled water treatment would be much simpler to integrate into W-WW utilities' SCADA systems and decision-making tools, and more likely to gain water sector participation.
Most W-WW utilities do not have access to real-time electric data (usage and costs).	The time and costs needed to procure and install real-time electric metering equipment and integrate that data into W-WW SCADA systems exceed many W-WW utilities' staff and financial resources.	Accessing real-time SCE AMI and other electric data could enhance the ability of W-WW utilities to integrate energy information into their real-time operational decision-making. Ideally, an SCE program would include technical sub-metering assistance, financial support, and training.
Lead-time for notifications about DR events is insufficient.	The lack of sufficient notice to determine whether and how much DR could be provided by meter reduces W-WW utilities' ability to make the operational changes needed, thereby reducing water sector participation in those programs.	SCE and other electric utilities need a diverse portfolio of electric reliability resources, dispersed throughout their service areas. The water sector has the unique ability to commit in advance to provide certain types of Flexible Electric Resources that provide more notice and run for longer durations of time (e.g., 15 minutes to hours, instead of a few minutes at a time).
With few exceptions, W-WW utilities are not good candidates for Auto DR.	Auto DR is not a viable option for most W-WW utilities that must assure that their mission-critical goals and objectives are being met before deciding to opt-in to DR or other discretionary revenue earning (or cost reduction) opportunities.	

Water and wastewater utilities can do much more

Until now, with few exceptions, water and wastewater utilities have been regarded primarily as "Customers" of their electric utilities. Elevating their relationship to that of "Partner" would create a very different dynamic and dialogue, substantially increasing both near- and long-term opportunities for water sector support for local and regional electric reliability.

> Inland Empire Utilities Agency and other water and wastewater utilities that have substantial quantities of self-generation resources stated that one of the highest potential opportunities for them to produce Flexible Electric Resources is to unbundle electric loads from self-generation. In other words, IEUA's electric requirements presently represent on a net basis (total electric load less on-site generation) on SCE's distribution system. If departing load, standby charges, and other legacy customer energy program penalties are eliminated, customers with substantial self-generation resources would be able to separately schedule grid electricity purchases and on-site generation in a manner that provides the real-time electric system impacts targeted by SCE.
>
> Note that of IEUA's 53 SCE electric meters, only four presently participate in SCE DR programs. Although these 4 meters account for 88% of the Agency's electric demand (the electric loads on these meters range from 1.5 MW to 4.0 MW and have a combined capacity of 10 MW), IEUA and other water and wastewater utilities indicated that the requirement to bid specific meters into DR programs limits their ability to provide support – often, when a single meter is unable to respond to a DR event, one or more other loads may be able to step into that position but they cannot unless they are separately bid into the program.

As noted previously, the water and electric sectors have many similarities with respect to planning, operations, and investment. Like the electric sector, water and wastewater utilities plan "today" for resource and infrastructure needs 2-3 decades in the future. The amount of water sector investment in infrastructure is substantial – the 7 water and wastewater utilities that participated in case studies have approved CIP budgets exceeding $2 billion in new and upgraded systems over the next 10 years (see Table 9 on the next page).

Table 9. Capital Improvement Plan (CIP) Budgets for 7 Participating Water-Wastewater Utilities

Water Sector Partner	Capital Improvement Budgets
Cucamonga Valley Water District	$28 million (2 years)[61]
Eastern Municipal Water District	$472 million (6 years)[62]
Inland Empire Utilities Agency	$921 million (10 years)[63]
Moulton Niguel Water District	$321 million (10 years)[64]
Palmdale Water District	$30 million (5 years)[65]
Rancho California Water District	$157 million (5 years)[66]
Willow Springs Water Bank	$343 million (10 years)[67]
Total Approved CIP Budgets	**$2,272 million**

California American Water explained that even more is possible with regulated water utilities for which a dollar in cost savings translates to $8 that can be made in infrastructure investments without impacting customers' bills. (See California American Water "snapshot" on the next page).

Electric utilities can influence these investments by collaborating with water and wastewater utilities to explain the types and amount of electric reliability resources they need within the water and wastewater utilities' service areas over the next 20-30 years. Water and wastewater utilities can then seek these types of opportunities and, if they can be cost-effectively implemented, can include these in their CIPs. If the proposed electric reliability improvements are deemed cost-effective, some long-term water sector improvements could be further upgraded and potentially even accelerated.

[61] "Cucamonga Valley Water District Budget, Fiscal Years 2019 & 2020." *Cucamonga Valley Water District*.

[62] Mouawad, Joe. "Capital Improvement Program Progress Report – 2018/10 Q1 & Q1." *Eastern Municipal Water District* presentation. March 7, 2019.

[63] "Executive Summary" recommending adoption of the Agency's Biennial Operating Budget [FY2020-2021] and Ten Year Capital Improvement Plan [FY2020-2029]. *Inland Empire Utilities Agency*. July 1, 2019.

[64] "Proposed Fiscal Year 2019-20 Budget, Special Board Workshop." *Moulton Niguel Water District* presentation. May 1, 2019.

[65] Provided by Palmdale Water District.

[66] "5-Year Capital Improvement Plan (FY 2020-2024)." *Rancho California Water District*. May 16, 2019.

[67] "Willow Springs Water Bank Conjunctive Use Project." California Water Commission (CWC) website: https://cwc.ca.gov/Water-Storage/WSIP-Project-Review-Portal/All-Projects/Willow-Springs-Water-Bank-Conjunctive-Use-Project.

California American Water (CAW)

Service Areas Description

California American Water (CAW) is an Investor-Owned Utility (IOU) that provides water and wastewater service to customers throughout California. CAW is a wholly-owned subsidiary of American Water which provides water and wastewater services to over 14 million people in 46 states.

Within SCE's service area, CAW operates potable water distribution systems in Los Angeles County and Ventura County.

- **In Los Angeles County**: CAW operates three geographically distinct distribution systems: Baldwin Hills, Duarte, and San Marino.
- **In Ventura County**: CAW operates two systems (Thousand Oaks/Las Posas) that are close enough geographically to be considered together. CAW also recently acquired the small Rio Plaza groundwater system located on the east side of Oxnard.

Service Areas Description	Baldwin Hills	Duarte	San Marino	Thousand Oaks/Las Posas
Population Served	17,700	29,200	17,800	64,000
Pressure Zones	7	12	6	18
Hydraulic Grade	275'-611'	611'-1,215'	500'-820'	500-1,037
Groundwater Wells (Active)	4	9	13	
Reservoirs	5	7	6	20
Booster Pump Stations	4	5	7	20

Flexible Electric Resources

CAW pumps a large amount of potable water during normal operations through wells for supply (in Los Angeles County) and through booster pump stations between the numerous pressure zones served by its distribution systems. CAW's potential for providing Flexible Electric Resources is based upon its potential to align well and booster pump operation times with the over-generation window. In particular, the distribution system that CAW operates in Ventura County appears to have sufficient storage to allow for modification of operations to align with over-generation while still meeting all hydraulic requirements for customers.

Unique Characteristics of an Investor-Owned Water Utility

As an IOU, CAW offers several benefits in providing flexible electric resources with regards to over-generation that cannot be offered from a City-operated or special district-operated distribution system.

- CAW operates several geographically distinct distribution systems within SCE's service territory. Because over-generation is both a territory-wide as well as local challenge, the ability to provide flexible electric resources at different localities within the service area is a potential benefit.
- The financial model for both water and electric IOUs is different from the typical debt financing of public water utilities. One benefit of this difference is that the elimination of one dollar in ongoing operational expenses breaks even with the investment of eight dollars in capital facilities.

$1 million in operational cost reductions = $8 million in infrastructure investments

With appropriate incentives that reduce electricity costs, CAW has substantial potential to invest in upgrades to its systems that increase operational flexibility to provide Flexible Electric Resources for over-generation mitigation and other types of electric reliability support.

Examples of future water and wastewater system upgrades that could be accelerated include:

- Increasing the number and capacities of pumps for groundwater wells and booster pump stations;
- Increasing the capacity of water and recycled water distribution pipelines; and
- Increasing the number and sizes of water, wastewater, recycled water, biogas, sludge, and other types of storage facilities.

Sometimes, but not always, there may also be discretion with respect to the specific locations selected for new or expanded facilities, potentially increasing the amount of water sector Flexible Electric Resources available at sites that are particularly electrically challenged. In addition to water and wastewater systems, opportunities for site-specific support could include future distributed generation projects.

The water sector is driving development of "SWEMS"

As noted in Chapter IV Water-Energy Management Tools, California's water and wastewater utilities are leading SCADA integration of water sector Energy Management Systems (EMS). In addition to the "basics" – metering and integrating real-time electric data into their SCADA systems – some water and wastewater utilities have already developed dashboards that display the estimated energy costs of real-time operational changes so that SCADA Operators can make better informed decisions. Rancho California Water District (RCWD) also leveraged its SWEMS system to create an application that performs automated pump testing on a weekly basis.[68]

Other notable leaders in development of SWEMS applications include:

- ***Inland Empire Utilities Agency (IEUA)*** recently completed submetering of more than 180 of its major equipment units and critical systems and sub-systems;
- ***Palmdale Water District (PWD)*** recently completed a major update of its SCADA system and is preparing to integrate real-time energy data;
- ***Moulton Niguel Water District (MNWD)*** is partnering with the University of California Davis on a tool that integrates hydraulic modeling with SCADA to provide real-time electric data for improved operational decision-making; and
- ***Coachella Valley Water District (CVWD)*** has partnered with University of California Riverside on a similar tool that integrates real-time electric data with SCADA.

[68] RCWD's automated pump test function is currently in beta testing and not yet fully automated. Nevertheless, its capabilities are promising and an attestation to RCWD's innovative approach to developing and deploying tools and techniques for operational improvement.

Building a culture of change and innovation requires training and buy-in

In 2006, Rancho California Water District adopted a new operating philosophy: ***To leverage operational flexibility and diverse energy resources in order to produce and distribute quality drinking water while being mindful of cost.***

A conscious decision to integrate consideration of energy costs as essential to achieving its overarching mission resulted in multiple innovations that have significantly improved RCWD's ability to efficiently manage its water resources and infrastructure.

Sources: Rancho California Water District's website and interviews with District staff and managers.

Because Rancho California Water District (RCWD) has unused capacity that can be utilized, and because RCWD operations staff have a deep and robust knowledge of their distribution system that allows them to make operational changes with the confidence that they will not degrade their primary objectives of providing the required water volume to customers at the required water quality, RCWD can move a large portion of their electrical demand from pumping to the over-generation window with minimal upstream or downstream impacts. The existing capacity of RCWD's distribution system and RCWD's knowledgeable Operations Staff give the District significant flexibility in this regard.

RCWD attributes its success to the following three-pronged strategy:

1. **Train, Empower, and Equip SCADA Operators** - A recognition that RCWD's SCADA operators are optimally positioned to identify and implement real-time operational improvements, and an organizational commitment to training, empowering, and equipping RCWD's operators with market-leading tools to help them optimize the District's water and energy operations.
2. **Leverage Flexible Water Pumping and Storage Capacity to Reduce Energy Costs** - Energy is the RCWD's third highest cost (imported water is first, salaries are second). RCWD is committed to reducing its energy costs, recognizing that water must first take priority.
3. **Continually increase the quality of data and tools to enhance management and operational decision-making** - RCWD made significant improvements to its SCADA system and collaborated with external parties on improving the types and quality of data needed to support real-time operational decisions that protect water supply and water quality, and that reduce energy and other costs.

Many other water and wastewater utilities interviewed for this Pilot Project also emphasized the need for a supportive organizational culture, effective decision-making tools, extensive training of Operators, and buy-in from all levels of management and staff, including their respective Boards of Directors.

The appropriate relationship is that of an Electric Reliability Partner

California's water and energy sectors are not just natural partners – they are inevitable partners:

- Their service areas overlap;
- They are customers of each other;
- They serve many of the same customers; and
- They are both essential to public health and safety.

Unlike other energy customers that may own and operate a single building or campus and connect to one or a few SCE distribution circuits, most medium to large water and wastewater utilities have service areas that span many miles.

> *We in the water sector understand reliability. Let's talk about how we can work collaboratively towards that common goal.*
>
> - Joone Lopez, General Manager, Moulton Niguel Water District

As providers of vital utility services to the State, both the water and electric sectors are subject to the same State policies that require cost-effective and environmentally responsible operations. Both also require substantial investments in infrastructure, with a need to prepare 2-3 decades in advance to assure they can continue to meet their customers' needs over the long-term.

In addition, both are responsible for assuring long term reliability ("resilience") of the State's valuable water and energy resources, and the success of each sector in achieving long-term resilience and reliability depends in part on the other.

The water sector has signaled willingness and interest in integrating electric reliability into their planning and operations processes. The sheer magnitude of the water sector's ability to provide electric reliability support at key locations through SCE's electric system over a multi-year period calls for converting the relationship from "Customer" to "Partner" as soon as possible.

An open dialogue is now needed to determine the best mechanism for engaging the water sector's assistance in providing electric reliability support expeditiously and on an on-going basis.

The path forward is a new "BAU"

Through meetings, interviews, case studies, and a workshop, water and wastewater utilities conveyed the following common messages:

1. ***Mission-critical goals have first priority.*** Water and wastewater utilities must assure they are meeting their mission-critical priorities before considering discretionary initiatives. Although energy is one of their largest costs and reducing costs is important to keeping utility services affordable for their customers, it is usually 3rd or 4th on their list of priorities. This needs to be taken into account when designing Demand Response and other customer energy programs. Although the water sector would like to participate, they must always have the option to decline to participate if doing so might incur a risk to their mission-critical operations.
2. ***Energy reliability is a critical element of water reliability***. The water sector is acutely aware of the critical relationship between reliable energy service and their ability to provide reliable water and wastewater utility services. It is top of mind whenever there is a disruption to electric service, whether through an electric utility outage or a natural disaster such as earthquakes. Most recently, water and wastewater utilities affected by fire - whether due to an actual fire or electricity being turned off to reduce fire risks – are urgently revisiting their emergency operations protocols and preparedness, including the quantity and types of emergency power needed at each site deemed "critical" to their ability to provide services.
3. ***The water sector can do a lot to support electric reliability***. Driven by a need to assure that they can weather most common types of outages, water and wastewater systems are designed with redundancy at many locations so that they can continue to provide mission critical services under most contingencies. As a consequence, most water and wastewater utilities have Flexible Capacity in some parts of their system. When not needed for water or wastewater emergencies, some Flexible Capacity can be used to provide electric reliability support.

That said, the fact that Flexible Capacity may exist in some parts of their systems doesn't necessarily mean that water or wastewater can be operated at much higher levels for shorter durations of time. In addition to public health and safety concerns such was water quality, water and wastewater utilities must always operate their systems prudently. It may not, for example, be possible to operate all 5 pumps at a pump station at the same time – the decision as to whether and how to operate these pumps depends on many factors including the age, condition, and capacity of pumps and pipelines. It also depends on whether there is sufficient storage to hold the additional water being pumped until it is needed to meet demand. For both groundwater wells and surface water pumps, increasing pump rates even for short periods of time could increase turbidity and other types of water quality issues. Depending on the condition of the pumps and pipelines, increasing the rate of pumping could also increase the risk of system failures.

"Tell Us What You Need …"

Water and wastewater utilities are constantly planning. They are also always looking forward to the next increment of investment that will be needed for new, upgraded, and/or expanded facilities. Water and wastewater utilities can and should integrate electric reliability into their plans. In fact, they do that now, since energy reliability is integral to continued provision of reliable water and wastewater services. The water sector can better coordinate these plans to also meet the needs of their electric utility if those needs are clearly understood.

"… But Don't Tell Us How to Do It"

As explained previously, the best way to engage the water sector's participation is to leave meter level DR behind. Given the networked nature of their facilities, the level of redundancy built into their systems to assure that they are able to achieve their own mission-critical goals and objectives, and the need to always put their mission-critical operations first, inhibit water and wastewater utilities' ability to bid specific meters into DR programs.

Water and wastewater utilities could, however, determine whether they would likely be able to commit to a certain level of Flexible Electric Resources at specific circuits, feeders, and substations, as long as they have the ability to withdraw from the commitment if needed to address an emergency on their own systems. And, as noted previously, their reliability relies in large part on SCE's reliability; so it is in their best interests to help.

The new "BAU" is a Partnership

Leveraging the operational flexibility inherent in the design of the State's water and wastewater systems will require first recognizing the essential nature of water and energy as partners, and then creating a special water sector partnership program that addresses the needs of both parties.

VII A Flexible Electric Resources Partnership

ILLUSTRATIVE Water Sector Electric Reliability Partnership Term Sheet

Name of Parties	Electric Utility Partner				Effective	MM-DD-YYY
	W-WW Utility Partner				Terminate	MM-DD-YYY
Product/ Service Description	Quantity of Load Shift		Duration		Notice Period	
	Min MW	Max MW	Min	Max	Min	Max
	###	###	## hrs	## hrs	## hrs	## hrs
Location	Circuit abc123		Feeder klm456		Substation xyz789	

TERM: Short (<= 3 Year)					
Products & Services	Product/Service	Compensation, Fixed	Compensation, Variable		
	Short 1	$/day	$/event	$/MW	$/MWh
	Short 2	$/month	$/event	$/MW	$/MWh
	Short 3	$/season	$/event	$/MW	$/MWh

TERM: Mid (4-7 Years)					
Products & Services	Product/Service	Compensation, Fixed	Compensation, Variable		
	Mid 1	$/month	$/event	$/MW	$/MWh
	Mid 2	$/season	$/event	$/MW	$/MWh
	Mid 3	$/year	$/event	$/MW	$/MWh

TERM: Long (8-15 Years)					
Products & Services	Product/Service	Compensation, Fixed	Compensation, Variable		
	Long 1	$/month	$/event	$/MW	$/MWh
	Long 2	$/season	$/event	$/MW	$/MWh
	Long 3	$/year	$/event	$/MW	$/MWh

General Principles:

- "Standard Offer" type of Agreement with pre-approved Standard Terms and Conditions and simple Term Sheet on Cover.
- Products & Services being offered are selected via a simple checklist.
- Pricing has fixed and variable components:
    - Fixed component compensates the Water/Wastewater Partner for its commitment to provide (structured to pay for any capital costs needed to provide the Products & Services);
    - Variable compensates the Water/Wastewater Partner for providing the requested products & services (structured to pay operating and other incremental variable costs incurred to provide the Products & Services).
- Risk premiums should compensate the Water/Wastewater Partner for any risks associated with providing electric reliability support.
- Revenue penalties would likely be assessed if the Water/Wastewater Partner is unable to meet its commitment; both debits and credits can be tracked in a balancing account.
- Provided the Water/Wastewater Partner attempts to provide the requested Products and Services in good faith when requested, net revenues should never be less than $0.

Key principles for compensation should include the following:

- **<u>Fixed Payments</u>** should be structured to enable the Water/Wastewater Partner to fully recover all incremental costs to install or modify new or retrofit equipment, systems, and/or infrastructure for purposes of providing electric reliability support. Ideally, the new or retrofit equipment, systems, and infrastructure will also have a water benefit that enables some co-investment that benefits both water and electric ratepayers.
- **<u>Variable Payments</u>** should be structured to compensate the Water/Wastewater Partner for all incremental variable costs of providing electric reliability support (operations and maintenance costs including staff time, capital repairs and replacements, and consumables).
- **<u>A Risk Premium</u>** should be paid to compensate the Water/Wastewater Partner for any incremental capital or operating risks associated with providing the requested electric reliability support.
- **<u>Financial Risk Mitigation</u>** should be structured along a “collar” that creates some upside for the Water/Wastewater Partner while minimizing downside risks.
    - **<u>Upside</u>** should be structured higher than the Water/Wastewater Partner would otherwise have been compensated for participating in traditional meter-specific DR programs, but less than the what might have been possible if the Water/Wastewater Partner would have needed to assume full wholesale market risk.
    - **<u>Downside</u>** should be structured in a manner that fully compensates the Water/Wastewater Partner for all capital and other investments made for changes to its systems and operations subject to debits for certain levels of non-performance (e.g., unable to provide scheduled Flexible Electric Resources at the times, locations, and quantities agreed to in the Standard Offer agreement more than ‘x’ times, except that revenue penalties shall not be assessed for failure to provide Flexible Electric Resources for reason of threats to mission-critical water sector operations).

Transitioning from “Customer” to “Partner”

Key to transitioning the electric utilities’ relationship with the water sector from “Customer” to “Partner” would be to change the structure of water sector electric reliability programs.

Simple Bilateral Agreements

Instead of opting into multiple diverse programs on a per meter basis, Water Sector Electric Reliability Partners could execute simple bilateral agreements comparable to the Standard Offer Agreements that were used to implement renewable energy purchase agreements between independent power producers and investor-owned electric utilities under the 1978 Public Utility Regulatory Policy Act (PURPA).[69]

The bilateral agreements would have two primary parts:

- The Term Sheet (cover) of the Agreement in simple checklist form that would enable the Parties to quickly and simply select the types of electric reliability products and services that will be provided by the Water Sector Partner at each location (circuit) and the bases of compensation for these products and services by the Electric Sector Partner.
- The Standard Terms and Conditions pre-approved by the CPUC that will govern the provision of electric reliability products and services under the Agreement.

In this manner, the products, services, and bases for compensation can be updated simply from time-to-time to reflect changed conditions in electricity policies, markets, rules, regulations, and technologies, as well as potential changed conditions for the Water and/or Electric Sector Partner(s), without need to renegotiate the entire Agreement.

The reasons for utilizing a Bilateral Agreement instead of retail or wholesale tariffs include the following:

1. ***Bilateral agreements can be customized***. Unlike tariffs in which one size is deemed to meet the needs of many, bilateral agreements allow the possibility of tailoring Terms and Conditions to each Water/Wastewater Partner's special needs and circumstances.

2. ***The need for Flexible Electric Resources is urgent***. As shown in Chapter I, even a conservative case anticipates that utility-scale solar PV will double over the next 5 years, and BTM solar PV is on a comparable trajectory. This means that both the quantity and the frequency of solar PV-related over-generation are likely to increase substantially over a relatively short period of time. Battery energy technology cannot catch up that quickly; nor are other industries able to provide comparable levels and types of electric reliability support – superior to that of lithium batteries – that can fend off large volumes of renewable energy curtailments.
3. ***The need for Flexible Electric Resources is long-term***. Over the next 25-30 years, as California continues to progress towards its goal of 100% clean and renewable energy resources, the State’s electric utilities and the CAISO will be scrambling to stay ahead of the inevitable solar PV over-generation avalanche to ensure that all clean and renewable energy that meets the goals articulated in SB100 can be reliably and economically integrated. The value that the water sector can provide to meet a significant portion of the Flexible Electric Resources is unique and substantial.

[69] Public Law 95–617, 92 Statute 3117.

4. ***To meet this long-term need, planning needs to start now***. Water and wastewater utilities are uniquely well positioned to provide electric reliability support now and in the future. As emphatically stated by the water and wastewater utilities that participated in this Pilot Project, a new "BAU" is needed – it can no longer be about shedding load at the meter level at a moment's notice – it needs to be: "This is the way we now operate!"
5. ***In order to leverage water sector investments, electric utilities need to clearly articulate the types, quantities, and locations of electric reliability support needed***. As stated previously, water and wastewater utilities are confident that if they understand clearly the types of electric system impacts that are needed, they will be able to determine how to structure their systems and operations to achieve those objectives. Water and wastewater systems are networked, and operational changes at one pump or part of a system can impact equipment and systems at other locations. Only the water or wastewater utility itself can determine whether and how the desired electric impact at any specific location can be achieved, and the time and duration that the targeted electric reliability support can be provided.

Water managers are sophisticated energy managers - they have needed to prepare for electric system emergencies long before the 2000/01 power crisis: earthquakes, flood, fire, and even minor events such as losses of transformers and circuit breakers, both on their own premises and on that of their electric utility(s). Many water and wastewater utilities attribute their current portfolio of energy resources to the combination of electricity shortages and very high prices of electricity during the 2000/01 power crisis, and the need to replace traditional diesel emergency generators with low emissions options due to increasingly stringent air quality regulations. As a result, many water and wastewater utilities have some amount of on-site distributed generation – most of it renewable. Some, such as Inland Empire Utilities Agency, are specifically building generation capacity sufficient to meet 100% of the peak electric demands at each of its four water recycling plants.

Note that there is no "one size fits all" – each potential Water/Wastewater Partner has a unique mix of resources, infrastructure, and service area characteristics (demand, topography, hydrology/climate, etc.) that need to be considered when developing proposed electric reliability services. Ideally, water and wastewater utilities will identify synergistic opportunities that enable them to provide electric reliability support while concurrently increasing the reliability of their own services. A "win-win" here will assure that electric reliability becomes fully integrated into the new Water "BAU".

Getting Started

Recognizing that the exploration of potential electric reliability partnerships between the electric and water sectors is at an early stage, the purpose of the ILLUSTRATIVE Water Sector Electric Reliability Partnership Term Sheet at the beginning of this chapter is to present a simple, easy to understand framework that could be used to facilitate a dialogue about the types of electric reliability products and services the water sector could provide, and the level and types of compensation the electric utility might be able to provide. Ultimately, creating a “Standard Offer” Agreement form with pre-authorized Standard Terms and Conditions would simply and expedite widespread implementation.

The ILLUSTRATIVE Term Sheet responds to the water sector’s advice: “Tell us what you need and where you need it; don’t tell us how to do it.” The water sector is knowledgeable about its resources and systems and understands it hydraulics and operations. From the outset of this Pilot Project, water and wastewater utilities have sent a consistent message: As long as they understand exactly what is needed, and when and where, they can figure out how to provide “it”.

The proposed Partnership structure is a significant departure from standard CPUC regulated DR programs. It does not require bidding specific meters into a program – water and wastewater utilities have stated emphatically that the individual meter DR program doesn’t work for them: not only does it risk not getting the right result from an electric reliability perspective (due to the networked nature of water and wastewater systems); it also significantly limits water and wastewater utilities’ ability to participate.

Undoubtedly some water sector investments will need to be made in order to provide the requested electric reliability support. Compensation will need to cover the water sector’s capital and operating costs, plus any incremental risks that could be incurred by committing to provide the support.

From the perspective of the CAISO, SCE, and other electric distribution utilities, the ability to secure long-term electric balancing resources from a partner that understands and reliably provides the needed services every day is invaluable, reducing the operational randomness, risks, and uncertainties associated with existing bidding programs. Further, the ability to leverage the billions of dollars being invested by California’s water sector throughout the State to integrate consideration of electric reliability support into their Capital Improvement Programs will produce economic benefits for both water and electric utilities and their ratepayers, most of which are shared.

The overarching objective of a Water Sector Electric Reliability Partnership is to substantially simplify and expedite the provision of near-term cost-effective electric reliability support to minimize confusion, streamline and expedite implementation, and manage costs.

Proposed Demonstration Projects

Water and wastewater utilities that participated in this Pilot Project recommended several different types of demonstration projects.

Proofs of Concept: Water Sector Ability to Provide Electric Reliability Services

Water, Wastewater, and/or Recycled Water Pumping to Storage

Although many water and wastewater utilities have considerable experience shedding load during high cost on-peak electric TOU periods, there has not yet been a "proof of concept" demonstration project that leverages additional pumping and storage capacity in a water utility's system to provide electric reliability support during periods of over-generation, nor has there been a demonstration of how Flexible Electric Resources at any particular site could be increased, potentially beyond the maximum electric demand at that site, by shifting pumping from other hours to the over-generation period.

Wastewater Electric Reliability Support through IDERs

Although wastewater treatment and water reclamation plants typically operate 24/7, they also have Flexible Electric Resource opportunities. For these types of facilities, electric reliability support can most likely be achieved through coordinated management and optimization of the wastewater utility's DERs – in short, true "IDER".

Wastewater utilities emphasized, for example, that they often have on-site biogas-to-energy facilities. As noted by both IEUA and LACSD, while some biological treatment functions may not be easily deferred, other parts of the wastewater treatment and recycled water production process can be interrupted without undue risks. These include, for example, storage of tertiary treated or recycled water, biogas, and biosolids. In addition, wastewater utilities believe that they can substantially change their real-time electric profile by adding battery energy storage to on-site generation resources to enable increasing purchases of grid electricity during periods of over-generation, and then relying upon self-generated electricity during periods of under-generation. A demonstration of how this could work would significantly enhance knowledge and understanding of the Flexible Electric Resources potential of water and wastewater treatment and water reclamation plants.

Enhanced Decision-making Tools

"SWEMS" (SCADA-integrated Water-Energy Management System)

As discussed in Chapter IV Water-Energy Management Tools, many water and wastewater utilities have independently embarked upon efforts to collect real-time electric data from large equipment units and critical systems, and to integrate that data into their SCADA systems. Significant progress has been made:

- ***Inland Empire Utilities Agency (IEUA)*** is submetering more than 180 of its major equipment units and facilities. Submetered electric loads 200 kW or larger are being integrated into IEUA's SCADA system, along with historical data about kW, kWh, amperes, and load factor. These data will help the Agency understand operating patterns and efficiencies to help reduce energy demand charges and identify malfunctioning equipment. SCADA systems for two of IEUA's Regional Water Recycling Plants have already been upgraded; the other two are expected to be completed within 2-3 years.
- ***Rancho California Water District (RCWD)*** has implemented a SCADA-Based Electric-Gas Energy Cost Gauge that helps its SCADA Operators understand the real-time energy use and estimated costs of major equipment units and facilities (see Figure 12 on page 38). In addition, RCWD has implemented real-time pump tests that allow SCADA Operators to assess the efficiency of individual pumps on a weekly or monthly basis. These tests allow the operators to select the most efficient pumps for preferred operation and to identify pumps with maintenance or repair needs earlier than was previously possible.
- ***Palmdale Water District (PWD)*** has upgraded its communication and SCADA systems and is now at the point where they would like to integrate real-time data about electric use by major equipment units and systems. In addition, they would like to integrate data and information about energy cost options.
- ***Moulton Niguel Water District (MNWD)*** and ***Cucamonga Valley Water District (CVWD)*** are both partnering with the University of California (MNWD with UC Davis and CVWD with UC Riverside) on SCADA-based tools that bring in real-time electric use data for integration with SCADA and decision-making tools to help SCADA Operators understand the electric costs and impacts of contemplated real-time water and wastewater operational changes.

These and other water and wastewater utilities interviewed for this Pilot Project indicated interest in testing the potential integration of SCE real-time AMI electric meter data into their SCADA systems, and also co-developing tools that help translate real-time electric usage data into estimated energy costs per unit of water pumped or treated. Some also recommended that SCE implement a technical assistance program that helps smaller water and wastewater utilities install CTs and submeters on critical parts of their system and integrate that data with their SCADA systems.

Optimization of Water Sector IDERs for Electric Reliability Support

The County Sanitation Districts of Los Angeles County (aka Los Angeles County Sanitation Districts, or LACSD) identified the need for one or more tools that would enable water and wastewater utilities to optimize their respective portfolios of Distributed Energy Resources (DERs) and operate them in a coordinated fashion to maximize their potential to provide electric reliability support. Among other things, LACSD stated that an optimization tool could help them determine when it would be more beneficial to self-provide electricity vs. when they could reduce generation in favor of purchasing grid power during periods of over-generation. The conceptual model would help to evaluate the net costs and benefits to LACSD vs. SCE and its ratepayers under various operating scenarios. This level of analysis would also enable LACSD to determine the level of capital investment it might be able to make to purchase and install the additional systems and equipment that would be needed in order to provide electric reliability support.

Hydraulic Analyses and Other Electric Reliability Project Screening Tools

As part of its Over-generation Pilot Project, SCE funded two projects for a large regional water, wastewater, and biosolids management utility partner that evaluated opportunities for providing electric reliability support. One project evaluated the potential to construct recycled water storage at the site of a regional water reclamation plant with the objective of shifting recycled water distribution pumping from on-peak periods to periods of over-generation. The other project evaluated the potential of using diurnal recycled water storage tanks to shift some recycled water pumping to periods of over-generation. It also evaluated the potential of shifting some recycled water pumping to spring months (seasonally) when over-generation is typically highest.

- The primary finding of the first project was that site and system constraints and high costs of equipment and infrastructure would make the proposed project uneconomic – i.e., from a Net Present Value basis, the project would not be able to pay for itself over its estimated useful life.
- The second project used the water district's hydraulic model to evaluate a segment of its recycled water service area. The hydraulic analysis concluded that there were feasible opportunities to provide both diurnal and seasonal over-generation mitigation support with minimal changes to systems and operations.

From these two projects, additional tools were identified that would be beneficial for other water and wastewater utilities to quickly and economically identify and evaluate their own opportunities to provide electric reliability support.

Electric Reliability Project Screening Tool

The first project would have benefited from conducting a high level "Fatal Flaw" analysis that input key characteristics of the proposed project. Projects that are unlikely to pay for themselves over their estimated useful life are often successfully screened out using high level assumptions that estimate the potential magnitude of costs and benefits. In addition, a screening tool that included inspection of the site (space) and pipeline constraints would have been able to more quickly determine that the project as configured would likely not be economic.

High Level Hydraulic Analysis

The second project utilized the regional water district's hydraulic model to evaluate diurnal hydraulic flow, storage, and pumping impacts, and also developed an Excel-based post-processor to extrapolate these diurnal impacts into seasonal impacts. Although the analysis was successful, it did highlight the fact that the time and cost needed to input and calibrate pump efficiency curves to the District's hydraulic model would not be justified if it was only needed to evaluate a single project. If, however, pump efficiency curves are routinely updated and calibrated as part of the hydraulic model's normal upkeep, the model can be a valuable tool for evaluating the place and time of electric system impacts under various operational scenarios.

Importantly, the second project also resulted in a recognition that if a hydraulic model is properly maintained and calibrated, pumping, pipeline, and storage constraints can be readily identified within a matter of minutes, significantly streamlining and reducing costs of project screening and evaluation. Further, the second project identified the fact that the Excel post-processor (or more generally, some sort of logic processor that can establish control points and boundary conditions that are beyond the hydraulic model's scope) that was developed for this project is a necessary and critical partner to the hydraulic model in the high level hydraulic analysis. Additionally, the post-processor can itself be utilized as an expedient and cost-effective means of conducting screening level evaluations of proposed projects or contemplated operating scenarios.

As the water and electric sectors begin collaborative identification and evaluation of potential changes to water and wastewater systems and operations for purposes of electric reliability, having access to "typical" project configurations and simple-to-use tools would help substantially expedite search for technically and financially viable project options.

In Summary

Without question, California's clean energy policies have been extremely successful. California is now poised to see solar PV more than double within 5 years and the bar has been set even higher – 100% clean, renewable and carbon-free electricity by 2045.

Visionary policies alone cannot account for the State's extraordinary success – the State also invested billions of dollars to establish the solar PV market and to advance development of other clean, renewable electric generation technologies. Everyone in California, the U.S. and the world benefited from California's ambitious renewable energy programs.

We are now at a point where real-time renewable electricity production has far surpassed the battery technologies that were being looked to as the primary means of integrating these unprecedented quantities of variable energy resources. It is time to look for alternatives.

Water and wastewater systems are designed to be reliable and flexible. Importantly, they are here now and the water sector is investing billions of dollars in upgrades and expansions to build drought resilience.

Also significantly, the water sector is ideally situated to become an electric reliability partner. Not only does the water sector's success in meeting its mission-critical goals depend on reliable electricity; but water and wastewater utilities' service areas span hundreds of miles, usually contiguous with electric transmission and distribution infrastructure. It is not a coincidence that water and wastewater utilities' service areas overlay areas in which SCE's electric distribution system is already at or near capacity – where there are people and businesses that need electricity, those same people and businesses need water and wastewater services.

The water sector is not the electric utilities' best option for traditional demand response programs that are bid a meter at a time. The water sector is, however, the perfect partner for electric utilities in supporting electric reliability throughout their respective service areas. As water and wastewater utilities interviewed for this Pilot Project reiterated many times:

"Tell us what you need, and where and when you need it;
but don't tell us how to do it. We know our systems; we will figure it out!"

Time is of the essence – there is much work to do to leverage the considerable operational flexibility inherent in the State's water and wastewater systems – let's figure it out now.

Abbreviations and Acronyms

ADR	Automated Demand Response
AF	Acre-foot
AFY	Acre-feet/year
aka	also known as
AMI	Advanced Metering Infrastructure
BAU	Business As Usual
BES	Battery Energy Storage
BTM	Behind-the-Meter
CAISO	California Independent System Operator
CEC	California Energy Commission
CIP	Capital Improvement Program/Plan
CNG	Compressed Natural Gas
CPUC	California Public Utilities Commission
CVWD	Cucamonga Valley Water District
CWC	California Water Commission
CY	Calendar Year
DDOR	Distributed Deferral Opportunity Report
DER	Distributed Energy Resource
DG	Distributed Generation
DR	Demand Response
DRP	Distribution Resources Plan
DRPEP	Distribution Resources Plan External Portal
EFC	Effective Flexible Capacity
EMC	Energy Management Control System
EMS	Energy Management System
EMWD	Eastern Municipal Water District
EPAct	Energy Policy Act
EPIC	Electric Program Investment Charge
FERC	Federal Energy Regulatory Commission
Flex DR	Flexible Demand Response
FY	Fiscal Year
GHz	Gigahertz

Abbreviations and Acronyms

HMI	Human Machine Interface
HRSG	Heat Recovery Steam Generator
ICA	Integration Capacity Analysis
IDER	Integrated Distributed Energy Resources
IEUA	Inland Empire Utilities Agency
IOU	Investor Owned Utility
kW	Kilowatt
kWh	Kilowatt hour
LACSD	Los Angeles County Sanitation Districts (aka The County Sanitation Districts of Los Angeles County)
LCR	Local Capacity Requirements
LNBA	Locational Net Benefits Analysis
LF	Load Factor
LNG	Liquefied Natural Gas
LSE	Load Serving Entity
MAF	Million Acre-Feet
MG	Million Gallons
MGD	Million Gallons per Day
MHz	Megahertz
MNWD	Moulton Niguel Water District
MW	Megawatt
MWh	Megawatt Hour
NCP	Non-Coincident Peak
NEM	Net Energy Metering
OCWD	Orange County Water District
OIR	Order Instituting Rulemaking
PAC	Program Administrator Cost
PCM	Pulse Code Modulation
PLC	Programmable Logic Controller
PCT	Participant Cost Test
PV	Photovoltaic
PWD	Palmdale Water District

Abbreviations and Acronyms

RAP	Regulatory Assistance Project
RCWD	Rancho California Water District
RES-BCT	Renewable Energy Self-Generation Bill Credit Transfer Program
RIM	Ratepayer Impact Measure
RWRP	Regional Water Recycling Plant
SCADA	Supervisory Control and Data Acquisition
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric Co.
SGMA	Sustainable Groundwater Management Act
SWC	State Water Contractors
SWEMS	SCADA-integrated Water-Energy Management System
SWP	State Water Project
TAF	Thousand Acre-Feet
TRC	Total Resource Cost
TOU	Time-of-Use
UCD	University of California Davis
UCR	University of California Riverside
UV	Ultraviolet
W-WW	Water and Wastewater
WSIP	Water Storage Investment Program
WSWB	Willow Springs Water Bank
WTP	Water Treatment Plant

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APPENDICES

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Appendix A - Flexible Electric Resources: Rancho California Water District (RCWD)

Substantial changes to agricultural and urban water use since 2006 created Flexible Capacity in Rancho California Water District's potable and recycled water distribution and storage systems. Recognizing the opportunity to leverage underutilized capacity to optimize water resource management and reduce operating costs, the District adopted an operating philosophy that specifically considered optimization of energy resources to reduce operating costs without impairing the District's mission critical goals and objectives – that of delivering "reliable, high-quality water, and reclamation services to its customers and communities in a prudent and sustainable manner."

