California Department of Water Resources

Clean Energy for the State Water Project

May 12, 2016

Introduction

The California Department of Water Resources (DWR) manages the State Water Project (SWP), a system of pumping plants, power plants, dams, reservoirs, canals and aqueducts constructed to deliver water for agricultural, industrial, environmental, and urban uses and to provide flood control, recreation, fish and wildlife enhancement, hydroelectric power and other economic benefits.

This document describes energy procurement and use strategies DWR is implementing to maximize the state-wide benefits of the SWP and minimize any environmental impacts that may occur as a consequence of its operation. One of the most significant environmental impacts that occur as a consequence of thermal energy generation is the emissions of greenhouse gases (GHG) that have been shown to contribute to climate change.

Operation of the SWP is responsible for about 99 percent of the GHG emissions DWR reports on an annual basis. Most of these emissions come from non-hydropower electricity used by the pumping plants to move water from the Sacramento-San Joaquin Delta to other parts of the State. Because energy generation and use are the most important aspects of the GHG management of the SWP, DWR has devoted considerable attention to analyzing, planning, and implementing strategies that:

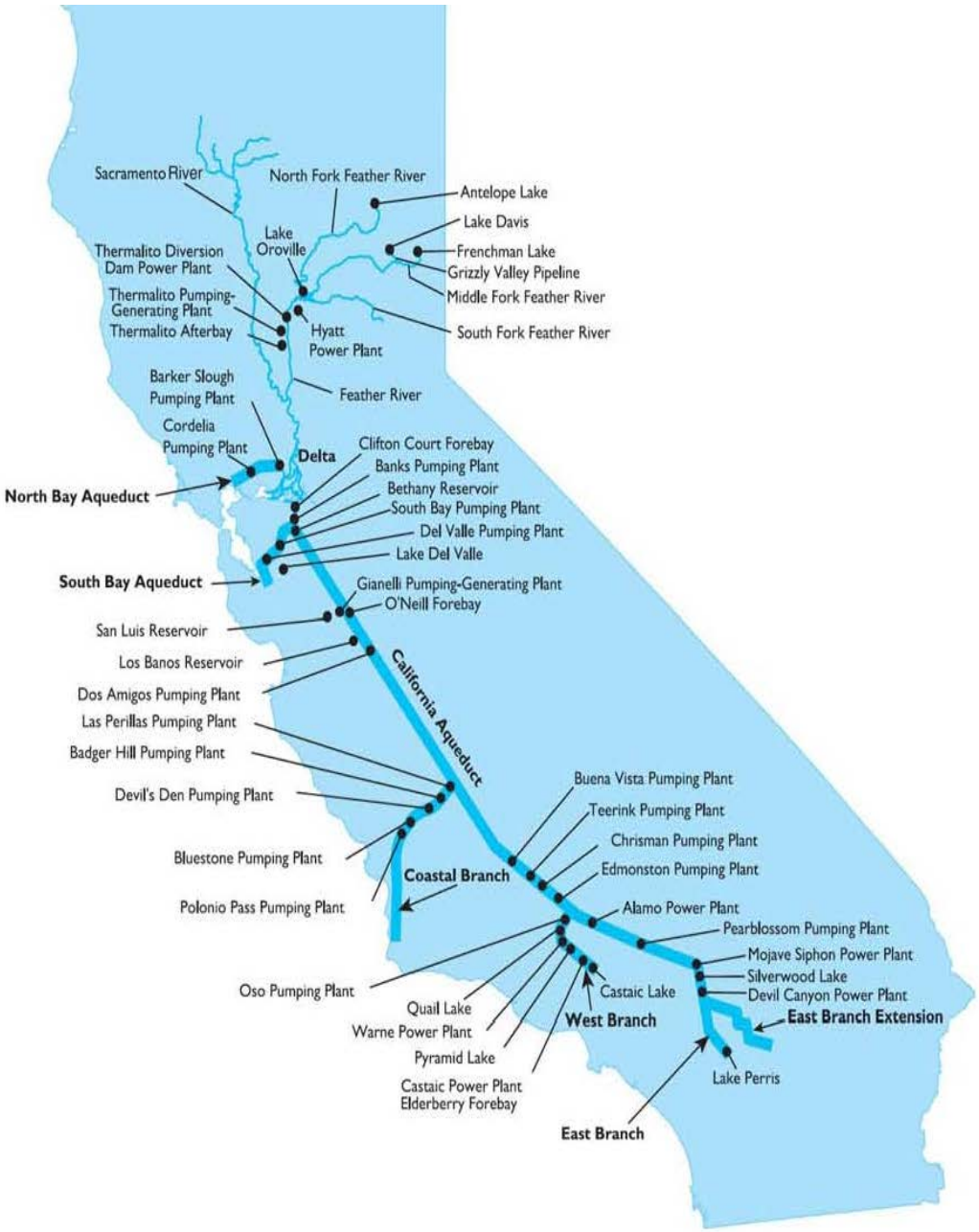
- minimize energy use
- maximize hydroelectric energy generation
- increase the use of clean and renewable energy supplies
- use SWP lands for building renewable energy projects

