Resource planning report

IRP filing report for submission to the California Energy Commission

APRIL 2019

SMUD

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1. Executive Summary

SMUD's 2018 Integrated Resource Plan (IRP) outlines an ambitious road map for lowering greenhouse gas (GHG) emissions in the Sacramento region while maintaining our historically low rates and reliable service to our customers. The IRP was developed by exploring alternative scenarios for decarbonization in the region and the final resource portfolio was adopted after extensive review by the SMUD Board of Directors and input from customers and other stakeholders. The IRP was adopted on Oct. 18, 2018 and is attached as Appendix C to this report.

This supplemental resource planning report provides additional information and background regarding our IRP, including a discussion of the resource portfolios considered and the underlying data, methodologies and analyses supporting the IRP. This report also provides transparency regarding the IRP process as it relates to requirements defined in Senate Bill 350 (SB 350) and elaborated in the IRP Guidelines developed by the California Energy Commission (CEC).

The IRP process considered a range of resource alternatives and scenarios for serving SMUD's customers in the 2019-2040 period, including energy efficiency and demand response, electrification, renewable generation, distributed generation and energy storage. Our IRP is focused on options for achieving significant decarbonization in the region while at the same time meeting objectives of affordability, minimizing rate impacts and maintaining reliability. Therefore, it includes significant advancements on the demand side, including energy efficiency, demand response, transportation electrification and building electrification. This supplemental report shows our results for the 2019-2030 period.

As with any long-term outlook, there is significant uncertainty regarding the resource plan outlined in our IRP and in this supplemental report. Our plan was developed based on assumptions regarding future load growth, regional demographics, energy efficiency improvements, capital costs for new resources, market and regulatory conditions and other potential scenarios. As these factors may change significantly over time, we expect to adjust our resource plan as needed to best reflect current market conditions. We will refresh our IRP annually based on strategic directions from our Board and conduct thorough updates and revisions every five years.

Our Integrated Resource Plan

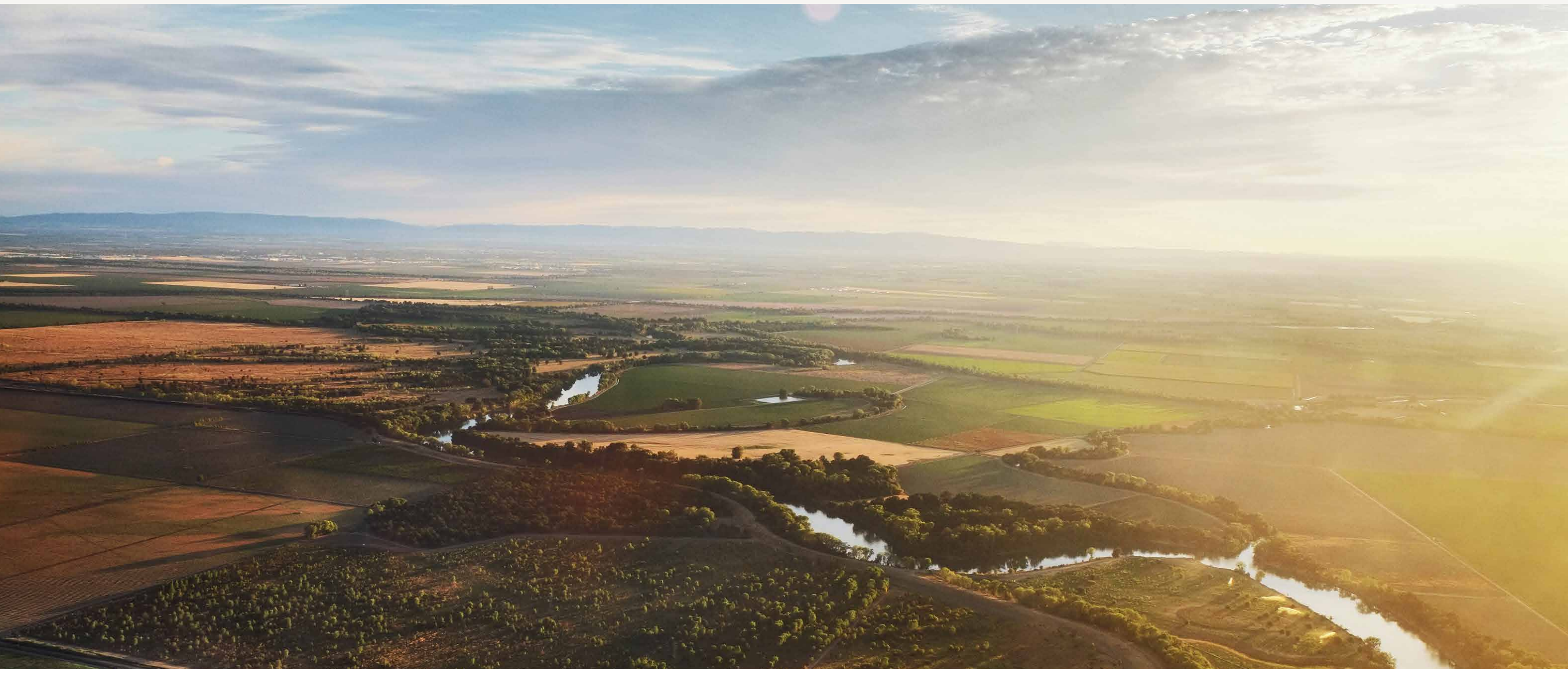
California is taking steps toward achieving a low-carbon economy, most recently by requiring that GHG emissions be reduced to at least 40% below 1990 levels by 2030 and that electric load serving entities source at least 60% of retail sales from renewable sources by 2030. These advances put California on a path to achieving a long-standing goal of reducing the state's GHG emissions to 80% below 1990 levels by 2050.

At SMUD, our goal has been to reduce emissions even further – to 90% below 1990 levels by 2050. As part of the 2018 IRP process, our Board modified this goal to achieve net zero greenhouse gas emissions by 2040, as explained below.

100%

NET-ZERO-CARBON
ELECTRICTY BY
2040

The scenarios we explored as part of the resource planning process focused on decarbonization that will put us on track for meeting net zero greenhouse gas emissions by 2040. We therefore examined several long-term decarbonization scenarios, all of which meet the statutory requirements in terms of GHG emissions, RPS requirements and energy efficiency. Our analyses suggest that in order for California to reach its goal of 80% GHG emission reductions and for the Sacramento region to achieve the same level of reductions, it may be necessary to dramatically scale up the pace of electrification of buildings and transportation while also maximizing improvements in energy efficiency, demand response



and renewable energy. This would have to be done at all points in the grid, from large scale grid-connected renewables and storage to small scale behind-the-meter resources.

In preparing the various IRP scenarios, we first considered how much our distributed energy resources portfolio would need to expand to reduce the Sacramento region's greenhouse gas emissions to 80% below 1990 levels by 2050 (electricity sector as well as transportation, buildings and other sources). We then considered other resource options, including renewable energy and storage as potential candidates for future resource expansion. Several scenarios were developed that considered different levels of GHG reductions and resource combinations for review and discussion with stakeholders and our Board.

The scenario we chose that became our resource plan (Adopted Scenario) includes a combination of supply and demand side measures that, together with a focus on electrification, has the potential to bring our 2040 emissions to net zero. While we expect to still use natural gas in our power plants, this will be offset by fossil fuel emission reductions from buildings and from transportation. A key action item resulting from our IRP is to develop the accounting methodology for our net zero concept.

Table 1 shows the expected peak load and resource capacity balance for the 2019-2030 period. Table 2 shows a subset of Table 1, namely the new resources that are part of the IRP, including incremental demand side impacts such as energy efficiency, demand response, distributed generation, electrification and electric transportation. Table 2 shows that beyond the near-term new supply-side renewable resources that we already have under development, we do not expect to need additional new energy and capacity resources until towards the end of the next decade.

More details regarding the IRP resource portfolio are available in Chapter 9 of this report as well as in the mandatory tables submitted together with this report.

Table 1. Peak Load and Resource Balance (MW, 2019-2030)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity Demand and Reserves												
Expected Peak Load(1)	3,096	3,125	3,177	3,204	3,229	3,254	3,285	3,315	3,344	3,377	3,409	3,447
15% Planning Reserve Margin	464	469	477	481	484	488	493	497	502	507	511	517
Distributed Energy	189	229	271	293	309	324	329	367	409	466	496	538
Demand Response(2)	111	116	124	130	136	143	149	153	159	170	185	197
Total Load & Margin	3,260	3,249	3,259	3,262	3,268	3,275	3,300	3,292	3,278	3,248	3,239	3,229
Resources (MW available for peak load)												
Battery	-	-	-	-	-	-	-	-	-	-	-	246
Natural Gas(3)	931	885	887	878	879	879	878	878	875	873	873	865
SMUD Hydro	677	677	677	677	677	677	677	677	677	677	677	677
WAPA Hydro	336	336	336	336	336	336	336	336	336	336	336	336
Biomass/Geothermal(4)	171	226	224	190	185	185	186	184	186	188	189	197
Solar	105	113	232	233	235	236	235	234	254	262	263	277
Wind	104	105	105	106	106	144	130	131	162	192	207	229
Market Capacity Purchases	936	907	798	842	850	818	859	853	787	720	694	403
Total Dependable Capacity	3,260	3,249	3,259	3,262	3,268	3,275	3,300	3,292	3,278	3,248	3,239	3,229

(1) 1-in-2 annual peak load.