A conscious decision to optimize both water and energy resources precipitated innovations in data, tools, and techniques that have significantly improved the District's ability to efficiently manage its water resources and infrastructure. With the aim of integrating energy cost-effectiveness into its operational decisions, the District initiated market-leading SCADA system enhancements and partnered with vendors on development of improved decision-making tools.

The District's objective was to enable first line operators to identify opportunities for operational efficiency. Success required support and collaboration among the District's Board of Directors, management, and staff to shift the organizational culture from a traditional risk-averse utility mindset to one that values continuous improvement and innovation. The result: Rancho California Water District (the District) estimates that it can provide up to 17 megawatts (MW) of flexible electric resources - 85% of its annual peak electric demand of 20 MW – to support local and regional electric reliability while also reducing its net energy costs and reducing future energy cost risks.

Two Potable Water Storage Tanks Totaling 6 Million Gallons
(*photo courtesy of Rancho California Water District*)

This case study describes the District's path to excellence in Flexible Resource Management: the tools and techniques that it developed and applied to create and manage 17 MW of flexible electric resources, and additional improvements that are being considered. The case study also captures the District's recommendations about changes needed to conventional energy customer programs to harness the considerable electric balancing resources that are inherent in California's water and wastewater systems.

This case study has been reviewed and approved by Rancho California Water District.

Contents

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Acronyms and Abbreviations

CPUC	California Public Utilities Commission
CT	Current Transformer
CY	Calendar Year
DER	Distributed Energy Resource
DRP	Distribution Resources Plan
DRPEP	Distribution Resources Plan External Portal
EMWD	Eastern Municipal Water District
FY	Fiscal Year
ICA	Integration Capacity Analysis
IOU	Investor Owned Utility
kW	kiloWatt
kWh	kiloWatt hour
LF	Load Factor
MW	Megawatt
MWD	Metropolitan Water District of Southern California
NCP	Non-Coincident Peak
PV	Photovoltaic
RCWD	Rancho California Water District
RES-BCT	Renewable Energy Self-Generation Bill Credit Transfer Program
SCADA	Supervisory Controls and Data Acquisition
SWP	State Water Project
WMWD	Western Municipal Water District

District Overview

Figure 1. Rancho California Water District Service Area

Rancho California Water District (RCWD) is located in the southwestern portion of Riverside County, bordering the County of San Diego. The District provides potable and non-potable water services to 150,000 residents within a service area of 155 square miles comprised of the City of Temecula, portions of the City of Murrieta, and unincorporated territory in the County of Riverside. Wastewater is collected and transported to Eastern Municipal Water District (EMWD) for treatment.

The District's water resources are comprised primarily of:

- Local groundwater from the Murrieta-Temecula Groundwater Basin;
- Imported State Water Project (SWP) and Colorado River water from the Metropolitan Water District of Southern California (MWD) through Eastern Municipal Water District (EMWD) and Western Municipal Water District (WMWD); and
- Recycled water from both District and EMWD facilities.

Table 1 below summarizes the District's facilities.

Table 1. Rancho California Water District's Systems and Facilities[1]

Potable Water System	▪ 40 reservoirs ▪ 31 pump stations ▪ 14 pressure reducing stations ▪ 211 miles pipelines (20'' & larger) ▪ 675 miles pipelines (16'' & smaller) ▪ 4 MWD turnouts ▪ 48 production wells	**Non-Potable Water System**	▪ 4 reservoirs ▪ 6 pump stations ▪ 27 miles pipeline (20'' & larger) ▪ 35 miles pipelines (16'' & smaller) ▪ 4 MWD turnouts (2 active, 2 inactive) ▪ 5 production wells ▪ 5 recycled water storage ponds ▪ 2 groundwater basins ▪ 1 lake impoundment (**Vail** Lake and Dam)
Wastewater System	▪ 2 lift stations ▪ 52 miles gravity sewer pipelines ▪ 2.5 sewer force main pipelines ▪ 1,455 manholes	**Other Facilities**	▪ 1 headquarters building ▪ 4 solar PV facilities ▪ Vail Lake property

[1] "5-year Capital Improvement Plan FY 2019-2023." *Rancho California Water District.* June 2018.

Electric Requirements

Electric Use

The District's primary electric uses are for pumping groundwater (38% of kWh and 26% of kW) and booster pumping (40% of kWh and 52% of kW). Together, groundwater pumping and booster pumps accounted for 78% of both the electricity (kWh) and the electric demand (kW) used by the District during 2018.

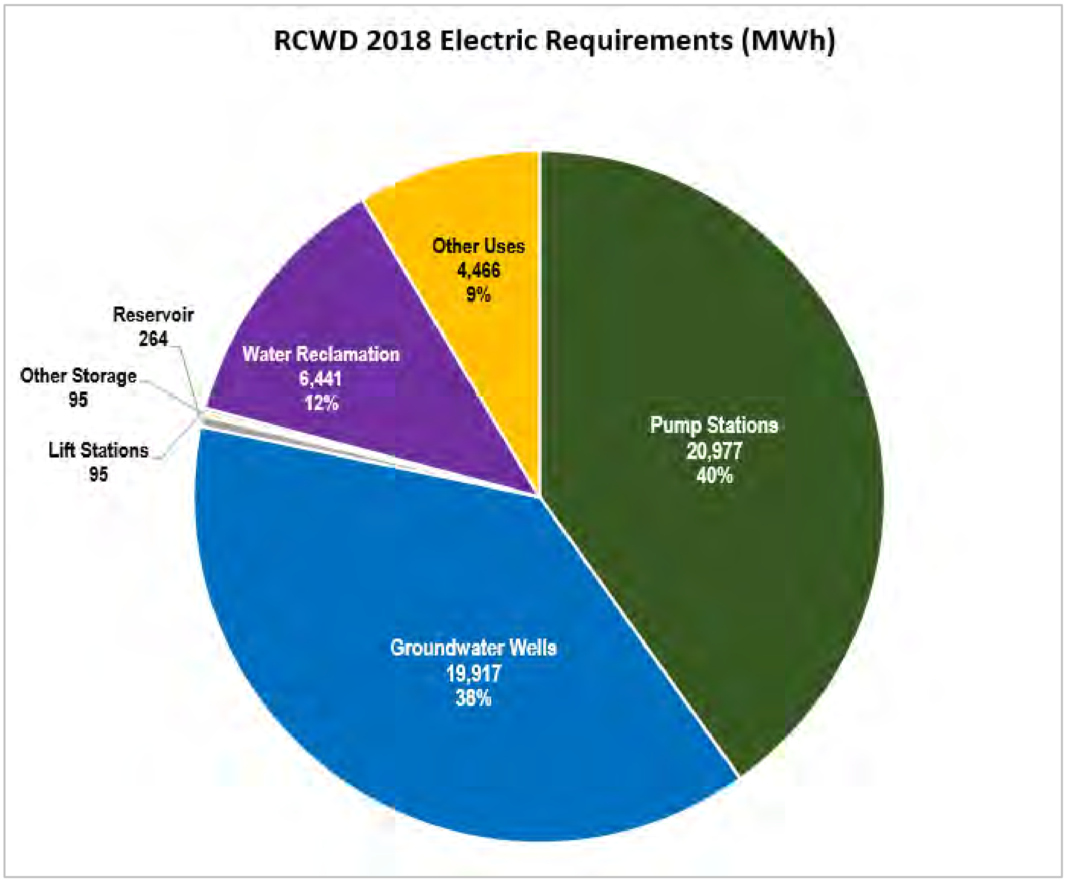

Figure 2. Rancho California Water District's 2018 Electric Requirements

The above diagram includes 2.575 MW of behind-the-meter Solar PV generation that produced 5.333 million kWh that were used behind-the-meter at 3 RCWD sites (the Senga Doherty Pump Station, the Santa Rosa Water Reclamation Facility, and RCWD's Headquarters) that were not included in SCE metered data (see Table 2 and Table 3 on pages A-6 and A-7 respectively).

Table 2. 2018 Electric Use (kWh) and Electric Demand (kW) by Type of Water Facility[2]

Type of Facility	Nbr of SCE Electric Meters	Total Electric Energy (kWh)		Maximum Electric Demand (kW)		Annual Electric Load Factor[1]	
		Total Electricity (kWh)	% kWh by Type of Facility	∑ Non-Coincident kW (NCP)[3]	% kW by Type of Facility	Utilized[2]	Unutilized[3]
Lift Station (Wastewater)	2	94,906	0.20%	53	0.27%	20.44%	79.6%
Pump Station (Potable and Recycled Water)	29	18,671,814	39.79%	10,642	54.23%	20.03%	80.0%
Reservoir	4	263,669	0.56%	220	1.12%	13.68%	86.3%
Other Storage	1	94,848	0.20%	90	0.46%	12.03%	87.97%
Groundwater Wells	36	19,916,728	42.45%	5,781	29.46%	39.33%	60.67%
Water Reclamation Facility	3	4,430,999	9.44%	1,227	6.25%	41.22%	58.78%
All Other Uses	78	3,448,392	7.35%	1,610	8.21%	24.45%	75.55%
Grand Total	**153**	**46,921,356**	**100.00%**	**19,623**	**100.00%**		

Table Notes:

[1] "Annual Load Factor" is the percentage of electric demand actually used (maximum annual kW) calculated as [Total Electricity (kWh) ÷ (Maximum Electric Demand x 8,760 hours/year)].

[2] "Utilized" is the amount of electric energy that was actually used during CY2018 as a percentage of the Maximum Electric Demand *("Non-Coincident" basis, see footnote 3 below*) by type of facility.

[3] "Unutilized" is the amount of additional electric energy that could have been used during 2018 under the maximum kW (i.e., additional kWh that was available without incurring additional demand charges).

[4] The above table includes electricity used by facilities that receive bill credits under a 5 MW RES-BCT solar PV project installed at one RCWD site. It does not, however, include electricity subject to Net Energy Metering (NEM) tariffs which is produced and used "behind-the-meter" (BTM) and therefore cannot be "seen" by SCE's electric meters. For this reason, BTM solar PV was added to the SCE metered data shown in Table 2 above to represent RCWD's total annual electric requirements in CY2018 (see Figure 2 on page A-5). Including BTM self-generated electricity is important to understanding the full potential of water and wastewater systems to provide locational electric reliability support.

[5] As is typical of most water and wastewater systems, the District's annual electric load factor for water, wastewater, and recycled water pumping tends to be fairly low – often in the 20-40% range. This is because water and wastewater utilities design critical systems with redundancy and excess pump capacity to assure reliable operations under a wide range of potential contingencies. For example,

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[2] Compiled from electric meter data provided by Rancho California Water District.

[3] NCP = "Non-Coincident Peak" is the sum of the maximum annual demand (kW) of each electric meter. ("Coincident Peak" is the total amount of electricity used by multiple systems and facilities at the same moment in time.)

redundancy and excess capacity enable maintenance to be performed on some pumps while others are operating.

Electric Resources[4]

One of the District's objectives is to "Leverage Operational Flexibility and Diverse Energy Resources in Order to Produce and Distribute Quality Drinking Water being Mindful of Cost." To support that objective, the District self-produces or purchases solar photovoltaic (PV) energy from four PV projects.

Table 3. Solar PV Projects

Solar PV Project	Year Implemented	Financial Structure	Design Capacity	Annual Output (FY2017-18)
Santa Rosa Water Reclamation Facility*	2009	Purchase Solar PV output from Sunpower under a 20 year PPA	1.0 MW	2,010,000 kWh
Rancho California Water District Headquarters	2011	District Owned/Operated	0.575 MW	1,018,000 kWh
Senga Doherty Pump Station*	2011	District Owned/Operated	1.0 MW	2,305,000 kWh
RES-BCT[5]	2016	Purchase Solar PV output from Sunpower under a 25 year PPA	5.0 MW	9,589,000 kWh
		TOTALS	**7.575 MW**	**14,922,000 kWh**

The largest of these solar PV facilities is a 5 MW solar project on 17 acres of land that is purchased via a Power Purchase Agreement (PPA) from a solar developer. This project is enrolled in SCE's Renewable Energy Self-Generation Bill Credit Transfer Program (RES-BCT) that allows the District to offset electric purchases at other sites with electricity produced at its designated RES-BCT site.

[4] "Review of District Energy Strategy and Annual Solar Performance." *Sage Renewable Energy Consulting for Rancho California Water District Engineering and Operations Committee*. October 25, 2018.

[5] The District's most recent Solar PV Project, RES-BCT (Renewable Energy Self-Generation Bill Credit Transfer Program) provides electricity for 35 sites. [Source: *Rancho California Water District*'s RES-BCT Benefiting Account Designation Form dated March 5, 2018.]

RCWD Solar PV Project Sites (*photo courtesy of Rancho California Water District*)

Flexible Electric Resources

The District has a substantial amount of flexibility through Flexible Capacity within its systems and operations. Most of the District's Flexible Capacity exists within its potable water distribution system.

Water and wastewater systems can often shape, shift, and shed electric loads within their systems by changing operating protocols and schedules.

The extent to which a water or wastewater utility can change its operations in a manner that produces flexible electric resources depends on multiple factors. Examples include:

- ***System design constraints*** - Pump capacity may be sufficient to increase pumping during some hours, but the quantity of increased pumping is limited to:
    - The capacity of the pipeline to deliver increased quantities of water pumped,
    - The amount of storage available to hold additional pumped groundwater, imported water, recycled water, or other water supplies until needed to meet demand, and/or
    - The amount of storage available to defer processing of wastewater to future hours.
- ***Regulatory and legal constraints*** – The water or wastewater utility may lack regulatory or legal rights to increase pumping at a particular time and location, such as an adjudicated groundwater basin or water contract that governs when and how much water can be withdrawn.
- ***Water quality*** – Increasing the rate of pumping from a particular water resource can sometimes impair water quality (e.g., by increasing turbidity).

Potable Water Distribution System

The District's potable water distribution system distinctly operates within two divisions: the Santa Rosa Division in the westerly half, and the Rancho Division in the easterly half. Each division provides water through a number of pressure zones ranging from 1060 to 2860 feet in the Santa Rosa Division, and 1305 to 2350 feet in the Rancho Division.

Most of the water supplied to customers enters the District at the lowest elevation (1305) with smaller amounts entering the 1380 Zone, 1610 Zone and 1790 Zone. Because the District serves customers up to 1,500 feet above the 1380 Zone, the District consumes a large amount of electricity to pump water from pressure zones at low elevations to successively higher zones.

The 1305 Zone provides service to the I-15 corridor and serves as the forebay zone for several pump stations that deliver water to higher zones within both Divisions. Treated water from MWD turnouts and the majority of groundwater production enters the District's system in the 1305 zone. Some additional groundwater also enters the system in the 1380, 1610 and 1790 Zones of the Rancho Division. (See Figure 4. Potable Water Distribution System Hydraulic Profile (SCADA view) on page A-10.)

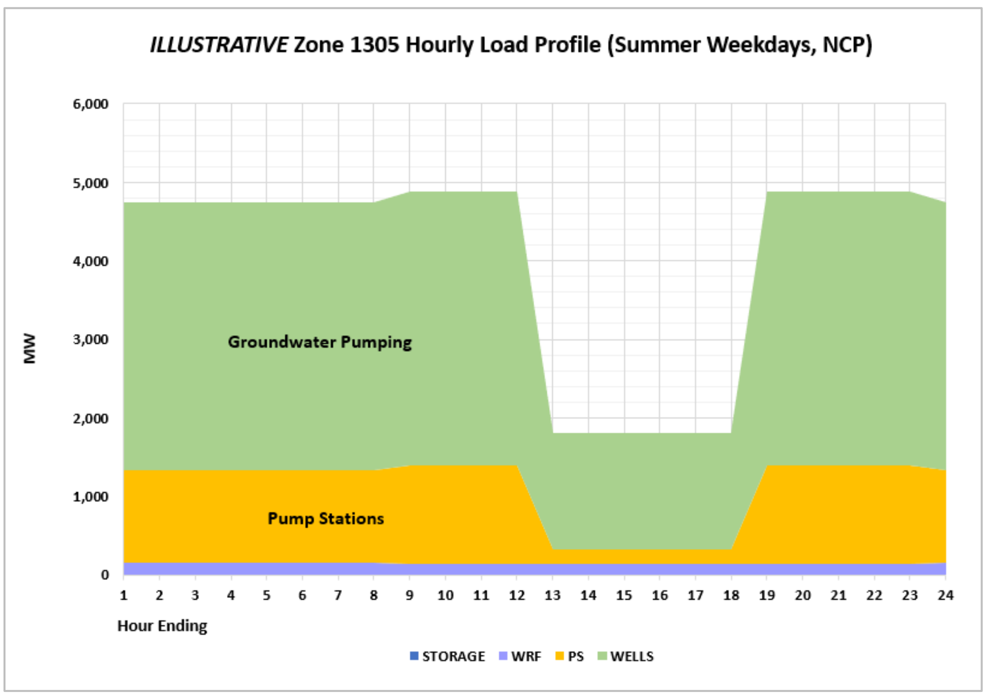

Figure 3. Diurnal Load Profile of Zone 1305 Electric Use during CY2018 Summer Weekdays (NCP)[6]

The above diagram depicts the 24 hour pattern of electric use by type of water and wastewater function within Zone 1305 during CY2018 Summer Weekdays. The Noon to 6pm "trench" is characteristic of most water and wastewater utilities that proactively manage the time of their electric use to minimize costs. This pattern changed in March 2019 when SCE's new TOU periods moved the highest cost electricity to 4pm to 9pm, except for electric loads that were grandfathered under old TOU time periods (see discussion on RES-BCT on page A-21).

[6] The above diagram does not include BTM solar PV under NEM tariffs.

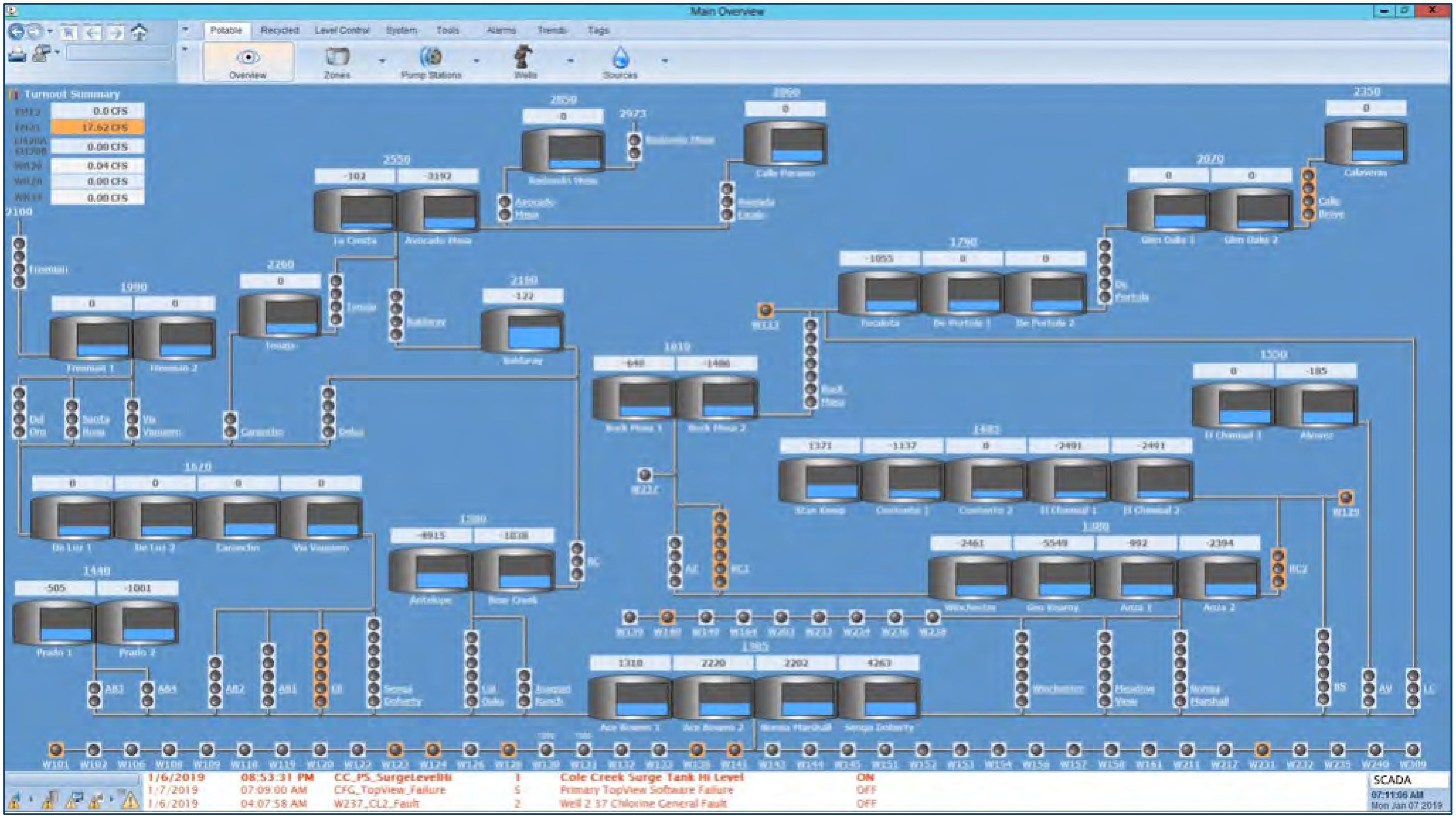

Figure 4. Potable Water Distribution System Hydraulic Profile (SCADA view)

The above screenshot from the District's SCADA system shows the relationship of the District's groundwater wells, booster pumps, and potable water storage within each pressure zone (yellow numbers above storage tanks and reservoirs) relative to other pressure zones. Pressure zone 1305 is the lowest elevation at which most of the groundwater wells are situated. From here, groundwater is pumped to higher elevations in other pressure zones as needed to meet demand. Most of the District's flexible electric resource capacity reside within Zone 1305 37 wells (161,230 GPM), 14 pump stations (128,309 GPM), 4 tanks and reservoirs (45 MG)]. ALL Pump Stations can contribute to Flex DR capacity but must be coordinated with zones above and below. Wells are less flexible but still available to coordinate with Flex DR.

Potable Water Distribution System Over-generation Mitigation Potential[7]

The District can shift up to 17 MW of pumping from groundwater wells and booster pump stations to SCE's diurnal over-generation time period (9 am to 4 pm).

The District's ability to shift pumping and electric demand to SCE's over-generation time period depends on the amount of capacity available in three types of distribution system infrastructure:

1. Pumping (groundwater, imported water, recycled water),
2. Storage capacity (reservoirs and tanks for both potable and recycled water), and
3. Conveyance capacity between pumping and storage.

District Operations staff stated that the District has adequate capacity in all three infrastructure types to focus the pumping to the overgeneration window. To minimize electric demand charges, the District utilizes only a portion of the available pump capacity and pumps over a longer timeframe.

District Operations staff and managers are knowledgeable about the impacts of operational changes on both mission critical water operations and on energy costs. This knowledge comes from carefully developed training programs that emphasize holistic understanding of the distribution system rather than rote or mechanical behavior, and from a consciously cultivated culture that emphasizes questioning, understanding, and constant improvement.

Because the District has unused capacity that can be utilized, and because District operations staff have a deep and robust knowledge of their distribution system that allows them to make operational changes with the confidence that they will not degrade their primary objectives of providing the required water volume to customers at the required water quality, the District can move a large portion of their electrical demand from pumping to the overgeneration window with minimal upstream or downstream impacts. The existing capacity of the District's distribution system and the knowledge of the District Operations Staff give the District significant flexibility in this regard.

To provide an approximate location of the overgeneration response potential, existing pumping and storage capacities within the potable water distribution system were evaluated by pressure zone (see Table 4 on the next page). These data were current as of December 2015, and the values contained in them are not expected to have changed significantly subsequently.

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[7] "Water Facilities Master Plan." *Rancho California Water District*. December 2015.

Table 4 below shows that 40% of the pumping capacity in the distribution system pumps out of Zone 1305 to various higher pressure zones. This value makes sense because the majority of the water entering the distribution system does so in Zone 1305. The pumping capacity generally decreases as the pressure zone elevation increases. Most storage capacity is found in lower pressure zones, but storage is not similarly clustered in Zone 1305 as is pumping capacity.

Table 4. Potable Distribution System Pumping and Storage Capacity by Pressure Zone[8]

Division	Zone	Pumping (GPM)				Storage (MG)			
		Pumping Capacity	% Capacity	Flexible Capacity	% Flexible	Storage Capacity	% Capacity	Flexible Capacity	% Flexible
Combined	1305	128,309	40%	43,738	33%	22.71	16%	10.57	18%
Rancho	1380	37,987	12%	15,252	12%	17.86	12%	5.75	10%
	1485	20,400	6%	4,979	4%	22.15	15%	7.45	13%
	1550	2,500	1%	1,252	1%	3.43	2%	2.11	4%
	1610	13,655	4%	5,074	4%	6.44	4%	2.16	4%
	1760	13,919	4%	8,011	6%	9.20	6%	6.25	11%
	2070	6,040	2%	3,140	2%	4.51	3%	1.90	3%
	2350	1,500	0%	1,256	1%	0.53	0%	0.13	0%
Santa Rosa	1440	12,100	4%	3,445	3%	11.41	8%	3.28	6%
	1500	13,260	4%	7,603	6%	7.83	5%	2.56	4%
	1670	44,350	14%	23,180	18%	17.05	12%	4.26	7%
	1900	8,720	3%	4,019	3%	8.24	6%	3.74	6%
	2150	200	0%	131	0%				
	2160	5,700	2%	3,538	3%	2.27	2%	1.91	3%
	2260	1,450	0%	384	0%	2.20	2%	1.56	3%
	2550	6,520	2%	4,002	3%	6.93	5%	4.50	8%
	2825	950	0%	942	1%	0.54	0%	0.35	1%
	2860	1,000	0%	953	1%	1.06	1%	0.83	1%
TOTALS		318,560	100%	130,899	100%	144.36	100%	59.31	100%
DIVISION TOTALS									
Combined		128,309	40%	43,738	33%	22.71	16%	10.57	18%
Rancho		96,001	30%	38,964	30%	64.12	44%	25.75	43%
Santa Rosa		94,250	30%	48,197	37%	57.53	40%	22.99	39%
TOTALS		318,560	100%	130,899	100%	144.36	100%	59.31	100%
FLEXIBLE CAPACITY DURING SUMMER MONTHS									
TOTALS		318,560		130,899	41%	144.36		59.31	41%

The potential for over-generation mitigation support is highest in Zone 1305, and then decreases as the pressure zone elevation increases away from this zone. Geographically, the potential for over-generation mitigation is highest along the valley floor along Interstate 15. The potential decreases as the elevation increases to the west and to the east away from the valley floor.

[8] Source: "Water Facilities Master Plan." *Rancho California Water District*. December 2015.

Note that if Zone 1305 pumps at the base of the "pumping ladder" are not focused to the over-generation window, it may limit the ability of the District to focus pumps in upper pressure zones to that window.

Flexible capacity in the District's potable water system averages 41% during summer months. During winter, the District's demand drops by approximately half – to about 30% of existing pumping and storage capacity. From an electric reliability perspective, the District could potentially provide electric reliability support from as much as 70% of its installed pumping and storage capacity.

Operational Changes Needed

Providing over-generation mitigation support would require pumping as much as possible during SCE's 9am to 4pm over-generation time period. Increasing the rate of pumping during some hours would increase the District's electric costs through increased demand (kW) charges. If a higher rate of pumping also causes pumps to operate outside the optimal range of pump efficiency, additional energy (kWh) costs may also be incurred.

Rancho California Water District's mission is: ***To deliver reliable, high-quality water, and reclamation services to its customers and communities in a prudent and sustainable manner.***

In 2006, the District adopted a new operating philosophy: ***To leverage operational flexibility and diverse energy resources in order to produce and distribute quality drinking water while being mindful of cost.***

A conscious decision to integrate consideration of energy costs as essential to achieving its overarching mission resulted in multiple innovations that have significantly improved the District's ability to efficiently manage its water resources and infrastructure.

Sources: Rancho California Water District's website and interviews with District staff and managers.

Flexible Electric Resources Strategies and Innovations

In 2006, the District shifted its operational philosophy to include consideration of energy costs. This shift in focus resulted in a number of important changes to the District's approach to collecting, analyzing and reporting operational data, and also in using data to support both near- and long-term decision-making.

One of the outcomes of the District's operational changes that is attributed to its new philosophy is the manner in which it operates it reservoirs. Historically, the District filled its reservoirs (storage tanks) to 75% of capacity, retaining 25% freeboard for operational purposes. In 2006, the District determined that it could actually operate safely at 90% of capacity. The change in the amount of space had the following benefits:

- Recovered 11 million gallons of usable water storage capacity at no additional cost.
- Reduced costs of imported water by $11 million (average cost $1/gallon) by increasing pumping of local groundwater for storage in the recovered reservoir capacity, thereby avoiding need to purchase water imports.
- The additional storage also enabled the District to avoid water pumping during high cost summer on-peak periods, reducing annual energy costs by $1 million/year.

The process of scrutinizing every aspect of the District's operations for efficiency improvements resulted in several valuable insights and innovations:

- **Train, Empower, and Equip SCADA Operators** - A recognition that the District's SCADA operators are optimally positioned to identify and implement real-time operational improvements, and an organizational commitment to training, empowering, and equipping the District's operators with market-leading tools to help them optimize the District's water and energy operations.
- **Leverage Flexible Water Pumping and Storage Capacity to Reduce Energy Costs** - Energy is the District's third highest cost (Imported Water is first, salaries are second). The District is committed to reducing its energy costs, recognizing that water must first take priority.
- **Continually increase the quality of data and tools to enhance management and operational decision-making** - The District made significant improvements to its SCADA system and collaborated with external parties on improving the types and quality of data needed to support real-time operational decisions that protect water supply and water quality, and reduce energy and other costs.

The District's market-leading strategies and innovations are described below.

1. **Train, Empower, and Equip SCADA Operators**. Success required a cultural transition from a traditional risk averse utility model that favors centralized management, to one that favors decentralized decision-making, continuous improvement, and innovation.

   Over the past 10 years, with the support of the District's Board and management, operators now have the ability to make real-time operational changes that protect water supply and water quality, while also reducing energy and other costs.

2. **Leverage Flexible Water Pumping and Storage Capacity to Reduce Energy Costs.** The District implemented two high priority energy cost reduction strategies:

   a. ***Increase Development or Purchases of Solar PV Energy*** to reduce the District's carbon footprint while also reducing its energy costs. The four solar PV projects totaling 7.6 MW that now provides 22% of the District's electric requirements was an outcome of that strategy. Additional solar PV is being investigated.

   b. ***Develop and Implement an Operating Protocol that Avoids Expensive On-Peak Electric Purchases***. The District's current time-of-use strategy consists of the following:

      - ***Potable Pump Stations***. The District has 31 potable pump stations, 28 of which can be shut off completely during on-peak hours.

      - ***Water Storage Reservoirs*****.** The District has Flexible Water Storage Capacity that enables shifting water pumping operations in a manner that provides energy storage benefits similar to those of electric batteries, but for longer durations than electric batteries are able to provide and at less costs and adverse environmental impacts.

      - ***Water Wells.*** Many of the District's wells have a limited run time. To minimize purchases of expensive on-peak electricity, the District runs off-peak first, mid-peak second, and on-peak last. The District's largest pumps are also powered by natural gas ("dual fuel"). Operators can run the gas pumps during the summer when water demand increases or during on-peak avoidance.

   c. ***Provide Electric Reliability Support***. A third strategy is being developed in partnership with SCE that is the focus of this Case Study: the potential opportunity to reduce costs of electricity purchases from SCE and potentially also earn electric reliability revenues and incentives by providing Flexible Electric Resources to support SCE's electric distribution system.

3. **Continually increase the quality of data and tools to enhance management and operational decision-making.** The District has made several innovative enhancements to its decision-making tools.

   a. ***The District's SCADA system now provides information about electric costs and use***. With this type of information directly in front of them, SCADA operators have the ability to consider energy costs when making real-time decisions about water operations. This is a “best-in-class” practice – very few other water or wastewater utilities have this capability.

> ***Innovation: Real-Time Electric-Gas Energy Cost Gauge***
>
> The District’s SCADA system has been programmed to enable inputting the pump efficiency curve for every pump motor, pump station, wells, storage tanks, and reservoirs.
>
> District staff upgraded the SCADA system to incorporate a Real-Time ***Electric-Gas Energy Cost Gauge*** to help Operators determine which energy resource to use based on forecasted pricing that is input to the system by the Systems Water Analyst.

Figure 5 on page A-17 provides a screen shot from the District’s SCADA system that shows the Electric-Gas Energy Cost Gauge for the Senga Doherty Pump Station.

b. ***Automated Real Time Pump Efficiency Tests***. Another SCADA system enhancement developed and implemented by District staff is the ability to conduct real-time pump efficiency tests. See description of this capability on p. A-23.

c. ***Energy Cost Analyses.*** The District also collaborated with one of its vendors on development of a tool that can analyzes electric and gas usage and costs by metered facility and site. The tool enables rolling up the analyses to functional and facility levels to enhance decisions about which energy resource should be used for which purpose, and when. See Figure 6 on page A-19 for a screenshot of this tool.

Because the District has unused capacity that can be utilized, and because District operations staff have a deep and robust knowledge of their distribution system that allows them to make operational changes with the confidence that they will not degrade their primary objectives of providing the required water volume to customers at the required water quality, the District can move a large portion of their electrical demand from pumping to SCE’s over-generation window (9am to 4pm daily) with minimal upstream or downstream impacts. The existing capacity of the District’s distribution system and the knowledge of the District Operations Staff give the District significant flexibility in this regard.

Figure 5. Rancho California Water District's SCADA Dashboard for the Senga Doherty Pump Station (SDPS)

This pump station has 7 x 500 hp pump motors. The District's SCADA Dashboard shows the current status of each pump ("In Service"/"Out of Service"), the applicable SCE tariff rate schedule, the current price of purchased electricity from SCE, the amount of power being supplied by the District's solar PV resources, and other key data needed by Operators to determine the most cost-effective energy resource option.

The District is an active participant in SCE's Pump Test Rehabilitation Incentive program and calls it one of its "critical tools.

Innovation: Automated Pump Tests

The District enhanced its SCADA system with the ability to conduct real-time electronic pump tests.

Although not yet fully automated, this beta technology uses the District's flow meters, suction pressure, discharge pressure, and recently installed CT equipment to capture the efficiency of a pump. To conduct a test, the SCADA Operator runs one pump at each pump station for 15 minutes and then shuts it off and starts another pump. After each pump has been tested individually, the center line efficiency can be tested. The District can now identify degradations in pump efficiency within days instead of months or years. If the data for a specific pump is over a month old it will become highlighted on the SCADA system so that operators are notified and can refresh the data.

Ace Bowen Pump Stations 2 & 4 – N.Gas Engines

Senga Doherty Pump Station

Both above photos are courtesy of Rancho California Water District.

The District uses biennial pump tests conducted by SCE to calibrate the results from its automated pump tests.

The District's automated pump tests is yet another "best-in-class" innovation.