SWP Overview

The SWP delivers an average of 2.6 million acre-feet of water annually to supply 25 million families and businesses and 750,000 acres of agriculture. It is the largest state-owned conveyance water system in the United States and is a critical component in keeping the State of California's (State) multi-billion dollar economy vibrant and healthy.

The maximum pumping capacity of the SWP is 2,600 megawatt (MW) and depending upon the amount of water conveyed across CA in a particular year, it uses and average of 6 to 9.6 million megawatt hours (MWh) of electricity per year. The SWP is also the third largest generator of clean hydropower in CA and during the course of a year, it generates 4 to 7 million MWh of clean electricity. The SWP produces approximately 14 percent of CA's hydropower.

Figure 1: SWP Primary Water Delivery Facilities, Pumping and Power Generating Plants



The SWP Power Portfolio

DWR develops and administers a comprehensive power resources program that includes forecasts of loads and resources, the strategic timing of generation and pumping schedules, and acquisition of power resources and transmission services. The SWP has over 1,500 MW of generation capacity as shown below:

Table 1: SWP Generating Facilities

Power Plant	**DWR's Share of Capacity (MW)**
Hyatt	645
Thermalito (currently not operational due to fire damage)	114
Thermalito Diversion Dam	3
Gianelli (Joint development with US Bureau of Reclamation)	222
William Warne	67
Castaic (Joint development with the Los Angeles Department of Water and Power) Capacity varies with water delivery	214
Alamo	15
Mojave Siphon	29
Devil Canyon	235
Total Capacity	**1,544**

Table 2: Power Plant Characteristics, by Type and Facility

Type and Facility	Number of Units	Normal Static Head (feet)	Total Flow at Design Head (cfs)	Net Dependable Capacity (MW)	Nameplate Capacity (MW)
Hydro					
Thermalito Diversion Dam	1	63-77	615	3	3
Robie Thermalito	4(3 p-g)[a]	85-102	17,400	114	114
Hyatt	6(3 p-g)[a]	410-676	16,950	645	645
Gianelli (shared with USBR)	8 p-g[a]	99-327	16,960	363	424
Alamo	1	115-141	1,740	15	17
Warne	2	719-739	1,600	67	74
Mojave Siphon	3	81-136	2,880	29	30
Devil Canyon	4	1,406	2,940	235	276
Castaic[b] (shared with LADWP)	7(6 p-g)[a]	900-1,050	20,820	1,128	1,254

[a] The term p-g indicates pumping-generating units.
[b] Castaic Pumping-Generating Plant is owned and operated by the Los Angeles Department of Water and Power.

In addition to the SWP generating facilities, DWR also has several bi-lateral or multi-lateral contracts for generation to help meet SWP's pump load, see Table 3.