(2) Demand Response is grossed up by 15% here to account for the fact that it is applied to the load and we do not carry planning reserves for it.

(3) Hydro and thermal generator capacities listed as the net dependable capacity (NDC) during peak summer conditions. Renewable energy resources show the expected load carrying capability (ELCC) at the expected peak hour of the annual peak net load.

(4) A share of Cosumnes Power Plant's Net Dependable Capacity is reported here as biomass – represents the proportion of Cosumnes expected to the fueled by biomethane.

Table 2. New Resources for the IRP

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Demand-Side Resources											
Additional Achievable Energy Efficiency (GWh)	85	178	276	394	508	612	754	900	1,050	1,196	1,322
Building Electrification (GWh)	7	13	24	44	71	104	144	189	240	298	365
Transportation Electrification (GWh)	68	98	138	189	259	367	446	548	652	779	936
Demand Response (MW)	101	108	113	119	124	130	133	139	148	161	171
Supply-Side Resources (Nameplate MW)											
Biogas/Biomass	7	7	7	-	-	-	-	-	-	-	-
Small Hydro	3	3	3	3	3	3	3	3	3	3	3
Wind	200	200	200	200	268	268	268	268	268	503	554
Solar	123	223	223	223	223	223	223	223	223	276	323
Solar SolarShares[SM]	20	20	32	44	56	66	79	94	111	126	141
Battery Storage 4hr	-	-	-	-	-	-	-	-	-	-	246
Market Capacity Purchases	907	798	842	850	818	859	853	787	720	694	403

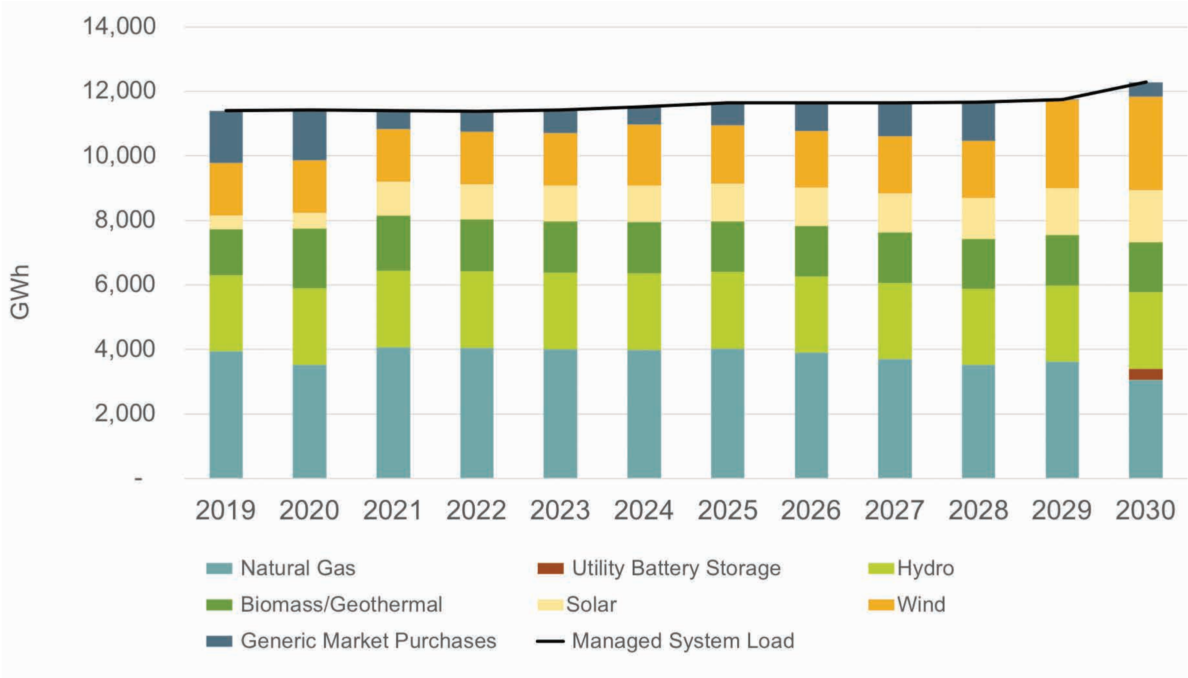
Because our IRP focuses on electrification of the Sacramento region, we expect to experience some load growth over the 2019-2030 period. This is because growth of Solar PV, improvements in energy efficiency, and demand response will be offset by increasing demand from more electric vehicles and all-electric homes and buildings.

After 2030, when electrification in the slow-to-change building sector gains momentum because of investments we expect to make in the next 5-10 years, load growth is expected to remain strong, even though we'll continue to see increases in the amount of behind-the-meter generation and storage as well as further improvements of energy efficiency.

Figure 1 shows the expected annual energy balance for the 2019-2030 period and Figure 2 shows the capacity balance (including a 15% reserve margin) for the same period. The figures show that over time, we will continue to pursue a highly diversified resource portfolio that includes an increasing share of renewable energy and eventually storage.

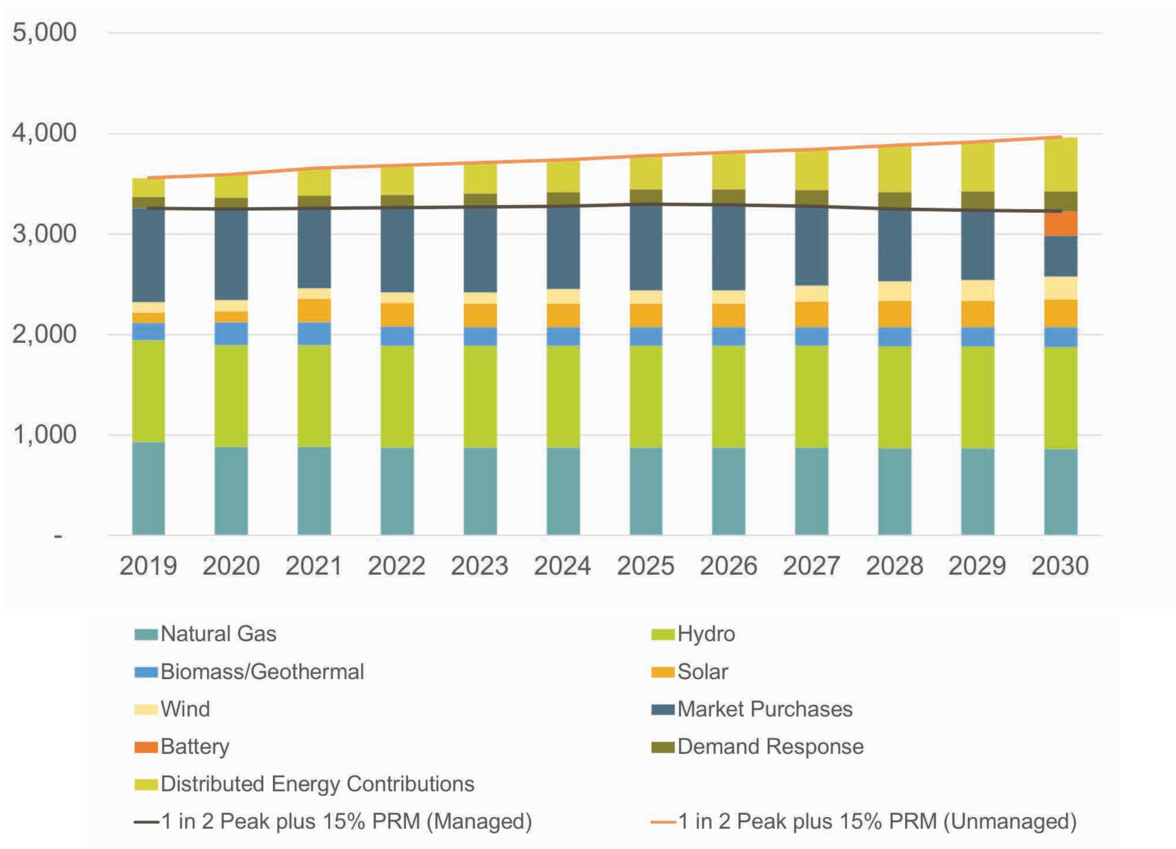
Figure 2 also shows that over time, we expect distributed resources and demand response to become increasingly important for cost-effectively maintaining capacity and reserves and making sure we have enough resources to serve load during high demand hours and during hours with significant ramping needs. Even though the penetration of renewable energy on SMUD's system will increase over time, we don't see any risk for curtailments within our service territory or balancing authority area due to overgeneration by solar or wind resources in the 2019-2030 period.

Figure 1. Annual Energy Balance 2019-2030 (GWh)



Charging and discharging of utility scale batteries is shown in both system load (charging) and energy supply (discharging).

Figure 2. Annual Capacity Balance 2019-2030 (MW)



SB 100 compliance

Our IRP scenarios and analyses were completed before the passage of SB 100 that requires utilities to meet electric demand with at least 60% eligible renewable resources by 2030. To ensure compliance with these requirements, we plan on filling gaps with a combination of purchases of renewable energy credits (RECs) and acquisition of additional renewable energy through ownership or contracting. The incremental rate impact of this additional procurement/contracting is expected to be minimal (see section 12 for details), compared to our adopted resource plan. Our updated RPS Procurement Plan, attached as Appendix B to this report, reflects these additional activities to meet SB 100.