Prologue - Energy Utility Billing

File Edit Help

View Fiscal Year | 2018 - 2019 | Add | Edit | Delete | Electricity | Gas | Accounting Codes | Tools | Refresh

Energy Rate	Month	Utility	Electricity (kWh)	Utility Charge Subtotal	Delivery Facility Demand	Delivery Facility Demand Charge	Generation Demand Charge	Utility Energy Charge	Taxes	Credits & Adjustments	Utility Deliver Charge	Energy Charge	Blended Charge/kWh	Total Delivery Component	Delivery Component % of Total Cost	Total Energy Component	Energy Component % of Total Cost	Total Utility Charge
TOU-8-B	Jun-19	Southern Cali...	174,232	$34,175.52	888	$16,497.21	$4,223.51	$9,279.56	$52.27		$4,175.24	$0.0533	$0.1964	$20,672.45	60.5 %	$13,503.07	39.5 %	$34,227.79
	Jun-19	SunPower	87,165	$6,842.46				$6,842.46		($9,279.56)		$0.0785	($0.0280)			$6,842.46	100.0 %	($2,437.10)
	May-19	SunPower	75,535	$5,929.49				$5,929.49		($4,155.37)		$0.0785	$0.0235			$5,929.49	100.0 %	$1,774.12
TOU-8-B	May-19	Southern Cali...	82,908	$14,924.93	468	$8,564.40		$4,155.37	$24.87		$2,205.16	$0.0501	$0.1803	$10,769.56	72.2 %	$4,155.37	27.8 %	$14,949.80
TOU-8-B	Apr-19	Southern Cali...	126,523	$22,436.90	706	$13,220.95		$6,019.38	$37.96		$3,196.57	$0.0476	$0.1776	$16,417.52	73.2 %	$6,019.38	26.8 %	$22,474.86
	Apr-19	SunPower	81,761	$6,418.20				$6,418.20		($6,019.38)		$0.0785	$0.0049			$6,418.20	100.0 %	$398.82
	Mar-19	SunPower	69,496	$5,455.40				$5,455.40		($2,591.23)		$0.0785	$0.0412			$5,455.40	100.0 %	$2,864.17
TOU-8-B	Mar-19	Southern Cali...	51,505	$13,296.84	471	$9,026.48		$2,591.23	$15.45		$1,679.13	$0.0503	$0.2585	$10,705.61	80.5 %	$2,591.23	19.5 %	$13,312.29
TOU-8-B	Feb-19	Southern Cali...	24,104	$11,036.46	468	$8,681.40		$1,098.90	$7.23		$1,256.16	$0.0456	$0.4582	$9,937.56	90.0 %	$1,098.90	10.0 %	$11,043.69
	Feb-19	SunPower	44,027	$3,456.10				$3,456.10		($1,098.90)		$0.0785	$0.0535			$3,456.10	100.0 %	$2,357.20
	Jan-19	SunPower	41,667	$3,270.84				$3,270.84		($2,068.20)		$0.0785	$0.0289			$3,270.84	100.0 %	$1,202.64
TOU-8-B	Jan-19	Southern Cali...	44,339	$12,459.38	468	$8,715.77		$2,068.20	$13.23		$1,675.41	$0.0466	$0.2813	$10,391.18	83.4 %	$2,068.20	16.6 %	$12,472.61
TOU-8-B	Dec-18	Southern Cali...	85,037	$15,912.80	492	$9,357.84		$4,025.78	$24.66		$2,529.18	$0.0473	$0.1874	$11,887.02	74.7 %	$4,025.78	25.3 %	$15,937.46
	Dec-18	SunPower	39,673	$3,114.34				$3,114.34		($4,025.78)		$0.0785	($0.0230)			$3,114.34	100.0 %	($911.44)
TOU-8-B	Nov-18	Southern Cali...	170,116	$21,098.76	472	$8,977.44		$7,828.04	$49.33		$4,293.28	$0.0460	$0.1243	$13,270.72	62.9 %	$7,828.04	37.1 %	$21,148.09
	Nov-18	SunPower	46,894	$3,681.20				$3,681.20		($7,828.04)		$0.0785	($0.0884)			$3,681.20	100.0 %	($4,146.84)
	Oct-18	SunPower	61,419	$4,821.41				$4,821.41		($5,865.33)		$0.0785	($0.0170)			$4,821.41	100.0 %	($1,043.92)
TOU-8-B	Oct-18	Southern Cali...	137,137	$22,707.08	676	$12,857.52	$376.80	$5,865.23	$39.77		$3,607.53	$0.0428	$0.1659	$16,465.05	72.5 %	$6,242.03	27.5 %	$22,746.85
TOU-8-B	Sep-18	Southern Cali...	220,951	$32,808.57	910	$17,308.20	$2,924.92	$7,217.70	$64.08		$5,357.75	$0.0327	$0.1488	$22,665.95	69.1 %	$10,142.62	30.9 %	$32,872.65
	Sep-18	SunPower	80,739	$6,337.99				$6,337.99		($7,217.79)		$0.0785	($0.0109)			$6,337.99	100.0 %	($879.80)
	Aug-18	SunPower	87,460	$6,865.63				$6,865.63		($11,020.75)		$0.0785	($0.0475)			$6,865.63	100.0 %	($4,155.12)
TOU-8-B	Aug-18	Southern Cali...	254,791	$37,299.57	866	$16,471.32	$3,672.24	$11,020.75	$73.89		$6,135.26	$0.0433	$0.1467	$22,606.58	60.6 %	$14,692.99	39.4 %	$37,373.46
	Jul-18	SunPower	94,135	$7,389.61				$7,389.61		($11,631.46)		$0.0785	($0.0451)			$7,389.61	100.0 %	($4,241.85)
TOU-8-B	Jul-18	Southern Cali...	269,427	$37,298.95	828	$15,748.56	$3,484.59	$11,631.46	$78.13		$6,434.34	$0.0432	$0.1387	$22,182.90	59.5 %	$15,116.05	40.5 %	$37,377.08
Totals:			2,451,041	$339,038.43	7,713	$145,427.09	$14,682.06	$136,384.27	$480.87	($72,801.79)	$42,545.01	$0.0621	$0.0982	$187,972.10		$151,066.33		$266,717.51

Figure 6. Rancho California Water District's Bill Analysis Tool (partial view)

This tool analyzes the District's electric and gas usage at each metered facility and site. The tool maintains and calculates energy cost information based on budgeted quantities vs. actual production quantities. Accounting can be tracked on an individual well, booster station basis or expanded to zone production or total system production costs. The tool allows for the calculation of cost/acre foot of water produced/pumped and enables users to visualize utility bills at the granular level thus allowing for the comparison of costs between different sources of energy.

Recommendations for a Water Sector Electric Reliability Program

District Operations staff and management stated that the District has substantial potential to provide electric reliability support. The key to providing that support depends, of course, on:

- Whether the District can assure continued ability to meet its mission-critical goals and objective, and
- Whether the revenues, incentives, and other potential benefits for providing electric reliability support are sufficient to justify the incremental costs and risks that the District may be assuming.

Table 5 on the next page summarizes the District's recommendations for a Water Sector Electric Reliability Program in which the District will likely be able to participate.

In addition, the District shared its vision for next steps:

- A single fully-integrated tool that can directly import real-time data to help analyze electric bills, electric and gas usage and costs, and water grid operations. The District feels that it is close to achieving this vision but needs some additional support and collaboration with SCE.
- The District continually seeks industry best practices and encourages SCE to include management training in its portfolio of classes at its Energy Education Centers.

Understanding the limiting factors are for participation in over-generation mitigation and other types of electric reliability programs is essential to gaining support and participation from water and wastewater utilities.

Table 5. District Recommendations for a Water Sector Electric Reliability Program

Challenge	Opportunity Description	Barrier	Recommendation
Existing Demand Response (DR) Programs rules.	The District identified 80 sites totaling 17 MW that are capable of providing Flexible Electric Resources. The District enrolled only 19 of these meters (total 1 MW) in SCE's Demand Response (DR) Programs.	The need to bid individual meters into SCE's DR programs discourages including meters that are able to provide support at some times but not at others.	Allow water and wastewater utilities to enroll in DR and other electric reliability programs on an entity basis that allows the District to determine which, if any of their facilities can provide the requested DR support at any particular time.
Some customer electric programs are not in sync with the goals and objectives of over-generation mitigation.	Solar PV output from eligible RES-BCT projects have been "grandfathered" under the old TOU rates, enabling these customers to continue to earn the highest value for their solar PV output during Noon to 6pm. This is fine; the problem is that designated "benefiting" meters must also honor the old TOU time periods, causing RCWD and other customers to avoid using electricity during Noon to 4pm (periods of over-generation).	Requiring RES-BCT benefiting meters to continue using Noon to 6pm as the highest electric rate period is in direct opposition with over-generation mitigation that anticipates surplus electricity daily from 9am to 4pm.	The District has 35 electric meters that benefit from its 5 MW RES-BCT Solar PV Facility that presently have no incentive (and in fact, have an economic disincentive) to shift electric use to over-generation periods (9am to 4pm). The District would be willing to participate in a modified schedule that continues to provide the economic benefits of RES-BCT that were in place at the time the project was implemented, but that also eliminates any rate penalties that may accrue by shifting electric use on their largest pumping loads to periods of over-generation.
Some electric program functions inhibit customers' ability to effectively manage their Flexible Electric Resources	Synchronizing water and wastewater SCADA systems with real-time electric use data from SCE's AMI meters would improve real-time water sector decision-making and their ability to provide Flexible Electric Resources.	The District is unable to consider real-time electric use when making operational decisions.	Expand SCE's Rate Analysis and other tools to include real-time electric use data.

In Summary

Water is Rancho California Water District's top priority. The District has an obligation to manage the resources and systems to which it has been entrusted in a manner that assures quality, safe, reliable, and affordable water for its ratepayers.

A combination of factors presented the District with unique opportunities to substantially reduce energy costs. In addition to developing and implementing market-leading systems to improve both long-term and real-time operational decisions, the District transitioned its organizational culture away from the traditional risk-averse utility mindset to one that values continuous improvement and innovation.

Support from both the District's Board of Directors and management team were essential to the successful transition. Buy-in from operations staff was equally important, as was providing tools and training to all levels of staff and management. The value these changes have brought to the District and its customers is undisputed as the District continues in its commitment to build long-term resilience for both its water and energy resources.

Staying ahead of the curve requires being continually alert, aware, and proactive in order to reduce costs and risks and successfully adapt its infrastructure, systems, and operations to continually evolving water and energy policies, markets, rules, and regulations. Throughout its 13 year water-energy awareness journey, the District has valued its partnership with SCE and is committed to expanding these efforts to demonstrate a "win-win" water-energy partnership model that can be deployed throughout California.

Appendix B - Flexible Electric Resources: Inland Empire Utilities Agency

During the 2000/01 California power crisis, Inland Empire Utilities Agency (IEUA) found itself in urgent need of building energy independence. IEUA thus embarked upon an ambitious multi-pronged program that included energy efficient design and operations, and development of on-site electric generation facilities.

The Agency's initial goal was to self-supply 100% of its electric requirements by 2020. However, regulatory program challenges caused IEUA to revise its goal to achieving grid independence during periods when electric costs are highest.

This case study describes IEUA's path to excellence in innovative energy management and opportunities to develop and provide Flexible Electric Resources for over-generation mitigation and other types of electric reliability support. The case study also captures the Agency's recommendations about changes needed to conventional energy customer programs to harness the considerable electric balancing resources that are inherent in California's water and wastewater systems.

Electric Batteries *(photo courtesy of Inland Empire Utilities Agency).*

Rooftop solar PV array. *(photo courtesy of Inland Empire Utilities Agency).*

This case study was reviewed and approved by Inland Empire Utilities Agency.

Contents

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Acronyms and Abbreviations

AF	Acre-Feet
AFY	Acre-Feet per Year
AMS	Advanced Microgrid Solutions
AWT	Advanced Water Treatment
BES	Battery Energy Storage
CBWCD	Chino Basin Water Conservation District
CBWM	Chino Basin Watermaster
CCWRF	Carbon Canyon Water Recycling Facility
CDA	Chino Desalter Authority
CIP	Capital Improvement Program/Plan
CPUC	California Public Utilities Commission
CWEA	California Water Environment Association
CY	Calendar Year
DG	Distributed Generation
DR	Demand Response
FY	Fiscal Year
GPM	Gallons Per Minute
GWR	Groundwater Recharge
HGL	Hydraulic Grade Line
IERCA	Inland Empire Regional Composting Authority
IERCF	Inland Empire Regional Composting Facility
IEUA	Inland Empire Utilities Agency
IOU	Investor Owned Utility
JPA	Joint Powers Authority
kW	kiloWatt
kWh	kiloWatt hour

Acronyms and Abbreviations (cont'd.)

LACSD	Sanitation Districts of Los Angeles County (aka Los Angeles County Sanitation District)
MBR	Membrane Bioreactor
MGD	Million Gallons per Day
MW	Megawatt
MWh	Megawatt hour
MWD	Metropolitan Water District of Southern California
NCP	Non-Coincident Peak
NEM	Net Energy Metering
NRW	Non-Reclaimable Wastewater
OCSD	Orange County Sanitation District
PRV	Pressure Reducing Valve
PS	Pump Station
PV	Photovoltaic
RP	Regional Plant
RP-1	Regional Plant No.1 in the City of Ontario
RP-2	Regional Plant No.2 in the City of Chino
RP-4	Regional Plant No.4 in the City of Rancho Cucamonga
RP-5	Regional Plant No.5 in the City of Chino
RP-5 SHF	RP-5 Solids Handling Facility
RWRP	Regional Water Recycling Plant
SARWQB	Santa Ana Regional Water Quality Board
SBCFCD	San Bernardino County Flood Control District
SCADA	Supervisory Controls and Data Acquisition
SCE	Southern California Edison
SWP	State Water Project
TOU	Time-of-Use
VFD	Variable Frequency Drive

Agency Overview

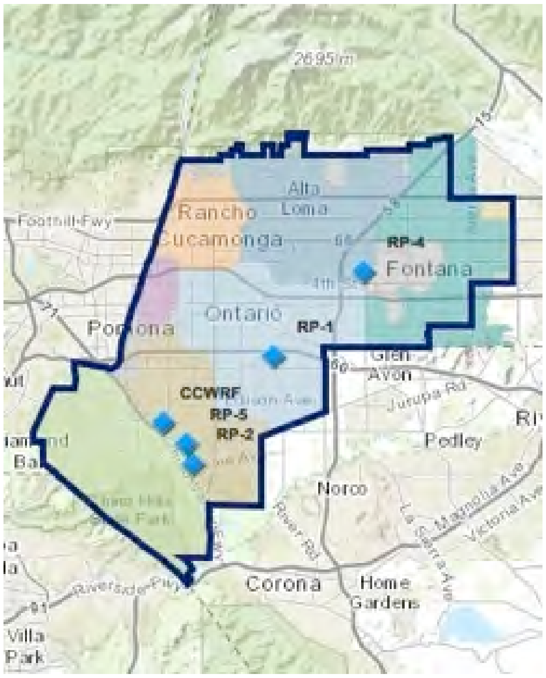

Figure 1. Inland Empire Utilities Agency service area

Originally established for the purpose of supplying supplemental imported water to municipalities in the Chino Groundwater Basin, Inland Empire Utilities Agency (IEUA) now provides three key services[1] to 875,000 people in western San Bernardino County:

1. ***Water*** - Treating wastewater, developing recycled water and other local water resources, and administering water conservation and efficiency programs that reduce the region's dependence on imported water supplies to increase regional water supply resilience.
2. ***Biosolids Management*** - Converting biosolids and waste products into high quality compost.
3. ***Energy Production*** – Producing clean and renewable energy resources that reduce the region's carbon footprint.

To meet its service obligations, IEUA operates the following key programs:

- Wastewater Treatment and Water Recycling
- Recycled Water Distribution
- Biosolids Management
- Groundwater Recharge
- Salinity Management
- Renewable Energy Development

The Agency is particularly distinguished in its collaborative approach to partnering with other organizations throughout the region to achieve shared goals and objectives. A partial list of its key partners is provided in Table 1 on the next page.

[1] "Fiscal Year 2018/19 Ten-Year Capital Improvement Plan." *Inland Empire Utilities Agency*. Page 7.

Table 1. Partial List of Inland Empire Utilities Agency's Key Partners

Priority	Partners	Activities
Composting	▪ Sanitation Districts of Los Angeles County (LACSD)	▪ Inland Empire Regional Composting Facility[2]
Energy	▪ Development of Clean/ Renewable Energy Projects	▪ Numerous 3rd Party Developers[3]
	▪ Advanced Microgrid Solutions (AMS)	▪ Battery Energy Storage[4]
Groundwater	▪ China Basin Watermaster (CBWM) ▪ Chino Basin Water Conservation District (CBWCD) ▪ Chino Desalter Authority (CDA) ▪ San Bernardino County Flood Control District (SBCFCD)	▪ Operate a network of groundwater recharge facilities[5] ▪ Operate the Chino Desalter I Facility
Recycled Water	▪ Chino Basin Leaders (14 cities and agencies within the Chino Basin)	▪ Chino Basin Program, including construction of an advanced water treatment (AWT) facility and distribution system to store up to 15,000 AFY of recycled water[6]
Water Use Efficiency	▪ Santa Ana Watershed Project Authority (SAWPA) ▪ Metropolitan Water District of Southern California (MWD) ▪ Santa Ana Regional Water Quality Board (SARWQB)	▪ Regional and Local Water Use Efficiency Programs[7,8]

[2] "Inland Empire Regional Composting Facility. *Inland Empire Utilities Agency* website: https://www.ieua.org/facilities/inland-empire-regional-composting-facility/.

[3] "2015 Energy Management Plan." *Inland Empire Utilities Agency*. Pages 5-7.

[4] "Inland Empire Utilities Agency and Advanced Microgrid Solutions Launch First-of-its-Kind Energy Storage Project." *Inland Empire Utilities Agency* Press Release. October 20, 2016.

[5] "Fiscal Year 2018/19 Ten-Year Capital Improvement Plan." Inland Empire Utilities Agency. Page 10.

[6] "IEUA in Partnership with Chino Basin Leaders Adopt Memorandum of Understanding to Move Chino Basin Program Forward." *Inland Empire Utilities Agency* Press Release. May 16, 2019.

[7] "Inland Empire Utilities Agency Regional Water Use Efficiency Business Plan 2015-2020." *Inland Empire Utilities Agency*.

[8] "Water Use Efficiency Programs." *Inland Empire Utilities Agency* website: https://www.ieua.org/use-water-wisely/water-use-efficiency-programs/.

Facilities Overview

Although IEUA distributes purchased imported water for its members, water facilities account for a small portion of its infrastructure. Below is a summary of the primary types of facilities that the Agency manages to achieve its mission.

Wastewater Treatment, Water Recycling, and Biosolids Handling Facilities

Four Regional Water Recycling Plants (RWRPs) produce Title 22 recycled water for indirect reuse and groundwater recharge. All have primary, secondary, and tertiary treatment and recycled water pumping facilities that are interconnected in a regional network. Sewage bypass and diversion facilities enable Agency operators to optimize flows and capacity utilization. In general, flows are routed between RWRPs to maximize recycled water deliveries while minimizing overall pumping and treatment costs.[9]

Table 2. Regional Water Recycling Plants[10]

<table>
<tr><th rowspan="2">Regional WRPs</th><th colspan="2">Functions</th><th rowspan="2">System Connections</th></tr>
<tr><th>Water Recycling</th><th>Biosolids Handling[11]</th></tr>
<tr><td>Regional Water Recycling Plant No. 1 (RP-1)</td><td>◆</td><td>◆</td><td rowspan="4">▪ <u>Flows</u>:
o RP-4 to RP-1 [up to 6MGD via Etiwanda Interceptor]
o CCWRF to RP-5 [Typically 1-2 MGD via Chino Interceptor]
o Cities of Upland & Montclair can be diverted to CCWRF [via Westside Interceptor] or to RP-1 [via Montclair Lift Station and Montclair Interceptor][12]
▪ Primary Effluent and sludge can be diverted from RP-1 equalization basins into the Eastern Trunk Sewer where it flows by gravity to RP-5</td></tr>
<tr><td>Regional Water Recycling Plant No. 4 (RP-4)</td><td>◆</td><td>RP-1</td></tr>
<tr><td>Regional Water Recycling Plant No. 5 (RP-5)</td><td>◆</td><td rowspan="2">RP-2</td></tr>
<tr><td>Carbon Canyon Wastewater Recycling Facility (CCWRF)</td><td>◆</td></tr>
</table>

The network configuration of the Agency's facilities provides substantial flexibility for effectively mitigating adverse impacts of equipment outages and other types of emergencies. This unusual level of infrastructure flexibility also enables the Agency to balance loads among its regional plants to reduce energy and other operating costs.

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[9] "Fiscal Year 2018/19 Ten-Year Capital Improvement Plan." *Inland Empire Utilities Agency*. Page 10.

[10] Id. Page 11.

[11] Once biosolids are thickened, digested, and dewatered, they are transported to the Inland Empire Regional Composting Facility for processing into soil amendment. [Source: "2015 Energy Management Plan." *Inland Empire Utilities Agency*. Page 4.]

[12] "The RP-1 to RP-5 Bypass is typically not used under normal operation in order to keep water north for GWR. In special circumstances (shutdowns, projects, upsets) the bypass is used and at these times average flows would be 1-2 MGD." "Fiscal Year 2018/19 Ten-Year Capital Improvement Plan." *Inland Empire Utilities Agency*. Page 11.

Wastewater Collection System

Wastewater within the Agency's service area is collected by two systems:

- The Non-Reclaimable Wastewater (NRW) System, and
- The Regional Trunk Sewer System.

The NRW System collects industrial and high-salinity wastewater for conveyance to the Sanitation Districts of Los Angeles County (LACSD) or the Orange County Sanitation District (OCSD) for treatment and eventual discharge to the Pacific Ocean.[13]

The Regional Trunk Sewer System collects municipal domestic wastewater and conveys it to the Agency's Regional Water Recycling Plants (RWRPs) for treatment and water recycling.[14]

Recycled Water Distribution System

Recycled water is distributed from each facility to six different recycled water pressure zones. Recycled water in excess of the recycled water demand is dechlorinated and discharged to streams that are tributary to the Santa Ana River.

The wastewater collected in the regional sewer system described above is treated at the four RWRPs to produce recycled water. Effluent that is not beneficially reused from the RWRPs is discharged to nearby creeks that feed into the Santa Ana River where it is used to recharge into the Chino Groundwater Basin.

The recycled water distribution system has six pressure zones: the 800 Pressure Zone, the 930 Pressure Zone, the 1050 Pressure Zone, the 1158 Pressure Zone, the 1299 Pressure Zone, and the 1630 Pressure Zone. The number in each of the pressure zone names indicates the approximate hydraulic grade line (HGL) that is served by each pressure zone. The HGL required for service generally increases as one moves south to north in the Agency's service area. Basic pressure zone operation is as follows:

- The 800 Pressure Zone is supplied by recycled water produced at RP-5. The 800 Pressure Zone Pump Station (PS) has a capacity of 9,625 gallons per minute (gpm). There is no storage in the 800 Pressure Zone.
- The 930 Pressure Zone is supplied by recycled water produced at RP-1 and CCWRF. The 930 Pressure Zone PS at RP-1 has a capacity of 27,000 gpm with use of a variable frequency drive (VFD) to enable more precision over pumping volumes. The 930 Pressure Zone PS at CCWRF has a capacity of 12,925 gpm. There is a storage reservoir in the 930 Pressure Zone at the western edge of the zone.

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[13] "Non-Reclaimable Wastewater System." *Inland Empire Utilities Agency* website: https://www.ieua.org/water-sources/pretreatment-source-control/non-reclaimable-waste-system/.

[14] "IEUA Wastewater Faciliities Master Plan DRAFT TM3 Regional Trunk Sewer Analysis." Prepared by *Carollo Engineers, Inc. for Inland Empire Utilities Agency*. August 18, 2014.

- The 1050 Pressure Zone is supplied by recycled water produced at RP-1. The 1050 Pressure Zone PS has a capacity of 11,250 gpm using pumps equipped with VFDs. There is no storage in the 1050 Pressure Zone.
- The 1158 Pressure Zone is supplied by recycled water produced at RP-1 and RP-4. The 1158 Pressure Zone PS at RP-1 has a capacity of 11,020 gpm. The 1158 Pressure Zone PS at RP-4 has a capacity of 22,500 gpm. There is storage in the 1158 Pressure Zone in a reservoir near RP-4.
- The 1299 Pressure Zone is served from a pump station that pumps out of the 1158 Pressure Zone. The 1299 Pressure Zone has storage at the eastern edge of the zone.
- The 1630 Pressure Zone is served by two pump stations that pump out of the 1299 Pressure Zone. There is storage in a reservoir at the western edge of this zone.

There are pressure reducing valves (PRVs) throughout the distribution system that allow recycled water to move from a higher pressure zone to a lower pressure zone as demands require. However, except where described above, there are no booster pump stations to move recycled water from a lower pressure zone to a higher one. Therefore, recycled water produced at RP-5 can only serve the 800 Pressure Zone, and recycled water produced at CCRWF can only serve the 930 Pressure Zone or 800 Pressure Zone (through PRV). Recycled water for higher pressure zones is produced at RP-1 or RP-4.

Because there is limited flexibility in the recycled water distribution system for moving water from south to north, the Agency uses the flexibility in the wastewater conveyance system to move recycled water from where it is produced to where it is needed. Wastewater conveyance bypass and diversion facilities are used to optimize flow and capacity within the system. Facilities used for this activity include the San Bernardino Avenue Lift Station, Montclair Lift Station and Diversion Structure, RP-4 and CCWRF influent bypass (CCWRF influent bypass), RP-1 primary effluent diversion, and Etiwanda Trunk Line.

Currently, wastewater flows are routed between RWRPs to maximize recycled water deliveries while minimizing overall pumping and treatment costs. Aside from the San Bernardino Avenue Lift Station and the Montclair Lift Station, the Agency also operates the Prado Park Lift Station and RP-2 Lift Station in the sewer collection system to shift flows from one portion of the service area to another and to pump from low points to high points.

IEUA’s recycled water distribution system is shown in Figure 2 on the next page.

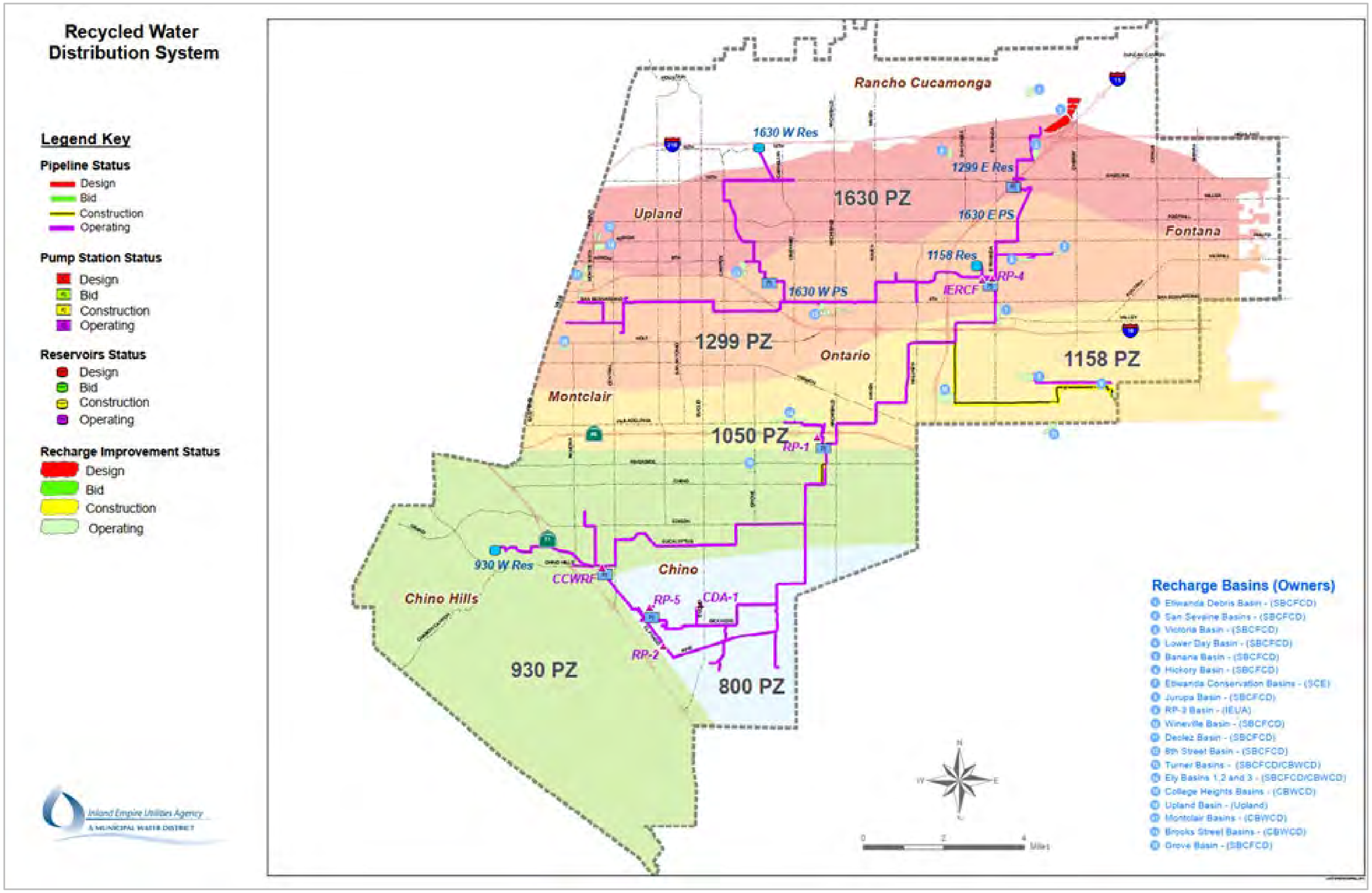

Figure 2. Inland Empire Utilities Agency's Recycled Water System[15]

[15] Retrieved from Inland Empire Utilities Agency's website: https://18x37n2ovtbb3434n48jhbs1-wpengine.netdnB-ssl.com/wp-content/uploads/2015/04/RWMap_Master-May-2015.pdf

Electric Requirements

Electric Use

The Agency's four water recycling facilities account for 96% of its electric energy requirements (kWh) and 88% of its electric demand (kW).

Table 3. 2018 Electric Use (kWh) and Electric Demand (kW) by Type of Water Facility[16]

Type of Facility	Nbr of SCE Electric Meters	Total Electric Energy (kWh)		Maximum Electric Demand (kW)		Annual Electric Load Factor[1]	
		Total Electricity (kWh)	% kWh by Type of Facility	∑ Non-Coincident kW (NCP)[17]	% kW by Type of Facility	Utilized[2]	Unutilized[3]
Lift Station (Wastewater)	5	1,225,156	1.70%	463	3.34%	30.21%	69.79%
Groundwater Recharge	26	767,559	1.06%	696	5.02%	12.59%	87.41%
Recycled Water Facility	10	69,188,107	95.93%	12,336	88.93%	64.03%	35.97%
Pump Station	1	894,074	1.24%	354	2.55%	28.83%	71.17%
Reservoir	3	41,469	0.06%	21	0.15%	22.54%	77.46%
All Other Uses	8	6,957	0.01%	1	0.01%	79.42%	20.58%
Grand Total	**53**	**72,123,322**	**100.00%**	**13,871**	**100%**	**59.36%**	**41.64%**

Notes:

[1] "Annual Load Factor" is the percentage of electric demand actually used (maximum annual kW) calculated as [Total Electricity (kWh) ÷ (Maximum Electric Demand (kW) x 8,760 hours/year)].

[2] "Utilized" is the amount of electric energy that was actually used during CY2018 as a percentage of the Maximum Electric Demand (Non-Coincident basis) by type of facility.

[3] "Unutilized" is the amount of additional electric energy that could have been used during 2018 under the maximum kW (i.e., additional kWh that could have been used without incurring additional demand charges).

As is typical of most wastewater systems, the annual electric load factor for wastewater treatment and recycled water production tends to be high relative to pump and lift stations. For IEUA, the 2018 average annual load factor of its Recycled Water Facilities was 64%, more than twice the average annual load factor of its lift stations (30%) and pump stations (29%) [*column named "Utilized"*]

[16] Compiled from SCE electric meter data provided by Inland Empire Utilities Agency.

[17] NCP = "Non-Coincident Peak", the sum of maximum annual demand (kW) of all electric meters by type of facility.

Electric Resources

"Grid independence during peak periods" – the ability to conduct mission critical operations reliably without need to purchase electricity when prices are at their highest – has been a priority for IEUA since the 2000/01 California power crisis. One of the strategies the Agency deployed to mitigate peak power costs was to balance wastewater flows among its water recycling plants to avoid treatment during high electric cost on-peak periods. Another was to seek innovative opportunities for continually increasing the efficiency and energy efficiency of its systems, facilities, and operations.[18] Commencing 2008, solar PV and other low carbon and renewable electric generation resources were added to IEUA's energy resilience portfolio. Battery energy storage was added in 2016.

Gridless by 2020

IEUA formally adopted its "Gridless by 2020" initiative in 2012. The initial goal was to self-supply 100% of the Agency's electric requirements by 2020. Existing State regulatory policies, however, assess penalties such as stand-by and departing load charges to customers that self-provide their electricity. "Since one of the pillars of the 'Gridless by 2020' initiative was to hedge against market volatility, IEUA adjusted its focus on achieving relative independence from the grid during peak periods, when electricity costs are highest."[19]

> "In order to achieve grid independence with renewable technologies, IEUA must build an energy infrastructure that is capable of handling the full demand of each facility at any given time."
>
> Source: Inland Empire Utilities Agency's 2015 Energy Management Plan

FY2018/19 Electric Costs

The cost of electricity is the Agency's highest non-labor operations and maintenance expenditure: during FY 2018/19, the annual cost for electricity was $8.3 million. For purposes of rate stabilization and cost effectiveness, IEUA purchases some of its on-site energy generation under long-term Power Purchase Agreements, and some wholesale electricity via Direct Access. The balance of the Agency's electric requirements is purchased from SCE.[20]

Peak Independence Status

IEUA's self-generation capacity is currently 9 MW (5 MW solar, 1 MW wind, and 3 MW biogas engines). If fully operational, on-site generation would have provided 86% of the electricity needed to meet Agency-wide electric demand during summer peak hours. However the biogas engines are presently off-line; consequently only 33% of summer peak demand was met with self-generation during 2019. Once the biogas engines are restored to service, IEUA will be able

[18] "Flex Your Power Energy Conservation and Efficiency Campaign 2001-2002, Final Report." Prepared by *Flex Your Power for the California Public Utilities Commission (CPUC)*. 2002.

[19] "2015 Energy Management Plan*.*" *Inland Empire Utilities Agency*. Pages 1-2.

[20] "IEUA FY 2018-2019 Annual Energy Report." Inland Empire Utilities Agency. Page 3.

to coordinate operations of its self-generation facilities with 4 MW of installed Battery Energy Storage (BES) to avoid relying upon grid power during summer peak periods altogether.[21]

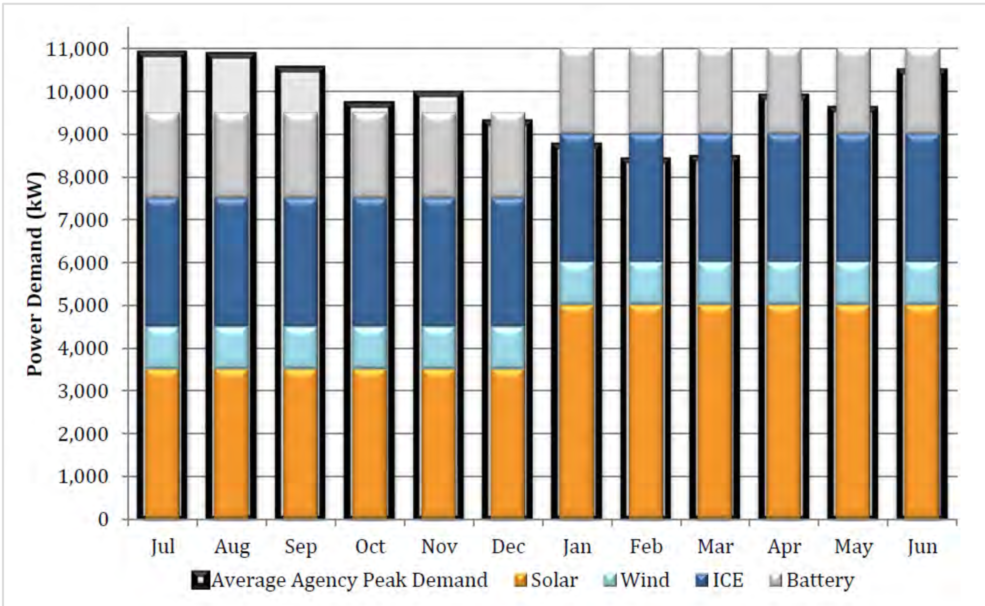

Figure 3. Connected Renewable Self-Generation Capacity vs. Agency-wide Power Demand (kW)[22]

Figure 4. IEUA's Renewable Energy Portfolio[23]

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[21] "IEUA FY 2018-2019 Annual Energy Report." *Inland Empire Utilities Agency*.

[22] Id. Figure 4.

[23] Id. Figure 3.

Flexible Electric Resources

Wastewater treatment and recycling plants are in many respects inherently inflexible because they are usually designed for 24/7 operations and are not turned on and off at will because restoring service requires carefully sequencing of systems.

From an energy perspective, water, wastewater, and recycled water plants tend to have a fairly constant diurnal electric load profile and a relatively high average load factor (often in the 70-90% range, reflecting their nearly steady 24/7 operations). Integrating flexibility into a 24/7 electric load with a high average load factor usually requires additional infrastructure and/or technologies.

Flexible Electric Resource Strategies for Existing Facilities

Typical Flexible Electric Resource strategies applicable to water systems primarily relate to having surplus capacity in pumps, pipelines, and water storage. The combination of these three types of facilities can enable water utilities to increase pumping to the maximum installed capacity during some hours of the day, provided that there are no constraints in connected facilities – whether upstream, downstream, and/or laterally to the pump site - that might limit pumping to less than the installed capacity. Potential constraints include:

- Pipeline capacity is not sufficient to deliver water at the increased rate of pumping.
- Demand for water being pumped at that location is not sufficient to accept delivery of higher volumes of water during the periods targeted for increased pumping;
- Diurnal and/or seasonal storage capacity is not sufficient to capture and store the water being pumped at a higher rate.
- The water utility does not have legal or regulatory rights to pump the volume of water at the targeted rate.
- Pumping at higher rates during the targeted hours could impair water quality to levels requiring additional treatment, and the additional treatment is not deemed acceptable (existing treatment methods cannot restore the impaired water resource to required levels, whether due to regulations or policy; and/or the type(s) of additional treatment required are too expensive.

Flexible Electric Resource strategies for treatment plants that operate 24/7 at high average load factors are very different:

- ***Pumping*** within a treatment plant is typically driven by factors related to the treatment technology(s). Storage between the various treatment functions may enable changing rates of pumping in some parts of the plant; however
- ***Storage*** of untreated wastewater is challenging because the biological solids in wastewater decay and produce odors and noxious chemicals. Further, the wastewater treatment process generally has biological components that require relative stability in the process rate. For these reasons, it is difficult to start and stop wastewater treatment processes a few minutes or hours at a time.

Solids handling at the end of the wastewater treatment process is one function that could be started and stopped relatively easily. In fact, Agency staff have requested sizing equipment for an upcoming expansion of RP-5 in a manner that allows dewatering to be completed within a 8-hour window.[24] While the 8-hour window was intended for purposes of scheduling operations staff, dewatering could be scheduled to coincide with the over-generation time period (9am-4pm).

Battery Energy Storage (BES)

Agency staff noted that Battery Energy Storage (BES) is the obvious strategy for increasing flexibility in electric time-of-use by 24/7 facilities such as wastewater treatment and water recycling plants. In fact, IEUA currently has 4 MW of BES that were installed under a partnership with a third party provider that is participating in an SCE Local Capacity Requirements (LCR) Energy Storage Program.[25]

This case study is focused on identifying means for water and wastewater utilities to provide the equivalent of battery energy storage, or superior capabilities, by harnessing surplus capacity within water and wastewater systems. BES is therefore not a specific focus of this Pilot Project.

BES is, however, a technically viable means to provide Flexible Electric Resources in any facility with a high average load factor, including water and wastewater treatment, and water recycling plants. IEUA and other water and wastewater utilities that participated in this Pilot Project therefore emphasized that BES should be considered an integral part of any water sector Flexible Electric Resources portfolio. All also stated that when BES becomes more affordable, they plan to include more of it in their own energy resource portfolios.

IEUA Flexible Electric Resource Opportunities

IEUA identified the following facilities as capable of providing Flexible Electric Resources.

Table 4. Agency Sites That Can Be Operated for Flexible Electric Resources

Facility	2018 kWh	2018 kW	Load Factor %
RP-1	26,335,468	4,144	56.91%
RP-2	2,107,202	360	72.55%
RP-4	18,342,480	3,824	66.82%
RP-5	13,036,672	2,112	54.76%
CCWRF	9,252,852	1,856	70.46%
TOTALS	69,074,674	12,296	64.13%

[24] Interview with Agency operations staff (July 15, 2019).

[25] The Agency's 4 MW Battery Energy Storage (BES) system was developed under a contract with a third party, Advanced Microgrid Systems (AMS). (BES at RP5 was installed in 2016; BES at RP1, RP4, and CCWRF were installed in 2018.) Under the agreement, AMS controls when the batteries cycle on or off. The Agency can request a change but there needs to be a monetary benefit for AMS in order for them to agree. For these types of 3rd Party projects (which many water and wastewater utilities have entered into as a means for accessing new/emerging technologies with minimal costs and risks), over-generation mitigation programs will need to allow the 3rd Parties to be able to access the incentives.

Looking Forward

Like many medium to large sized water and wastewater utilities in California, IEUA has an ongoing multi-year capital improvement planning process. The Agency's proposed Ten Year Capital Improvement Plan (CIP) for FY2020 through FY2029 is $921 million.