Table 3: SWP Source-Specific Power Purchases

Renewable and Clean Energy Contracts Shaded in Green

Power Plant & Fuel Type	DWR's Share of Capacity (MW)	DWR's Share of Energy (GWh)	Contract Status
Pine Flat (hydro)	165	431	Active
MWD Phase I (small hydro)	30	128	Active
Reid Gardner (coal)	235	1,024	Terminated in July 2013
Lodi Energy Center – Combined Cycle Combustion Turbine (natural gas)	99	422	Active
NCPA Geothermal 1 & 2 (geothermal) and Ameresco Ox Mountain Energy (landfill gas)	34	182	Active
Dominion - Camelot (solar)	45	130	Active
sPower – Solverde 1 (solar) COD in Dec 2016	85	240	Active
SunPower – Pearblossom (solar) COD in Dec 2016	9.5	28	Active
MWD (small hydro) 2016-2020	51.4	95	Active
Total (Active Contracts)	**519**	**1656**	

DWR Climate Action Plan

In an effort to reduce its impact on the environment and lead by example, DWR in 2012 developed and approved a Department-wide Climate Action Plan. The first phase of this plan was a Greenhouse Gas Emissions Reduction Plan (GGERP). The GGERP guides project development and decision making with respect to GHG emissions.

The GGERP shows how DWR will make substantial reductions in its GHG emissions in the near term and how it will continue to reduce emissions beyond 2020 to achieve its long term GHG emissions reduction goals, as follows:

- Near-term goal—reduce emissions by 50 percent below 1990 levels by 2020
- Long-term goal—reduce emissions by 80 percent below 1990 levels by 2050

The GGERP covers all of DWR's activities from flood protection to lighting and HVAC systems in the buildings it owns and occupies and includes several strategies specific to the energy resources of the SWP including:

- Termination of power supply agreements from high GHG intensity energy supplies
- Procurement of high-efficiency energy resources
- Procurement of renewable energy resources
- Planning and implementing renewable energy projects on DWR property
- Replacement and refurbishing of generating or pumping equipment to increase energy efficiencies

DWR's aggressive actions to achieve the goals described in the GGERP will reduce GHG emissions by over 1 million metric tons per year by 2020 and over 2.5 million metric tons per year by 2050.

Termination of Power Supply Agreements from High GHG Intensity Energy Supplies

From 1979 until July 2013, DWR held a partial interest in Unit #4 of the coal-fired Reid Gardner Power Station located in Moapa, NV. Reid Gardner Unit #4 supplied up to 235 MW of capacity to the SWP and produced disproportionally high amounts of GHGs as compared to other SWP generation sources.

In July 2013, DWR ceased taking power and relinquished its generation share from Reid Gardner Unit #4 and completed divestiture of its ownership interest in the facility in October of 2013 following Federal Energy Regulatory Commission (FERC) approval of NV Energy's acquisition of DWR's interest. The cessation of power deliveries from Reid Gardner reduced DWR's GHG emissions by almost a million metric tons per year. With the elimination of Reid Gardner power, DWR no longer uses any coal fired generation to operate its facilities.

Procurement of High Efficiency Energy Resources

In 2009, DWR finalized its participation in the construction of a new, state-of-the-art combined-cycle natural gas plant, the Lodi Energy Center (LEC). The new facility uses advanced emission control technology, is highly efficient and replaces a portion of the SWP power needs that were previously served by coal-fired generation. LEC has one of the lowest GHG emissions rates for natural gas-fired power in the state and possibly the nation.

DWR has contract rights for approximately one-third of the output (99 of 302 MW) of LEC. Groundbreaking for construction occurred in July 2010 and the plant started operation in late November 2012. This plant is also the first in CA to have fast-start capability that supports integration of renewable energy resources onto the electrical grid.

A summary of LEC features is provided below:

- Operational November 2012
- 302 MW combined-cycle natural gas power plant
- Highly efficient heat rate: 6,850 British Thermal Unit/Kilowatt Hour (Btu/kWh)
- Fast-start technology: 80 minutes compared to 120-180 minutes for conventional combined cycle
- Lower start emissions: 12 lbs/hr. NOx and 20 lbs/hr.CO Vs. 160 lbs/hr .NOx and 900 lbs/hr. CO for conventional combined cycle
- Ramp up and down quickly: 17 MWs per minute
- Help provide firming power for intermittent renewable energy
- Partnership of 13 Public Participants
- DWR's share:
    - 99 MW
    - 33 percent of facility
    - $140 Million Capital Investment Cost

Procurement of Renewable Resources

DWR has created a Renewable Energy Procurement Plan (REPP) to meet the aggressive goals to reduce GHG emissions under the GGERP emissions reduction strategy OP-1. Under the REPP, DWR will procure an increasing amount of renewable energy from a variety of sources through a competitive bidding process.