Minimizing rate impact

SMUD's retail electric rates are among the lowest in California. Over the 2019-2030 period, our IRP is expected to result in annual rate increases of about 1-2% per year, in real terms, for residential customers.[1] This estimate covers only the incremental changes associated with our IRP, such as investments in new capacity, distribution infrastructure upgrades to support DERs and new load, and customer programs to support energy efficiency and electrification. When factored in with other costs that typically impact rates but are not part of this IRP – such as adjustments for changing costs of operations, programs maintenance, etc – the actual rate impact may be different than what is estimated in this report.

2030 greenhouse gas reductions and beyond

SMUD continues to deliver reliable power to our customers with a minimal greenhouse gas footprint, thanks to our renewable energy portfolio, greenhouse gas-free hydro resources and forward-looking research and development programs that consider voluntary programs and potential new greenhouse gas offsets.

Over the 2019-2030 period, our goal is to reduce GHG emissions from over 2.2 million metric tons in 2019 to 1.35 million metric tons in 2030. This would be a reduction of more than 40% from today's levels and 60% below our 1990 emission levels. Our 2030 goal also puts SMUD's emissions on the low end of the greenhouse gas emissions target range for SMUD established by the ARB in its 2018 report on greenhouse gas planning targets for the electricity sector.[2]

In adopting our 2018 IRP, the Board also required that we attain net-zero greenhouse gas emissions by 2040. By focusing on electrification programs, education and incentives, we expect that our power plant GHG emissions in 2040 will be more than offset by GHG emission reductions that are achieved by electrification in the building and transportation sectors in the Sacramento region.

A key action item for SMUD over the next few years is to develop and evolve effective electrification programs and adopt a methodology for how we account for emission reductions in other sectors. The greenhouse gas emission reductions estimated in this report do not account for secondary emission reduction impacts resulting from our efforts in other sectors or regions. The mandatory CEC reporting tables submitted with this report do, however, include the estimated impact on GHG emissions in the transportation sector resulting from our electrification efforts, based on using the calculator that the CEC has provided for this purpose.

[1] This value does not include effects of inflation.

[2] https://www.arb.ca.gov/cc/sb350/staffreport_sb350_irp.pdf.

Disadvantaged communities benefit from lower emissions

About 190,000 of Sacramento County residents live in disadvantaged communities, some of which are also near our fossil fuel power plants. Because the IRP reflects our plans to invest more in renewable energy, storage, electrification, energy efficiency and demand response, emissions from our existing power plants will decline over time. For all power plants, including those in disadvantaged communities, our plan is expected to reduce criteria air pollutant emissions by over 50% by 2030, compared to 2016 levels. We also expect to reduce emissions due to equipment investments at our cogeneration facilities that allow us to provide required steam while running our power plants less. In addition, our focus on electrification and renewable energy programs for low income customers will benefit disadvantaged communities through economic opportunities, cleaner energy supply, lower overall bills for energy, and reduced emissions from buildings and transportation.

CEC guidelines and SB350

This supplemental report was developed to ensure the documentation supporting our IRP meets the requirements of SB 350 and follows the IRP guidelines provided by the CEC. To help identify how this report addresses each of the issues identified in the Public Utility Code and the CEC IRP guidelines, Table 3 provides a guide to where each of the issues are discussed in the report.

Table 3. Report reference guide

CEC guidelines chapter			SMUD resource planning report chapter reference	Report chapter #	Starting on page
2A	**Planning horizon**		Executive summary	1	7
			IRP objectives	2.7	29
			IRP scenarios	2.8	31
2B	**Scenarios and sensitivity analysis**		IRP scenarios	2.8	31
			Results	9	80
2C	**Standardized tables**		Filed separately	N/A	N/A
2D	**Supporting information**		N/A	N/A	N/A
2E	**Demand forecast**		Electric demand 2019-2030	5	44
	1	Reporting requirements	CRAT &EBT	N/A	N/A
	2	Demand forecast methodology and assumptions	Load forecast methodology and data	5.1	46
			Appendix D. Load forecast methodology and data sources	19	199
	3	Demand forecast – other regions		N/A	N/A
2F	**Resource procurement plan**				
	1	Diversified procurement portfolio	Existing generation portfolio	6.1.2	63
			New resource supply options	7	67
			Results	9	80
	2	RPS planning requirements	Appendix B	17	128
	3	Energy efficiency and demand response resources	Demand response	5.2	48
			Energy efficiency	5.3	50
			CRAT & EBT	N/A	N/A
	4	Energy storage	Energy storage	7.1.2	70
			Adopted Scenario	9.1	80
	5	Transportation electrification	Transportation electrification	5.3.3	53
2G	**System and local reliability**		System and local reliability	8	76
	1	Reliability criteria	Planning reserve margin	8.2	76
			Operating reserves and NERC reliability standards	8.3	78
	2	Local reliability area	Local reliability and capacity needs	8.1.1	77
	3	Addressing net demand in peak hours	Net demand during summer peak hours	9.1.3	84
			Net demand during springtime low load and peak hydro conditions	9.1.4	85
2H	**Greenhouse gas emissions**		Greenhouse gas emissions	11	100
2I	**Retail rates**		Retail rates	12	105
2J	**Transmission and distribution systems**		Transmission and distribution plans	13	107
	1	Bulk transmission system	Bulk transmission system	13.1	108
	2	Distribution system	Distribution	13.2	110
2K	**Localized air pollutants and disadvantaged communities**		Localized air pollutants and disadvantaged communities	10	93

2. Introduction

SMUD's IRP is a living document that is intended to guide efforts to supply reliable electricity in an environmentally-responsible and cost-effective manner through planning strategies that achieve high-level policy goals. Our IRP is refreshed annually to address staff recommendations for additional study and to reflect legislative, regulatory, market and technology changes.

In 2015, California enacted the Clean Energy and Pollution Reduction Act (Senate Bill 350) that introduced new requirements on both investor-owned and publicly-owned electric utilities. SB 350 directed SMUD to adopt an IRP by Jan. 1, 2019 that met specific RPS procurement and GHG reduction goals, while considering other goals, such as reliability, ratepayer impacts and effects on disadvantaged communities. We're required to submit the plan to the CEC for review. SB 350 also requires SMUD's Board to adopt a process to update the IRP at least every 5 years to ensure we continue on a path to meet the state's goals.

SMUD's IRP was developed as part of a public process that included involvement from our customers and community. Our Board of Directors adopted the IRP on Oct. 18, 2018 and the IRP is the basis for this supplemental resource planning report.

The IRP relies on numerous planning assumptions that help model our electricity system under various scenarios. While these assumptions and scenarios are plausible and simulated using the best available modeling techniques, the results are illustrative and may not correlate fully with SMUD's near-term budgets and plans. Our analyses are conducted from a policy perspective to demonstrate how different planning targets affect operations, revenues, reliability and costs/rates.

This report is organized as follows:

- The remainder of this section provides a general overview of SMUD as well as an overview of the current IRP process and how we expect to update our resource plan in the future.
- The majority of the report is focused on providing background data, assumptions and methodology that drive our IRP, such as demand, fuel prices and modeling methodology. Chapter 3 of this report presents policy and market context for the analyses and Chapter 4 provides an overview of our modeling methodology.
- The results are shown in Chapter 9 and our action plan resulting from this IRP is highlighted in Chapter 14.
- In addition to presenting results in Chapter 9, the report also breaks out specific findings and results for disadvantaged communities, GHG emissions and provides an overview of how the IRP results are integrated with our transmission and distribution planning processes.

Environmental leadership

SMUD's commitment to renewable energy and the environment stretches back many decades. Below are some examples of our legacy in environmental stewardship.

- Solar power has been in our mix since 1984 when we began operating our pioneering Photovoltaic 1 (PV1) solar farm near our Rancho Seco Recreational Area in south Sacramento County.
- Since 1990, our Sacramento Shade Program has delivered more than 500,000 free shade trees to local homes and businesses. It's one of our most popular programs and is recognized nationally.
- Also in 1990, we began vehicle electrification efforts when our Board adopted a clean air policy that prompted the electrification of some of our fleet vehicles.
- We established our Solano Wind Farm in 1994 on the Montezuma Hills in Solano County. It's gone through several expansion phases and a fourth one is expected to be operational in 2023.
- In 1997, we began one of the country's first green energy programs. This pioneering program called Greenergy® today has more than 70,000 residential customers, ranking second nationally among utility voluntary green power programs.
- SolarShares was launched in 2008 as one of the first community solar programs in the country. The program's customers include the Sacramento Kings, State of California, City of Sacramento and CalPERS.

In recent years, we were the first large California utility to have 20% of its power from resources classified as renewable by the state.