Table 5. Proposed 10 Year Capital Improvement Program (FY2020-FY2029)[26]

Fund ($Millions)	Proposed Budget
Wastewater	$620.9 M
Recycled Water	$204.4 M
Non-Reclaimable Wastewater	$ 30.5 M
Water Resources	$ 24.7 M
Recharge Water	$ 26.5 M
Administrative Services	$ 13.6 M
Total Proposed 10 Year Budget	**$920.6 M**

These investments provide opportunities for integrating consideration of Flexible Electric Resources into new and expanded or retrofit facilities. Following are some examples of CIP opportunities that were identified by Agency staff.

RP-5 Expansion

The FY2020-2029 Ten Year CIP includes $330 million for the RP-5 expansion project that is scheduled to begin construction during FY2021.[27]

> *"Due to the United State Army Corps of Engineers (USACE) decision to raise the elevation of the Prado Dam, all facilities at RP-2 need to be abandoned and moved to RP-5. The liquid treatment capacity was relocated in March 2004; the solids facilities will be relocated during the 20-year planning period."*[28] *"The RP-5 upgrade and expansion will increase liquid treatment to 30 million gallons per day (mgd) using membrane bioreactor (MBR) and ultraviolet (UV) disinfection processes and will expand the biosolids management system to 40 mgd, including thickening, anaerobic digestion and dewatering, and potential food waste treatment. It also includes cogeneration upgrades (as part of the Renewable Energy Recovery Project) as well as ancillary support facilities that involve the replacement, relocation, and construction of new offsite facilities such as sewage lift stations, force mains, brine lines, and recycled water conveyance pipelines."*[29]

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[26] "Executive Summary" recommending adoption of the Agency's Biennial Operating Budget [FY2020-2021] and Ten Year Capital Improvement Plan [FY2020-2029]. *Inland Empire Utilities Agency*. July 1, 2019.

[27] Id. Pages 1-11.

[28] "Draft Technical Memorandum: IEUA Wastewater Facilities Master Plan, TM7 RP-5 and RP-2 Complex Future Plans." Prepared by *Carollo Engineers, Inc. for Inland Empire Utilities Agency*. November 6, 2014. Page 2.

[29] Mackie, Alec. "IEUA Awards Water Recycling Plant Upgrade Planning to Parsons." *California Water Environmenta Association (CWEA)* E-Bulletin Highlights. June 29, 2017.

Agency staff identified the following types of potential opportunities for integrating Flexible Electric Resources into the RP-5 Upgrade and Expansion:

- ***Pumps***. The addition of higher head pumps to the recycled water pump station at RP-5, in addition to some pipeline improvements to connect these pumps to higher pressure zones, could greatly improve the flexibility of the recycled water system and the ability to get recycled water to where it is needed in the system. Such pumps would also allow recycled water produced at RP-5 in the south to be conveyed to the north for groundwater recharge during the winter and spring when water demands are low and the majority of the recycled water produced in the south is discharged to streams. Such pumping could be focused into both daily and seasonal over-generation periods.
- ***Sludge Dewatering***. As previously noted, Agency staff have been exploring up-sizing dewatering equipment for the RP-5 expansion so that the dewatering process can heretofore be completed within one 8-hour shift. The dewatering process could be scheduled to coincide with SCE's over-generation period (about 9am to 4pm).

Coordinated Recycled Water Deliveries with Customers

Another potential opportunity could be to coordinate some recycled water distribution with customers. Large recycled water users such as golf courses have their own storage ponds. Although they would be unlikely to agree to irrigate during the day when customers and members are on the green, they might be able to accept delivery of recycled water into on-site storage during over-generation periods and continue to irrigate during off-peak hours (late evening and early morning).

Additional Opportunities

Agency staff observed that brainstorming with complex water and wastewater utilities such as IEUA would likely result in identifying additional opportunities. Some thoughts included:

- ***Centrifuges*** are large power consumers. It may be possible to increase the number and installed capacity of centrifuges to operate them at higher levels for fewer hours.
- ***Liquid Storage and/or Digested Sludge Storage*** capacity could be increased.
    - <u>Primary Treated Water</u>. Raw influent is typically not stored due to concerns about odor and septicity. However, IEUA staff believe that under some conditions, there may be opportunities to store primary treated water for accelerated treatment during over-generation periods.
    - <u>Secondary and/or Tertiary Treated Water</u>. The primary treatment process in wastewater treatment removes the majority of the biological solids from the wastewater. The secondary and tertiary treatment processes that follow tend to be more energy intensive, depending on the technologies employed to produce the desired quality of recycled water. If primary treated water can be stored for at least several hours, the secondary and tertiary treatment processes could potentially be conducted during the over-generation window.

Note: It is currently difficult to "turn down" secondary and tertiary treatment equipment during non-overgeneration periods so that treatment could be accelerated during periods of over-generation. Technical assistance is needed to identify and evaluate strategies and technologies that could enable IEUA and other wastewater treatment utilities to provide over-generation mitigation support at various stages of the wastewater treatment process.

IEUA Water Recycling Plant *(photo courtesy of Inland Empire Utilities Agency)*

- o Recycled Water Storage. Like many wastewater utilities, IEUA discharges treated effluent to natural waterways during some times of the year, when there isn't enough water demand to use the recycled water being produced and there isn't enough storage to hold all of the surplus recycled water until it is needed (i.e., seasonal storage). Agency staff indicated that adding seasonal recycled water storage could enable producing and storing more recycled water. Extending the season for production of recycled water and pumping it into seasonal storage would also provide opportunities for increased electric use during spring months when over-generation is highest.

- ***Stormwater Retention Basins***. During dry periods, surplus recycled water is used to recharge stormwater basins; however, during wet weather, it is difficult to put recycled water into already wet ground. Injection wells could enable recycled water to be injected into stormwater basins even during wet weather. That would require additional infrastructure and capital costs; but from an electric reliability perspective, more flexible electric load would be created that could be used to provide electric reliability support during periods of both over-generation and under-generation.
- ***Groundwater Recharge***. IEUA is a co-sponsor[30] of the Chino Basin Recycled Water Groundwater Recharge Program that is an integral part of the Chino Basin Watermaster's "Optimum Basin Management Plan" that was implemented to enhance water supply reliability and improve drinking water quality throughout the greater Chino Basin.[31] As with stormwater basins, groundwater recharge creates more flexible load opportunities to provide electric reliability support.

[30] Along with the Chino Basin Watermaster (CBWM), the Chino Basin Water Conservation District (CBWCD), and the San Bernardino County Flood Control District (SBCFCD).

[31] "Groundwater." *Inland Empire Utilities Agency*'s website: https://www.ieua.org/water-sources/groundwater/.

Flexible Electric Resources Strategies and Innovation

An early adopter of new technologies since 1990 when it invested in its first internal combustion engines to produce electricity from biogas, IEUA followed this early innovation with solar, wind, fuel cells, battery energy storage - and most recently, electro-chemical batteries operated in conjunction with a solar PV system at the Inland Empire Regional Composting Facility (IERCF).

Inland Empire Utilities Agency's Technology Adoption Evolution

1990	Biogas-Fueled Internal Combustion Engine
2008	Solar PV
2009	Variable Frequency Drives (VFDs)
2011	Wind Turbine
2012	Biogas Fuel Cell
2015	Food Waste to Energy
2016	Battery Energy Storage (BES)
2018	Began Integration of Sub-metered Electric Loads into SCADA
2019	Solar PV in conjunction with BES

In addition to a diverse supply of renewable energy resources, Agency staff noted that there are multiple locations in its systems where surplus capacity could be leveraged to provide Flexible Electric Resources. Staff also stated that designing future expansions with a mix of equipment sizes would increase operational flexibility while concurrently increasing the Agency's ability to efficiently meet load growth over time.

> <u>For Example</u>: *It takes many years to design and construct new or expanded water and wastewater systems so the planning process starts early with the goal of building enough capacity to meet projected load growth for 20-30 or more years. While surplus capacity is a potential source of Flexible Electric Resources (i.e., enabling water and wastewater agencies to increase pumping and other types of electric use during over-generation periods), equipment is over-sized and less efficient in the near-term. It may be more economic to build a flexible system that can be staged for expansion when needed – e.g., install a combination of large and small pumps to optimize pumping at any particular time, and replace small pumps with larger pumps when needed to meet load growth. In the meantime, the mix of different sizes of equipment would provide maximum operational flexibility in the near-term while concurrently reducing the time and costs of future expansions.*

One of IEUA's most significant innovations is the enhancement of its SCADA system to enable Operators to make real-time operational changes that enhance both water and energy benefits while better managing operating costs. The level of integration of real-time energy data into its SCADA platform planned by the Agency is a water sector best practice that several market-leading water and wastewater utilities are independently developing.

Integrating Energy Data into SCADA[32]

Over the past 7 years, IEUA completed installation of over 180 submeters at its major facilities. Critical submeters of loads greater than 200 kW are being integrated into the Agency's SCADA system, along with historical data. The submeters connect to the SCADA system to monitor kW, kWh, amperes, and load factor. These data help the Agency understand operating patterns and efficiencies to help reduce energy demand charges and identify malfunctioning equipment.

Recycled Water Pipe *(photo courtesy of Water Energy Innovations)*

Of the Agency's four treatment plants, two have already been upgraded for SCADA (RP-5 and CCWRF); the other two (RP-1 and RP-4) are expected to be completed within 2-3 years. By then, there will be visibility across all four plants via a single dashboard.

Examples of the types of decisions Agency staff will be able to make include:

- Determine when to turn sequenced or multiple equipment on and off to avoid triggering increases in demand charges.
- Avoid accidentally turning on discretionary equipment during high on-peak time periods.
- When to rely upon self-generation resources, battery power (when the Agency has the ability to dispatch power from its own batteries), or power purchases from SCE and/or the grid.

The Agency anticipates that its enhanced SCADA system will also enable operators to determine whether and how to shift electric usage to over-generation time periods. Additionally, the enhanced SCADA dashboard will help the Agency's operators make informed real-time decisions about whether it will be both technically and operationally feasible, and economically beneficial to provide electric reliability support at any point in time and at any particular location.

[32] Discussions with Agency staff during a meeting on July 15, 2019 and Inland Empire Utilities Agency FY 2013/14 Biennial.

***SCADA System**. (photo courtesy of Inland Empire Utilities Agency).*

Energy Efficiency

Since the 2000/01 California power crisis, IEUA has continued proactively seeking opportunities to integrate energy efficient design and operations into all of its systems and facilities. Table 6 below lists some recently completed and currently active energy efficiency projects. All projects shown received incentives from SCE.

Table 6. Recently Completed and Active Energy Efficiency Projects[33]

RECENTLY COMPLETED PROJECTS			
Project	**Energy Savings (kWh/year)**	**Cost Savings ($/year)**	**SCE Incentives**
Pump Rehabilitation	1,490,414	$165,539	$144,985
Operational Optimization	41,005	$4,938	$475
Lighting Retrofit	1,158,635	$126,331	$104,677
Totals	**2,690,054**	**$296,809**	**$250,137**
ACTIVE PROJECTS			
Pump Rehabilitation/Replacement	1,179,027	$124,959	$111,596
Operational Optimization	1,213,537	$128,617	$117,859
Totals	**2,392,564**	**$253,576**	**$229,455**

[33] Source: *Inland Empire Utilities Agency*.

Recommendations for a Water Sector Electric Reliability Program

Anticipated Challenges

Structure of Existing Demand Response Programs

One of the biggest obstacles to water sector participation in existing Demand Response programs is the program design itself.

- Over the past several years, the amount of lead-time for the Agency to decide whether and how much DR to provide got shorter and shorter, reducing the Agency's ability to make the operational changes needed to shed load at the requested meter(s).
- Auto DR is not a viable option for most water and wastewater utilities that must assure that their mission-critical goals and objectives are being met before deciding to opt-in to DR or other discretionary revenue earning (or cost reducing) opportunities.

Importantly, for IEUA and other water and wastewater utilities that have significant self-generation resources, the best way to identify and increase potential Flexible Electric Resources is to unbundle electric loads from self-generation. In other words, the Agency's electric requirements presently represent on a net basis (total electric load less on-site generation) on SCE's distribution system. If departing load, standby charges, and other legacy customer energy program penalties are eliminated, customers with substantial self-generation resources would be better able to schedule their TOU electric requirements in a manner that provides the locational electric system impacts targeted by SCE. In this manner, self-generation assets could be separately optimized from electric use to also provide electric reliability support.

Note that of the Agency's 53 SCE electric meters, only four participate in Demand Response at the present time. Although these 4 meters account for 88% of the Agency's electric demand (the electric loads on these meters range from 1.5 MW to 4.0 MW; they have a combined capacity of 10 MW), IEUA indicated that the requirement to bid specific meters into DR programs limits their ability to provide support – often, when a single meter is unable to respond to a DR event, one or more other loads may have been able to step into that position.

Eliminating the barriers in existing DR programs may enable the Agency to bid additional electric meters into DR. Hydraulic modeling of the system may also enhance the Agency's ability to run DR scenarios so that they can develop some pre-set responses to future events.

Additional Hurdles

Below are additional challenges identified by Agency staff with respect to participating in a Flexible Water Sector Electric Reliability Program.

- **Incremental Capital Investments.** Flexible load opportunities such as groundwater recharge could increase water supplies by storing excess runoff and enabling increased recycled water production and storage, but incremental capital investments would be needed to fund new infrastructure.

- **Diverse Providers.** It is challenging to work with multiple providers for wind, solar, battery, and electricity. While these multiple providers have enabled the Agency and other water and wastewater utilities to adopt new/emerging technologies more quickly, without need to provide investment capital and with little or no operating risk, they do constrain the Agency's ability to change how and when specific electric generation units and batteries can be dispatched.

Recommended Elements of a Successful Water Sector Electric Reliability Program

IEUA attributes its success in adopting new technologies and ways of thinking to a supportive organizational culture that embraces change and values innovation. With that context, Table 7 below summarizes Agency staff recommendations for a successful Water Sector Electric Reliability Program.

Table 7. Agency Recommendations for a Water Sector Electric Reliability Program

Program Elements	Opportunities
Capital Costs	The biggest barrier for the Agency is the high capital cost of new and enhanced infrastructure and equipment. Any proposed capital improvement that may have an electric reliability benefit needs to compete for funding with mission-critical infrastructure. Incentives can help to offset a portion of the incremental capital costs that may be needed to increase the Agency's ability to provide Flexible Electric Resources.
Education	Continue to educate operations and maintenance staff on the connection between energy consumption and costs and plant operation. Energy is the Agency's largest expense next to labor so having clarity as to the cost of each plant's processes enables operators to understand the economic impacts of their decisions.
Trust	Trust and enhanced communication are essential to facilitating understanding and transparency between water utilities and SCE so that more "out-of-the-box" projects can be done.
Partnering	The Agency is very effective in partnering with other agencies and has been able to optimize both its water and energy resources based on those relationships.
Tools	Hydraulic modeling would help water and wastewater utilities optimize system efficiencies.
Data Transparency	There are opportunities for the Agency and SCE to collaborate on improving energy data management and visibility for increased savings and efficiencies.

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Appendix C - Flexible Electric Resources: Moulton Niguel Water District

> *"Our agency is known for our partnerships, innovation, and outstanding customer service. We believe that we are not just in the water business, but we are in the people business. We build strong relationships with our customers, with our stakeholders, and with our partnering agencies because those kinds of relationships and trust create ideas and momentum."*
>
> - ***J.Lopez, General Manager***

Moulton Niguel Water District (MNWD) imports most of its water resources since there are very little natural resources within its service area. Because of this, MNWD has been operating a very successful Recycled Water Program for the last 50 years. The Program began with a couple of golf course customers but now includes over 1,300 connections using 7 million gallons per day. This Program has helped shift the load off the District's potable system and has helped diversify their supply to increase system reliability.

In addition to building a successful Recycled Water Program, MNWD's operations staff have also focused heavily on minimizing energy costs per acre-foot of water delivered to customers. This focus began in the early 1990s with the development of the Country Village project, which brought five 2,000 gallon per minute (GPM) pumps online. To avoid peak costs, the District began pumping during off-peak hours and added variable speed drives (VSDs) to enable filling their reservoirs slowly to use less-than-full pump capacity. This successful energy management was achieved in a complex environment since MNWD spans the border between Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E). This means that MNWD operations staff have had to develop operational strategies that avoid pumping during TOU peak periods for two different electrical utilities.

Operations staff also collaborate regularly with other district departments regularly to improve processes and optimize efficiencies. The operations staff collaborated with the IT department to integrate automation into the District's SCADA system. The day-to-day operations are now automated via satellite facilities so that operators can use their electronic devices—such as laptops and cellphones—for control of the system.

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Acronyms and Abbreviations

AF	Acre-Feet
AFY	Acre-Feet per Year
AMP	Allen-McColloch Pipeline
AWT	Advanced Water Treatment
CEC	California Energy Commission
CPUC	California Public Utilities Commission
CY	Calendar Year
DER	Distributed Energy Resource
DPR	Direct Potable Reuse
DRP	Distribution Resources Plan
DRPEP	Distribution Resources Plan External Portal
EPIC	Electric Program Investment Charge
ETo	Evapotranspiration
ICA	Integration Capacity Analysis
IOU	Investor Owned Utility
IPR	Indirect Potable Reuse
kW	kiloWatt
kWh	kiloWatt hour
LACSD	Los Angeles County Sanitation District
MG	Million Gallons
MNWD	Moulton Niguel Water District
MW	Megawatt
MWD	Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
MWh	Megawatt hour
NCP	Non-Coincident Peak
SCAB	South Coast Air Basin
SCADA	Supervisory Controls and Data Acquisition

Acronyms and Abbreviations

SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric Company
SMWD	Santa Margarita Water District
SOCWA	South Orange County Wastewater Authority
SWP	State Water Project
TAF	Thousand Acre-Feet
TOU	Time-of-Use

District Overview

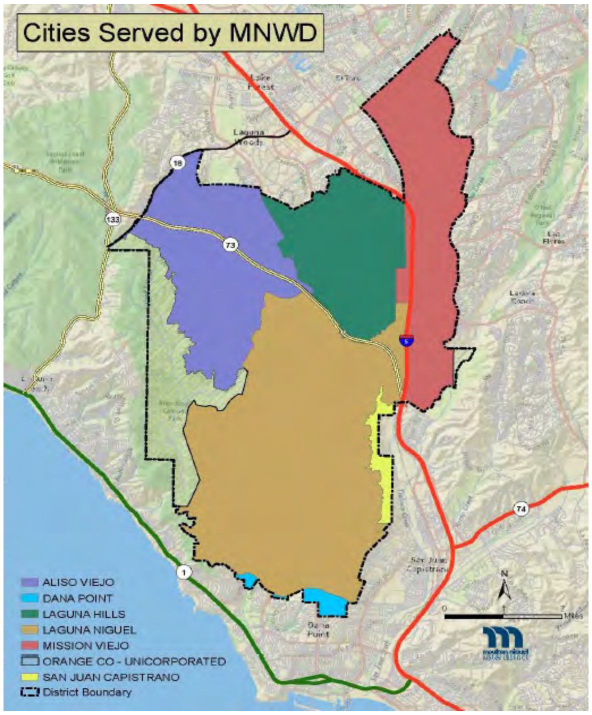

Figure 1. Moulton Niguel Water District Service Area

Moulton Niguel Water District (the District) delivers high-quality drinking water, recycled water and wastewater collection and treatment services to more than 170,000 customers in Laguna Niguel, Aliso Viejo, Mission Viejo, Laguna Hills, Dana Point, and San Juan Capistrano. The District's urban service consists primarily of residential customers. As of July 2015, the District's service area was primarily built out.

Located in an area known as the South Coast Air Basin (SCAB), the District's service area is characterized by mild, dry summers and winters. The SCAB is a semi-arid environment with mild winters, dry, warm summers and moderate rainfall. The rainy seasons occur in the semi-permanent, high pressure zone of the Eastern Pacific Ocean. The usually mild climatological pattern is interrupted by periods of extremely hot weather, winter storms, or Santa Ana winds. Temperatures in MNWD's service area range from an average of 55 degrees Fahrenheit in January to 73 degrees Fahrenheit in August with an average annual temperature of 63 degrees Fahrenheit. Annual precipitation is typically 14 inches, occurring mostly between November and March. The average actual reference evapotranspiration (ETo) is almost 50 inches per year, which is four times the annual average rainfall.

Existing Potable Water Supplies

MNWD's current water needs are met by a combination of imported potable water and recycled water. MNWD's potable demands are supplied from imported sources via the Municipal Water District of Orange County (MWDOC) that purchases imported water from Metropolitan Water District of Southern California (MWD) on behalf of its members. The recycled water supply is locally sourced and has steadily increased to account for almost 25 percent of the District's overall water supply.

Existing Water Facilities

The District's potable water is treated at MWD's Diemer Filtration Plant in Yorba Linda and the Baker Treatment Plant in Lake Forest, in which Moulton Niguel is part owner. Treated water is delivered to the District through three major transmission facilities: the South County Pipeline, the East Orange County Feeder #2, and the Allen-McColloch Pipeline (AMP).

Table 1 and Table 2 on the next page summarize the District's facilities.

Table 1. Moulton Niguel Water District's Facilities[1]

System/Function	Facilities	Purpose	Current Volume	Combined Capacity
Potable Water	Baker Water Treatment Plant (Lake Forest, CA)[2]	Secondary treatment to imported water	8.4 MGD	28.1 MGD (MNWD's capacity rights = 8.4 MGD)[3]
Wastewater/ Recycled Water	SOCWA Joint Regional Wastewater Treatment Plant	Process wastewater to tertiary standards for recycled water	7.8 MGD[4]	12 MGD
	Plant 3A[5]	Activated sludge treatment facility	1.7 MGD	2.4 MGD

Table 2. Moulton Niguel Water District's Storage Facilities[6]

Facility	Storage	Purpose	Capacity
Potable Water	26 steel and 2 pre-stressed concrete storage reservoirs	Storage of potable water	70 MG

Existing Potable Water Distribution System

The District operates and maintains approximately 663 miles of potable water distribution pipelines. In addition, the District has 26 steel and 2 pre-stressed concrete operational storage reservoirs for a total potable water storage capacity within the District of approximately 70 million gallons.

The District owns capacity rights in several adjoining water agencies' reservoirs and pipelines:

- El Toro Water District R-6 Reservoir
- Santa Margarita Water District (SMWD) Upper Chiquita Reservoir
- Joint Transmission Main (an operational agreement between MNWD and other water agencies)
- Eastern Transmission Main jointly owned by MNWD and the City of San Juan Capistrano
- South County Pipeline, which conveys water from the AMP to several south county water agencies.

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[1] Moulton Niguel Water District. 2015 Urban Water Management Plan. June 2016.

[2] Baker WT Plant is jointly owned by Moulton Niguel, El Toro, Irvine Ranch Water District, Santa Margarita and Trabuco Canyon Water Districts.

[3] Baker Water Treatment Plant Fact Sheet." Irvine Ranch Water District. https://www.irwd.com/images/pdf/construction/untitled%20folder%202/Baker%20Plant%20Fact%20Sheet%20Oct%202016.pdf.

[4] "Regional Treatment Plant." South Orange County Wastewater Authority (SOCWA website): https://www.socwa.com/infrastructure/regional-treatment-plant/

[5] South Orange County Watershed Management Area, Integrated Regional Water Management Plan, May 2018.

[6] Moulton Niguel Water District Website: https://www.mnwd.com/operations/.

The District also operates 22 pump stations to pump water from lower pressure zones to the higher pressure zones and 20 pressure reducing stations and flow control facilities to convey water from high to low zones.

The District's potable water service area encompasses a wide variety of topography. Pressure zones served (the number in the pressure zone name indicates the approximate hydraulic grade line served by the zone) include the 450 Pressure Zone, the 650 Pressure Zone, the 750 Pressure Zone, the 790 Pressure Zone, the 850 Pressure Zone, the 880 Pressure Zone, the 920 Pressure Zone, and the 1050 Pressure Zone. A hydraulic profile of the potable water distribution system can be found in Figure 2 on the next page.

Existing Recycled Water Distribution System

The District owns two Advanced Wastewater Treatment (AWT) facilities providing expansive recycled water service for landscaping. Approximately 140 miles of recycled water distribution pipelines with five pre-stressed concrete and six steel storage reservoirs were constructed by the District to service its recycled water system. The District operates 10 recycled-water pump stations. In addition, the District owns 1,000 acre-feet of capacity rights in the Upper Oso recycled water reservoir, owned by Santa Margarita Water District (SMWD).

Moulton Niguel Water District's Aliso Viejo Pump Station (*photo courtesy of Caroline Minasian*)

Wastewater Collection System

The District maintains approximately 504 miles of wastewater collection pipelines. The District's wastewater system has 16 lift stations that pump wastewater over the ridge lines to the various treatment plants for treatment and recycling. The District is a participant in the South Orange County Wastewater Authority (SOCWA), a joint powers agency comprised of ten governmental agencies, that operates three regional treatment plants which the District owns capacity and two ocean outfalls. The District also owns and operates a fourth wastewater treatment plant, Plant 3A.

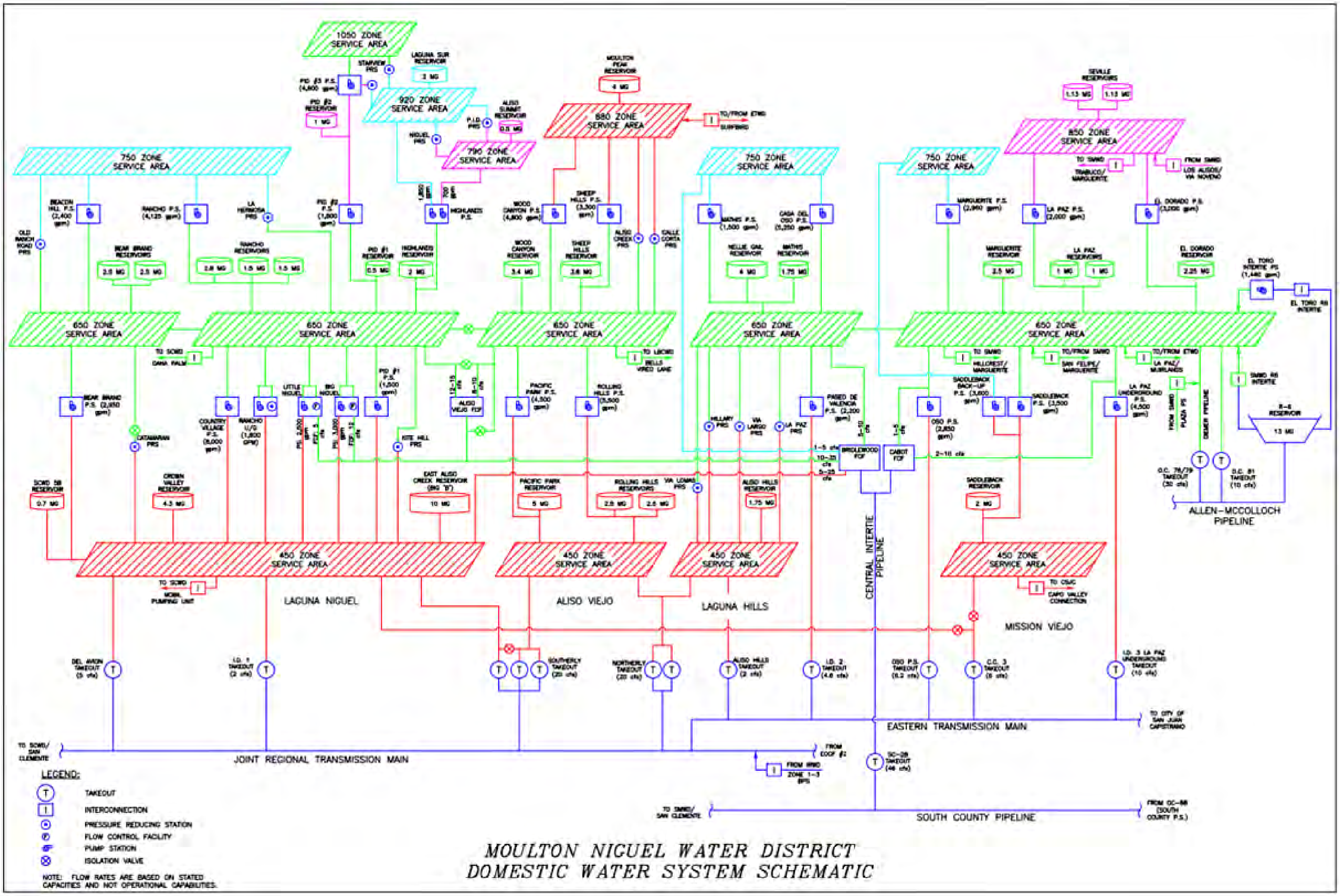

Figure 2. Potable Distribution System Hydraulic Profile

Electric Requirements

District operations staff strive to minimize the energy costs per acre-foot of water delivered to customers. This focus began in the early 1990s with the development of the Country Village project, and this focus has successfully lowered the average energy intensity of water delivered within the District up to the present day. This successful energy management has been achieved in a complex environment. Because the District's service area spans the border between Southern California Edison (SCE) and San Diego Gas and Electric (SDG&E), District operations staff have had to develop operational strategies that avoid pumping during TOU peak periods for two different electrical investor-owned utilities (IOUs).

Electric Use

The District's primary electric uses are for pumping water, wastewater and recycled water across the District's service area (67.5%) and treating wastewater (31.4%). Collectively, these functions account for nearly 99% of MNWD's electric use.

During CY2018, the District's electric use exceeded 8 million kWh with a Non-Coincident Peak Electric Demand of 3,134 kW.

Table 3. 2018 Electric Use (kWh) and Electric Demand (kW) by Type of Water Facility[7]

Type of Facility	Nbr of SCE Electric Meters	Total Electric Energy (kWh)		Maximum Electric Demand (kW)		Annual Electric Load Factor[1]	
		Total Electricity (kWh)	% kWh by Type of Facility	∑ Non-Coincident kW (NCP)[8]	% kW by Type of Facility	Utilized[2]	Unutilized[3]
Potable Pump Stations	9	2,164,556	26.88%	1,192	38.03%	20.73%	79.27%
Lift Stations	8	1,666,068	20.69%	495	15.79%	38.42%	61.58%
Recycled Water Pump Stations	4	1,604,892	19.93%	529	16.88%	34.63%	65.37%
Flow Control Station	1	18,364	0.23%	163	5.20%	1.29%	98.71%
Raw Water Treatment	1	2,529,678	31.41%	740	23.61%	39.02%	60.98%
Other	24	69,824	0.87%	15	0.48%	53.14%	46.86%
Grand Total	**47**	**8,053,382**	**100%**	**3,134**	**100%**	**29.33%**	**70.67%**

[7] Compiled from SCE electric meter data provided by Moulton Niguel Water District.

[8] NCP = "Non-Coincident Peak", the sum of maximum annual demand (kW) of all electric meters by type of facility.

Notes to Table 3 on the previous page:

[1] "Annual Load Factor" is the percentage of electric demand actually used (maximum annual kW) calculated as [Total Electricity (kWh) ÷ (Maximum Electric Demand x 8,760 hours/year)].

[2] "Utilized" is the amount of electric energy that was actually used during CY2018 as a percentage of the Maximum Electric Demand (Non-Coincident basis) by type of facility.

[3] "Unutilized" is the amount of additional electric energy that could have been used during 2018 under the maximum kW (i.e., additional kWh that could have been used without incurring additional demand charges).

As is typical of most water and wastewater systems, the annual electric load factor for water pumping tends to be low. This is because there typically is redundancy and excess pump capacity to assure reliable operations of mission critical water services (e.g., maintenance can be performed on some pumps while others are operating). For the District, the average annual electric load factor ("Utilized") ranges from 20% to 40%. A low average annual electric load factor, such as 20% for potable pump stations, may indicate available flexible capacity that could provide over-generation mitigation support.

Electric Resources

Moulton Niguel Water District does not presently produce any of its own electric supplies except via emergency generators which are permitted by the South Coast Air Quality Management District (SCAQMD) for very limited purposes and hours.

Flexible Electric Resources

The ability of a water utility to provide over-generation response depends on the amount of flexibility to be found in the various components of the distribution system. Moulton Niguel Water District does not have much flexibility in its water sources (although it does have flexibility in how that water is brought into its distribution system, as will be discussed below). The pumping and storage capacities of the District's potable water distribution system do provide some flexibility for over-generation response.

District staff have already developed pumping and storage strategies in the potable water system that minimize energy costs. The District responds to both SCE and SDG&E price structure incentives and penalties, including Time-of-Use (TOU) rate schedules and peak demand charges. District operations staff are confident that if tariff rates are modified to incentivize over-generation response, they will be able to re-optimize their pumping and storage strategies to shift energy consumption and demand to over-generation time periods.

District staff also believe that they could increase demand beyond current levels during the over-generation time periods. Some pump stations are not operated at their maximum capacity. In particular, the Wood Canyon and Sheep Hills Pump Stations pumping into the Moulton Peak Reservoir; the El Dorado and La Paz Pump Stations pumping into the Seville Reservoirs; and the Highlands Pump Station pumping to the Aliso Summit Reservoir have the potential to be operated at higher pumping (and therefore energy demand) capacities if peak demand charges are waived. The amount that pumping could be increased before pipeline constraints would dominate would need to be confirmed by hydraulic modeling.

District staff identified that water from the Baker Treatment Plant that currently is brought into the District's potable water distribution system via the 650 Pressure Zone could be moved through pressure reducing stations into the 450 Pressure Zone before being pumped into higher zones if desired to increase energy demand and consumption. It should be noted that such an action **would** increase the District's overall energy consumption in addition to shifting the time of consumption.

Operational Changes Needed

Table 4. Opportunities to Provide Over-generation Mitigation Support with Existing Facilities

Opportunity	Challenge(s)
Increase ("shift") pumping to SCE over-generation periods (9am to 4pm)	▪ Increasing the rate of pumping during some hours could increase the District's electric costs through increased demand (kW) charges. ▪ If a higher rate of pumping also causes pumps to operate outside the optimal range of pump efficiency, additional energy (kWh) costs may also be incurred.
Developing a different rate for pumps presently grandfathered under the old Agricultural & Pumping TOU rates ("PA" tariff schedules) would enable MNWD to provide over-generation support at these sites. (Presently, these grandfathered loads avoid pumping during Noon to 6pm, 4 hours of which coincide with periods of over-generation.[9])	Electric loads presently under grandfathered TOU rates that are in direct opposition with over-generation mitigation support involve multiple parties that were involved in Settlement Agreements. Unless the District can negotiate a separate agreement without undoing the CPUC adopted Settlement Agreement(s), all of the parties involved in those Settlement Agreements would need to be reconvened to renegotiate and the CPUC would need to adopt the revised Settlement Agreements.

Looking Forward

The District owns some seasonal recycled water storage capacity in the Oso Reservoir that is owned and operated by Santa Margarita Water District (SMWD). Limited amounts of recycled water could be pumped to seasonal storage during daily and seasonal over-generation periods, except that the existing pipeline could not support the level of increased pumping that would be needed to implement that strategy. Removal of the pipeline capacity constraint could enable the District to provide over-generation mitigation support at this location, and at other similar facilities where pumping, pipeline, and or storage constraints limit our ability to increase pumping during over-generation periods.

[9] MNWD has 9 meters totaling 1,568 kW (non-coincident peak) that participated in the legacy "Super Off-Peak" option under agricultural pumping rates that were granted grandfathered TOU status pursuant to CPUC Decision 18-11-027 "Decision on Southern California Edison Company's Proposed Rate Designs and Related Issues" (November 29, 2018). The grandfathered TOU time periods remain in effect until replaced with new Agricultural and Pumping rates in SCE's 2021 General Rate Case (GRC) Phase 2.

Flexible Electric Resources Strategies and Innovation

The District is partnering with the University of California Davis' Center for Water and Energy Efficiency on a $3.1 million project funded by an Electric Program Investment Charge (EPIC) grant administered by the California Energy Commission (CEC). The purpose of the pilot project is to develop tools to help a water utility reduce or shift energy demand loads, or ramp up energy demands, in response to different price signals. Moulton Niguel Water District is the host water utility for this pilot.[10]

> *"There are opportunities for water utilities to do demand response. The key part of that is to provide tools in the right format for the people on the ground so that it meets the day-to-day considerations of the operators who are managing the system."*
>
> – ***D.Atwater, Director of Finance and Water Resources***

The project focuses on understanding how to optimize a water distribution utility's energy usage and costs. The scope includes leveraging the water utility's hydraulic model and overlaying an energy model to determine the energy cost impacts of different operating strategies and scenarios.

To conduct this work, U.C. Davis documented the design and capacity of Moulton Niguel Water District's potable water distribution system and in conjunction with District operations staff, developed "operating ranges" for various parts of the system. The safe operating ranges sought to optimize pump schedules given water demands and water quality compliance. The final stage of the project will involve building a prototype model that integrates the intelligence inherent in both hydraulic models and energy management systems.

The preliminary results show that there are opportunities for water utilities to do Flexible Demand Response but better tools are needed that enable operators who are managing the system to understand the potential impacts of real-time operational changes requested for electric reliability purposes. In addition to needing to first understand the potential impact on mission-critical water operations, operators need and to be able to integrate this additional responsibility into their existing work. The more easily they can access the right information, the more likely they will be able to integrate real-time energy management decisions into day-to-day water operations.

[10] "Advancing Demand Response in the Water Sector." Grant Application submitted by U.C. Davis to the California Energy Commission, EPIC Grant No. EPC-16-062. Approved May 10, 2017.

Recommendations for a Water Sector Electric Reliability Program

Below are Moulton Niguel Water District recommendations for a Water Sector Electric Reliability Program.

- **More Resources.** District staff operate and maintain sites, pumps, and reservoirs while also trying to operate the system as efficiently as possible. Increasing the District's ability to provide real-time electric reliability support to SCE would require full-time operators and more sophisticated SCADA and real-time decision-making systems and tools to enable operations to make real-time operating adjustments
- **Consistency.** Additional training and skillsets would be required to participate in real-time electric markets. Additionally, consistency with respect to the types of electric reliability responses SCE needs from the District would make it more possible for the District to participate.
- **Clear Messaging**. Until recently, water utilities have been asked to decrease their electric usage during certain hours of the day. Over-generation is very different – the idea of increasing electric use during some hours of the day may be possible, but it needs to be clearly understood. Instead of including over-generation mitigation support in dialogues about energy efficiency and conservation, the District suggests targeting the message towards "smart usage" which would be more understandable by the District, its staff, and its customers.
- **Eliminate Demand Charges**. The District schedules pumping operations to minimize demand charges. To avoid triggering increased demand charges, the District was advised by a consultant to spread its pumping over as many hours as possible. Shifting as much pumping as possible to over-generation periods would require changing current customer energy programs to avoid demand charge penalties when customers increase electric use to support electric reliability.

One of our pump stations has 5 x 200 hp pumps. The first electric bill was $54,000 for one month. A third of that bill was for demand charges. Our Director of Operations looked at that and said we need to do something about this.