DWR plans to increase the annual amount of renewable energy that it will purchase in future years as shown in Figure 2. The REPP is designed to achieve DWR's long-term GHG emissions reduction goal by incrementally reducing GHG emissions associated with operation of the SWP so that total operational emissions fall to 80 percent below 1990 levels by 2050. DWR structured the REPP to be more than adequate to meet its near-term goal for 2020.

This approach enables DWR to initiate renewable procurement in the short-term and expand that procurement as the renewable energy market matures. This approach will also provide the smoothest ramp up of renewable power procurement to meet DWR's projected Long-Term Goal for 2050. DWR will monitor emissions trends and modify the

schedule for procurement of renewable energy as necessary to meet its near-term and long-term goals.

Landfill Gas

Since October 2012, DWR has received 183,220 MWh of renewable energy annually from Alameda Municipal Power. This contract consists of 28.3 MW of geothermal and 5.3 MW of landfill gas generation and it terminates at the end of 2016.

Solar

Through a power purchase agreement, DWR purchases 100 percent of the energy produced from a 45 MW solar generating plant in Kern County, CA. The term of this contract is 20 years. Over the life of the contract, this solar power plant is expected to produce approximately 124,000 MWh of energy per year. The facility reached commercial operation in December 2014.

In November 2015, DWR executed a new power purchase agreement with sPower for its 85MW Solverde Solar Facility, located 10 miles west of Lancaster, adjacent to portions of the East Branch of the CA Aqueduct. Solverde will provide DWR with 240,000 MWh per year of solar energy through a 20-year power purchase agreement. Solverde is expected to achieve commercial operation date (COD) status in December 2016.

In October 2015, DWR executed a new power purchase agreement with SunPower to construct and operate a 9.5MW solar facility on State lands adjacent to the Pearblossom Pumping Plant. More information is provided below under energy development projects on DWR property.

Hydropower

DWR has also applied for and been awarded a contract with the Western Area Power Administration (WAPA) to purchase 6.6 million kWh per year for the next 50 years as a participant in the federal Boulder Canyon Project.