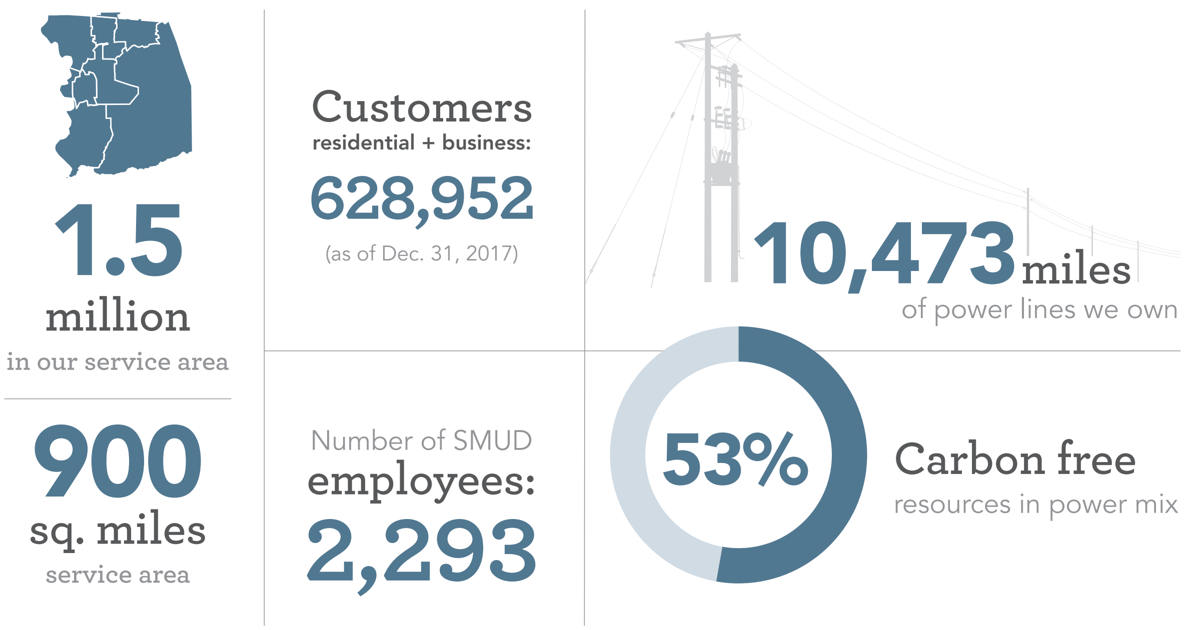
2.1 SMUD Overview

SMUD began serving Sacramento in 1946 and is now the nation's sixth-largest community-owned electric utility. SMUD provides reliable, affordable electricity to most of Sacramento County and small portions of Yolo and Placer counties. Our consistently low rates are important to the economic vitality of the Sacramento region.

For the past several decades, SMUD has been recognized nationally and internationally for our environmentally-conscious and innovative renewable power and energy efficiency programs. For example, we were the first large California utility to receive more than 20% of its energy from eligible renewable resources.

Our vision is to provide our customers and community with innovative solutions to ensure energy affordability and reliability, improve the environment, reduce our region's greenhouse gas footprint and enhance the vitality of our community.

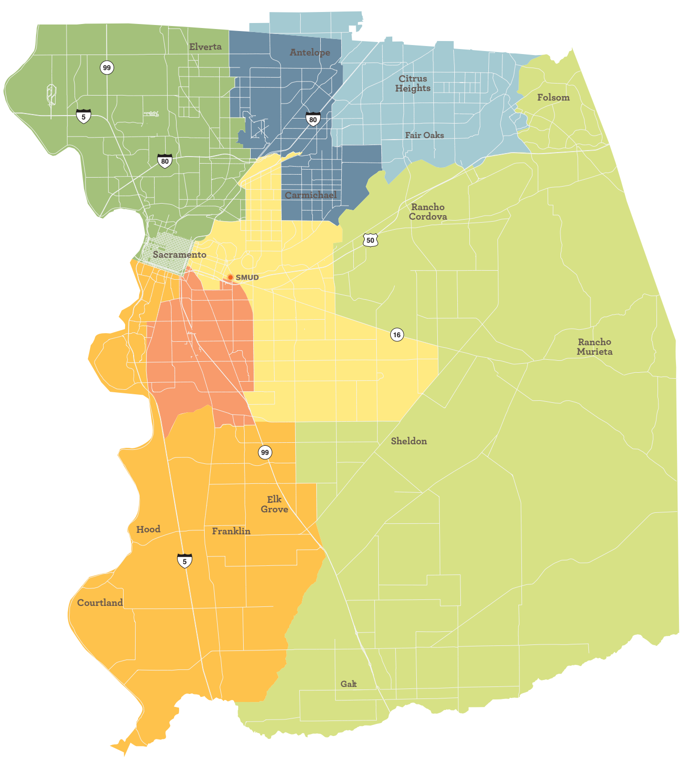
Figure 3. SMUD basic facts and figures



We're doing this by implementing and expanding several important programs, including making time-of-day (TOD) rates standard for all residential customers. For years, TOD rates were the standard for commercial customers, and starting in 2019, it became phased in as the standard for residential customers, too. We will also be expanding programs to encourage electrification – electric vehicles, all-electric homes and other buildings, distributed generation adoption, community solar, voluntary green pricing, energy efficiency and much more.

SMUD is governed by a publicly-elected 7-member Board of Directors, with each representing an area, or "ward," of our service territory (See Figure 4). Each member is elected by SMUD customers in their respective ward and serve a 4-year term on the Board.

Figure 4. SMUD service territory



2.2 Balancing Authority of Northern California

The Balancing Authority of Northern California (BANC) is a Joint Powers Authority (JPA) consisting of SMUD, Modesto Irrigation District, Roseville Electric, Redding Electric Utility, Trinity Public Utility District and the City of Shasta Lake. BANC assumed the balancing authority responsibilities on May 1, 2011 from SMUD. This means that BANC is responsible for matching of generation to load and coordinating system operations with neighboring balancing authorities.

BANC is the third largest balancing authority in California and the 16th largest within the Western Electricity Coordination Council (WECC) area. The BANC partnership between public and government entities is an alternative platform to other balancing authorities like the California Independent System Operator (CAISO). BANC provides reliable grid operation consistent with standards developed and enforced by the Federal Energy Regulatory Commission (FERC), the North American Electric Reliability Corporation (NERC) and WECC. BANC contracts with SMUD for operations of the Balancing Authority.

As a member of BANC, SMUD will join CAISO's Energy Imbalance Market (EIM) in 2019. This is expected to help integrate renewable energy resources within our service territory. Joining the EIM may also allow us to find additional value from SMUD's flexible hydro and thermal resources.

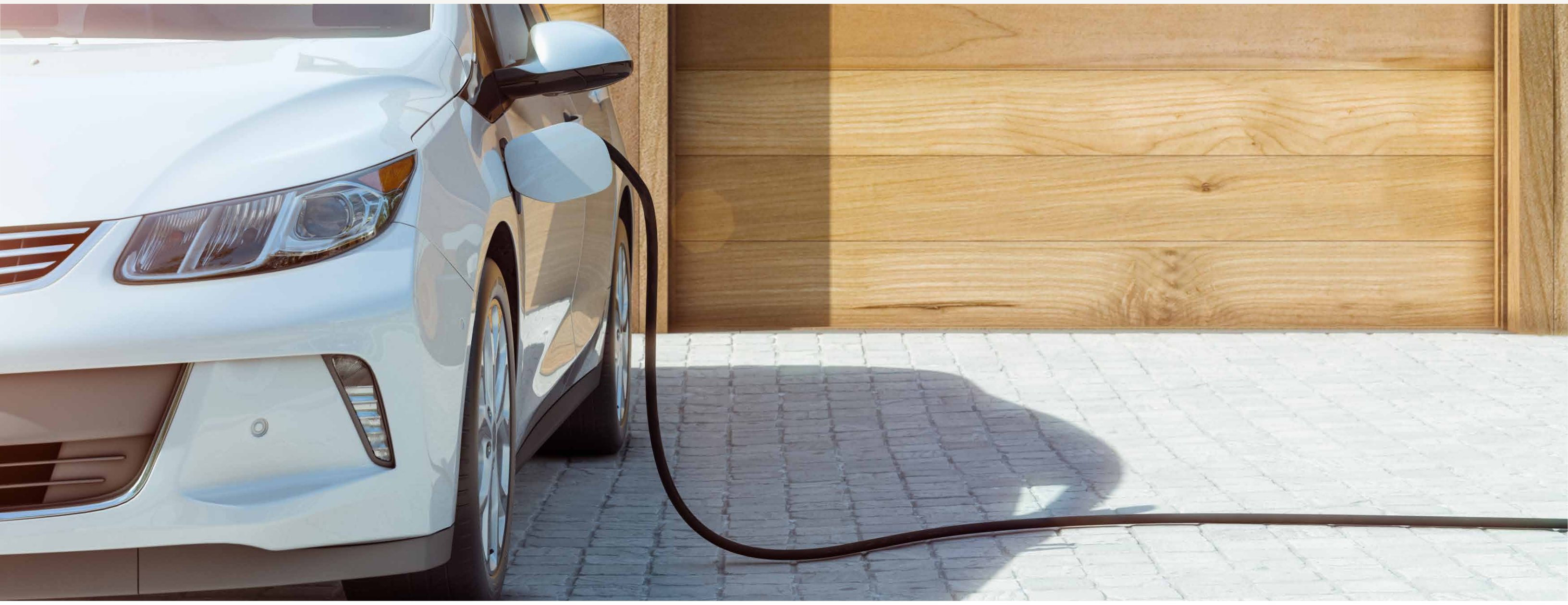
2.3 Customer programs

This section provides an overview of SMUD's customer programs, most of which are geared toward energy efficiency, access to renewable energy, low-income residents or electrification. Our IRP accounts for these programs' impact on total demand and peak demand for electricity. The IRP also anticipates an increased focus in the 2019-2030 period on both energy efficiency and electrification – 2 potentially counterbalancing forces that we expect will draw on existing programs and be enhanced by creating new programs over the next 10 years. The IRP electric demand forecast in Section 5 provides further detail on this outlook.