We changed our pumping to off-peak time periods. It took us a year to put time clocks in all the controllers so that we would know what time period we were in, and then change all the rate schedules.

During the first year of the change, we saved $200,000.

During 2018, the District operated only two of the four pumps at the Wood Canyon Potable Water Booster Pump Station at any one time. This operation resulted in a maximum electrical demand of 250 kW. If the downstream hydraulics allow three pumps to be operated, the maximum electrical demand could be increased by 50% and focused to the over-generation time period.

Statement from Moulton Niguel Water District's General Manager

Water and Energy go hand-in-hand. It takes energy to convey water, and a lot of the challenges that we face are similar. Because of that, our opportunities for collaboration are substantial.

Working together and understanding our collective challenges and figuring out how we can leverage those opportunities to our mutual benefit builds the relationship and network that enable us to do great things together that individually we could not do. One of my early lessons about the energy sector was about how it approaches rate design. Understanding that helped me understand that they can develop rates that benefit the water community.

We're all trying to be efficient, and we're all trying to use our precious resources in a smarter way. Working together, we can figure out what those strategies should look like. We are stronger when we work together.

One thing that could be very helpful in forging partnerships between water and energy is clarity and better understanding. We all use industry jargon and lots of acronyms - we're all guilty of that. That makes it difficult to understand because while we share some common language, not all are the same. We need to work together to distill technical information in a manner that we can understand as a water agency, and that also allows us to clearly communicate to our joint customers and stakeholders. We in the water sector understand reliability. Let's talk about how we can work collaboratively towards that common goal.

Financial assistance would also be helpful. Unlike the energy world where there are only a few large electric utiltiies, California has more than 2,000 water providers. Water agencies come in many different sizes and shapes, each with its own unique challenges and demands. I believe that incentives for water and wastewater utilities that can provide electric reliability support would really catch the attention of the State's water leaders, many who are struggling day-to-day, just to make sure that their customers have safe and reliable water.

Data is another bridge. Energy utilities have very sophisticated data collection systems and evaluation processes. Although the water community has come a long way, we need to catch up to where energy utilities are now. The more commonality we have in data and systems, the better equipped we will be to have effective dialogues.

Partnering in general is a very public commitment. Sharing resources to increase public awareness about our common challenges and opportunities, and how we can effectively tackle them together, is essential as we go forward.

Joone Lopez

Joone Lopez, General Manager
Moulton Niguel Water District

Appendix D - Flexible Electric Resources: Palmdale Water District

The single highest operating cost for Palmdale Water District (PWD) is energy. California's 2000/01 energy crisis propelled PWD to seek opportunities to substantially increase operational efficiencies to reduce energy costs and mitigate financial risks. The result was a three-pronged strategy:

1. **Flexibility**: Increase the flexibility of PWD assets;
2. **Awareness**: Increase awareness of energy price options and the impact of PWD's systems and operations on energy costs; and
3. **Buy-in**: Engage and build buy-in from the Board of Directors and all levels of management and staff, including distribution system operators, operations managers, and the General Manager.

"Our emphasis is always on being efficient with our resources. Power is the highest single cost for Palmdale Water District so having efficiency in that arena is vitally important."

- *P. Thompson, Resources and Analytics Manager*

PWD's focus on energy management led to several key changes to systems and operations. One of those changes, including upgrading the radio system for SCADA, reduced lag times of 20-30 minutes to near instantaneous feedback. This change alone increased opportunities to improve real-time operational efficiencies. Today, PWD continues to invest in SCADA system improvements to continually enhance its "best-in-class" system, including market-leading HMI (Human Machine Interface) software that provides the types of real-time information that operators need in order to make real-time operational changes with confidence.

Palmdale Water District's Leslie O. Carter Water Treatment Facility
(*photo courtesy of Palmdale Water District*)

This case study was reviewed and approved by Palmdale Water District.

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DRP	Distribution Resources Plan
DRPEP	Distribution Resources Plan External Portal
EIR	Environmental Impact Report
GHz	Gigahertz
GPM	Gallons Per Minute
HGL	Hydraulic Grade Line
HMI	Human Machine Interface
HP	Horsepower
ICA	Integration Capacity Analysis
IOU	Investor Owned Utility
kW	kiloWatt
kWh	kiloWatt hour
MDD	Maximum Daily Demand
MG	Million Gallons
MHz	Megahertz
MW	Megawatt
MWh	Megawatt hour
NCP	Non-Coincident Peak
NEM	Net Energy Metering

Acronyms and Abbreviations (cont'd.)

PCM	Pulse Code Modulation
PLC	Programmable Logic Controller
PRS	Pressure Reducing Stations
PRV	Pressure Reducing Valve
PWD	Palmdale Water District
SCADA	Supervisory Controls and Data Acquisition
SCE	Southern California Edison
SGIP	Self-Generation Incentive Program
SWP	State Water Project
TAF	Thousand Acre-Feet
TOU	Time-of-Use
USDA	U.S. Department of Agriculture
WTP	Water Treatment Plant

District Overview

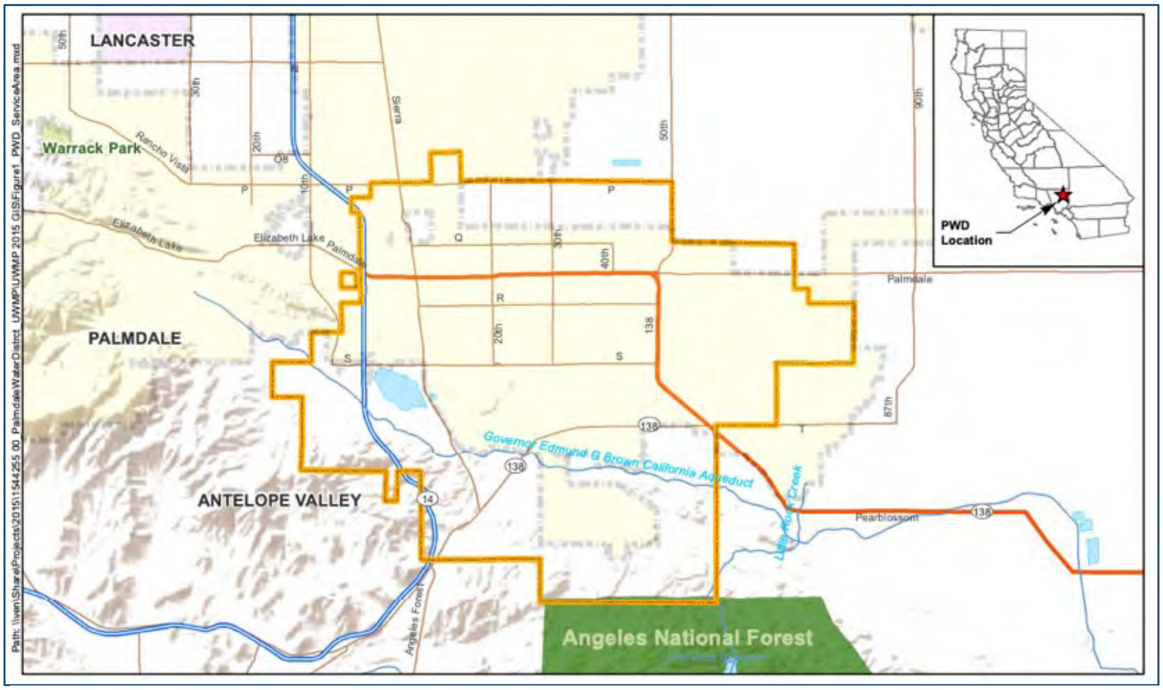

Figure 1. Palmdale Water District Service Area

Palmdale Water District (PWD) was originally established as an irrigation district in 1918 to supply irrigated water to approximately 4,500 acres of agricultural land. Today, PWD supplies, conveys, treats and distributes water to more than 115,000 residents within a 40-square-mile service area in northeast Los Angeles County.

PWD is located within the Antelope Valley in Los Angeles County, approximately 60 miles north of the City of Los Angeles. The service area includes the central and southern portions of the City of Palmdale and adjacent unincorporated areas of Los Angeles County. The City of Palmdale's nearest neighbor, Lancaster, is approximately 10 miles to the north. The Antelope Valley Freeway (State Highway 14) runs north-south and Pearblossom Highway (State Highway 138) meanders in an east-west direction through PWD.

The climate within PWD's service area is characterized by wide temperature fluctuations, hot summers, cold winters, strong winds, low humidity, and scant rainfall. Temperatures in the summer months vary between 52°F and 110°F. In the winter months, the average temperature extremes vary from 28°F to 67°F. Most of the precipitation occurs during the winter and spring months.

Existing Potable Water Supplies

PWD has three primary sources of water: local surface water from Littlerock Creek Reservoir, imported surface water from the State Water Project (SWP), and local groundwater pumped from PWD-owned wells in the adjudicated Antelope Valley groundwater basin. Water from Littlerock Creek and the SWP is treated at PWD's Leslie O. Carter Water Treatment Plant (WTP).

Presently, PWD is evaluating a conjunctive groundwater storage and recovery project that would bank SWP water, in addition to recycled water from the Palmdale Recycled Water Authority, a joint venture between PWD and the City of Palmdale. This venture would introduce a fourth water supply to PWD's portfolio. Four independent water supplies are more than typical for a water utility of comparable size. Additional water resource options provide a significant amount of flexibility, reliability, and redundancy for PWD and its customers.

During an average year, PWD's water supply portfolio is comprised roughly of 40% local groundwater, 50% imported water, and 10% local surface water.

Existing Water Facilities

Tables 1 and 2 below summarize PWD's facilities.

Table 1. Palmdale Water District's Facilities[1]

Facility Type	Number
SWP Service connection	1
Pressure Zones	10
Wells (active)	22
Wells (Inactive)	4
Booster Pump Stations	15
Booster Pumps	39
Storage Tanks	21
Operational hydropneumatic tanks	9
Pipelines (miles)	433
Pressure Regulating Stations	20
Pressure Reducing Valves	30

Table 2. Palmdale Water District's Treatment and Storage Facilities[2]

Facility	Description	Current Volume	Combined Capacity
Leslie O. Carter Water Treatment Plant	Treats water through granulated activated carbon. Facility also produces its own chlorine for disinfection.	20 MGD	35 MGD
Storage Reservoirs	21 storage tanks	30 MG	50 MG

[1] Ibid. See Table 2-1 Summary of Water Distribution System Components on page 2-1.

[2] Provided by PWD Staff and PWD's website: https://www.palmdalewater.org/about/infrastructure/.

Potable Water Distribution System[3]

PWD's potable water distribution system is divided into seven main pressure zones, which are labeled by the approximate hydraulic grade line (HGL) within the zone: the 2800 zone, 2850 zone, 2950 zone, 3000 zone, 3200 zone, 3250 zone, and the 3400 zone. There is an additional small zone at a remote location, the 3600 zone.

All pressure zones in the existing and future system are gravity-fed from storage reservoirs through pressure reducing stations (PRS) or by hydropneumatic tanks. The 3600 zone is served from booster stations and hydropneumatic tanks.

The maximum hydraulic grade elevation for each main pressure zone is determined by the high water level of the reservoirs feeding the zone or the normal pressure setting of the pressure reducing valves (PRVs). Booster pumping stations are used to pump water from lower to higher pressure zones, where needed.

A hydraulic profile of the distribution system can be found in Figure 2 on the next page. Water from the supply sources listed above enters the distribution system through the 2800 pressure zone, the 2850 pressure zone, and the 2950 pressure zone.

45th Street Booster that feeds into the 2850' zone *(photo courtesy of Palmdale Water District)*

[3] "2016 Water Systems Master Plan." *MWH for Palmdale Water District.* December 2016. Page 2-1.

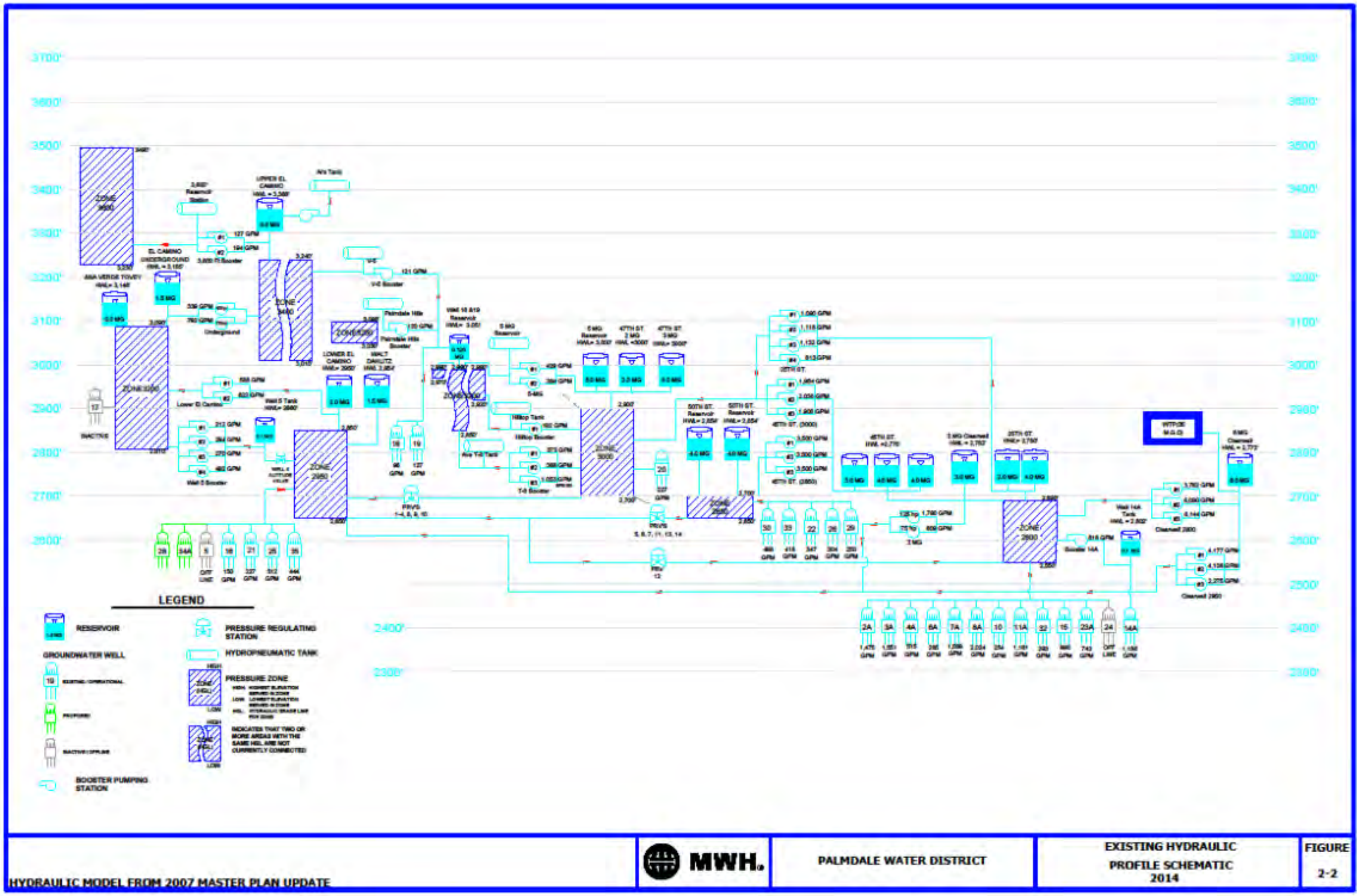

Figure 2. Palmdale Water District's Potable Distribution System Hydraulic Model Profile[4]

[4] "2016 Water Systems Master Plan." *MWH for Palmdale Water District*. December 2016. See Figure 2-2. Hydraulic Schematic of the Existing System, p. 2-4.

Electric Requirements

Electric Use

PWD's primary electric uses are for pumping groundwater (49% of kWh and 51% of kW) and booster pumping (33% of kWh and 32% of kW). Together, groundwater pumping and booster pumps account for 81% of the electricity (kWh) used by PWD during 2018 and 84% of the electric demand (kW). Groundwater wells are presently PWD's highest energy density water resource.

Table 3. 2018 Electric Use (kWh) and Electric Demand (kW) by Type of Water Facility[5]

Type of Facility	Number of SCE Electric Meters	Total Electric Energy (kWh)		Maximum Electric Demand (kW)		Annual Electric Load Factor[1]	
		Total Electricity (kWh)	% kWh by Type of Facility	∑ Non-Coincident kW (NCP)[6]	% kW by Type of Facility	Utilized[2]	Unutilized[3]
Groundwater Well	28	5,501,278	48.72%	2,605.5	51.02%	24.10%	75.90%
Pump Station (Booster)	15	3,691,780	32.70%	1,658.8	32.48%	25.41%	74.59%
Water Treatment Plant	2	1,401,584	12.41%	544	10.65%	29.41%	70.59%
Lake/Littlerock Dam	3	76,035	0.67%	29	0.57%	29.93%	70.07%
Tanks	2	621	0.01%	1	0.02%	7.09%	92.91%
All Other Uses	4	619,861	5.49%	269	5.26%	26.30%	73.70%
Grand Total	**54**	**11,291,159**	**100%**	**5,107.3**	**100%**	**25.24%**	**74.76%**

Notes:

[1] "Annual Load Factor" is the percentage of electric demand actually used (maximum annual kW) calculated as [Total Electricity (kWh) ÷ (Maximum Electric Demand x 8,760 hours/year)].

[2] "Utilized" is the amount of electric energy that was actually used during CY2018 as a percentage of the Maximum Electric Demand (Non-Coincident basis) by type of facility.

[3] "Unutilized" is the amount of additional electric energy that could have been used during 2018 under the maximum kW (i.e., additional kWh that could have been used without incurring additional demand charges).

As is typical of most water and wastewater systems, the annual electric load factor for water pumping tends to be low. This is because there typically is redundancy and excess pump capacity to assure reliable operations of the mission critical to water services (e.g., maintenance can be performed on some pumps while others are operating). PWD's average annual electric load factor ("Utilized") ranges

[5] Compiled from SCE electric meter data provided by Palmdale Water District.

[6] NCP = "Non-Coincident Peak", the sum of maximum annual demand (kW) of all electric meters by type of facility.

from 24% to 30%. A low average annual electric load factor may indicate Flexible Capacity that could provide over-generation mitigation support.

Electric Resources

Wind

PWD has two electric generating facilities, one of which is a 950 kW wind turbine at the Leslie O. Carter Water Treatment Plant (WTP) that provides 60% to 70% of the electricity for the treatment plant. At the time it was completed (2004), it was the largest wind energy net metering project in the United States. The turbine is connected directly to the 12kV system of the treatment plant.

Wind turbine at Leslie O. Carter Water Treatment Plant *(photo courtesy of Caroline Minasian)*

PWD owns and operates the wind turbine. The project benefitted economically from SCE's Net Energy Metering (NEM) program. While the 2018 annual peak electric demand for the WTP was 104 kW[7], PWD was able to oversize the wind turbine considerably, relative to the WTP's actual peak electric demand.[8] Oversizing the wind turbine relative to the site's peak electric demand (kW) enabled PWD to meet nearly 70% of the WTP's annual electricity requirements (kWh) from wind power. PWD also received a substantial Self-Generation Incentive Program (SGIP) incentive from SCE that brought down the project cost by 50%.[9]

Inexpensive energy from the wind turbine enables PWD to cost-effectively produce its own chlorine. Bulk solar salt is mixed with softened water. Electrolysis then creates sodium hypochlorite and hydrogen as a byproduct.[10]

Hydroelectric Generator

The second electric generating facility at PWD is the hydroelectric generator (hydro-gen). The hydro-gen was put in service in 2008, and since then has generated over 4.5 million kWh. The hydro-gen generates energy as water flows from the State Water Project aqueduct into Lake Palmdale, and its generation is used to offset energy usage at the booster stations at PWD's clearwell.

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[7] August 2018. [Source: SCE electric billing data by meter provided by Palmdale Water District.]

[8] Under NEM, the wind turbine was allowed to be sized at 950 kW, producing 846 kW more electric power than the Water Treatment Plant's peak 2018 electric demand of 104 kW.

[9] "Town of Brewster Wind Turbine Feasibility Study". *Black and Veatch.* June, 2009.

[10] Source: Palmdale Water District.

Solar

Solarbee® Water Circulators[11] are used at the WTP and throughout the distribution system to help circulate water in the tanks to equally disperse disinfectants. Solar water circulators are also used in Lake Palmdale to help disperse nutrients and stop toxic blue-green algae from blooming (algae prefers stagnant water). These circulators can draw up to 10,000 gallons of water per minute from depths ranging from 100 to 2 feet below surface.

Flexible Electric Resources

Potable Water Distribution System Over-Generation Mitigation Potential

As part of PWD's 2016 Water System Master Plan, existing storage capacity and existing pump station capacity evaluations were performed for the existing distribution system by pressure zone. The results of the storage capacity analysis can be seen in Table 4 below.

The distribution system has very small storage deficiencies in a number of pressure zones. Such deficiencies most likely do not impact operations.

The distribution system has a more significant storage deficit in the 2950 pressure zone. This pressure zone is one of the critical pressure zones through where water supply enters the distribution system. Consequently, any storage deficit in this pressure zone presents operational challenges and limits flexibility with the distribution system.

Table 4. Existing Potable Water System Storage Assessment[12]

Pressure Zone	MDD of Zone (MGD)	Fire Storage(1)	Operational Storage	Emergency Storage	Total Volume Required (MG) (2)	Existing Storage Tank Volume (MG)	Surplus/ Deficit Storage (MG)
		(MG)	25% MDD (MG)	100% MDD (MG)			
3600 (4)	0.04	0.15	0.01	0.04	0.2	0	-0.2
3400W	0.23	0.15	0.06	0.23	0.44	0.3	-0.14
3400E and 3250	0.19	0.54	0.05	0.19	0.86	0.04	-0.73
3200	0.46	0.54	0.12	0.46	1.12	1.8	0.68
3000	3.36	0.54	0.84	3.36	4.74	10	5.26
2950	7.92	0.96	1.98	7.92	10.86	3.6	-7.26
2850	5.98	0.96	1.5	5.98	8.44	8	-0.44
2800	15.52	0.96	3.88	15.52	20.36	20.1	-0.26
System Total	**33.7**		**8.42**	**33.7**	**46.92**	**43.84** (3)	**-3.08**

(1) Fire Storage is calculated by multiplying the Fire Flow Required (gpm) by the Fire Duration (hrs).
(2) Total Volume Required is the summation of the Fire Storage, Operational Storage, and Emergency Storage.
(3) 6 MG Clearwell is unable to provide emergency storage since without a pump they are unable to provide supply for a zone.
(4) Pressure zone only includes the existing demands and does not include the anticipated Quail Valley development demands.

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[11] Solar powered mixing drive systems for water systems. [Source: Medora Corporation website: https://www.medoraco.com/equipment/sb-series-solar-powered-mixers.]

[12] "2016 Water Systems Master Plan." *MWH for Palmdale Water District.* December 2016. See Table 8-1 Existing Potable Water System Storage Capacity Evaluation on page 8-5.

The results of the evaluation for the booster pump station capacity of the distribution system are provided in Table 5 below. As can be seen in the table, several of the pressure zones in the distribution system are reported to have pumping capacity deficits. However, these deficits are related to fire flow capacity, which is an emergency condition outside of daily operations. All the pressure zones have adequate pumping capacity for daily operations.

Of the critical pressure zones through where water enters the distribution system, the 2850 pressure zone has Flexible Pumping Capacity. The 2800 pressure zone and 2950 pressure zone have adequate pumping capacity under existing conditions.

As described, the distribution system does not have an excess of storage or pumping capacity. However, the operations team operates the distribution system with efficiency and with the maximum flexibility that the existing infrastructure allows. They are able to achieve this high level of operations through detailed knowledge and high levels of understanding about the distribution system.

Table 5. Existing Booster Pump Capacity Assessment[13]

Pressure Zone	Pump Station	In-Zone MDD (gpm)	Higher Zone MDD (gpm)	Total MDD (gpm) (1)	Fire Flow Required (gpm)(2)	Firm Pumping Capacity (gpm)(3)	Surplus/Deficit (gpm)(4,5)
3600(6)	3600 Ft Booster	28		28	1,250	127	**-1,151.00**
3400W	Underground	161	28	189	1,250	352	**163.2**
3400(6)	V-5 Booster	11	0	11	3,000	0	**-3,011.40**
3250(6)	Palmdale Hill Booster and T-8 Booster	118	0	118	3,000	796	**-2,321.90**
3250A(6)	5 MG	4	0	4	1,250	790	**-463.9**
3250C(6)	Hilltop Booster	6	0	6	1,250	96	**-1,159.80**
3200	Lower El Camino and Well 5 Booster	312	189	501	3,000	1,401	**900.4**
3000	45th Street (3000), 25th Street, Well 20	2,332	139	2,471	3,000	5,778	**3,307.1**
2950	Clearwell 2950, 3MG and wells	5,500	501	6,000	4,000	6,865	**864.7**
2850	45th Street (2850) and Wells	4,153	0	4,153	4,000	6,991	**2,837.60**
2800	Las Flores Canyon	10,776	12,625	23,440	4,000	24,152	**751.6**

(1) The “Total MDD” = “In-Zone MDD” + “Higher Zone MDD”, which is the flow required to meet the demand for that particular zone.
(2) The “Fire Flow Required” is the highest fire flow requirement for that particular zone.
(3) The “Firm Pumping Capacity” is the capacity of a pump station when the largest pump is out of service.
(4) The “Surplus/Deficit” = “Firm Pumping Capacity” – “Total MDD” for pressure zones with existing storage.
(5) The “Surplus/Deficit” = “Total Pumping and Well Capacity” – “Total MDD” – “Fire Flow Required” for pressure zones without existing storage.
(6) Pressure zones without existing storage.

[13] “2016 Water Systems Master Plan.” *MWH for Palmdale Water District.* December 2016. See Table 8-3 Existing Potable Water System Zone Booster Evaluation on page 8-8.

PWD's detailed knowledge about its potable water distribution system is a product of the radio system and SCADA system upgrades recently completed. These robust systems provide real-time information about the status of all key infrastructure and allow operations staff to make decisions on critical data in a timely manner. The high level of understanding of the distribution system results from a consciously-developed culture that emphasizes holistic knowledge of the system and its goals so that operational strategies can be constantly refined and optimized. This culture de-emphasizes operation based upon rote adherence to a schedule or set of memorized activities. With the data from the SCADA system, the operations staff identify challenges and solve them in real time.

Potential Operational Changes for Over-generation Mitigation Support

According to the 2016 Water Facilities Master Plan, PWD has five active "large mover" wells that have a capacity of approximately equal to or greater than 1,000 gpm, and a motor with 500 hp or greater. At a minimum, these wells (well 2A, well 3A, well 7A, well 8A, and well 23) should be operational during the over-generation period.[14] To the extent allowed by the transmission, storage, and pumping capacity of the distribution system, other wells should be active during the over-generation period and, pumping out of the pressure zones that are receiving the well water during the over-generation period (primarily the 2800 pressure zone, the 2850 pressure zone, and the 2950 pressure zone) to higher zones should be maximized as well. Such operation will increase the amount of water that can be pumped before storage limits are reached and will increase energy demand during the over-generation period.

The primary impediment to the over-generation response described above appears to be the lack of storage in the 2950 pressure zone. CIP Project ES-03 in the 2016 Water Facilities Master Plan, which calls for 4.2 million gallons of storage for this pressure zone, may be necessary to maximize the over-generation response. Hydraulic modeling of the distribution system will be required to confirm this impediment as well as to identify others. Another impediment may be the fact that use of the groundwater resource as described above may not allow PWD to utilize SWP water when it is available. A "mass balance" evaluation of water supply sources would need to be conducted to assure that the use of valuable SWP supply is not reduced.

The over-generation response will have impacts on other energy demands throughout the distribution system. For instance, with the groundwater wells supplying more water, the pumps operating at the clearwell will not be used as much. Given that the groundwater pumps consume more energy, this may be an acceptable trade-off. However, the mass balance and hydraulic modeling indicated above should be performed to confirm this operation.

[14] "2016 Water Systems Master Plan." *MWH for Palmdale Water District.* December 2016. See Table 2-3 Groundwater Well Characteristics on page 2-8.

Looking Forward

Another great opportunity for future over-generation response can likely be found in PWD's proposed Groundwater Recharge and Recovery Project. Banking of additional State Water Project water into spreading basins and recovery of groundwater from the proposed wells could potentially be scheduled during over-generation periods.

Table 6. Palmdale Water District Groundwater Recharge & Recovery Project

Project Description	New 80-acre recharge basin on 160-acre site. This project would construct recharge basins to bank PWD's SWP allocation when available. A blend of untreated SWP water and tertiary recycled water from the Palmdale Recycled Water Authority would be delivered to 4 spreading basins to recharge the Antelope Valley groundwater aquifer with up to 52,000 acre-feet per year (AFY). Targeted recovery is 15-30 thousand acre-feet (TAF) per year via 8-16 wells that will either be chlorinated prior to delivery to customers or returned via the California Aqueduct to other State Water Contractors.
Phased Development	▪ **Phase 1a**: Construct conveyance pipelines, 4 recovery wells and a well collection pipeline that connects to the potable water distribution system. ▪ **Phase 1b**: Expand facilities and construct a third recharge basin, up to 4 additional recovery wells, a water storage tank to meet chlorine contact time requirements, and a potable water pump station and distribution system that includes chlorine generation. ▪ **Phase 2**: Build all remaining facilities including a 4th recharge basin, up to 8 additional recovery wells, and a potential return water pump station that would bypass the storage tank to pump non-chlorinated return water to the East Branch of the California Aqueduct.
Project Location	Northeastern portion of the City of Palmdale in portions of Alpine Butte, Lancaster East, Littlerock, and Palmdale.
Environmental Impact Report	Finalized June 2016.
Estimated Project Cost	$103,730,000
Benefits	• Diversify PWD's portfolio of ground and surface water; • Increase supply reliability; • Replenish groundwater supplies; • Save for future droughts; • Cost-effective drought resilient supply.
Current Status:	• On June 24, 2019, PWD's Board of Directors approved a WaterSMART grant application for $1.1 million in federal funds for final design phase. • PWD is continuing groundwater tests to determine project feasibility.[15]

[15] "Minutes of Regular Meeting of the Board of Directors of Palmdale Water District." *Palmdale Water District.* April 22, 2019.

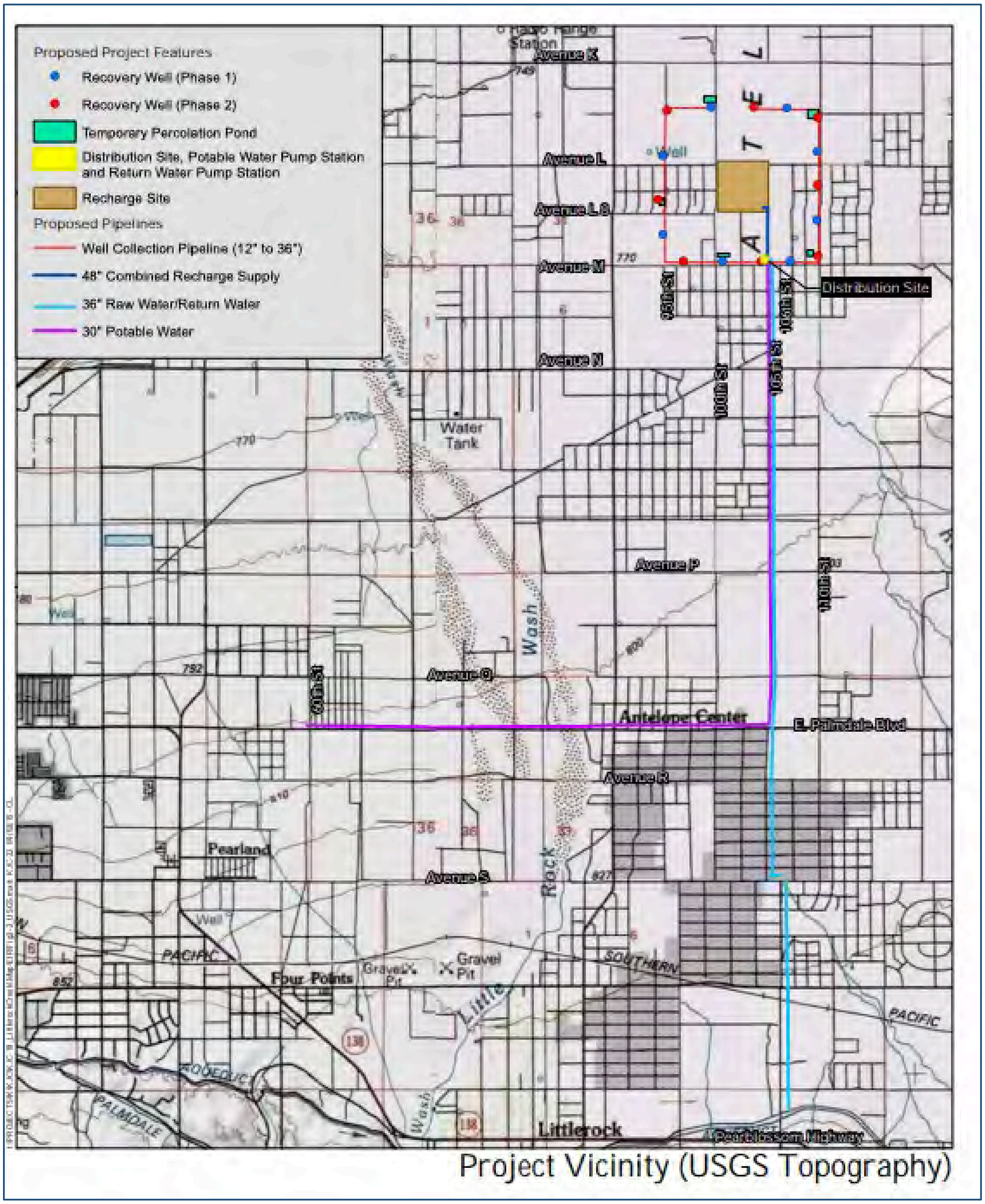

Figure 3. Palmdale Water District's Groundwater Recharge and Recovery Project Site Map[16]

[16] "Palmdale Regional Groundwater Recharge and Recovery Project: Final Environmental Impact Report". *Helix Environmental Planning.* June 2016. See Figure 2-2 Palmdale Regional Groundwater Recharge and Recovery Project page 2-2.

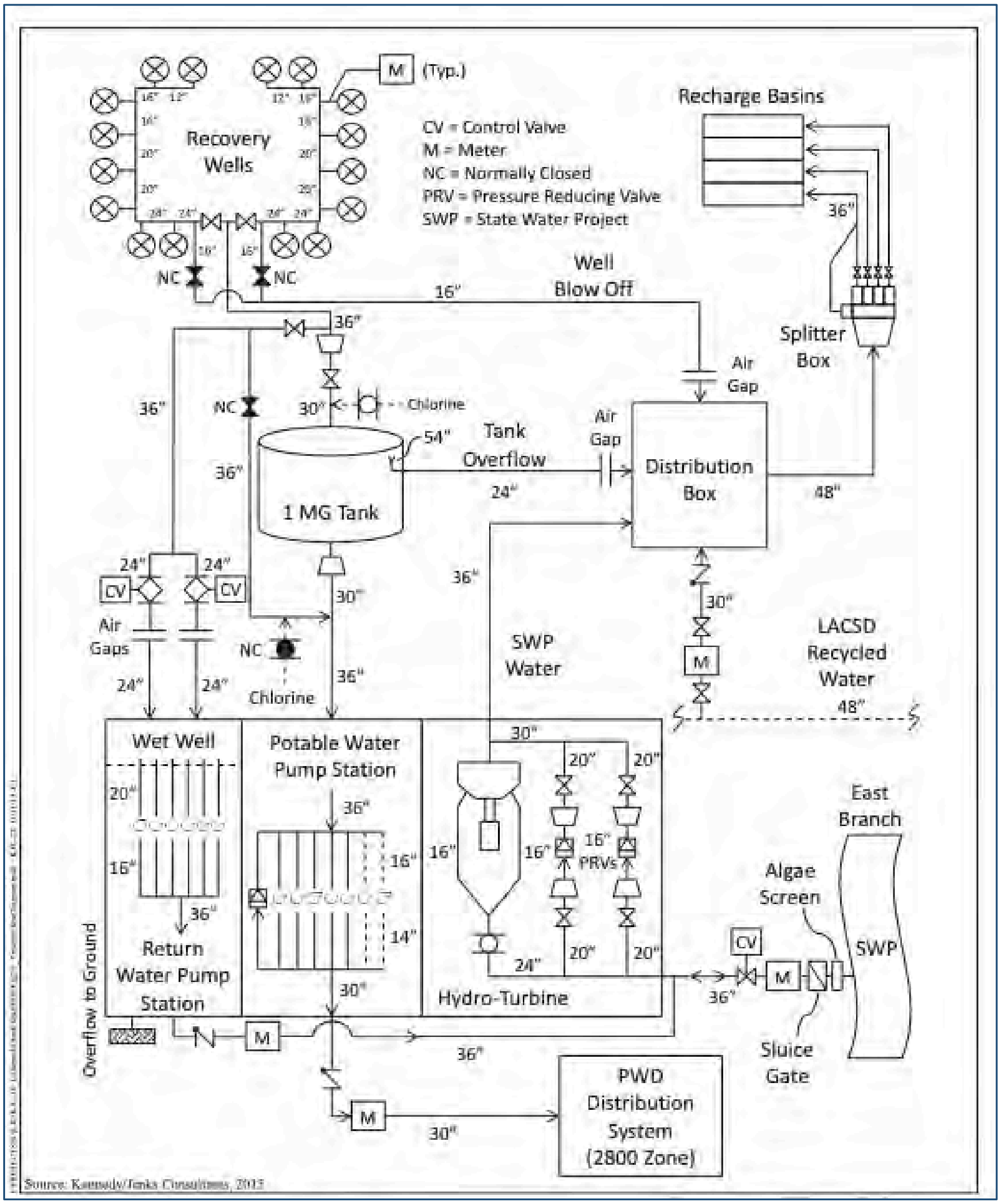

Figure 4. Palmdale Water District's Groundwater Recharge and Recovery Project Process Flow Diagram[17]

[17] "Palmdale Regional Groundwater Recharge and Recovery Project: Final Environmental Impact Report". *Helix Environmental Planning.* June 2016. See Figure 2-5 Palmdale Regional Groundwater Recharge and Recovery Project Process Flow Diagram, p. 2-5.

PWD is also removing 1,165,000 cubic yards of sediment to restore Littlerock Reservoir to its 1992 water storage levels. The Environmental Impact Report (EIR) was completed in March of 2017 and construction of a grade-control structure began in October of 2018. Removing the 1.1 million cubic yards of sediment is expected to take 7 to 12 years to bring water storage capacity back to 3,500 AF. Upon completion, PWD's water supply diversity and flexibility of sources would be further increased.[18]

Flexible Electric Resources Strategies and Innovation

Over the past 10 years, PWD has continued its quest for improvements that increase resource and operating efficiencies while reducing energy costs and financial risks. Particularly notable has been PWD's adoption of market-leading SCADA systems and decision-making tools to empower its operators to identify and implement operational enhancements.