Small Hydro

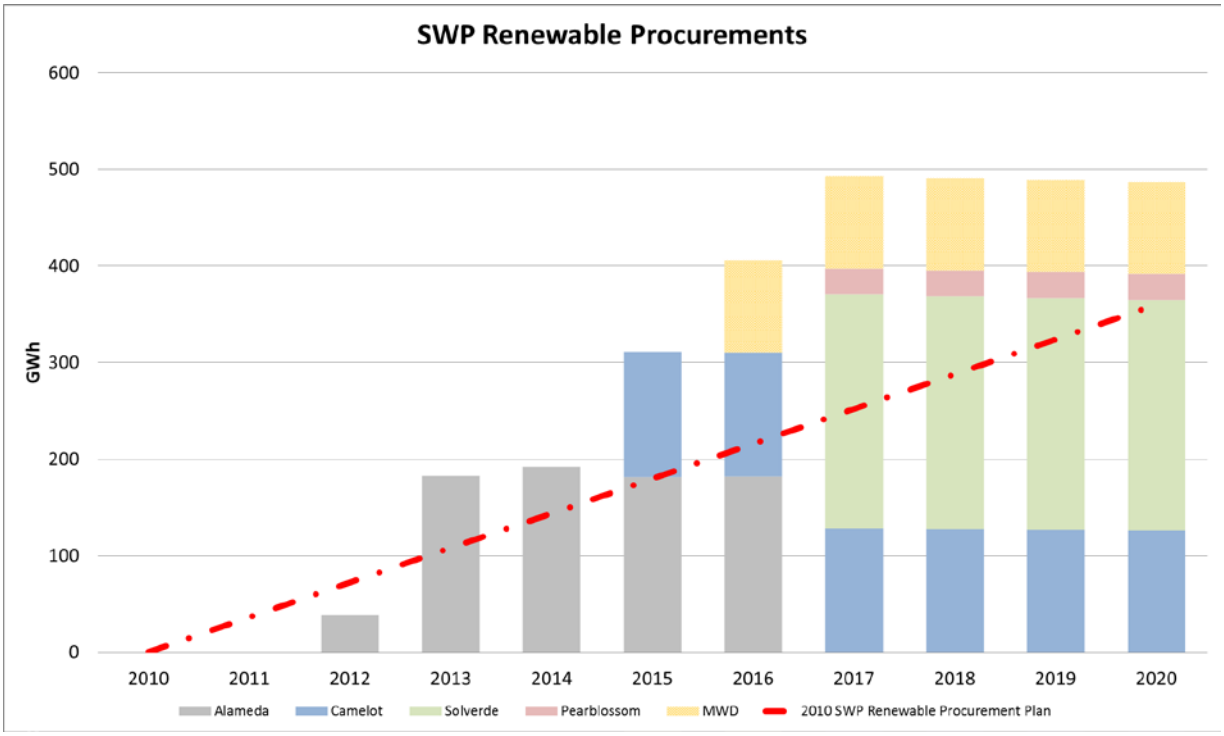
The Metropolitan Water District of Southern CA (MWD), a public corporation, owns and operates several small hydroelectric generating units from which DWR purchases a total of about 30 MW with an average annual output of 128,000 MWh. In November 2015, DWR contracted with MWD for an additional 51.4 MW of small hydro resources that are expected to provide DWR with 95,000 MWh per year of renewable energy from January 2016 through December 2020.

Large Hydropower

DWR funds Kings River Conservation District's (KRCD) Pine Flat Hydroelectric Power Plant, which is located at the U.S. Army Corps of Engineers Pine Flat Dam 20 miles east of Fresno, and generates power using irrigation and flood control releases from the Pine Flat Reservoir. KRCD manages the power plant and DWR funds the construction, operation and maintenance of the plant in exchange for clean hydropower to operate the SWP pumping facilities. It is a run-of-the-river plant with annual generation ranging from 115 GWh to 795 GWh.

The following is a graphical representation of DWR's REPP over the next several years.

Figure 2: Renewable Energy Procurement Plan



Planning and Implementing Renewable Energy Projects on DWR Property

Over the past several years, DWR has conducted several surveys of its property, including land and waterways, to determine its suitability to support the development of renewable energy generation. Below are summaries of several project evaluations:

- Installation of photovoltaic solar panel arrays on 70 acres of DWR-owned land located in the Antelope Valley of Southern CA, adjacent to its Pearblossom Pumping Plant. Installation of solar at this location shows merit due to the sun intensity and vacant land that has been graded and fenced with 24/7 security

(due to adjacent pumping plant). In October 2015, DWR executed a power purchase agreement with SunPower to construct, operate and maintain the 9.5 MW solar facility which is located on DWR land adjacent to the Pearblossom Pumping Plant.

Installing solar at Pearblossom will realize dual State energy policy objectives of finding appropriate State lands for constructing renewable energy facilities and utilizing renewable energy to meet State Water Project pumping needs.

The facility will provide DWR with 28,000 MWh per year of solar energy through a 20-year power purchase agreement. Commercial operational date is expected to be achieved in December 2016. For operational and security reasons, this project is not connected to the SWP switchyard and will be owned, operated and maintained by a third party separate from the SWP.

- DWR plans to install canopy-mounted photovoltaic solar panel arrays at two SWP maintenance facilities to reduce its dependence on grid-based power. The PV system at Oroville Field Division Headquarters is expected to generate 575 MWh per year and 221 MWh per year at Lost Hills Sub Center.