2.3.1 Commercial/Industrial programs

- **Construction of all-electric new homes:** Provides incentives to builders and their design teams for residential developments of all-electric homes in support of electrification initiatives.
- **Commercial electric vehicle program:** SMUD offers incentives to commercial customers and residential customers who live in multifamily dwellings for the installation of level 2 electric vehicle chargers. Some large corporations and city, county and state government entities benefit from EV charging infrastructure to support fleet vehicles and employees and customers with EVs.
- **Demand response program:** SMUD offers incentives to its commercial and industrial customers through a variety of demand response programs. The programs give customers an opportunity to reduce energy costs during peak hours while allowing SMUD to reduce demand during tight supply conditions.
- **SolarShares℠:** SMUD offers commercial customers a community solar product where the participant signs an agreement with SMUD for us to provide solar power for up to 20 years. This product provides an alternative to net energy metering (NEM) or site located solar (e.g. rooftop solar) giving customers many of the same benefits as behind-the-meter generation. We retire all renewable energy credits (RECs) on behalf of our participants. This program is Green-e certified by the Center for Resource Solutions.[3]
- **Greenergy®:** SMUD offers a traditional utility green pricing product called Greenergy, which is Green-e certified by the Center for Resource Solutions. The program gives participants the opportunity to receive a blend of renewables from a power content label that is their own, and customers can make renewable and environmental claims in their external and corporate marketing. We offer Partner and Partner Plus products to all customers and for large commercial customers we offer the option of tailored Power Content. We retire all RECs on behalf of our participants.
- **Customized energy efficiency incentives:** Promotes the installation of energy-efficient equipment, controls and processes at commercial and industrial customers' facilities. Provides incentives to contractors and/or customers to promote the installation of energy-efficient lighting, heating, ventilation, and air conditioning (HVAC), motors and refrigeration equipment and controls. The program also provides incentives for retro-commissioning, process improvements and data center storage projects that result in energy savings.

[3] https://resource-solutions.org/.



- **Express Energy Solutions:** Provides prescriptive incentives to participating qualified contractors for high-efficiency equipment across a variety of end-uses: lighting, HVAC, refrigeration and food-service equipment. Incentives are targeted to the contractor/supplier to stimulate the market for energy-efficient equipment and services and are designed to cover a significant portion of the incremental cost of the equipment.
- **Complete Energy Solutions:** A third-party administrator performs comprehensive energy audits of small- and medium-sized businesses. A customer receives a customized report detailing recommended energy improvements, estimated savings, estimated cost and payback. Third-party administrator then assists customer in hiring a contractor to complete the project.
- **Savings by Design:** Provides incentives to builders and their design teams to design new commercial and industrial buildings that are 10-30% more energy efficient than required by California Code of Regulations Title 24 (or typical new construction in the case of Title 24-exempt buildings and processes).

2.3.2 Residential programs

- **Electric vehicles for residential customers:** SMUD offers residential customers incentives equivalent to the cost of a Level 2 EV charger or a cash incentive corresponding to the estimated cost of 2 years' charging with an EV ($599). Residential customers are also offered a rate discount for charging their EV during certain time-periods. The program helps facilitate faster adoption of low- and zero-emission vehicles in the Sacramento region and has been very popular so far. The program captures approximately 85% of the residential light duty vehicle sales in our service territory and helps customers self-identify as EV owners. This helps SMUD gain insight on the location of the region's EVs, which improves planning for future grid investments and upgrades. In Q4 of 2019, a new statewide program modeled after SMUD's $599 program is expected to launch. This will supplant SMUD's current program and result in a wider, more effective program with higher rebate levels that could further increase adoption.

Electric vehicle charging incentives

- These incentives are provided to encourage more installation of EV charging infrastructure outside of single-family housing locations to address range anxiety, which is a major EV adoption barrier. SMUD offers $1,500 incentives for EV charging at workplace and multifamily facilities. Until recently, SMUD also offered a $100,000 DC Fast Charger incentive, but it was restructured in late 2018 because of lack of customer interest. Restructured workplace and multifamily fast charger incentives are planned for 2019 and beyond to align with a new California Energy Commission EV Infrastructure Program (CalEVIP) that will fund $14 million worth of charging infrastructure in Sacramento County in 2019 and 2020. SMUD will align our incentives with the CalEVIP to make it easier for customers to apply and get both incentives simultaneously.

Outreach, education and awareness

- SMUD's integrated marketing and advertising campaigns complement our community education and hands-on driving demonstrations to reach customers, raise awareness of EVs and provide them with an opportunity to learn about and road test EVs. Examples of this include our ad campaign for the $599 "Free fuel for two years" incentive and our ride-and-drive demonstrations at the California State Fair, Sacramento Auto Show and other events that typically draw thousands of participants.
- **SolarShares℠:** SMUD offers residential customers a community solar product where the participant signs an agreement with SMUD for us to provide solar power to them for up to 20 years. This product provides an alternative to NEM or site-located solar (e.g. rooftop solar) and gives customers many of the same benefits as behind-the-meter generation. We retire all RECs on behalf of our participants. This program is Green-e certified by the Center for Resource Solutions.
- **Greenergy®:** SMUD offers a traditional utility green pricing product called Greenergy to its residential and commercial customers. The program gives participants the opportunity to receive a blend of renewables from a power content label that is their own. We retire all RECs on behalf of our participants. This program is Green-e certified by the Center for Resource Solutions.
- **Shade Tree Program:** This program provides free shade trees to SMUD customers and is implemented by the community-based nonprofit Sacramento Tree Foundation. The foundation's foresters review tree selection and site locations with customers, who plant the trees. The program has greenhouse gas reduction and greenhouse gas sequestration goals.
- **Equipment efficiency:** This program provides rebates and/or SMUD financing for qualifying (ENERGY STAR®, Consortium for Energy Efficiency, and/or other high-efficiency products) efficiency and electrification improvements to homes' building shells and equipment. Improvements include mini split heat pumps, whole house fans, central air conditioners and heat pumps, and heat pump water heaters.
- **Home Performance Program:** Participating contractors use building-science principles and diagnostic equipment to evaluate the current performance of the whole house, and then recommend comprehensive improvements that will yield an optimal combination of savings and comfort for homeowners. Once the homeowner selects the improvements that fit their needs and budget, participating contractors will do the work to Building Performance Institute standards. Program packages include both energy efficiency and electrification.

- **Appliance efficiency program:** This program provides rebates for qualifying (ENERGY STAR or Consortium for Energy Efficiency-listed) appliances. This includes smart thermostats, refrigerators, variable speed pool pumps and room air conditioners. The program also offers refrigerator/freezer recycling, pool pumps and a retail partnership program. The refrigerator/freezer recycling program provides rebates for free pick-up and environmental recycling of old refrigerators and freezers. Our retail partnership program works with big box retailers to pay retailer incentives for all the energy efficiency items they sell in their stores.
- **Retail lighting:** This program promotes energy efficient residential lighting products by providing incentives for manufacturers and their retail partners to sell ENERGY STAR qualified light-emitting diode (LED) lightbulbs at a discount and is implemented through agreements with manufacturers and retailers that involve cost buydowns, marketing and/or advertising.
- **Low-Income Energy Retrofits:** This program completes energy retrofits for qualifying low-income households through four offerings: Weatherization, Energy Saver Deep Retrofit, Energy Saver House Bundle and Energy Saver Apartment Bundle.

2.3.3 Information and education programs

In addition to programs that provide direct incentives to customers, we also have a Residential Advisory Service that provides on-site homes energy audits, online energy audits and telephone assistance for customers, with recommendations to reduce their homes' energy use (and bills). Recommendations include practices and home-improvement projects that will increase the energy efficiency of their dwellings.

2.4 Rates

SMUD's Board of Directors has autonomous authority to establish SMUD's electricity rates. Unlike investor-owned utilities (IOUs) and some other municipal utilities, retail rate and revenue levels are not subject to regulation by federal or state agencies. Changes to SMUD rates require formal action by the Board of Directors after public hearings. SMUD is also not required by law to transfer any portion of its collections from customers to any local government. SMUD typically reviews and sets rates on a two-year cycle.

SMUD's approach to rate setting is based on the Board's Strategic Direction 2, Competitive Rates, which provides the following guidance:

- Establish rate targets that are 18% below Pacific Gas and Electric (PG&E) and at least 10% below PG&E's published rates for each customer class.
- Reflect the cost of energy when it is used.
- Reduce use of energy during peak periods.
- Encourage energy efficiency and conservation.
- Minimize "sticker shock" in the transition from one rate design to another.
- Offer flexibility and options.
- Be simple and easy to understand.
- Meet the electricity service needs of people with fixed, low incomes and severe medical conditions.
- Equitably allocate costs across and within customer classes.