Palmdale Water District's Ten-Year Journey to Build a Best-in-Class SCADA System

- Upgraded Programmable Logic Controllers (PLCs)
- Added Power CT and PT Instrumentation to wells and booster pumps for pump efficiency data
- Added emergency power generation and programming for various electric rate schedules
- Built new control panels in-house
- Replaced and reprogrammed SCADA Packs
- Visited other water districts to view functionality and ease-of-use of Master Station management software options
- Selected new Master Station software and sent several staff for training
- Integrated production and distribution functions into a single SCADA system (previously run on 2 separate systems)
- Upgraded communications system from 900 MHz to 4.9 GHz, substantially increasing speed to real time (also enabled communicating on the U.S. Public Safety Band recommended for water district use by the Department of Homeland Security)
- Installed SCADA Room and SCADA Development Servers
- Continuing testing and reprogramming SCADA Pulse Code Modulation (PCM)
- Calibrated and maintained distribution and treatment plant automation and control
- Purchased and working on deployment of SCADA Watch computer program
- Continuing enhancements of PWD's Human Machine Interface (HMI) to improve operators' ability to make informed real-time decisions.

Sources:

Jeters, Kelly P. "Customer Spotlight: Out with the Old." *Palmdale Water District for The Sage Advisor*. Volume 24, Issue 2, Fall 2014 and Palmdale Water District Operating Budgets for Calendar Years 2018 and 2019.

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[18] Press Release: "Construction Begins at Littlerock Dam, Area Closed to Public." *Palmdale Water District*. October 9, 2018.

The SCADA enhancements have enabled operators to adapt operating plans on a real-time basis to take advantage of opportunities to increase operational efficiencies. The ability to make real-time changes enables increasing operational flexibility.

> <u>For Example</u>: *In the past, PWD used SCADA to set operational limits, upper and lower, with little ability to adjust to changed conditions. Now, operators can tweak the system whenever there is an opportunity to gain some efficiency, with the confidence that they will not be risking mission critical goals and objectives. This is key to increasing resource and operational efficiencies. Optimizing performance requires understanding pump curves, operational means, system demands – all key factors in operational optimization. Once all of this data is understood, the operators need the flexibility to turn each groundwater or booster pump on and off, and choose which ones to run at any point in time.*
>
> *With the enhanced SCADA system:*
>
> - *Operators can re-sequence pumps in the field on the basis of their relative efficiencies.*
> - *Operators can also now measure "baseline" performance of groundwater wells and determine whether and when wells should be rehabilitated.*

The enhanced SCADA system and tools also improved communication, collaboration, and confidence among operations, planning, engineering, and other departments. Operations can now confer with engineering about the potential costs and benefits of operating a part of the system at 60% instead of 90%. Engineering has a hydraulic model that enables simulations, which are very valuable for long-term planning. But, ultimately, the SCADA system enables testing of various operating strategies to calibrate output from the hydraulic model and other planning tools and assures that a proposed operating strategy is capable of achieving the targeted results without taking any undue risks.

Importantly, with real-time information, PWD has the ability to monitor performance degradation over time and identify pumps and wells that need attention before, rather than after, they fail.

Additional Resources and Tools Needed to Effectively Provide Over-generation Mitigation

- **Water Storage.** More storage and booster capacity at PWD's 2950 zone would provide greater flexibility. There is currently a $3 million project in PWD's Water Master Plan that would increase capacity from the WTP to 2950 zone, Currently, it is an unfunded project.
- **Digital Meters.** Many of PWD's metering devices are analog (15+ years old). These need to be converted to digital meters that can communicate with the modernized SCADA system.
- **Real-Time Data.** Now that PWD is able to manage its systems and equipment on a real-time basis, the next step is to sub-meter pumps, treatment plant, and other systems and facilities, and integrate the sub-metered data into the SCADA dashboard. Ideally, PWD would like to integrate SCE's real-time electric meter data and prices so that operators can see the cost per kW and/or AF when they're making equipment changes such as turning a pump or a well on or off, etc.

Recommendations for a Water Sector Electric Reliability Program

PWD has participated in SCE's Agricultural Interruptible Program (API) in the past. Currently, the clearwell booster pumps are enrolled in SCE's Automated Demand Response (Auto-DR) program.

PWD has the following recommendations for a Water Sector Electric Reliability Program.

Table 7. PWD Recommendations for a Water Sector Electric Reliability Program

Challenge	Opportunity Description	Barrier	Recommendation
▪ Historical pricing programs that assess demand charges are a deterrent to water sector participation in electric reliability programs. ▪ The structure of demand charges in traditional customer energy programs contradict the goals of over-generation mitigation that encourage INCREASING electric use during certain hours of the day.	Removing price disincentives, such as facilities demand charges that penalize customers for providing over-generation mitigation support, would enable water and wastewater utilities to produce more Flexible Electric Resources.	The demand charge is a legacy of historical rate regulation. It would require the CPUC, the IOUs, technical service providers, energy program administrators, and many other parties to embrace new, more flexible and appropriate pricing models.	Reduce or eliminate ALL meter-level facilities demand charges: ▪ Annual peak demand ▪ Maximum demand by season and by TOU period ▪ Back-up and Stand-by Services
▪ IOU concerns about potential risks of customers making decisions on the basis of unscrubbed AMI data will delay implementation. ▪ Electric pricing options are becoming increasingly dynamic and complex.	Optimization of water and wastewater resources and systems would benefit significantly by being able to access SCE's AMI data and integrating different types of pricing options so that operators can make better informed decisions about which pumps to dispatch and when.	Although progress is being made, technical barriers remain for directly accessing SCE's real-time (AMI) meter data.	Work with SCE to obtain and integrate real-time electric meter data from SCE's AMI system and information about electric price options into PWD's SCADA system and HMI interface.
PWD does not yet have access to real-time data that would be important to increasing its ability to provide Flexible Electric Resources.	▪ Sub-metering all of the pumps, treatment plant, tanks, and other key infrastructure would significantly	▪ The cost of sub-metering the key systems and equipment and then integrating those points into the SCADA system	Partner with SCE on a technology partnership that would implement sub-metering and integrate the sub-metered data into the SCADA system and

Challenge	Opportunity Description	Barrier	Recommendation
	enhance the ability to optimize operations, and it would also increase the ability to provide Flexible Electric Resources. ▪ PWD also expects submetering would further increase its ability to identify and address equipment degradation in advance of equipment failures.	would be expensive. ▪ Upgrading the SCADA HMI to include energy price information into real-time operational decisions would require additional investments.	upgrade the SCADA HMI to integrate real-time energy cost information into the SCADA dashboard so that operators can consider the energy cost impacts of alternative operating scenarios.
Although the SCADA system helps to monitor pump efficiency, physical (annual, biennial) pump tests are still needed to validate the SCADA system's observations.	SCE's pump tests are valuable in validating pump efficiency curves indicated by the SCADA system.	The CPUC has, in prior years, required the IOUs to reduce pump test services.	Continue partnering with SCE on pump tests.

Palmdale Water District proactively pursues energy and economic efficiency in its operations. The pursuit incorporates continuous evaluation of energy costs; routine analysis and adoption of the best available rate plans; investigation and implementation of energy generation technologies; and careful strategic adjustments to water production and distribution system operations. PWD recognizes that its most important asset in the pursuit of efficiency is its staff. Their knowledge, education, and training are of the utmost importance when looking into new programs. Over-generation is a great example of how the three-pronged strategy can come into play. PWD wants to continue to increase the flexibility of the system, increase awareness of the different possibilities available within the system, and ensure there is buy-in so that over-generation can be implemented successfully.

Appendix E - Flexible Electric Resources: Willow Springs Water Bank (WSWB)

Willow Springs Water Bank (WSWB) is a groundwater recharge, recovery, and banking system located in the adjudicated Antelope Groundwater Basin (the Basin) near Rosamond, California. The Basin spans the northeastern border of Los Angeles County and with the southern border of Kern County. WSWB has embarked upon phased development for up to 1 million acre-feet (MAF) of groundwater banking storage.

Phase	Major Facilities	Year Online
Existing	AVEK West Feeder, 320 acres of ponds, 7 irrigation wells	Now
IA	48” pipe to Los Angeles Aqueduct #2	2020
IB	84” recharge pipe, remainder of percolation ponds	2022
II	16 new wells, 150 cfs lift station (60% of 250 cfs)	2024
III	60 new wells, full lift station, substation, 84” and 48” pipes	2028

WSWB has a visionary approach: that of optimizing the State’s water and energy resources on a coordinated basis through conjunctive use of surface and groundwater resources that are operated in a manner that produces clean, renewable electricity and provides valuable electric reliability support to the statewide electric grid.

This case study describes the types of challenges that are anticipated to implementation of WSWB’s Water-Energy Bank, the considerable benefits that could be achieved, and a proposed path forward.

This case study has been reviewed and approved by Willow Springs Water Bank

Contents

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Acronyms and Abbreviations

AF	Acre-feet
AVEK	Antelope Valley - East Kern Water Agency
CEC	California Energy Commission
CPUC	California Public Utilities Commission
CVP	Central Valley Project
CY	Calendar Year
DER	Distributed Energy Resource
DRP	Distribution Resources Plan
DRPEP	Distribution Resources Plan External Portal
DWR	Department of Water Resources
EBMUD	East Bay Municipal Utility District
EPIC	Electric Program Investment Charge
FY	Fiscal Year
IOU	Investor Owned Utility
kW	kiloWatt
kWh	kiloWatt hour
LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LF	Load Factor
MAF	Million Acre-feet
MW	Megawatt
MWD	Metropolitan Water District of Southern California
NCP	Non-Coincident Peak
PV	Photovoltaic

Acronyms and Abbreviations, continued

SCE	Southern California Edison
SFPUC	San Francisco Public Utilities Commission
SWC	State Water Contractors
SWP	State Water Project
TAF	Thousand Acre-Feet
TRC	Total Resource Cost
WSWB	Willow Springs Water Bank
WY	Water Year

Entity Overview

Willow Springs Water Bank (WSWB, formerly known as the Antelope Valley Water Bank) is located in Kern and Los Angeles counties near Rosamond, California in the adjudicated Antelope Valley Groundwater Basin (Basin 6-044 as defined in Department of Water Resources Bulletin 118). The WSWB has embarked upon a phased plan to develop up to 1 MAF (million acre-feet) of groundwater recharge, recovery, and banking.

Three major aqueducts – the California Aqueduct, the Los Angeles Aqueduct, and the Antelope Valley – East Kern Water Agency – are nearby, providing an opportunity to optimize surface and groundwater resources "conjunctively." WSWB and its technical consultants conducted extensive modeling of a variety of scenarios to estimate the incremental water, energy, climate, ecosystem, and other benefits that might be achievable through optimization of the State's water and energy resources in Antelope Valley.

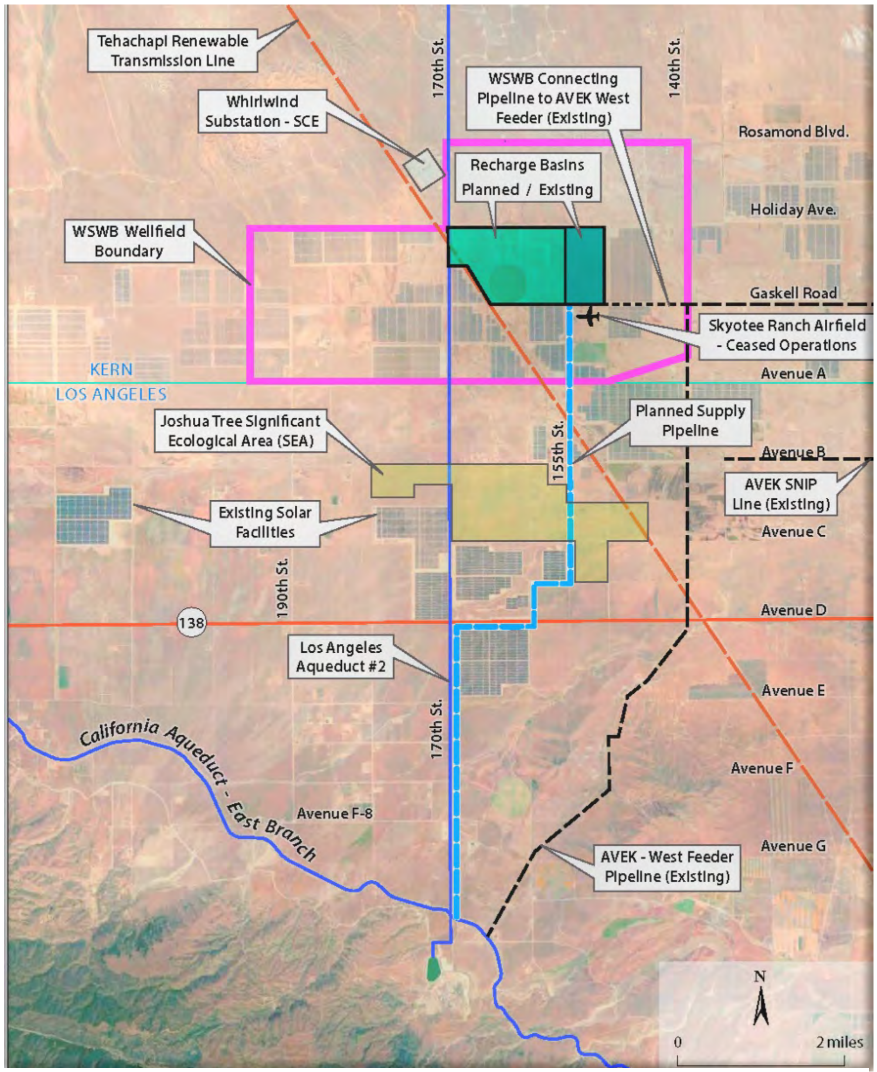

Figure 1. Site of Willow Springs Water Bank Relative to California Aqueduct

This case study describes the types of scenarios evaluated by WSWB, and the types and levels of incremental benefits that they believe could be achieved by adopting a statewide perspective to managing the State's water and power resources.

A Water-Energy Bank

In 2017, WSWB completed a study of "Groundwater Bank Energy Storage Systems" pursuant to an Electric Program Investment Charge (EPIC) grant administered by the California Energy Commission (CEC). This study modeled conceptual operations of a pumped storage hydropower configuration with a groundwater bank serving as the lower reservoir. The study concluded that a pumped storage hydropower configuration of this kind could cost-effectively reduce on-peak electric use. Under some conditions, in-conduit hydropower may also be economic.[1]

> "Conjunctive use" is the coordinated and planned management of both surface and groundwater resources to maximize efficient use of the water resources.
>
> Source: "Glossary." California Department of Water Resources (DWR) website: https://water.ca.gov/Water-Basics/Glossary.

A subsequent study was conducted that estimated the types of water, energy, climate, and other benefits that could be achieved by operating the WSWB conjunctively with the State Water Project (SWP).[2] The operating scenarios were structured to maximize statewide benefits; i.e., instead of focusing on the economic performance of WSWB's operations alone, the second study estimated the net benefits that could be achieved through coordinated ("conjunctive") operations of WSWB and another entity, the State Water Project (SWP).

WSWB's proposed Water-Energy Bank seeks to shift pumping at the SWP's San Luis Reservoir from summer months to winter months by using WSWB groundwater recharge and withdrawals to meet SWP water supply commitments to the State Water Contractors (SWC).[3] In addition, the operating plan contemplated reducing pumping at five SWP pumping plants during peak summer hours.

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[1] Beuhler, Mark, Naheed Iqbal, Zachary Ahinga, and Lon W. House. Antelope Valley Water Storage, LLC. 2017. "Groundwater Bank Energy Storage Systems: A Feasibility Study for Willow Springs Water Bank." *California Energy Commission*. Publication Number: CEC-500-2017-042.

[2] Beuhler, Mark , Naheed Iqbal, Megan Lionberger, Jeffrey Weaver, John Koreny, Jillian Brown, Jamie Lubeck, Ida Fischer, Michael Sontag, Eric Cutter, Mark Cowin, Mark Williamson and Lon House. 2019. "Water-Energy Bank Project. An evaluation of the use of aquifer storage to facilitate reduction of the California State Water Project pumping peak energy use, cost and greenhouse gas emissions." *California Energy Commission*. (Publication Number not yet assigned.)

[3] The State Water Contractors Association is a non-profit association comprised of 27 public water agencies throughout the State of California that purchase water under long term contracts from the State Water Project. Source: "Our Association." *State Water Contractors* website: https://www.swc.org/our-association.

The study evaluated two operating scenarios:

(1) Baseline Spill Capture Scenario: The baseline operating plan representing projected 2030 SWP operations under "business as usual" (BAU, modeled using CalSim II),[4] and

(2) Water-Energy Bank Scenario: Proposed operating plan targeting optimized water, energy, climate, and other statewide benefits through conjunctive use of SWP and WSWB resources and assets. The Water-Energy Bank scenario was modeled using a spreadsheet tool developed by the Study Team. The results of operations under the two scenarios were evaluated under three types of hydrologic years: "wet", "normal", and "dry".[5]

Background and Context

State Water Project

The State Water Project (SWP) is the largest state-built, owned, and operated water project in the U.S. The SWP is comprised of a reservoirs, aqueducts, power plants, and pumping plants that serve 27 million people and irrigate about 750,000 acres of farmland. In addition to serving as the State's primary water conveyance system, transporting water from northern to southern California, the SWP provides flood control, recreation, and fish and wildlife habitat.[6]

The SWP is both a very large user of electric power, and a very large producer. Figure 2 on the next page depicts the pump capacity vs. generating capacity at each SWP facility.

Actual net electric requirements vary widely from one year to the next, based largely on hydrology but also impacted by contracts, laws, regulatory rules, environmental impacts, and other factors. Table 1 below shows SWP's Energy Balance during CY2016:

Table 1. State Water Project Energy Balance During CY2016 (MWh)[7]

Sources of Electricity	MWh Generated, Purchased, Sold
Electricity Generated	3,075,218
Electricity Purchases	4,108,601
Total Electricity Resources	**7,183,819**
Electric Sales	**<579,934>**
Total Electricity Used	**6,603,885**

[4] CalSim-II is the State's model used to simulate State Water Project and Central Valley Project operations. [Source: "CalSim 2 Model." DWR website: http://baydeltaoffice.water.ca.gov/modeling/hydrology/CalSim/index.cfm]

[5] Characteristics of the different types of hydrologic water years were determined by DWR's Sacramento Valley Water Year Index. [Source: Buehler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank* for California Energy Commission Grant No. EPC 16-029. Table 3-1. Summary of hydrologic water year type classifications according to the Sacramento Valley Water Year Index, p.33.]

[6] "State Water Project." Department of Water Resources (DWR) website: https://water.ca.gov/Programs/State-Water-Project.

[7] "Management of the California State Water Project." DWR Bulletin 132-17. January 2019. See Table 10-2 Energy Generated and Purchased in 2016, by Month (megawatt-hours) on p.217. [Note: CY2016 is the most recent power data available for the SWP.]

More than 1,300 MW is needed to lift SWP water over the Tehachapis to southern California at an average energy intensity of 3,412 kWh/AF.[8]

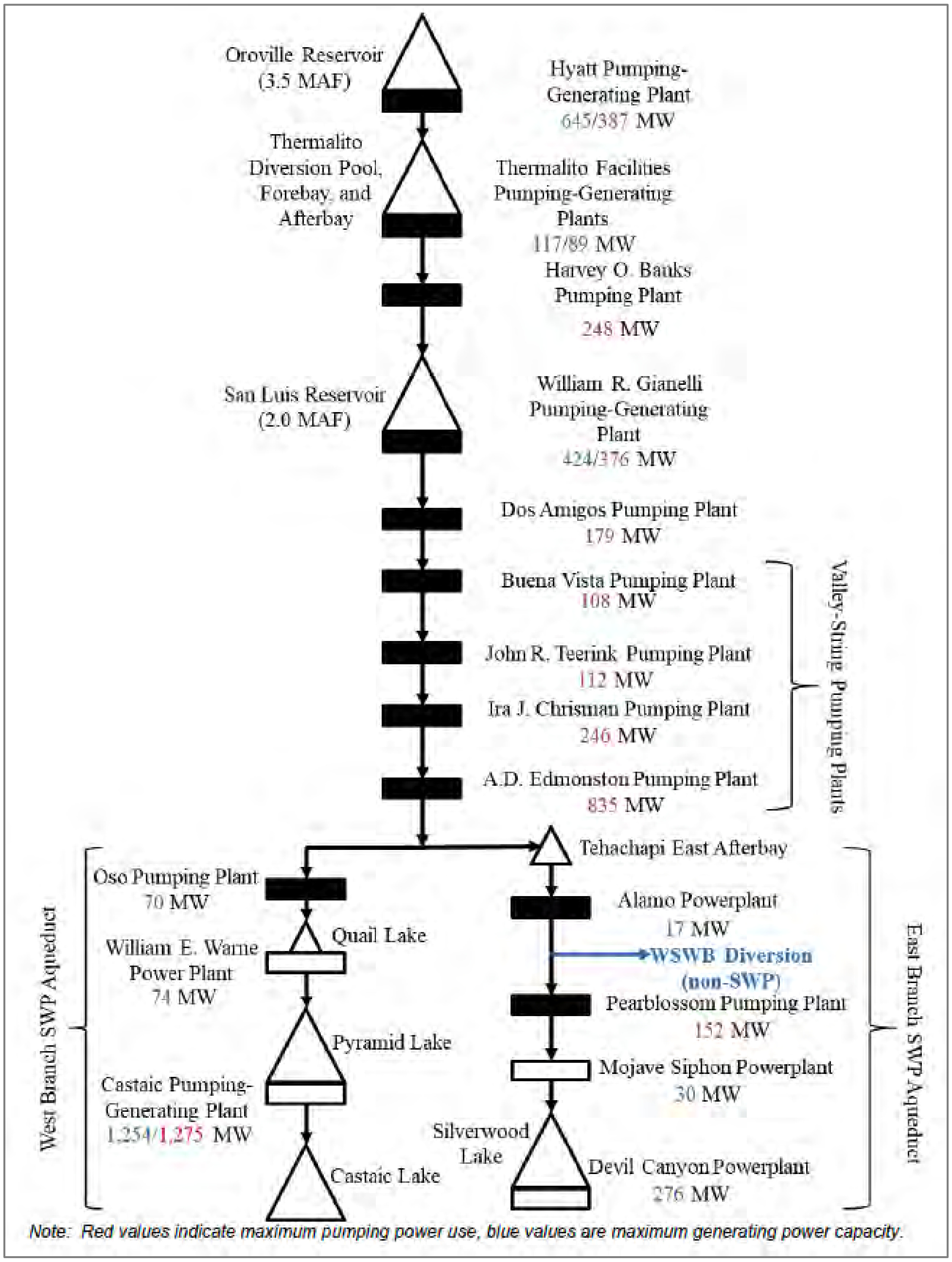

Figure 2. Pumping Capacity vs. Generation Capacity at State Water Project Facilities[9]

[8] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank* for California Energy Commission Grant No. EPC 16-029. See Table 2. Embedded Energy through Valley String Pumping Plants.

[9] Id. See Figure 2-3. Schematic of SWP Facilities with maximum pumping4 and generating capacities on p.18.

Willow Springs Water Bank (WSWB)

WSWB has embarked upon phased development of 1 MAF (one million acre-feet)[10] of groundwater storage. Figure 3 below depicts WSWB's planned operation of its groundwater bank.

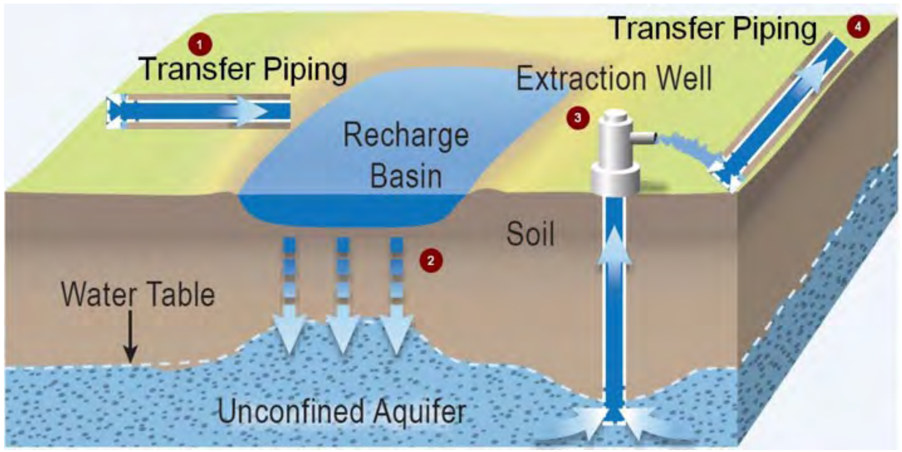

Figure 3. Willow Springs Water Bank Planned Groundwater Operations[11]

Planned Operations at Full Build-Out:

- Recharge 280,000 acre-feet/year (AFY)
- Withdraw 225,000 AFY

The Water-Energy Bank

WSWB proposes to operate conjunctively with the State Water Project (SWP) to maximize statewide water, energy, climate, environmental, and other benefits. Specifically, WSWB proposes operating its groundwater aquifer in a pumped-storage configuration that utilizes the SWP's San Luis Reservoir as the upper reservoir, and WSWB as the lower reservoir. (See Figure 4 on the next page.) When operated conjunctively in this pumped-storage configuration, WSWB anticipates being able to help SWP shift a significant portion of its summer electric requirements to fall and spring with no adverse impacts on SWP's contractual water deliveries. A seasonal shift of electric use from summer to fall and spring could increase statewide electric reliability by:

- Reducing electric demand during periods when the State is electric supply short (summer on-peak periods), and

[10] One million acre-feet is equivalent to 325.851 billion gallons.

[11] "Water-Energy Bank 'Proof-of-Concept'." DWR image from powerpoint presentation by Mark Beuhler, General Manager of Willow Springs Water Bank to Southern California Edison. June 19, 2019.

- Increasing electric demand during periods when the State has substantial quantities of surplus electricity (during fall and spring days when real-time electric supplies exceed real-time electric demand, known as "over-generation" or "over-supply").

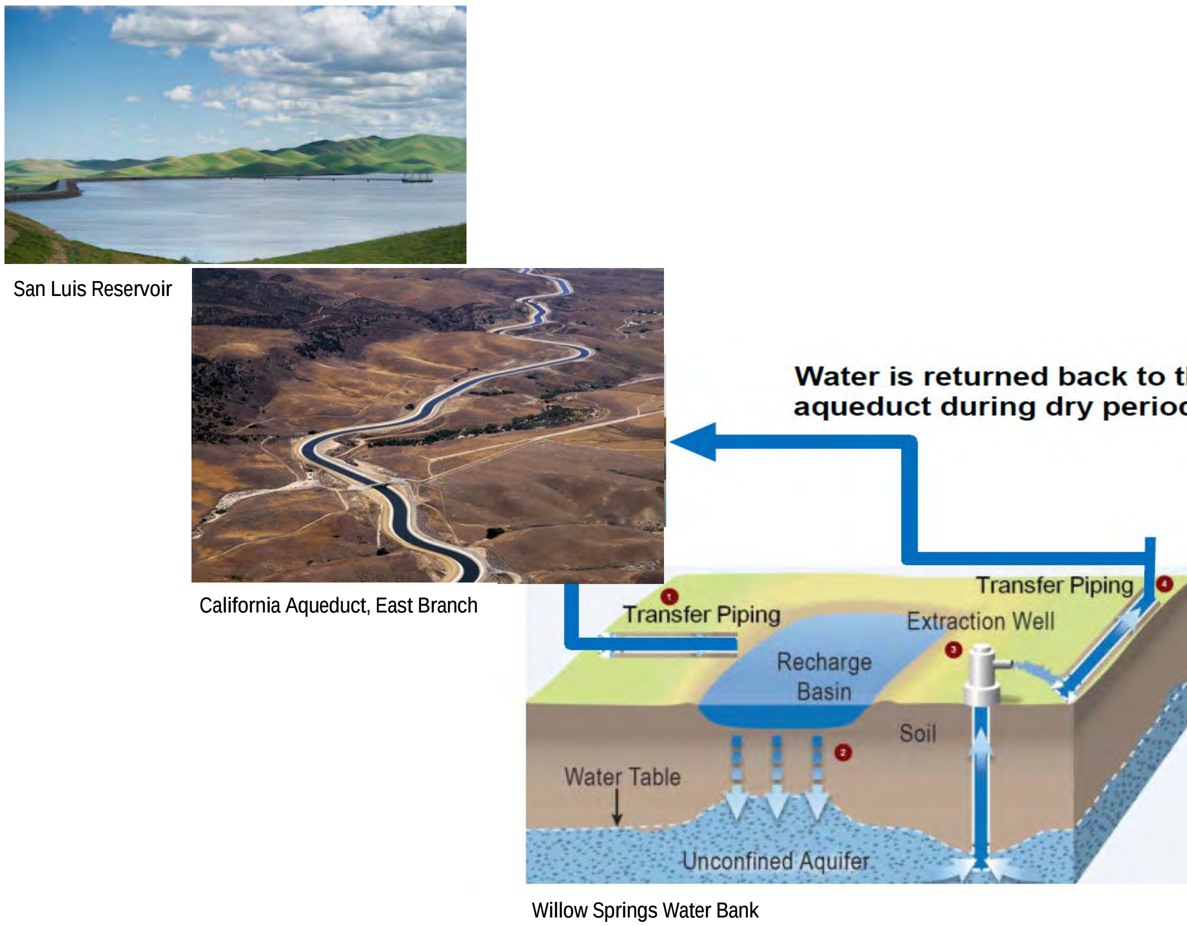

Figure 4. Proposed Water-Energy Bank Operations[12]

Note that the SWP already optimizes pumping operations to minimize electric use during summer peak periods. They do this by pumping at maximum capacity during off-peak hours and reducing pumping to zero during on-peak hours. The SWP's ability to optimize its operations from an energy perspective is constrained by its contractual obligations to deliver water supplies to the State Water Contractors (SWC).[13] A diagram illustrating SWP's typical operating schedule is provided on the next page (Figure 5).

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[12] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank* for California Energy Commission Grant No. EPC 16-029. See Figure 2-7. Schematic of WSWB Aquifer Recharge, Storage and Recovery Operations on p.26; added photos of San Luis Reservoir and East Branch of the California Aqueduct. Graphic image and photos courtesy of DWR.

[13] "Water-Energy Bank 'Proof-of-Concept'." Powerpoint presentation by Mark Beuhler, General Manager of Willow Springs Water Bank to Southern California Edison. June 19, 2019. Slide 13.

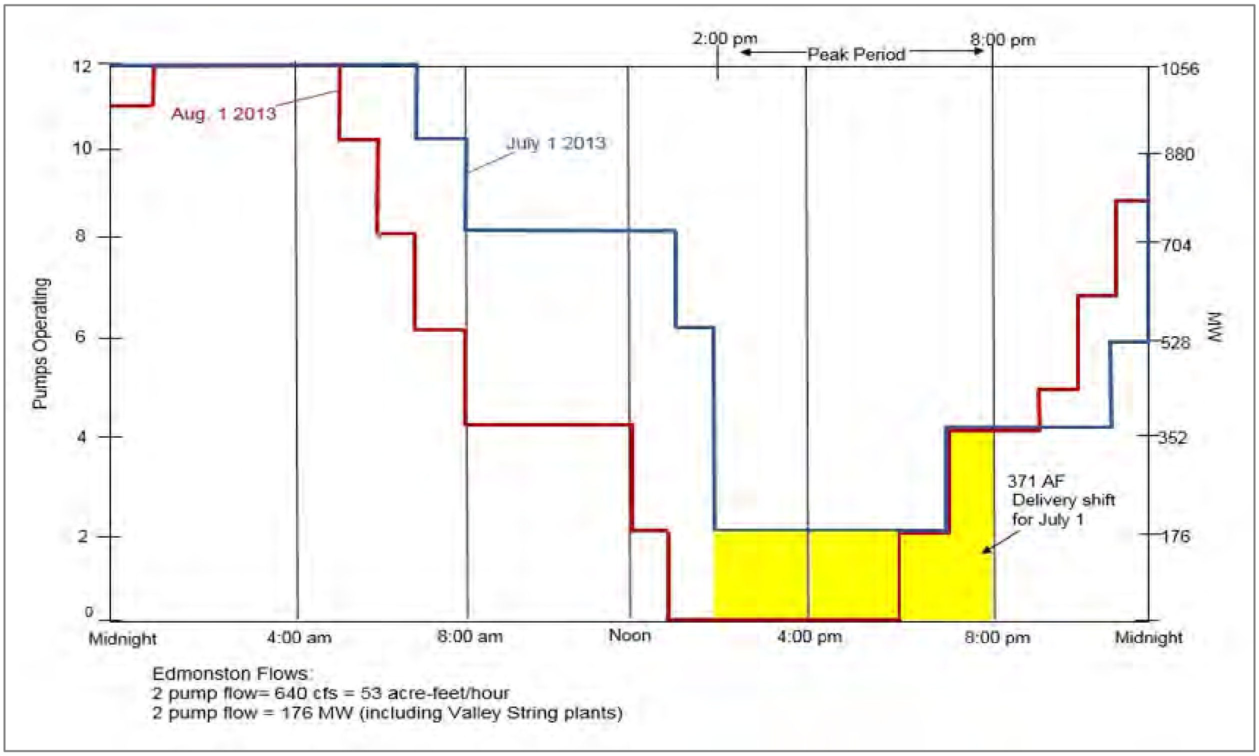

Figure 5. Diurnal Flows at Edmonston Pumping Plant

Edmonston Pumping Plant provides the largest lift, nearly 2,000 vertical feet, in the SWP system.[14] The Plant has 14 x 80,000 hp centrifugal pumps. During CY2016, Edmonston Pumping plant alone used nearly 3 million MWh.[15]

WSWB proposes to achieve a substantial seasonal shift in electric use through two key changes to the SWP's existing operations protocols:

1. During spring months, WSWB will receive surplus water from SWP's San Luis Reservoir.
2. Instead of pumping SWP resources to southern California during summer months, SWP summer water deliveries will be met by extracting water from WSWB.

Figure 6 on the next page shows the results of the simulated operational changes using CalSim II.

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[14] "State Water Project Facilities." *DWR* website: https://water.ca.gov/Programs/State-Water-Project/SWP-Facilities.

[15] "Management of the California State Water Project." DWR Bulletin 132-17. January 2019. See Table 10-1 Energy Used at Pumping Plants and Power Plants in 2016, by Month (megawatt-hours) on p.216.

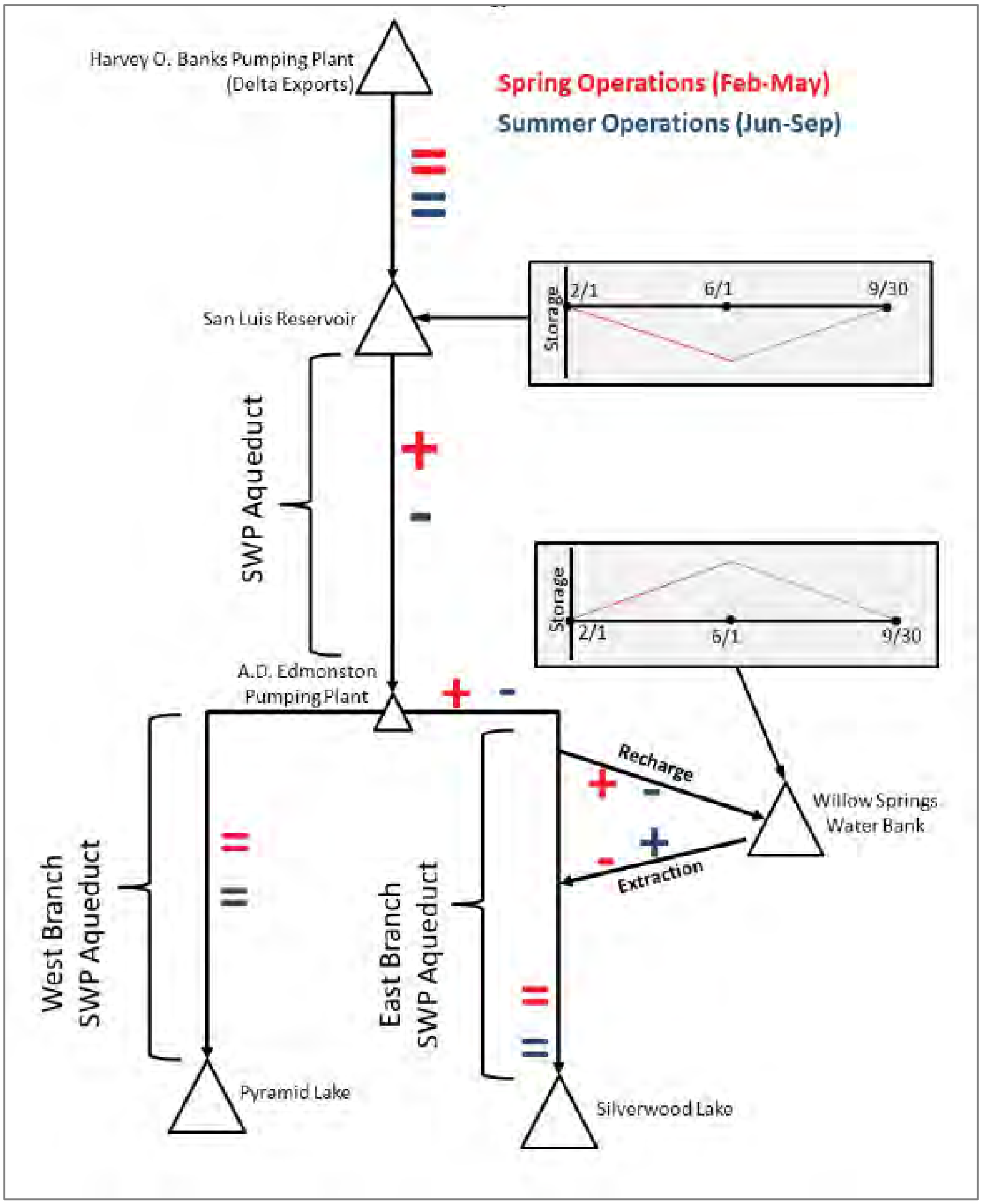

Figure 6. Schematic Showing Simulated Seasonal Changes in SWP Operations Between the Baseline and Water-Energy Bank Scenarios[16]

Figure 7 on the next page illustrates the monthly operations of the WSWB's Water-Energy Bank by Hydrologic Year.

[16] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank* for California Energy Commission Grant No. EPC 16-029. See Figure 3 of the same name on p.11.