- In 2010, DWR completed a power planning study that supports adding a second 12 MW generation unit to the existing 18 MW small hydro energy recovery unit at Alamo Powerplant. The study results recommended proceeding with the preliminary design and a schedule is being developed.

- In 2010 and again in 2015, DWR investigated the feasibility of installing solar generating technology along sections of the CA Aqueduct right of way. This concept has drawn substantial public interest because of the perceived benefits of such a facility. However, both investigations have yielded negative feasibility determinations. Several different design configurations were evaluated but significant safety and maintenance conflicts exist, as described in the next paragraphs.

DWR conducts daily visual inspections of the aqueduct to assess the condition of critical features including canal embankments, concrete liners, roads, bridges, overcrossings, turnouts and other appurtenances. Daily, unobstructed observation of the water surface conditions such as water currents eddies, vortices, etc. are also important to identify developing or deteriorating conditions below the surface that may require further investigation or repairs.

Rapidly developing conditions such as canal lining failures and leaks do occur and require immediate emergency response. Overhead access for inspections, maintenance and emergency repairs is critical to maintaining employee safety, public

safety and the reliability of water deliveries. There is also limited narrow right of way adjacent to the aqueduct with a dirt patrol road.

Most of the open canal portion of the Aqueduct was constructed with embankments that were not designed or constructed to support the structures that would likely be required to install solar panels over the canal. Construction of heavy solar structures could cause these embankments to fail, thereby resulting in a catastrophic failure and prolonged outage of the Aqueduct. Secondly, state-owned right of way is very limited along the Aqueduct, typically limited to the width of the canal embankments plus dirt patrol roads along the embankment toes. These areas along the toe also include other buried utilities such as cables and pipelines with existing property rights that would prevent construction of large structural footings along the embankment toe.

To the degree that the operational, structural and adjacent infrastructure challenges cited above can be overcome, DWR will continue to evaluate new technologies and additional design configurations, including those from academia, for solar facilities along the CA.

Retail Energy Efficiencies at SWP Facilities

In 2012, Governor Brown issued order B-18-12 requiring all state agencies to reduce retail energy usage 20 percent below the usage in 2003. At that time, DWR already had a program in place to reduce its energy usage and in 2014, DWR commissioned energy audits that compared the retail energy usage at key SWP maintenance facilities between 2003 and 2013. The audit revealed energy reduction measures could yield substantial annual savings at each of the facilities as described below. DWR implemented some of these measures and is identifying funding, feasibility and logistics for the others.

<u>Completed Energy Reductions</u>

- Oroville Field Division Headquarters (lighting): 113 MWh per year
- Lost Hills Sub Center (lighting): 74 MWh per year
- Coalinga Sub Center (lighting): 60 MWh per year
- Sutter Maintenance Yard (lighting): 71 MWh per year
- Pearblossom Operations and Maintenance Center, Southern Field Division:
    - Installation of a 30 KW solar rooftop system
    - LEED Platinum Building
    - Energy Efficiency Upgrades
    - Water Efficiency Upgrades
    - Improved Indoor Environmental quality

<u>Potential Energy Reductions</u>

- Oroville Field Division Headquarters (HVAC): 184 MWh per year
- Lost Hills Sub Center (HVAC): 193 MWh per year

- Castaic O&M Center (lighting): 204 – 252 MWh per year
- Cedar Springs Maintenance Center: 39 – 41 MWh per year
- Tehachapi Trailer: 7 – 8 MWh per year
- Pearblossom Complex: 26 MWh per year
- Water Quality Test Building (Devil Canyon): 12 – 13 MWh per year
- Coalinga Sub Center: 54 MWh per year

In addition, DWR has installed three Level–2 Electric Vehicle Charging Stations at the Pearblossom O&M Center in its Southern Field Division, where both plug-in electric and hybrid vehicles can be recharged for both employee and State-owned vehicles. DWR has installed two electric vehicle chargers at Oroville Field Division as well and is planning installations at other field division locations. At full utilization, the chargers currently installed have the potential to reduce GHG emissions by 14 metric tons per year. In the years to come, the reductions in GHG emission will continue to increase as more electric vehicles, charging stations and solar PV systems are installed and regularly used.