SMUD continues to maintain rates that are below PG&E's, both at a system level and by rate class, as shown in the table below.

Table 4. SMUD rate comparison

	SMUD Rates (cents/kWh)(1)	PG&E Rates (cents/kWh)(2)	Percent Below PG&E(3)
Residential – Standard	15.01¢	22.89¢	34.4%
Residential – Low Income	9.69¢	13.07¢	25.9%
All Residential	14.17¢	20.52¢	30.9%
Small Commercial (Less than 20 kW)	14.78¢	24.15¢	38.8%
Small Commercial (21 to 299 kW)	13.75¢	23.10¢	40.4%
Medium Commercial (300 to 499 kW)	12.88¢	21.49¢	40.1%
Medium Commercial (500 to 999 kW)	12.11¢	18.57¢	34.8%
Large Commercial (Greater than 1,000 kW)	10.26¢	14.98¢	31.5%
Lighting – Traffic Signals	11.86¢	23.09¢	48.6%
Lighting – Street Lighting	13.81¢	23.29¢	40.7%
Agriculture	13.15¢	20.35¢	35.4%
System Average	**13.20¢**	**19.82¢**	**33.4%**

(1) Projected 2018 average prices for SMUD with rates effective Jan. 1, 2018, nominal (For comparison purposes, the 2018 system average rate is 12.8 cents in real 2016 dollars).

(2) PG&E average prices in 2018 reflect rates effective Sept. 1, 2018, per Advice Letter 5339-E dated July 27, 2018.

(3) The rates in the Average Class Rates table are calculated by dividing the total revenue of each class by the total usage of that class in kWh. The actual savings per customer will vary based on their actual electricity consumption.

In 2017, SMUD's Board of Directors approved the transition to standard Time-of-Day (TOD) rates for residential customers, with implementation starting in late 2018. By the end of 2019, we expect most customers to have transitioned to this new rate structure. TOD is a cost-based rate that more accurately reflects the cost to provide power to customers and is expected to help with integrating increasing amounts of renewable energy by providing incentives to consume electricity when it is less costly to generate. Customers may also choose to be placed on a fixed rate that is approximately 4% higher than the TOD rate. Commercial customers are already on a TOD rate. Our TOD rates are listed in Table 11 further below in Section 5.5.

Additionally, in 2017 the Board approved a restructuring of SMUD's low-income program. Historically, eligibility for the Energy Assistance Program Rate (EAPR) was based on income, but the dollar value of the total monthly discount was based on the volume of energy usage. Under the changes approved by our Board, the monthly discount on energy charges are based on household income instead of the volume of energy usage. The changes to the EAPR discount better focus our limited resources to the lowest-income customers. The restructuring will occur over a 3-year period, ending in 2021.

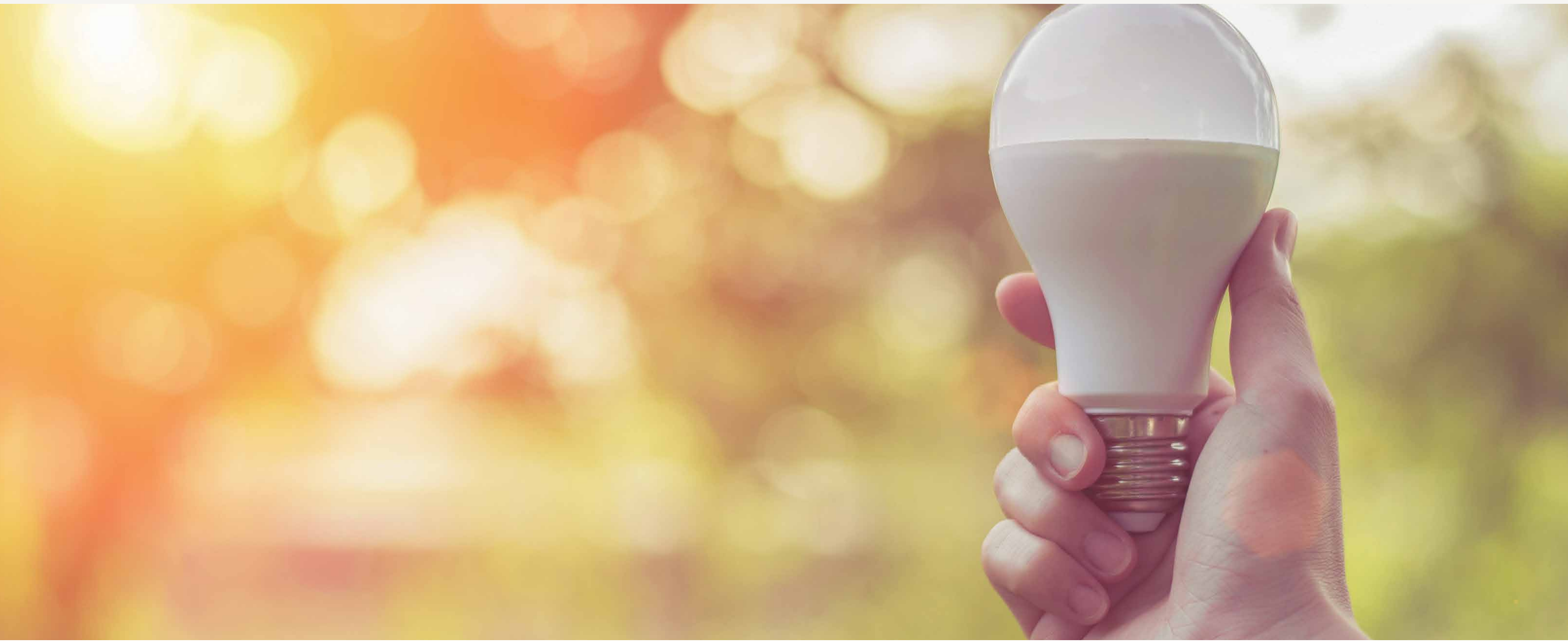


Table 5. EAPR rate discounts 2019-2021

Maximum discounts				
Federal poverty level	Baseline	2019	2020	2021
0- 50%	$42	$50	$60	$70
>50-100%	$42	$40	$41	$42
>100-150%	$42	$30	$25	$20
>150-200%	$42	$30	$20	$10

In 2018, SMUD's Board of Directors approved changes to the Economic Development Rate, which is used to attract, retain and promote the expansion of businesses within our service area. The changes, which are effective no later than Dec. 31, 2019, include extending the discount from 5 years to 10 years, removing industry restrictions and removing the requirement that customers receive all their power from SMUD. Customers may choose from 2 discount options: A flat discount for 5 years followed by a declining discount for 5 years or a flat discount for 10 years. Additionally, customers moving to a disadvantaged community will get a larger discount.

Even though the low-income-program and the Economic Development rates are not specifically focused on disadvantaged communities, as defined by the CalEPA,[4] we expect our revised and improved rates will bring significant benefits to low-income customers in disadvantaged communities in our service territory. Section 10 of this report provides a more detailed overview of our outlook of localized air pollution and impact on disadvantaged communities. As discussed in that section, our low-income programs are particularly important for having a positive impact in those communities since socio-economic issues are the leading drivers for the disadvantaged communities' designation in the Sacramento region.

[4] Disadvantaged Communities are defined by California Environmental Protection Agency as California communities that are disproportionately burdened by, and vulnerable to, multiple sources of pollution. More information is available at: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

2.5 IRP process overview

Our resource planning process is a collaborative process with input from all major business areas at SMUD as well as input from our Board and the public. Our internal resource planning team and committee coordinate and integrate strategic plans and priorities from across SMUD including those from power generation, energy trading, grid planning and operations, distributed energy strategy, research and development, load forecasting, pricing and rates, customer programs and regulatory and legal. The result of this planning process is an IRP that considers a wide range of available options in meeting IRP objectives.

We also reviewed and discussed potential scenarios to research, IRP study results, and developed staff recommendations that were discussed with our Board and with the public.

As part of the 2018 IRP process, our resource planning team presented detailed scenario information to the SMUD Board of Directors and the public at 6 separate Board meetings that were open to the public. Each of these public meetings included the opportunity for public comments and input regarding the draft IRP. As shown in Figure 5 below, SMUD's Board was key in both the development and the approval of the IRP, reviewing scenario results and in making the final decision on our 2018 IRP.