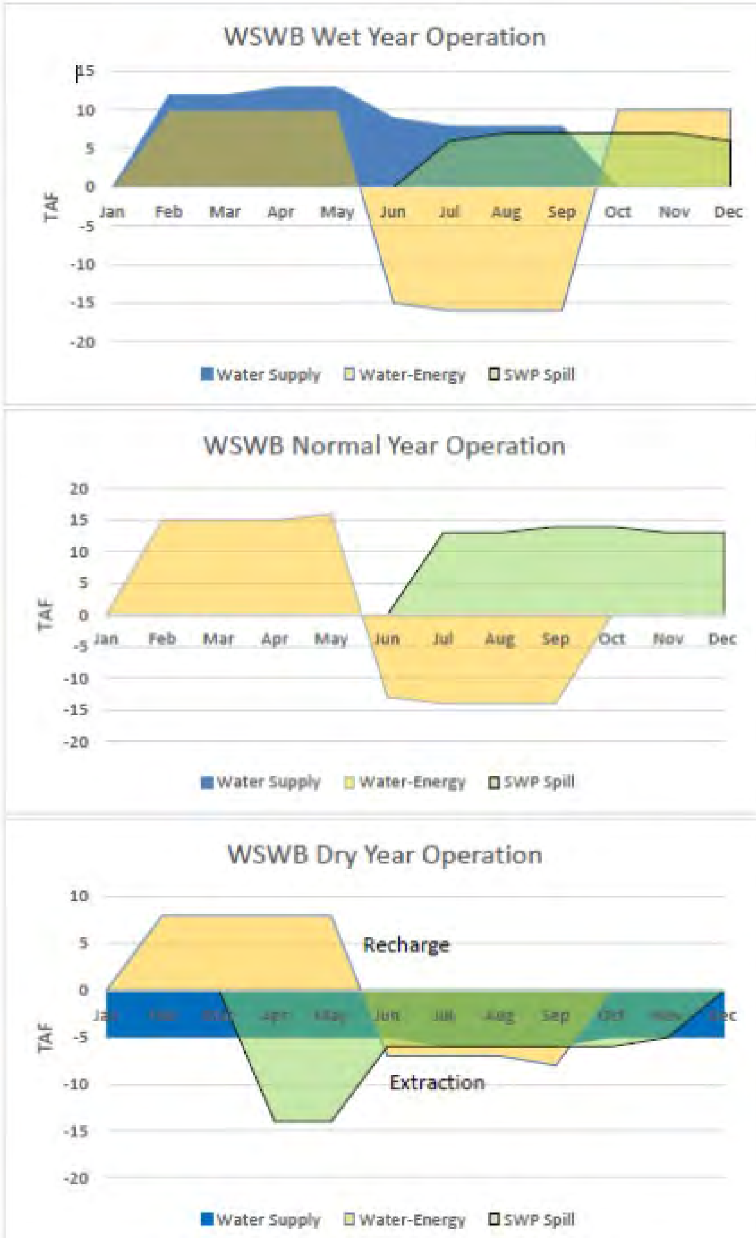

Figure 7. WSWB Monthly Water-Energy Bank Operations by Type of Water Year[17]

Figure 8 on the next page visually depicts the seasonal shift in SWP electric use that was achieved under the Water-Energy Bank operating protocol (solid green line) relative to "typical"

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[17] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank* for California Energy Commission Grant No. EPC 16-029. See Figure 5-3 Monthly Operations of WSWB by Hydrologic Year on page 71.

SWP operations. Hydrology data for water year 1940 (a nearly "normal" hydrology year) was used for this simulation.

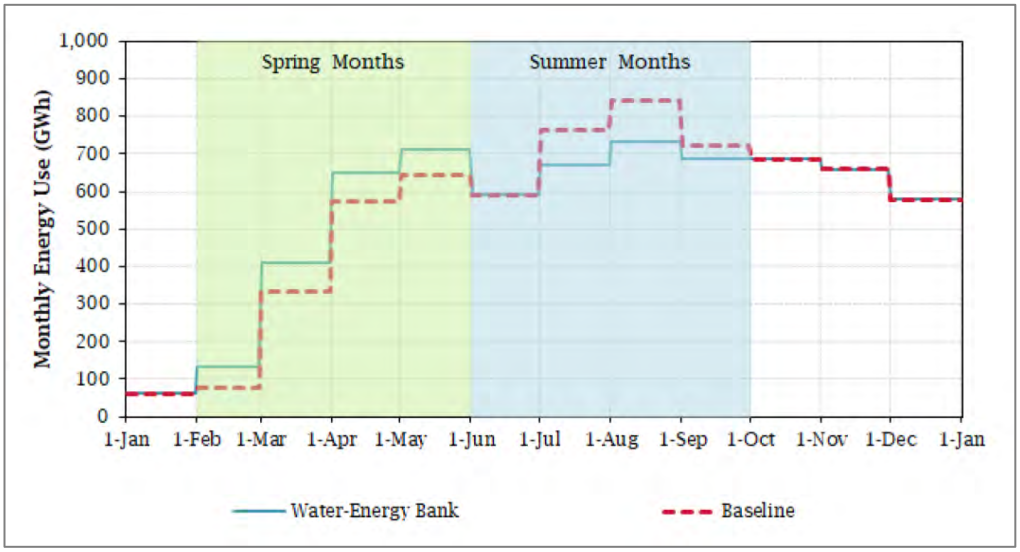

Figure 8. Baseline vs Water-Energy Bank Operations, "Normal" Water Year[18]

Figure 9 below and Figure 10 on the next page show the results by type of water year.

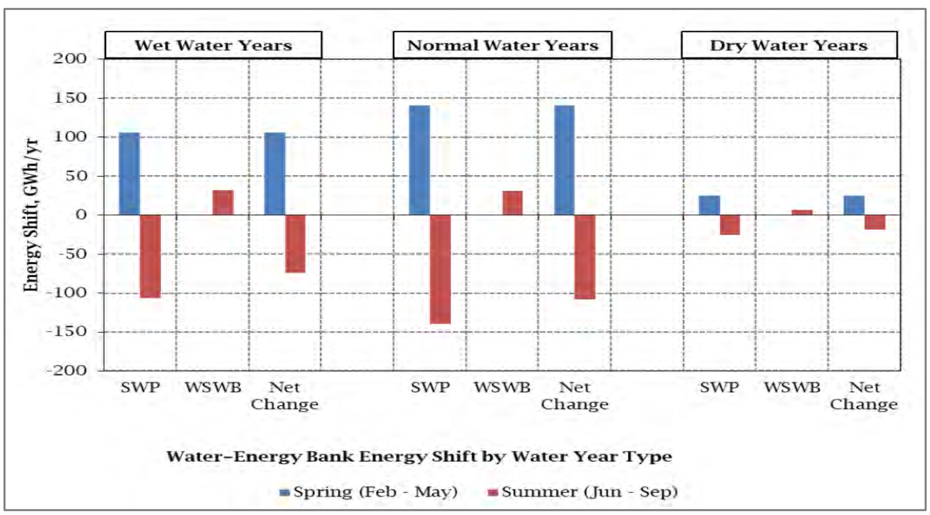

Figure 9. Seasonal Electric Shifts for Water-Energy Bank Operations by Type of Hydrology Year[19]

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[18] Beuhler, Mark , Naheed Iqbal, Megan Lionberger, Jeffrey Weaver, John Koreny, Jillian Brown, Jamie Lubeck, Ida Fischer, Michael Sontag, Eric Cutter, Mark Cowin, Mark Williamson and Lon House. 2019. "Water-Energy Bank Project. An evaluation of the use of aquifer storage to facilitate reduction of the California State Water Project pumping peak energy use, cost and greenhouse gas emissions." *California Energy Commission*. (Publication Number not yet assigned.) See Figure 13: Example Year 1940 Net Energy Use to Convey Water Between San Luis Reservoir and WSWB for the Baseline and Water-Energy Bank Scenarios on p.28.

[19] Id. See Figure 16: Water-Energy Bank Scenario Annual Average Seasonal Energy Shift from the Baseline to Water-Energy Bank Scenario on p.32.

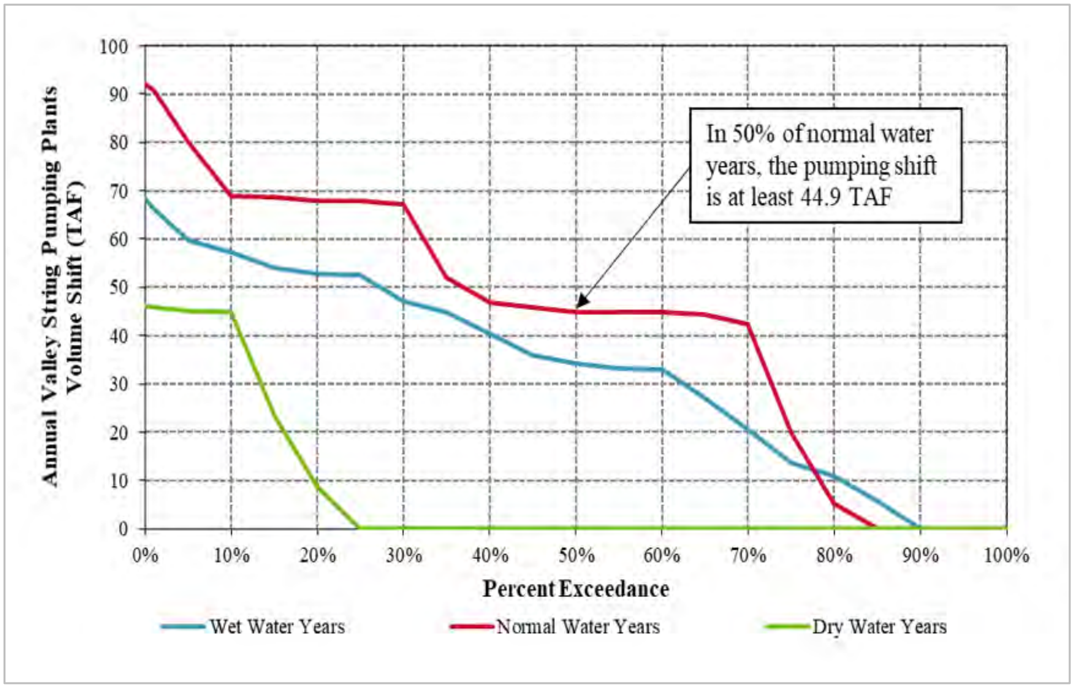

Figure 10. Percent of Exceedance of Water-Energy Bank Operations by Type of Water Year[20]

- Normal Water Years have the most potential for electric shift (44.9 TAF at 50% exceedance).
- During Wet Years, pumps need to be on to move enough water.
- During Dry Years, not much can be done differently than DWR's present operations.

If future operations mimic the past 10 years, the peak load shift potential is 208 MW.

Water-Energy Bank Economic Evaluation

The WSWB project team developed two Avoided Cost Frameworks for evaluating the net economic benefits of the proposed Water-Energy Bank:

1. The first framework emulated the CPUC's adopted framework for evaluating Distributed Energy Resources (DERs).
2. The second framework used the CPUC's Integrated Resource Planning (IRP) framework in conjunction with E3's RESOLVE power system operations and dispatch model (linear program) to compute Total Resource Cost (TRC). RESOLVE seeks to minimize operational and investment costs over a defined time period. RESOLVE was used in conjunction with

[20] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." *Willow Springs Water Bank* for California Energy Commission Grant No. EPC 16-029. See Figure 4-1 Annual valley-string pumping plant volume shift out of summer months, by percent exceedance and water year type (page 60).

AURORA, a third-party simulation modeling software that enables simulating hourly electric grid dispatches to estimate wholesale energy market prices.[21]

Three scenarios of renewable energy curtailments – low, mid, and high – were used to evaluate the range of potential economic benefits.

The results of the two economic analyses – DER vs. TRC – are shown in Figure 11 below.

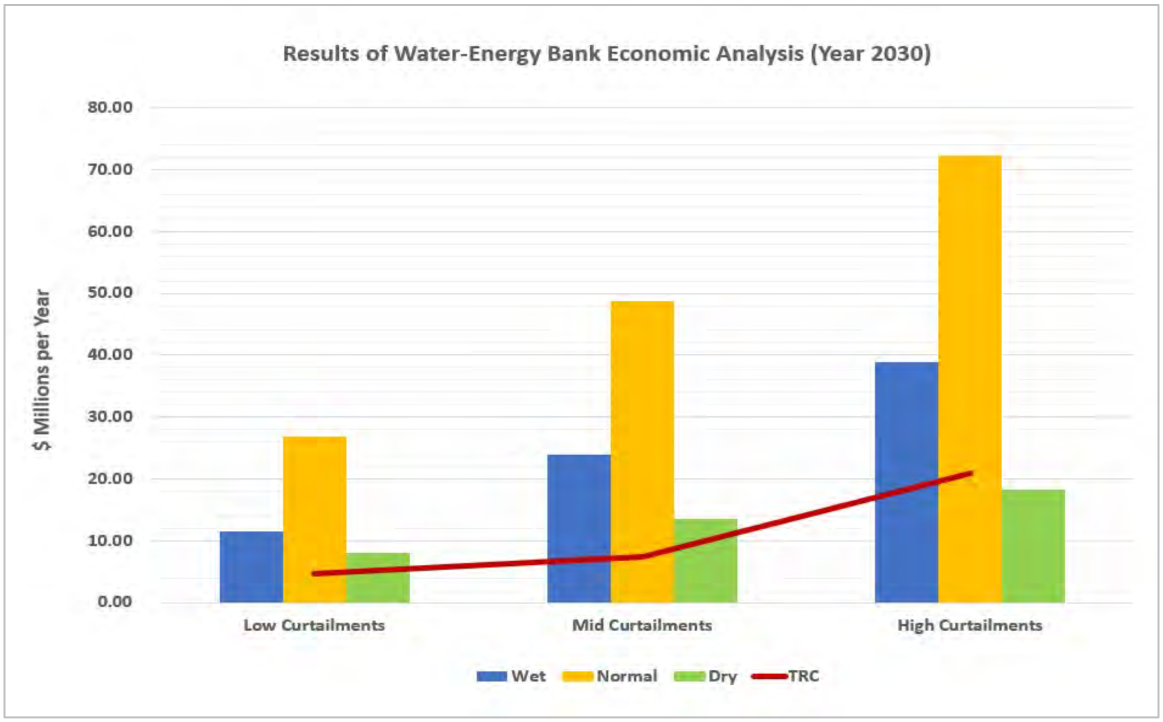

Figure 11. Results of Water-Energy Bank Economic Analysis (Year 2030): CPUC DER vs. TRC Methodologies

Table 2 below shows the values in $Millions per Year that were used to produce the above graph.

Table 2. Results of Water-Energy Bank Economic Evaluation for CY2030 ($Millions)[22]

Methodology	Hydrology	Low Curtailments	Mid Curtailments	High Curtailments
Avoided Cost of Distributed Energy Resources (DERs)	**Wet**	11.51	23.93	38.94
	Normal	26.82	48.76	72.24
	Dry	8.00	13.54	18.31
Integrated Resource Planning (IRP)	**Total Resource Cost (TRC)**	4.60	7.40	20.90

[21] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." Willow Springs Water Bank for California Energy Commission Grant No. EPC 16-029. See Chapters 3.3 Development of Wholesale Energy Price Forecasts (page 39) and 3.5 Economic Evaluation with Avoided Costs Framework (pages 50-58).

[22] Id. See Table 6: Water-Energy Bank Analysis Results Summary for the Year 2030 on pages 50-51.

As can be seen in Figure 11 and Table 2, the TRC methodology yields a much more conservative value than the DER avoided cost methodology.

> "*The combined benefit streams in the Avoided Cost Framework show a large discrepancy in value between water years; the different curtailment scenarios exaggerate this discrepancy even further (Figure 23). Normal water years are potentially the most beneficial, when surplus operational flexibility is the greatest, while dry years exhibit the least potential benefit. The benefit streams based on peak load reduction, generation capacity and transmission deferral contribute the most to the overall potential value of the Water-Energy Bank. Generation capacity and transmission deferral benefit streams are significantly greater than avoided energy costs, meaning the Water-Energy Bank will need to provide verifiable peak load reductions to the system to realize its full benefit.*
>
> "*The RESOLVE Framework exhibits lesser total resource cost savings (and therefore lesser calculated benefit of the Water-Energy Bank) than the Avoided Cost Framework because RESOLVE represents fewer capacity-based values. The transmission and deferral value in the Avoided Cost Framework is location-specific. However, the RESOLVE Framework does not represent this same value because the model does not evaluate transmission costs within load balancing regions (geographic regions that balance energy supply and demand). Furthermore, with new energy storage, solar and other renewable generation, RESOLVE forecasts a surplus of generation capacity resources on the system. The excess of generation capacity resources drives down the value of generation capacity in the RESOLVE Framework and exhibits a lesser overall value compared to the Avoided Cost Framework.*"[23]

Summary of Findings

1. Shifting SWP pumping out of peak periods with high electric costs appears feasible.
2. The most significant potential benefits are generation capacity, transmission deferral, and demand response.
3. Under the CPUC's avoided cost analysis framework for Distributed Energy Resources (DERs), the average total avoided cost value for the low-, mid- and high-curtailment scenarios were $12.6, $23.1, and $38.0 million per year, respectively.
4. Under the RESOLVE framework, the average total avoided cost value (TRC perspective) for the low-, mid- and high-curtailment scenarios were $4.6, $7.4, and $20.9 million per year, respectively.

[23] Beuhler, Mark, et. al. "Technical Report Water-Energy Bank Project." Willow Springs Water Bank for California Energy Commission Grant No. EPC 16-029. See discussion about the results of the economic analyses on page 51.

Recommendation[24]

The strategies identified through this project to shift imported water deliveries out of high priced electric peak periods via a pumped storage configuration with groundwater aquifers as the lower reservoir and surface water systems as the upper reservoirs can be applied throughout California.

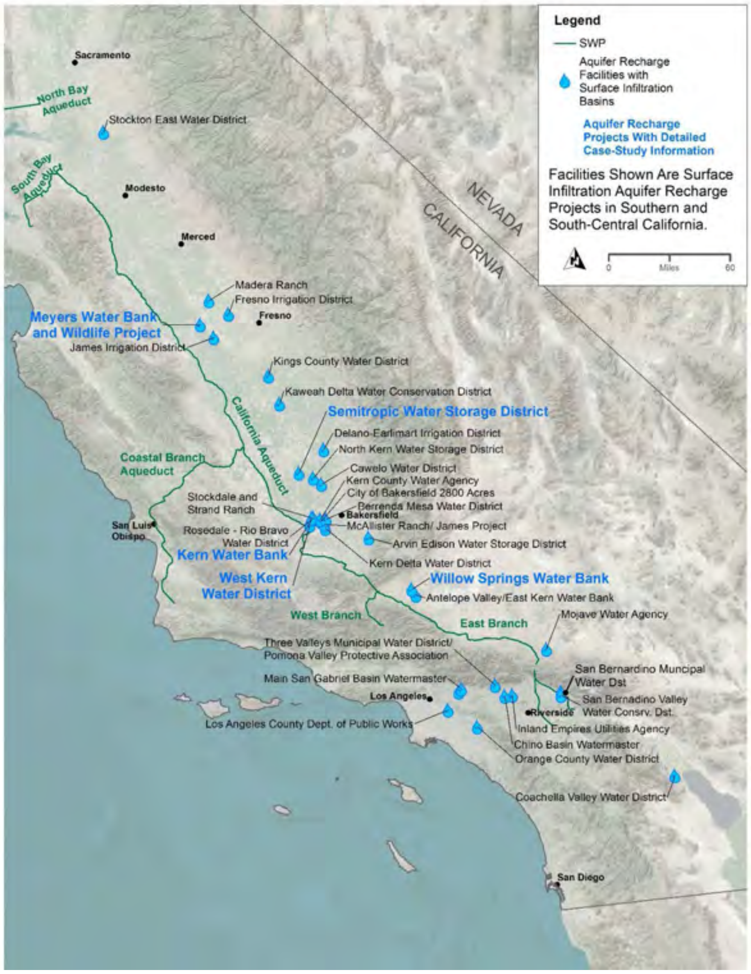

Figure 12. Candidate Groundwater Banks[25]

Opportunities to shift imported water deliveries out of electric peak periods via groundwater storage include:

1. Shift timing of pumping or generation in other aqueduct systems. The combined capacity of the Los Angeles (1,000 cfs) and Colorado River Aqueducts (1,700 cfs) exceed the 2,010 cfs SWP East Branch at Pearblossom Pump Station by 34%.
2. The storage capacity of other groundwater banks in different aquifers total about 3.2 million acre-feet/year in recharge capacity, about 11 times the size of WSWB.
3. In addition, many agricultural wells throughout the State's Central Valley may be candidates.

Potential aqueducts that can be leveraged for Demand Response are shown on Table 3 on the next page.

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[24] "Water-Energy Bank 'Proof-of-Concept'." Powerpoint presentation by Mark Buehler, General Manager of Willow Springs Water Bank to Southern California Edison. June 19, 2019. Slides 23-25.

[25] Id. Slide 23.

Table 3. Aqueducts that May Be Candidates for Demand Response[26]

Aqueduct	Type	Units	Power*	Embedded Unit Energy	Upper/Lower Reservoir (TAF/TAF)
California Aqueduct [SWP]	Lift	12	1,080 MW	3,200 kWh/AF	San Luis/Castaic & Perris [2,010/325]
Colorado River Aqueduct (1700 cfs) [MWD]	Lift	8	275 MW	2,000 kWh/AF	Mead/Matthews [26, 100/325]
Los Angeles #1 (422 cfs) [LADWP]	Drop	3	122 MW	1,500 kWh/AF	Bouquet/none [34/0]
Hetch Hetchy [SFPUC]	Drop	3	384 MW	TBD	H.Hetchy/Calaveras [360/100]
Mokelumne [EBMUD]	Drop	5	34 MW	TBD	Pardee/Briones et al [198/155]
		Grand Total	**1,895 MW**		

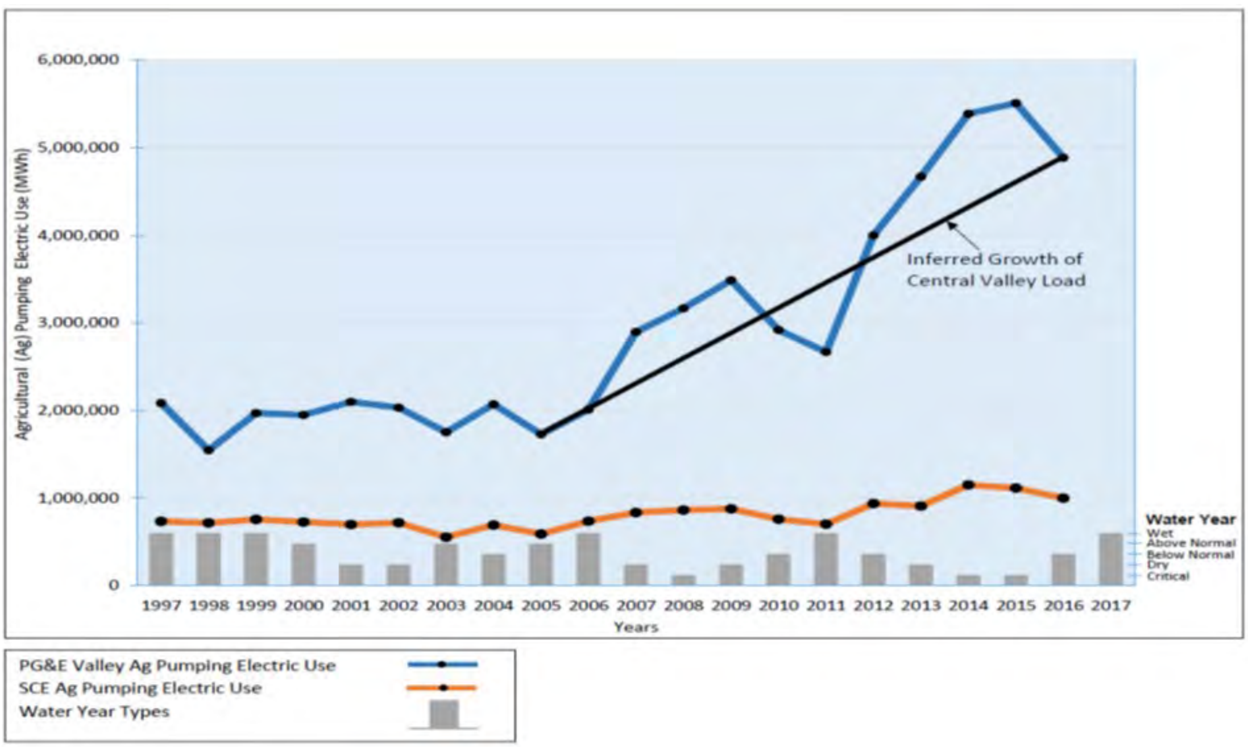

Figure 13. Potential DR with Agricultural Wells[27]

[26] "Water-Energy Bank 'Proof-of-Concept'." Powerpoint presentation by Mark Beuhler, General Manager of Willow Springs Water Bank to Southern California Edison. June 19, 2019. Slide 24.

[27] Id. Slide 25.

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Appendix F - Flexible Electric Resources: Cucamonga Valley Water District

Photo Courtesy of Cucamonga Valley Water District).

Cucamonga Valley Water District (CVWD) provides "high quality, safe and reliable water and wastewater services, while practicing good stewardship of natural and financial resources."[1] The District has long valued innovative solution-based ideas and continually encourages collaborative partnerships to approach problem solving.

- In 2005, CVWD received accolades for using Itron's fixed network meter reading technology and was the first in the nation to try their advanced leak detection software. The software helped detect a leak that was measured to be 86,000 gallons of water per month.[2]
- In 2012, the District participated in Southern California Edison's Automated Demand Response Program (ADR) via Honeywell's aggregation program, shedding 5.3 megawatts over a two-hour period when requested by SCE. CVWD received an initial participation rebate of $400,000 and saved $80,000 per year by shedding load during peak periods.[3]
- Between 2016 and 2018, the District worked collaboratively with Southern California Edison, Lincus, and Los Angeles County to optimize pump energy efficiency by rehabilitating pumps and implementing pump sequencing and zone optimization. These projects reduced the District's annual electric use by 4.2 million kWh and reduced peak electric demand by 270 kW, reducing annual energy costs by $550,000. Incentives from SCE's energy programs reduced the $1 million project costs by $265,000, yielding a simple payback of 1.3 years.[4]

This case study highlights CVWD's innovative energy management practices including a research grant with the University of California Riverside that is optimizing the District's pumping through a customized SCADA-integrated Energy Management System (EMS).

This case study was reviewed and approved by Cucamonga Valley Water District.

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[1] "About Us." *Cucamonga Valley Water District* website: https://www.cvwdwater.com/35/About-Us.

[2] "Cucamonga Calif., water district shows early success with Itron's fixed network." *WaterWorld.* Sept. 12, 2005.

[3] "Project Profile: Cucamonga Valley Water District." *Honeywell.* August 2012.

[4] "Production and Energy Management Strategies." *Cucamonga Valley Water District.* Slides Presented to Vistage July 11, 2019.

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Acronyms and Abbreviations

ADR	Automated Demand Response
AF	Acre-Feet
CEC	California Energy Commission
CIP	Capital Improvement Program/Plan
CPUC	California Public Utilities Commission
CVWD	Cucamonga Valley Water District
CY	Calendar Year
DR	Demand Response
EMS	Energy Management System
FY	Fiscal Year
GPM	Gallons Per Minute
IEUA	Inland Empire Utilities Agency
IOU	Investor Owned Utility
kW	kiloWatt
kWh	kiloWatt hour
LF	Load Factor
MW	Megawatt
MWh	Megawatt hour
NCP	Non-Coincident Peak
SCADA	Supervisory Controls and Data Acquisition
SCE	Southern California Edison
SWEMS	SCADA-integrated Water-Energy Management System
TOU	Time-of-Use
UCR	University of California at Riverside

Agency Overview

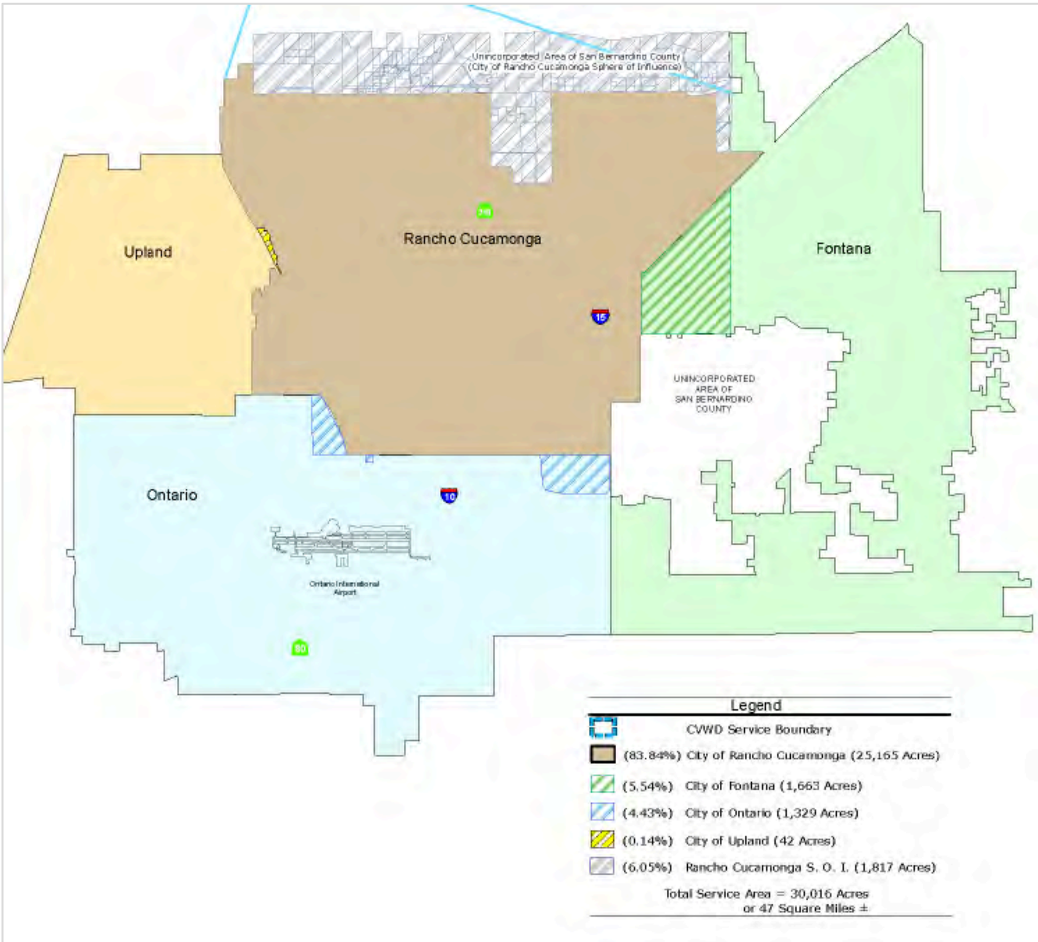

Figure 1. Cucamonga Valley Water District's Service Area[5]

Cucamonga Valley Water District (CVWD) provides water, wastewater, and recycled water services to 190,000 customers within a 47 square mile area that includes the City of Rancho Cucamonga and portions of Fontana, Ontario, Upland and unincorporated areas of San Bernardino County.[6] The District articulates its values in context of three essential components —people, service and water.

1. People are innovative, empowered and provide exceptional customer service;
2. The District is a servant-oriented organization providing Service Beyond Expectations to all customers; and
3. The District provides high quality, sustainable water supply that is safe, reliable and delivered at a cost-effective price.[7]

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[5] "Forms, Plans & Maps." *Cucamonga Valley Water District* website: https://www.cvwdwater.com/DocumentCenter/View/129/Service-Boundary-Map.

[6] "About Us." *Cucamonga Valley Water District* website: https://www.cvwdwater.com/35/About-Us.

[7] "About Us." *Cucamonga Valley Water District* website: https://www.cvwdwater.com/35/About-Us.

CVWD's water supply is provided from the following sources:[8]

- ***Imported Water*.** The District purchases water from Inland Empire Utilities Agency (IEUA), a member agency of Metropolitan Water District (MWD). Imported water accounts for about 47% of the District's supply.
- ***Local Canyon Sources.*** Sources include Cucamonga Canyon, Day/East Canyon, Deer Canyon, Lytle Creek, Smith Canyon Group, and the Golf Course Tunnel; however, the main three sources are Cucamonga, Deer, and Day/East Canyons. Local Canyon water accounts for approximately 6.5% of the District's total supply
- ***Groundwater.*** The District obtains groundwater from the Chino Basin and the Cucamonga Basin. Groundwater accounts for about 45% of the District's total supply.
- ***Recycled Water.*** IEUA recharges recycled water in Chino Basin and CVWD has a share based on its contribution to wastewater influent. The District's recycled water supply is small, averaging 1.6% of its total supply between 2005 and 2015.

Facilities Overview

Table 1 below provides a snapshot of the District's facilities.

Table 1. Cucamonga Valley Water District's Facilities[9]

Facilities	
3 Surface Water Treatment Facilities	22 Booster Stations
13 Pressure Zones (8 primary)	7 Disinfection Systems
24 Reservoir Sites	29 Wells (20 operating)
35 Reservoirs	3 Imported Water Connections
95 Million Gallons of Storage	33 Pressure Reducing Valves
703 Miles of Pipeline	

The District collects wastewater and transports it to the regional wastewater treatment utility, Inland Empire Utilities Agency (IEUA). Figure 2 on the next page depicts the District's potable and recycled water distribution system.

[8] "2015 Urban Water Management Plan." *Cucamonga Valley Water District.* Page 39.

[9] "Annual Opereating and Capital Improvement Budget for FY Ending June 30, 2018." *Cucamonga Valley Water District.*

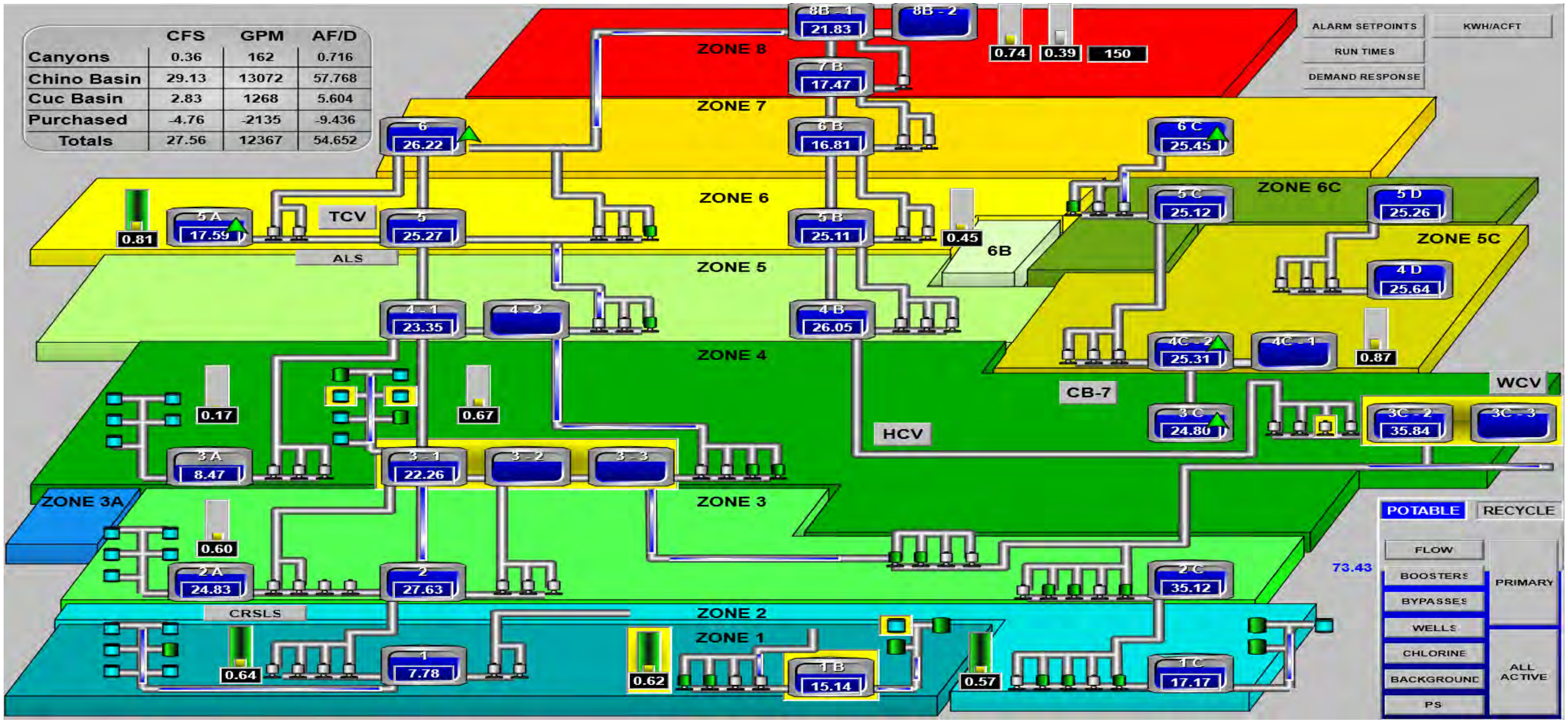

Figure 2. Cucamonga Valley Water District's Distribution System[10]

[10] Maestas, M. (2019). *Production and Energy Management Strategies* [PowerPoint Slides]. Provided by *Cucamonga Valley Water District.*

Water Distribution System

The District's water distribution system consists of eight primary pressure zones and five subzones. Pump stations move water between zones. The District's 35 reservoirs are used to equalize fluctuations between supply and demand. Most of CVWD's wells and imported supplies start at lower elevations so the reservoirs are designed to be replenished from the lower pressure zones.

CVWD's pressure zones are shown below in Figure 3. The blue dots indicate the District's reservoir locations within each of the pressure zones.