Replacement and Refurbishing of Generating or Pumping Equipment to Achieve Energy Efficiencies

The table below describes the various completed and in-progress projects that will result in energy and associated GHG emissions savings.

Table 4: Energy Efficiency Upgrades to SWP Facilities

Project	Description	MWH Saving/Yr	MT CO2e Saving/Yr
Hyatt Unit 1	Turbine Runner replacement	15,000	4,712
Thermalito Unit 1	Turbine Runner replacement	4,833	2,069
Hyatt Unit 3	Turbine Runner replacement	15,000	4,712
Hyatt Unit 5	Turbine Runner replacement	15,000	4,712
Alamo Power Plant Unit 2	Install a second generating unit	60,000	18,900

SWP Energy and the California Grid

Beyond DWR's strategies to improve energy efficiency and reduce GHG emissions, the SWP is an important power producer and user in the CA's integrated statewide electrical grid. The California Independent System Operator (ISO) is charged with operating the grid and manages approximately 80 percent of CA's energy generation and use to ensure electricity is delivered when and where it is needed, reliably.

On average, SWP clean hydropower facilities generate nearly 4,500 GWh of electricity per year at various points throughout the SWP. These facilities are operated flexibly to maximize electricity generation when statewide demand is highest (within the water delivery and regulatory requirements) and water supply of the SWP. The SWP's energy-consuming pumping plants are also operated flexibly to minimize demand during peak energy use periods and maximize energy consumption during lower energy use times of the day for the ISO.

DWR has had discussions with ISO on potential ways the SWP may participate in the energy market to support the integration of renewable resources into the CA electricity grid. As intermittent renewable energy supplies like solar and wind become a larger part of CA's energy portfolio, ISO requires additional "demand response resources" to balance the inconsistent generation of renewable power as the sun goes behind clouds or the wind dies down.

Eric Schmitt, Vice President of Operations at ISO, explained this benefit during his participation in the US Department of Energy's Quadrennial Energy Review Public Meeting on June 19, 2014 in San Francisco: "Because California's electric and water operations are very closely tied, the vision to integrate renewables into the power grid is absolutely possible. Integrating renewables into the California power grid requires a large amount of flexible demand response generation capabilities and the SWP hydropower provides that." Potential benefits the SWP may be able to provide for renewable integration will be considered over the next several years.

Recognitions for Climate Action

In April 2016, the American Society of Civil Engineers, Sacramento Section, selected the DWR Climate Action Plan as the 2015 Sustainability Project of the Year. This plan not only includes the GGERP but also a framework and guidance for consistent incorporation and alignment of analysis for climate change impacts on its projects and program planning activities.

DWR has also received a prestigious national Climate Leadership Award from the United States Environmental Protection Agency, The Climate Registry, The Association of Climate Change Officers and the Center for Climate and Energy Solutions for Excellence in Greenhouse Gas Management (Goal Setting Certificate) in February 2015. This award recognizes organizations that publicly report and verify organization-wide GHG inventories

and publicly set aggressive GHG emissions reduction goals. DWR is the only public agency to ever receive the award.

These same entities awarded DWR their 2016 Organizational Leadership Award, the highest honor bestowed. This Department-wide award recognized the depth and breadth of DWR's commitment to climate change mitigation, adaptation and preparation.