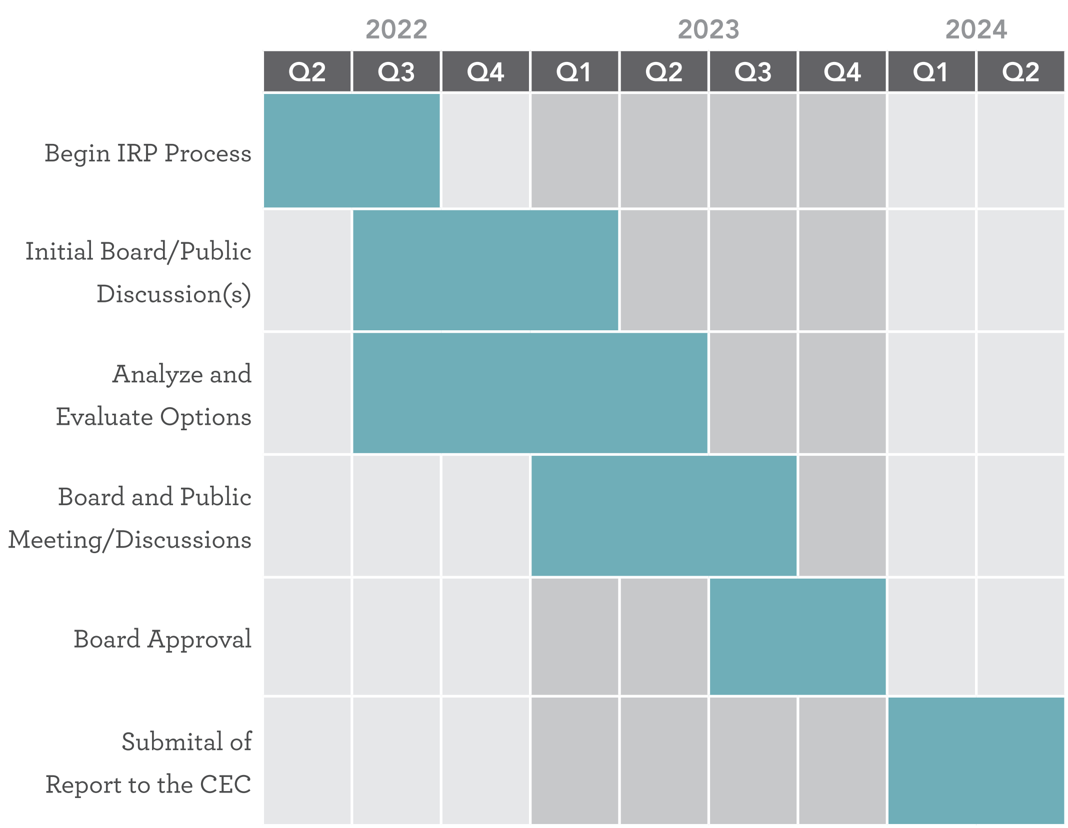
Figure 5. 2018 IRP Development, Stakeholder Engagement and Board Approval Process

1st Board meeting	2nd Board meeting	3rd Board meeting	4th Board meeting	5th Board meeting	6th Board meeting
APRIL 4	**JUNE 6**	**AUG. 1**	**SEPT. 5**	**OCT. 2**	**OCT. 18**
• IRP objectives and scenarios • Board/public comment	• High level scenario results • Board/public comment	• Detailed scenarios results • Public report released • Board/public comment	• Evaluate new scenarios and address Board questions • Board/public comment	• Evaluate new scenarios and address Board questions • Draft SD-9 language • Board/public comment	• Board adoption of SMUD IRP • Board/public comment

2.5.1 IRP refresh and update process

SMUD's Board has traditionally provided annual guidance to the resource planning process through one of its strategic directions, SD-9, Resource Planning. We expect this process of refreshing and revisiting the long-term planning process will continue. In addition, and in reflection of the regulatory changes that were enacted with SB 350, SMUD intends to also perform a major update of our IRP every 5 years that will be filed with the CEC. We plan to use the same internal process for developing our next IRP and expect to begin this process in the second quarter of 2022, with initial Board and public discussions occurring after the third quarter. SMUD's Board is expected to consider and adopt our next IRP by the end of 2023 as required under SB 350. The following figure provides an overview of the process and timeline adopted by the Board in October 2018. SMUD plans to follow a similar process and timeline at least once every 5 years thereafter.

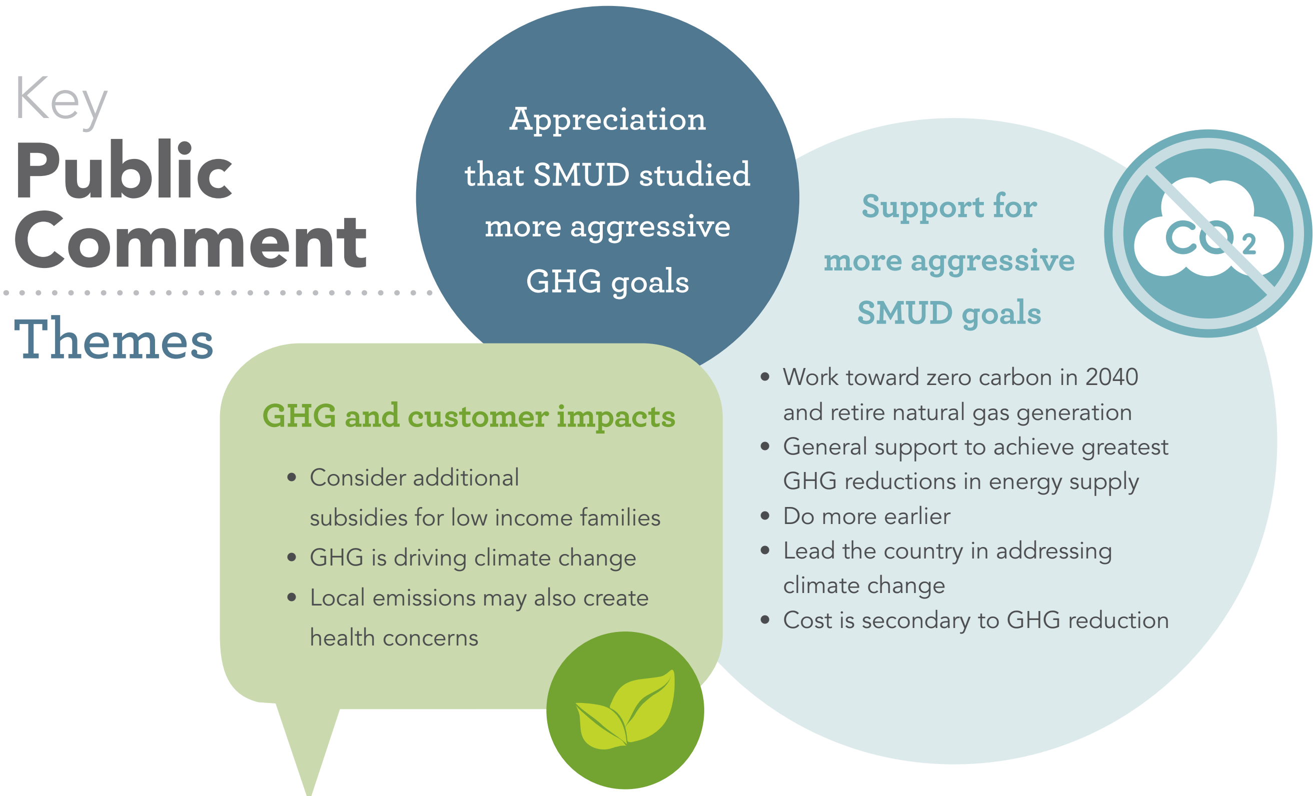
Figure 6. Process for updating SMUD's integrated resource plan



2.6 Stakeholder process

SMUD staff presented the 2018 IRP and associated materials at 6 separate Board meetings that were open to the public and invited public comment. In each of these meetings, staff gathered both Board and public comment for consideration in developing the IRP scenarios. During these meetings, the public provided 49 IRP-related comments. Most commenters represented local environmentally-focused organizations with the remainder being unaffiliated concerned citizens. General themes of the public comments are summarized in Figure 7 below. Staff and the Board considered the public comments during the IRP process, while also considering environmental impacts, cost, and rate and customer impacts and system reliability and safety.

Figure 7. 2018 key themes in public comments



2.7 IRP objectives

In accordance with one of its strategic directions, SMUD's Board regularly reviews and provides guidance to the long-term resource plan. The latest version approved by the SMUD Board in October 2018 is shown in Figure 8. It summarizes our long-term goals that form the basis of the resource plan.

As discussed in more detail in Section 3.1, below, recent changes in California law require SMUD to, among other things, meet at least 60% of our retail sales with eligible renewable energy resources by 2030, increase energy efficiency savings and reduce GHG emissions.

The changes also require that we consider stakeholder impacts and minimize rate increases with special consideration on disadvantaged communities and local air pollutants.

After consulting with staff and stakeholders, SMUD's Board determined that the objective of our 2018 IRP would be to identify a path towards carbon neutrality for SMUD while maintaining the financial health of the company and providing maximum benefits for our customers, community and the Sacramento region.

As a community-owned utility, SMUD is uniquely positioned to consider and balance both utility-specific greenhouse gas reductions plus SMUD investments in local community measures that help achieve greater overall regional greenhouse gas reductions.

This resource plan focuses on advancing demand response and energy efficiency programs, procuring renewable generation and accelerating local vehicle and building electrification to achieve significant greenhouse gas reductions over the planning horizon. Increased investments in renewable energy and enhanced electrification in our region represent promising areas to achieve additional GHG reductions beyond efforts already underway by SMUD and other entities in the Sacramento region.

We identified key areas to study during this IRP cycle. First is the long-term role of SMUD's existing resources, including our thermal fleet and hydro resources, in keeping the lights on and maintaining competitive rates. After understanding the flexibility and limitations of our system, the study looked at the GHG reduction options both within our resource portfolio and more broadly across our region. Finally, we analyzed the costs and benefits of various potential alternatives to achieve a low-carbon pathway for SMUD.