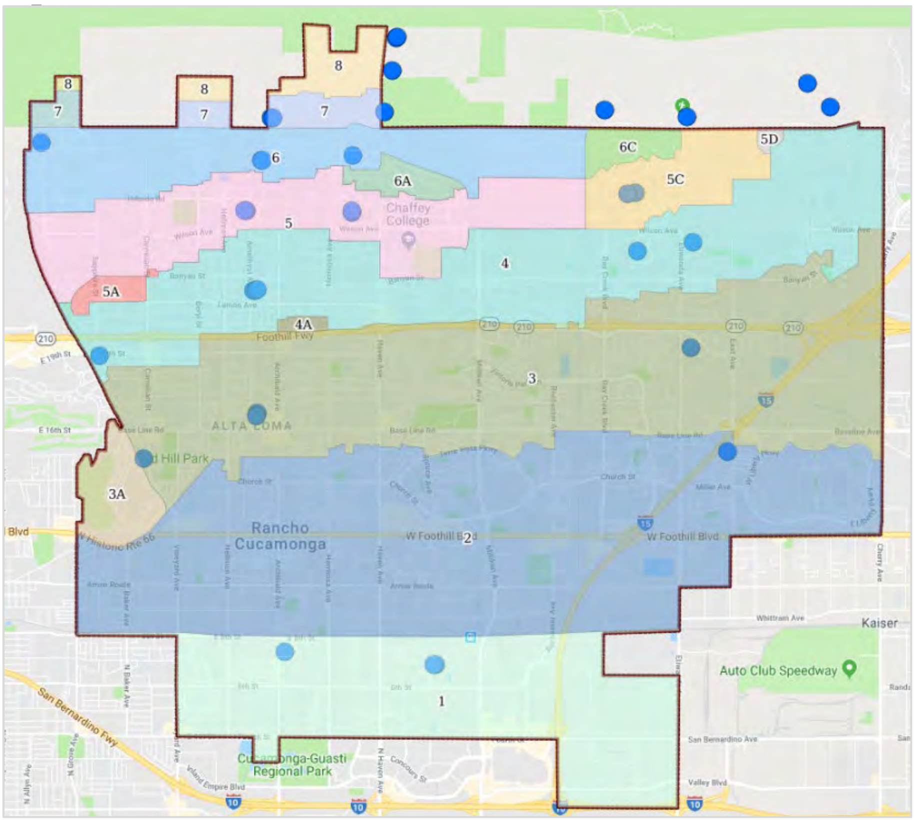

Figure 3. Cucamonga Valley Water District's Pressure Zones[11]

Wastewater System[12]

The District has approximately 37,000 sewer connections with an average conveyance of 12.5 million gallons per day (MGD) of wastewater. Collected wastewater is delivered to IEUA for treatment or disposal.

[11] Maestas, M. (2019). *Production and Energy Management Strategies* [PowerPoint Slides]. Provided by *Cucamonga Valley Water District.*

[12] Id.

Electric Requirements

Electric Use

The Agency's primary electric use is for pump stations (66% of both kWh and kW) and groundwater wells (30% of both kWh and kW). Together, CVWD's pump stations and groundwater wells account for 96% of both electricity (kWh) and electric demand (kW).

Table 2. 2018 Electric Use (kWh) and Electric Demand (kW) by Type of Water Facility[13]

Type of Facility	Nbr of SCE Electric Meters	Total Electric Energy (kWh)		Maximum Electric Demand (kW)		Annual Electric Load Factor[1]	
		Total Electricity (kWh)	% kWh by Type of Facility	∑ Non-Coincident kW (NCP)[14]	% kW by Type of Facility	Utilized[2]	Unutilized[3]
Groundwater	22	10,190,253	29.87%	3,826.5	30.04%	30%	70%
Pump Station/Reservoirs	26	22,639,639	66.36%	8,458	66.39%	31%	69%
Water Treatment	1	1,77,585	0.52%	30	0.24%	68%	32%
All Other Uses	8	11,10,093	3.25%	425	3.34%	30%	70%
Grand Total	57	34,117,570	100%	12,739.5	100%	31%	69%

<u>Notes</u>:

[1] "Annual Load Factor" is the percentage of electric demand actually used (maximum annual kW) calculated as [Total Electricity (kWh) ÷ (Maximum Electric Demand x 8,760 hours/year)].

[2] "Utilized" is the amount of electric energy that was actually used during CY2018 as a percentage of the Maximum Electric Demand (Non-Coincident basis) by type of facility.

[3] "Unutilized" is the amount of additional electric energy that could have been used during 2018 under the maximum kW (i.e., additional kWh that could have been used without incurring additional demand charges).

As is typical of most water and wastewater systems, the District's annual electric load factor for water, wastewater, and recycled water pumping tends to be fairly low – often in the 20-40% range. This is because there typically is redundancy and excess pump capacity to assure reliable operations of mission critical water and wastewater services (e.g., maintenance can be performed on some pumps while others are operating).

Water and Wastewater Treatment Plants' load factor ("Utilized"), however, tends to be high relative to pump stations. For example, CVWD's annual load factor in CY2018 for Water Treatment was 68%, more than twice the average annual load factor of its Groundwater Wells (30%) or Pump Stations (31%).

[13] Compiled from SCE electric meter data provided by Cucamonga Valley Water District.

[14] NCP = "Non-Coincident Peak", the sum of maximum annual demand (kW) of all electric meters by type of facility.

Electric Strategies and Partnerships

To achieve its supply, quality and efficiency goals, CVWD is working collaboratively with the project partners identified in Table 3 below.

Table 3. Cucamonga Valley Water District's Project Partners

Project Partner	Administer	Description
Water Infrastructure System Efficiency Program (WISE)	Program administered by SCE and Lincus and funded by the California Public Utilities Commission (CPUC).	Provides assistance with assessments, identification and implementation of system wide pump efficiency improvements, and savings verification and incentive processing.
Southern California Regional Energy Network Project Delivery Program	Administered by Los Angeles County and funded by the CPUC.	Provides assistance with identifying energy efficiency projects, project closeout, and recognition of all CVWD's energy efficiency efforts.

The above projects have resulted in savings of over 4.2 million kWh per year and a reduction of 270 kW during peak hours. These energy savings have reduced the District's annual energy costs by $550,000. In addition, the District earned incentives from SCE totaling $265,000, reducing the $1 million project costs to a net of $735,000 and achieving a payback of 1.33 years. These projects also reduced greenhouse gas emission by 2,970 metric tons of carbon dioxide, the equivalent of removing 631 passenger vehicles from crowded roads and freeways each year.[15]


Cucamonga Valley Water District's efficient strategies include pump efficiency projects *(Photos courtesy of Cucamonga Valley Water District).*

[15] "Production and Energy Management Strategies." *Cucamonga Valley Water District.* Slides Presented to Vistage July 11, 2019.

Flexible Electric Resources Strategies and Innovation

CVWD has been an early adopter of innovative technologies and solutions that increase the District's efficiencies while maintaining its mission of bringing high-quality water reliably to its customers. One of the District's priorities has been achieving operational improvements through customized SCADA-integrated Water-Energy Management Systems ("SWEMS"). SCADA enhancements including real-time energy monitoring and management has been implemented via several strategic partnerships. One of those strategic partnerships is with the University of California at Riverside (UCR).

California Energy Commission (CEC) EPIC Grant

In 2015, the University of California Riverside (UCR) was awarded an EPIC grant of $3,017,034 for "Bringing Energy Efficiency Solutions to California's Water Sector With the use of Customized Energy Management Systems (EMS) and SCADA". The goal of the project is to demonstrate that technology and hardware can create greater efficiencies while reducing peak electric loads and electricity costs of treating and delivering water. CVWD was one of several water utilities that participated in UCR's pilot project.

Cucamonga Valley Water District Operators use SCADA system to increase operational efficiencies and reduce costs *(Photo courtesy of Cucamonga Valley Water District).*

<u>Pilot Project Description</u>

The site selected for the Pilot was CVWD's Reservoir 1c that is comprised of 3 wells and 5 booster pumps with a potential electric demand of 2,095 kW.

Table 4. Reservoir Site 1C Facilities

Facility	HP	Kilowatt (kW)	GPM
Well 39	700	520	2850
Well 40	600	450	2000
Well 43	700	520	2175
Booster 1	300	225	2500
Booster 2	300	225	2500
Booster 3	300	225	2500
Booster 4	300	225	2500
Booster 5	300	225	2500
Total Electric Potential	**3,500 hp**	**2,615 kW**	

Figure 4 on the next page illustrates the configuration of the Reservoir 1c facility as depicted on CVWD's SCADA system.

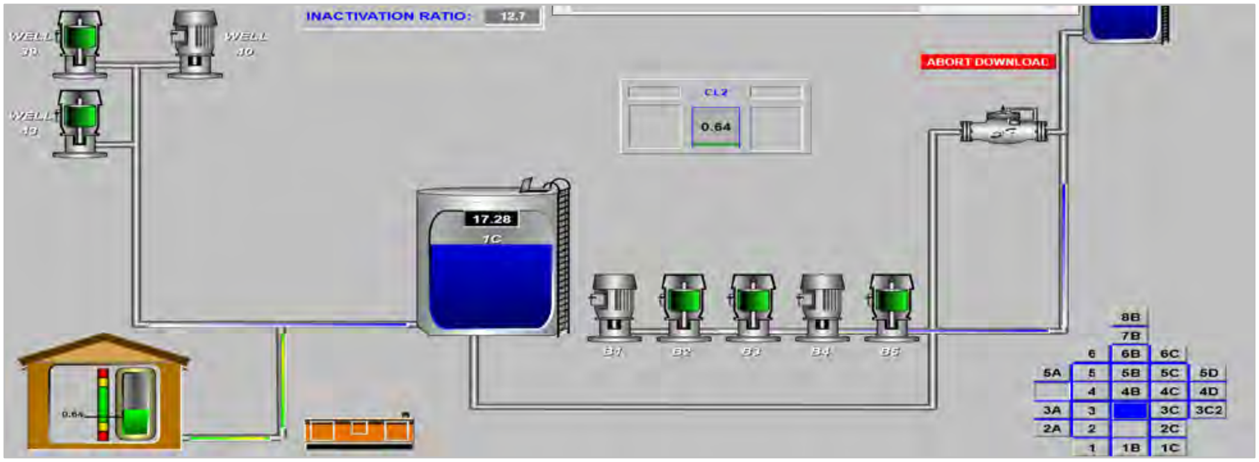

Figure 4. SCADA Screen of Cucamonga Valley Water District's Reservoir Site 1C[16]

The project was conducted in two iterations:

<u>Iteration 1</u>: The first iteration was conducted by the University of California at Riverside (UCR) as a "proof of concept". Specifically, UCR collected real-time electric data and helped CVWD correlate that data with real-time water production. The objective of the first iteration was to determine whether the data could be integrated into CVWD's SCADA system to help Operators manage electric demand charges. Figure 5 below shows that the water and electric data correlated well.

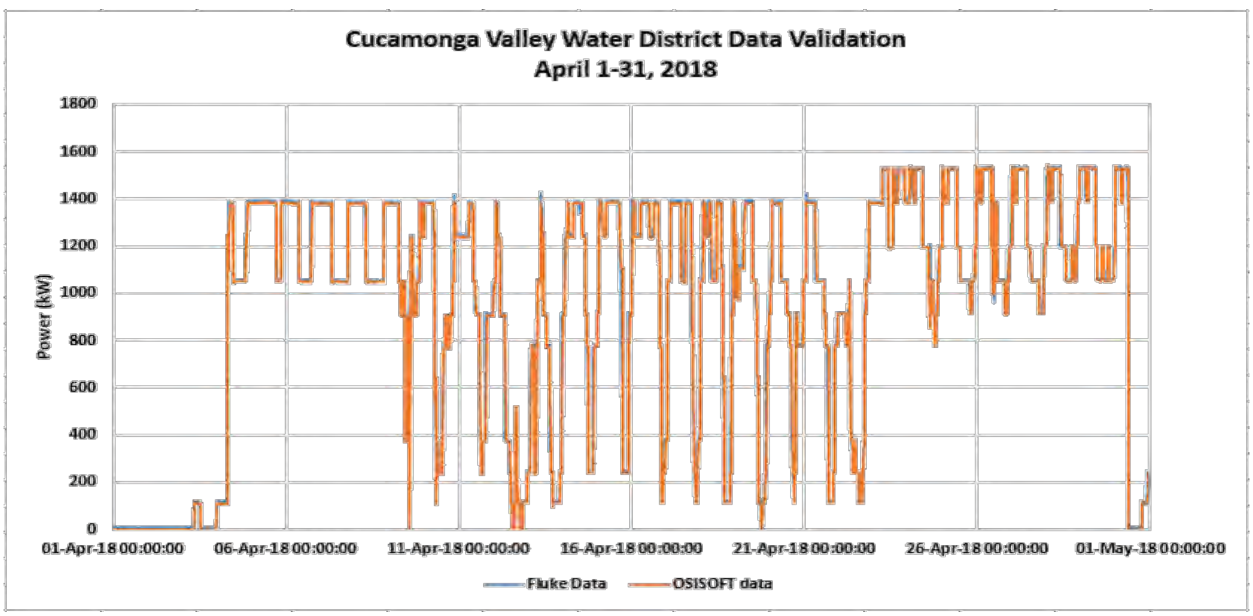

Figure 5. Iteration 1 for Energy Management System (EMS), University of California Riverside[17]

[16] Maestas, M. (2019). *Production and Energy Management Strategies* [PowerPoint Slides]. Provided by *Cucamonga Valley Water District.*

[17] Id.

<u>Iteration 2</u>: The second iteration was designed to implement the findings of the first iteration. Specifically, since the electric and water data calibrated well, CVWD integrated the data into its existing SCADA system with the aim of integrating demand management into daily operational strategies. Specifically, CVWD integrated the real-time electric data into the portion of its SCADA system that conducts pump sequencing.

Figure 6 is a shot of CVWD's screen that shows how the electric data were integrated for the 5 booster pumps:

- The colored boxes with numbers in them (top left of each pump icon) indicate the real-time kWh/AF performance of each pump.
- The pump sequencing function in CVWD's SCADA system then determines the pump sequencing according to energy efficiency: the pump with the lowest kWh/AF is designated at the Lead Pump (in this case, it is Booster #5). Other pumps are ranked as "Lag #" on the basis of least to highest kWh/AF.
- The setting for "Max Number of Pumps" is a constraint based on the amount of water demand that needs to be met from this facility. During summer peak periods when water demand is high, the maximum number of pumps that can be operated at this site is 4. During winter months, when water demand is low, the maximum number of pumps is set to 2. In this manner, CVWD's SCADA constrains the number of pumps that can be operated to the number needed to meet maximum water demand various time periods and seasons. That, in turn, manages the amount of electric demand charges that will be incurred at this site.

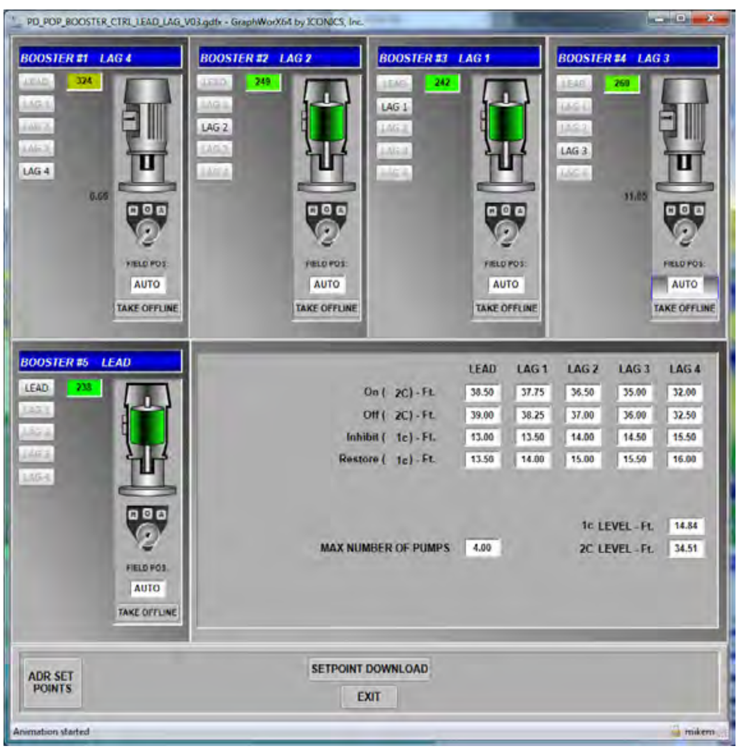

Figure 6. Iteration 2 for Energy Management System (EMS), University of California Riverside[18]

[18] Maestas, M. (2019). *Production and Energy Management Strategies* [PowerPoint Slides]. Provided by *Cucamonga Valley Water District.*

With the successful integration of real-time electric data into its SCADA system, CVWD integrated these data systemwide for all pumps with high electric demands.

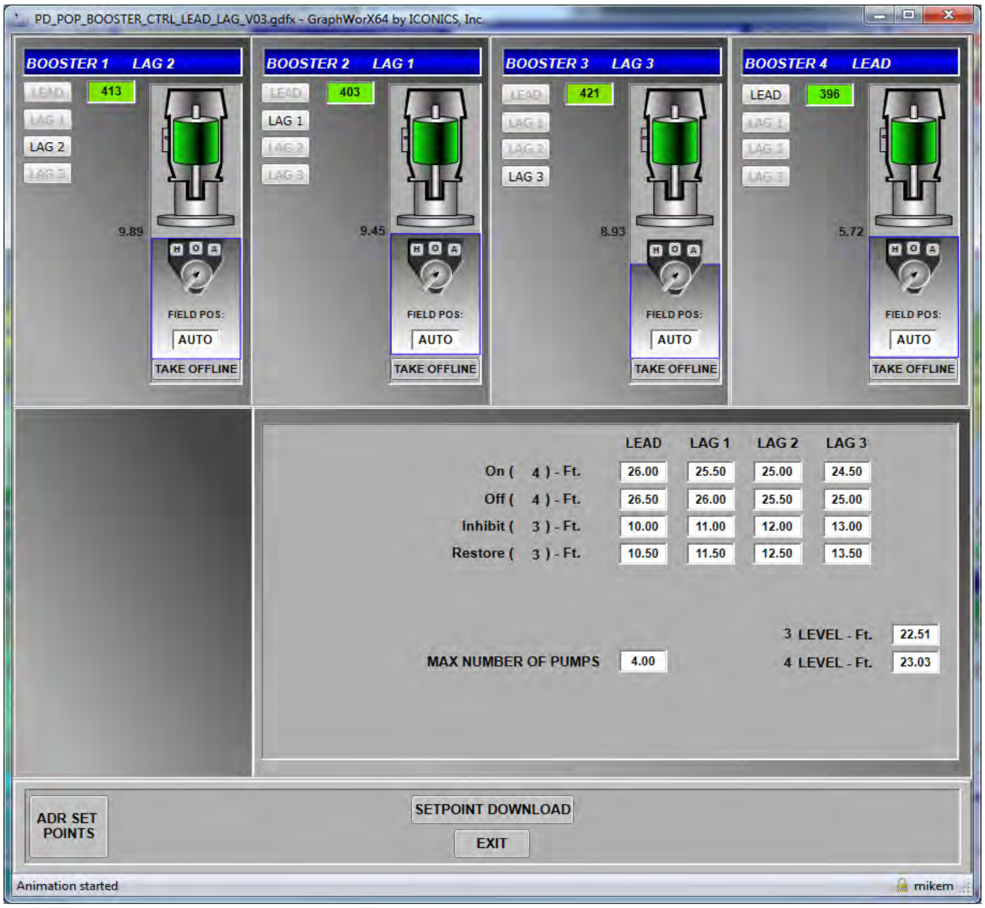

Figure 7. CVWD SCADA Lead/Lag Settings Based on kWh/AF[19]

Figure 7 depicts lead/lag settings based on kWh/AF and the maximum number of pumps based on 24 hour run times. Again, the kWh/AF is displayed in a color box next to each pump. Although not clearly visible on this screen shot, the relative energy intensity of each pump and recommended sequencing is readily determinable by differentiated colors of each box (dark green is the most energy intense; light green boxes are less energy intense). In addition, blue lines under each pump icon show at a glance which pumps are running at or near full capacity (blue lines are longer) vs. those that are not yet running at capacity (e.g. the blue lines under Booster #3 are shorter than the other pumps).

Integration of real-time and historical electric data into its SCADA system has enabled CVWD Operators to reduce electric demand charges by an average of 41%.[20]

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[19] Maestas, M. (2019). *Production and Energy Management Strategies* [PowerPoint Slides]. Provided by *Cucamonga Valley Water District.*

[20] "Water-Energy Nexus Research." *UC Riverside Center for Environmental Research and Technology.* Website: https://www.cert.ucr.edu/renewable-energy-production-integration/sustainable-integrated-grid-initiative-sigi/water-energy-nexus-research.

Recommendations for a Water Sector Electric Reliability Program

Below are CVWD's recommended principles for design of a successful Water Sector Electric Reliability Program.

- **Demand Charges:** The current structure of demand charges in traditional customer energy programs contradict the goals of over-generation mitigation that encourage increasing electric use during certain hours of the day. To encourage participation, these charges would need to be reduced or eliminated for all participating facilities.
- **Specify Targeted Electric Impacts:** The electric impact targeted by SCE and the CAISO and how those impacts can be achieved through water and wastewater systems needs to be clearly defined.
- **Pilots:** The District encourages conducting near-term pilot demonstration projects to achieve a deeper understanding of what is possible, and how best to achieve the targeted locational electric reliability benefits.
- **Data:** Improved integration with SCE's real-time electric meter and cost data are needed to increase water sector's ability to develop cost-effective strategies that provide benefits for both water and electric ratepayers. Synchronizing billing periods for all SCE metered accounts (e.g., to calendar month bases) would help water and wastewater utilities understand the energy cost implications of options.
- **Timing:** A clear understanding as to what time periods and seasons are most in need of electric reliability support would enable water sector operators to make plans.

Aerial **view of Cucamonga Valley Water District facilities** *(photo courtesy of Cucamonga Valley Water District).*

Appendix G - Flexible Electric Resources: Eastern Municipal Water District

District Overview

Eastern Municipal Water District (EMWD) provides domestic and agricultural water, wastewater collection and treatment service, and recycled water in a 542-square-mile service area in Western Riverside County.

Potable water is supplied to five regional service areas through the following facilities:

- 77 Booster Pump Stations
- 78 Storage Reservoirs
- 18 Groundwater Wells
- 2 Filtration Plants
- 2 Desalting Facilities (a third is under construction)
- 2,400 miles of pipeline

Potable water is served through 70 pressure zones with hydraulic grade lines ranging from 1,347 feet above sea level to 2,664 feet above sea level.

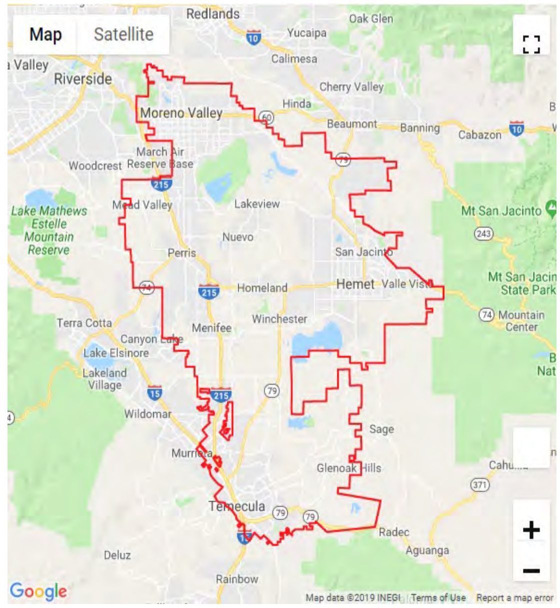

Figure 1. Eastern Municipal Water District Service Area

Wastewater service is provided by five distinct wastewater collection systems via the following facilities:

- 5 Regional Water Reclamation Facilities (one for each collection system – Moreno Valley, San Jacinto Valley, Perris Valley, Sun City, and Temecula Valley)
- 50 Lift Stations
- 1,800 miles of gravity mains

Four of the five regional water reclamation facilities listed above (the Sun City Regional Water Reclamation Facility is the exception) provide tertiary treated recycled water. EMWD also operates the following recycled water facilities:

- 4 Tertiary Effluent Pump Stations
- 5 Recycled Booster Pump Stations
- 11 Ponds/Pond Systems
- 6 Recycled Water Reservoirs

Recycled water is distributed through 200 miles of pipelines in six pressure zones with hydraulic grade lines ranging from 1,384 feet above sea level to 1,710 feet above sea level.

Electric Requirements

Electric Use

EMWD's primary electric uses are for Booster Pump Stations (30%), Regional Water Reclamation Facilities (23%), Wells (16%), and Water Filtration (11%). These three uses account for 80% of EMWD's total annual electric use. Lift Stations use an additional 5%, and administrative purposes (buildings) use only 1%. All other uses account for the remaining 14%.

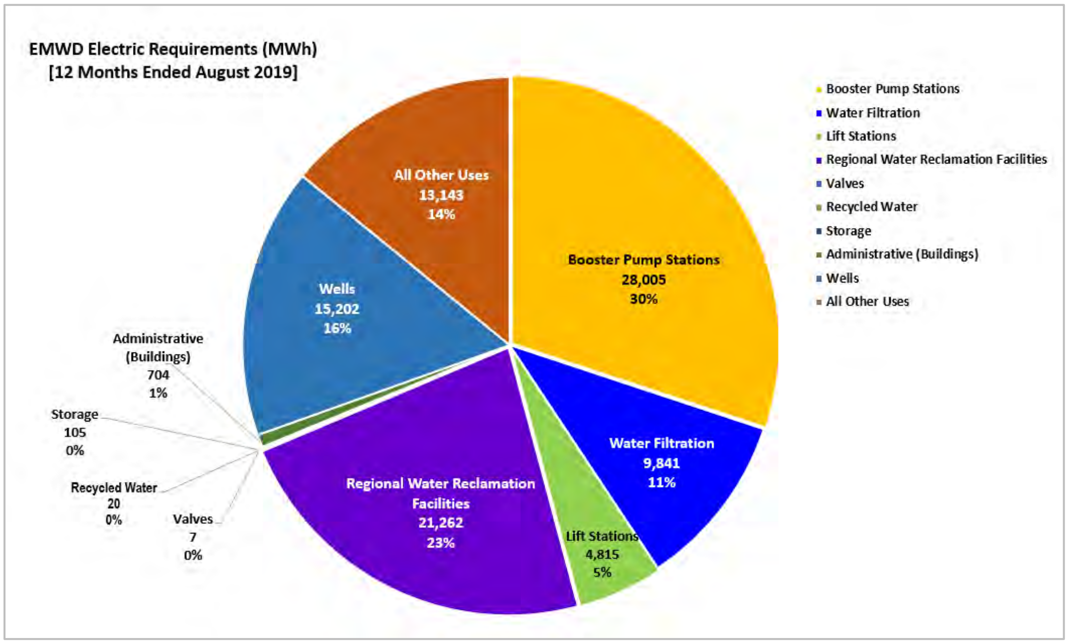

Figure 2. EMWD Electric Requirements (MWh) for the 12 Months Ended August 2019[1]

Table 1 on the next page shows the data underlying Figure 2 above.

- The data are ordered from highest to least energy use (MWh).
- Electric requirements met by self-generation are not included in this table.
- Maximum electric demand is shown by facility type on a non-coincident basis.
- The average load factor (amount of electric energy used vs. the total amount of electric energy that was available without incurring an increase in demand charges) is shown in the column labeled "Utilized".

"Non-Coincident Peak" is the sum of the maximum annual demand (kW) of each electric meter. ("Coincident Peak" is the total amount of electricity used by multiple systems and facilities at the same moment in time.)

[1] Compiled from Electric Data provided by *Eastern Municipal Water District*.

Table 1. Twelve Months of Electric Use (kWh) and Electric Demand (kW) by Type of Facility[2]

Type of Facility	Nbr of SCE Electric Meters	Total Electric Energy (kWh)		Maximum Electric Demand (kW)		Annual Electric Load Factor[1]	
		Total Electricity (kWh)	% kWh by Type of Facility	∑ Non-Coincident kW (NCP)[1]	% kW by Type of Facility	Utilized[2]	Unutilized[3]
Booster Pump Stations	95	28,004,650	30.08%	14,208	44.26%	22.50%	77.50%
Regional Water Reclamation Facilities (RWRF)	3	21,261,808	22.84%	5,744	17.89%	42.26%	57.74%
Wells	27	15,202,395	16.33%	3,385	10.55%	51.27%	48.73%
Water Filtration	3	9,841,272	10.57%	2,336	7.28%	48.09%	51.91%
Lift Stations	44	4,815,137	5.17%	2,377	7.40%	23.12%	76.88%
Administrative (Buildings)	4	704,127	0.76%	282	0.88%	28.50%	71.50%
Storage	39	104,524	0.11%	39	0.12%	30.59%	69.41%
Recycled Water	2	20,323	0.02%	6	0.02%	38.67%	61.33%
Valves	4	6,887	0.01%	1	0.00%	78.62%	21.38%
All Other Uses	33	13,143,167	14.12%	3,722	11.60%	40.31%	59.69%
Grand Total	**254**	**93,104,290**	**100.00%**	**32,100**	**100.00%**	**33.11%**	**66.89%**

Notes:

[1] "Annual Load Factor" is the percentage of electric demand actually used calculated as:

[*Total Electricity (kWh) ÷ (Maximum Electric Demand x 8,760 hours/year)*].

[2] "Utilized" is the amount of electric energy that was actually used during CY2018 as a percentage of the Maximum Electric Demand (Non-Coincident basis) by type of facility.

[3] "Unutilized" is the amount of additional electric energy that could have been used during 2018 under the maximum kW (i.e., additional kWh that could have been used without incurring additional demand charges).

As is typical of most water and wastewater systems, the District's annual electric load factor for water, wastewater, and recycled water pumping (Booster Pump Stations and Lift Stations) is fairly low (23%). This is because there typically is redundancy and excess pump capacity to assure reliable operations of mission critical water and wastewater services (e.g., maintenance can be performed on some pumps while others are operating).

EMWD's load factor for Regional Water Reclamation Facilities, however, is very low relative to most wastewater treatment plants (42% vs more typically 70+%). This is likely attributable to the fact that EMWD self-provides solar PV on under NEM tariffs, resulting in lower electric energy purchases from SCE at these sites.

[2] Compiled from Electric Data provided by *Eastern Municipal Water District*.

Distributed Energy Resources

On June 5, 2019 EMWD adopted its Triennial Strategic Plan (2019-2021).[3] In that plan, the District articulated "Energy Independence" as one of its key objectives:

> "*Implement industry-leading programs and procedures to ensure EMWD is operating at optimal efficiency to minimize costs, manage risk and ensure best value for our customers.*"[4]

Distributed Energy Resources (DERs): Energy Efficiency, Demand Response, Clean/Renewable Distributed Generation, and Energy Storage are the pinnacles of EMWD's Energy Independence strategy, as well as its Climate Action Plan.

> *"In addition to efficiency investments that are already paying off, EMWD has a two-pronged approach for investing in projects that address climate change. EMWD is committed to investing in projects that adapt to climate change such as climate resilient water supplies and landscapes as well as demand reduction efforts. EMWD is also committed to investing in projects that mitigate climate change by maximizing energy independence, reducing GHG emissions, and advancing policies and strategies that address climate adaptation."*[5]

Components of EMWD's DER portfolio are described below.

Energy Efficiency

EMWD conducted multiple energy efficient upgrades to its systems and facilities. Over the past 5 years, has completed 8 energy efficiency programs that resulted in annual energy savings of 6.557 million kWh.[6]

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[3] "Action/Info Item 3936: Adopt 2019-2011 Strategic Plan and Strategic Priorities." *Eastern Municpal Water Districtd (EMWD)*. Approved June 5, 2019.

[4] "Triennial Strategic Plan, 2019-2021." *Eastern Municipal Water District*.

[5] "Climate Action Leader." *Eastern Municipal Water District (EMWD)* website: https://www.emwd.org/post/climate-action-leader.

[6] EMWD Energy Efficiency Projects with SCE as of October 4, 2019.

Demand Response[7]

EMWD currently participates in the following demand response programs:

- **<u>Base-Interruptible Program (BIP)</u>**: EMWD has participated in SCE's Time-of-Use Base Interruptible Program (BIP) for 12 years. Currently, EMWD curtails up to 5.3 MW on 15 minutes notice at EMWD's three largest water reclamation facilities (Moreno Valley, Perris Valley, and Temecula Valley).

- **<u>Demand Response Auction Mechanism Program (DRAM)</u>**: Pursuant to a decision by the California Public Utilities Commission in 2014, the State's electric IOUs established a Demand Response Auction Mechanism (DRAM) program in 2016. EMWD's participation during 2019 is 3.7 MW.

Perris II Desalter (DRAM). (*photo courtesy of Eastern Municipal Water District*)

- **<u>Agricultural Pumping Interruptible (API) Program</u>**: EMWD presently has 13 pump stations enrolled in SCE's Agricultural Pumping Interruptible (API) program. These 13 meters have a total non-coincident peak demand of 1,493 kW and summer on-peak demand of 305 kW.

Total EMWD curtailments from these 3 programs is 8.5 MW.

Temecula Valley RWRF (BIP). (*photo courtesy of Eastern Municipal Water District*)

[7] Data provided by Eastern Municipal Water District.

Clean/Renewable Self-Generation

"A significant electrical load, coupled with capacity issues with the regional electrical power grid, and the cost of electrical power led EMWD to pursue alternative sources of electrical power supply. These alternative sources included solar, digester gas, fuel cell technology and microturbines."[8]

EMWD presently self-generates 30% of its electricity requirements. Below is a summary of EMWD's renewable energy generation facilities.

Solar

EMWD is presently in the 3rd phase of its Solar Photovoltaic Renewable Energy Initiative Project that was adopted in 2018. By the end of Phase II (2016), 5.5 MW of Solar PV had been installed at EMWD facilities. The Phase 2 solar projects were designed to provide 30% of each of the RWRFs' annual electric requirements. In 2018, EMWD commenced Phase III development of an additional 14.7 MW of solar PV capacity.

Typical Ground-Mounted Solar PV System at EMWD Regional WRFs (*photo courtesy of Eastern Municipal Water District*)

Table 2. Eastern Municipal Water District's Solar Photovoltaic Renewable Energy Initiative Project[9,10]

Phase	Site	Installed Capacity (MW)	Year In-Service
I	EMWD's Administrative Campus	0.5 MW	2015
II	Moreno Valley RWRF	1.0 MW	2016
	Perris Valley RWRF	1.0 MW	
	San Jacinto Valley RWRF	1.0 MW	
	Sun City RWRF	1.0 MW	
	Temecula Valley RWRF	1.0 MW	
III	Moreno Valley RWRF	2.5 MW	Projected 2020
	Perris Valley RWRF	3.2 MW	
	San Jacinto Valley RWRF	2.0 MW	
	San Jacinto Valley RWRF	5.0 MW	
	Sun City RWRF	2.0 MW	

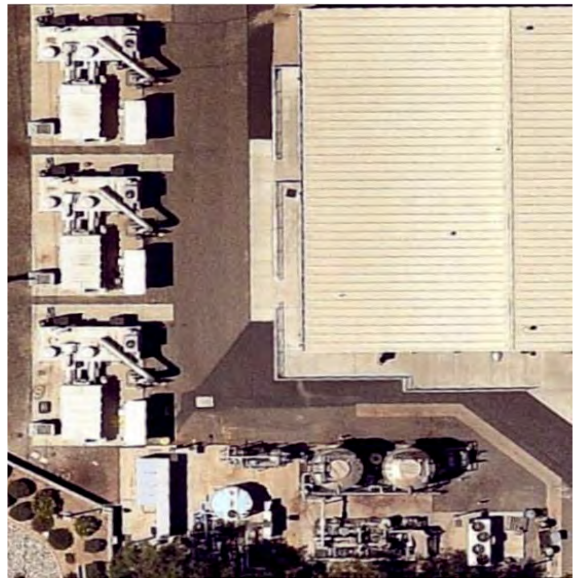
[8] "Energy Efficiency Programs." EMWD website: https://www.emwd.org/post/energy-efficiency-programs.

[9] "Focused Draft Environmental Impact Report: Solar Photovoltaic Renewable Energy Initiative – Phase III (State Clearinghouse No. 2018081021). Prepared for *Eastern Municipal Water District (EMWD) by K.S. Dunbar & Associates, Inc*. October 2018.

[10] Data provided by Eastern Municipal Water District.

Digester Gas Fuel Cells

Biogas fuel cells totaling 2 MW have been installed at EMWD's Moreno Valley and Perris Valley Regional Water Reclamation Facilities. The fuel cells provide 25-40% percent of each facility's energy requirements with virtually zero emissions, resulting in greenhouse gas emissions reductions of more than 10,600 tons per year.



Fuel cell facilities at Moreno Valley Regional Water Reclamation Facility (*photo courtesy of Eastern Municipal Water District*)

An aerial photo of the fuel cell facilities at the Moreno Valley Regional Water Reclamation Facility (MVRWRF) is shown on the right. The source fuel (methane gas) enters the gas dryer where moisture is removed. Next, hydrogen sulfide and siloxane are removed before the methane enters the fuel cells, where it is converted to electricity.[11,12]

Microturbines

Eight 60-kw microturbines (installed where?) provide additional power generation. The exhaust from these microturbines heats water to power a 150-ton air conditioning unit.

SCADA System (*photo courtesy of Eastern Municipal Water District*)[1]

[11] "Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2010." *Eastern Municipal Water District*.

[12] Data provided by Eastern Municipal Water District.

Battery Energy Storage (BES)

EMWD does not presently have any Battery Energy Storage. However, EMWD is currently evaluating the integration of battery storage at facilities identified to benefit from demand and peak shaving. Changes in the SGIP funding has also made the prospects of incorporating batteries at CPUC identified tier 2 and tier 3 high fire risk areas more appealing.

EMWD plans to evaluate all sites for eligibility for Disadvantaged Community (DAC) and Self Generation Incentive Program (SGIP) qualifications as well as estimate value of peak and demand shaving. Sites will be selected on the basis of both cost effectiveness and SGIP/DAC eligibility.

EMWD's Opportunities for Overgeneration Support

The following opportunities for overgeneration support have been identified:

- EMWD operations staff at the regional water reclamations facilities currently operate to maximize efficiency. They could instead operate to concentrate energy usage. For example, if they had been using a 250 hp pump for aeration, they could use a 660 hp pump for a shorter time period.
- EMWD has an extensive network of pond storage for recycled water and could move tertiary treated water around during DR events, from one storage pond to another. Currently, pond capacity is high enough that hundreds of thousands of gallons could be moved. Some of the electricity used during overgeneration periods could be rescheduling functions that need to take place anyway. However, if the grid needs demand increased during some hours for electric reliability purposes (i.e., to keep power flowing), recycled water could simply be circulated when needed to provide voltage support and other ancillary services.
- EMWD has a significant amount of solar PV on-site; could change how and when Solar PV is used to offset EMWD's electric purchases from grid sources.
- EMWD's potable water system is currently operated to avoid existing TOU charges and peak demand charges. There is capacity to modify operation to better account for overgeneration patterns.

EMWD's Requirements for Further DR Participation and Overgeneration Support

EMWD has identified the following requirements for further DR participation and potential overgeneration support:

- EMWD requires as much advance notice as possible for required response. (The DRAM program structure is "close to 'perfect' for EMWD).
- EMWD requires an incentive and/or elimination of all demand charges that could be triggered by EMWD load shifts for electric reliability purposes.
- EMWD would require an evaluation using the hydraulic model and Derceto operations software to identify specific actions to align operations with overgeneration support.
- EMWD has multiple accounts connected to each circuit that serves it. Having a Flexible Electric Resources Program that is tied to providing desired electric impacts at each circuit instead of by individual meter would allow for more participation because it would allow EMWD to use its hydraulic flexibility and operational expertise to maximize its DR response.

This summary was reviewed and approved by Eastern Municipal Water District

Water Sector Over-Generation Mitigation and Flexible Demand Response, Phase 2 Program Recommendations. *Water Energy Innovations, Inc. for Southern California Edison*. October 25, 2019.