Summary

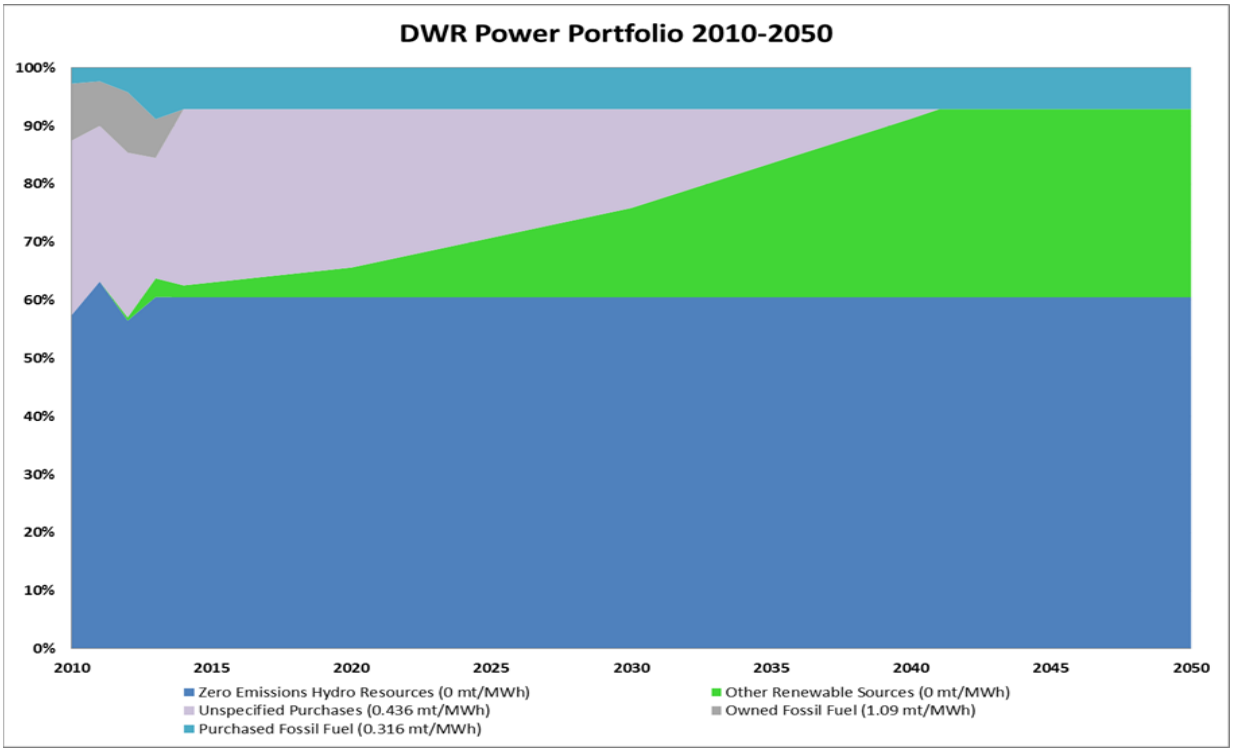
DWR's GGERP is a comprehensive plan that ensures the SWP power portfolio meets or exceeds aggressive GHG reduction targets. The plan includes divestment of coal-fired energy supplies and investment in high-efficiency and renewable energy supplies while at the same time improving energy efficiency at its operations facilities and power plants. DWR's progress toward achieving its GHG emissions reduction targets is monitored and reported each year.

DWR's membership in The Climate Registry (TCR) and its participation in CA's mandatory reporting requirements under AB32 serve as consistent and transparent mechanisms to report, update, track and verify DWR's carbon footprint. Reports are filed annually with both TCR and the California Air Resources Board and are verified by professional third party verifiers.

As of January 2016, annual GHG emission reports through 2014 have been verified and accepted by TCR. Gathering of the data for 2015 GHG emissions is underway. Summary GGERP monitoring reports are also prepared annually and are posted on DWR's website at: http://www.water.ca.gov/climatechange/GHGReports.cfm

DWR has been tracking and reporting its GHG emissions since 2007 and is publicly committed to its 2020 and 2050 GHG emissions reduction goals in 2012. In the three years since this commitment, DWR has made significant progress and is actually ahead of schedule for achieving its goals. Figure 3 below shows the changes in the SWP energy portfolio that have already occurred and those that are projected to occur (projections are made based on historic average hydrology, pumping load and resource output). Figure 4 shows DWR's estimated 1990 GHG emissions, its actual emissions between 2007 and 2013 and projected emissions out through 2050.

Figure 3: DWR Power Portfolio 2010-2050



Note: Figure 3 depicts the long-term planning portfolio; real-time operations include purchases and sales to the market to ensure water delivery reliability.

Figure 4: DWR's GHG Emissions