As we developed this analysis, we limited our assessment on the supply-side to mainly renewable resources and battery storage due to cost, technical maturity and relative development and operational risk of the measures considered. Because our IRP is a living document – one that will be comprehensively updated every 5 years to reflect changes in SMUD's environment, including the economy, demographics, technology, the legislative and regulatory environment and the needs of our customers, we may consider additional or different resources in future IRPs as well on a case-by-case basis if opportunities arise outside of the IRP process.

Figure 8. Strategic planning directive 9 on resource planning from SMUD Board

SMUD's Board Strategic Direction on Resource Planning (SD-9)

It is a core value of SMUD to provide its customer-owners with a sustainable power supply through the use of an integrated resource planning process. A sustainable power supply is defined as one that reduces SMUD's net long-term greenhouse gas (GHG) emissions to serve retail customer load to NetZero by 2040. Net Zero is achieved through investments in vehicle and building electrification, energy efficiency, clean distributed resources, RPS eligible renewables, large hydro, and biogas. SMUD shall assure reliability to the system, minimize environmental impacts on land, habitat, water quality, and air quality, and maintain a competitive position relative to other California electricity providers. To guide SMUD in its resource evaluation and investment, the Board sets the following interim goal (as shown in the below table):

Year	Net Greenhouse Gas Emissions (metric tons)
2020	2,318,000
2030	1,350,000
2040	Net Zero
2050	Net Zero

In keeping with this policy, SMUD shall also achieve the following:

a) SMUD's goal is to achieve Energy Efficiency equal to 1.5% of retail load over the next 10-year period. On an annual basis, SMUD will achieve energy efficiency savings of 1.5% of the average annual retail energy sales over the three-year period ending with the current year.

   To do this, SMUD will acquire as much cost effective and reliable energy efficiency as feasible through programs that optimize value across all customers. SMUD shall support additional energy efficiency acquisition by targeting one percent (1%) of retail revenues for above market costs associated with education, market transformation, and programs for hard to reach or higher cost customer segments. The market value of energy efficiency will include environmental attributes, local capacity value of energy efficiency will include environmental attributes, local capacity value and other customer costs reduced by an efficiency measure.

b) Provide dependable renewable resources to meet 33% of SMUD's retail sales by 2020, 44% by 2024, 52% by 2027, and 60% of its retail sales by 2030 and thereafter, excluding additional renewable energy acquired for certain customer programs.

c) In meeting GHG reduction goals, SMUD shall emphasize local and regional environmental benefits.

d) SMUD will continue exploring additional opportunities to accelerate and reduce carbon in our region beyond the GHG goals in this policy.

e) Promote cost effective, clean distributed generation through SMUD programs.

2.8 IRP scenarios

In developing our IRP, we examined long-term resource portfolio options that are consistent with our Board Strategic Directions and achieve the GHG targets set by the California Air Resources Board as well as statutory requirements as of mid-2018.

We examined 3 scenarios, the detailed results of which were reviewed with the Board and with inputs from the public before arriving at the scenario that was adopted by the Board (Adopted Scenario).

Each of the scenarios considered was consistent with, California's long-term goal of reducing statewide greenhouse gas emissions by 80% below 1990 levels by 2050 (referred to as CA80x50).

2.8.1 Option1: The Adopted Scenario

This scenario, which was adopted by SMUD's Board as the IRP and which is the basis of our IRP filing, aims to ensure that SMUD is on a path to reach its 2030 GHG emissions goal of 1.35 million metric tons (MMT) and a net zero GHG emissions goal for 2040 and beyond, while preserving SMUD's existing gas-fired generation to serve load as necessary. This is the lowest cost alternative considered in this IRP.

Under this scenario, we also considered a focused and deliberate approach to increase beneficial electrification of the Sacramento region, consistent with levels needed to achieve California's GHG reduction goals, while simultaneously ensuring new transportation and building electrification loads in the Sacramento region are served with low-greenhouse gas generation. Our analyses of electrification under the IRP suggest that our efforts on building and transportation electrification will result in a net reduction of regional GHG emissions of at least 1 MMT by 2040. Thus, our electrification plan is expected to result in a significant reduction of local GHG emissions associated with investments in electrifying transportation and buildings that offsets the emissions from SMUD's power plants, thereby resulting in a net zero greenhouse gas footprint for SMUD, an ambitious plan that will benefit our customers, the environment and the entire Sacramento region.

2.8.2 Option 2: multiple GHG targets

The second option studied the impacts of the same electrification loads as in the Adopted Scenario while reducing electricity-sector GHG reductions below 1 MMT by 2040. Option 2 focused on greenhouse gas emissions reductions that would maintain our electrification and energy efficiency objectives while making deeper cuts in emissions from our electricity generation portfolio that would be equivalent to accelerating our greenhouse gas reduction goals by up to 10 years.

Under this option, we studied 3 GHG emission paths with 2040 targets of: 750,000, 500,000 and 350,000 MT. Like the Adopted Scenario, these options are discussed in terms of their net GHG impacts. However, due to its focus on finding the lowest cost resources for the additional GHG reductions, the additional GHG emission reductions in this scenario resulted from expanding renewable energy generation outside of SMUID's immediate service territory. Therefore Option 2 scenarios did not deliver greater reduction of local GHG emissions and criteria pollutants, nor did it improve economic opportunities compared to the Adopted Scenario.

2.8.3 Option 3: Absolute zero scenario

An important consideration for SMUD's Board was to study the feasibility of an absolute zero GHG emission goal by 2040 or sooner. Part of the motivation for this scenario was legislative proposals for California to achieve a zero GHG goal by 2045 for the electricity sector. Under this scenario, SMUD could only generate and procure electricity from greenhouse gas-free resources.

Within the absolute zero scenario, we assumed that our entire gas-fired fleet was retired over the forecast period. We opted for shutting them down versus fueling them with biogas for two reasons: first, there is regulatory uncertainty regarding how RPS requirements will evolve in the future, and, second, there is a limited supply of biogas available. The RPS program has changed considerably since it began, particularly regarding restrictions on procurement of biomethane, which creates potential risks purchases.

In this scenario, we also limited market purchases of power to greenhouse gas-free resources. The effect on the absolute zero option would be to isolate SMUD from the rest of the WECC electricity market, limiting our interactions to bilateral purchases where the source can be confirmed as greenhouse gas-free. Renewables and other greenhouse gas-free resources contracted by SMUD would also need to be dynamically scheduled and balanced by SMUD internal resources.

With the significant operational restrictions identified above, it was also necessary to consider the use of very long duration energy storage to safeguard reliability. Taken together, this would result in significant cost increases and a dramatic increase in rates to support the necessary revenues under this scenario. Therefore, our Board dismissed this scenario from consideration at a relatively early stage and we do not further consider this scenario in this report. For a brief summary of the absolute zero scenario and its results, please see materials from SMUD Board Meetings in June 2018.[5]

2.8.4 Summary of key scenario assumptions

The key assumptions that define each of these scenarios are shown in Table 6. Each scenario is consistent with a future in which SMUD, the Sacramento region, and the state are assumed to undertake a significant new effort to enable higher levels of energy efficiency, building electrification and vehicle electrification. These demand-side assumptions are represented in the table below as "CA80x50" on the Distributed Energy Resources category.

[5] https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2018/Jun/ERCS-6618-Exhibit-1---IRP-Update.ashx?la=en&hash=8E6BFA49170C2463BB32DBA88752D86C5FB87077.

Table 6: IRP scenarios overview

	Option 1: Adopted Scenario	Option 2: Multiple GHG Targets			Option 3: Absolute Zero
2040 GHG Emissions Target 000MT	1,000 (& net zero)	750	500	350	0
2040 GHG-Free Procurement(1)	86%	91%	96%	98%	137%
Distributed Energy Resources	CA80x50				
Existing Gas Generation	Maintained				Retired
Balancing	Internal and Market				Internal

(1) This represents the share of SMUD's retail sales served by GHG-free generation. This includes procurement for the RPS compliance and meeting SolarShares℠ demand, as well as additional generation from other renewable energy and hydroelectric resources. Procurement percentage greater than 100% represents excess procurement needed to maintain reliability and charge batteries. Excess procurement may be sold into the wholesale market or curtailed depending on market prices.

3. Policy and economic planning environment

This section provides an overview of the policy environment in which this IRP supplemental document was completed and summarizes our outlook and assumptions for the 2019-2030 period regarding key economic and regional drivers that influence the resource plan.

SMUD's IRP reflects existing California policy and regulations as of September 2018. The IRP reflects current expectations regarding economic development and technology costs. The IRP also complies with all regulatory and statutory requirements and covers all areas that were identified in Public Utilities Code Sections 9621 and 9622 as implemented by the CEC guidelines.[6]

[6] Vidaver David, Melissa Jones, Paul Deaver, and Robert Kennedy. 2018. Publicly Owned Utility Integrated Resource Plan Submission and Review Guidelines (Revised Second Edition). CEC. Publication Number: CEC-200-2018-004-CMF.

3.1 California policy snapshot

California has a long history of being at the forefront of environmental policy, and it has been more than 10 years since the state adopted goals for GHG reductions. Figure 9 provides a snapshot of the main energy policy developments over the past 2 decades that impact our IRP. A few recent legislative developments are of particular importance:

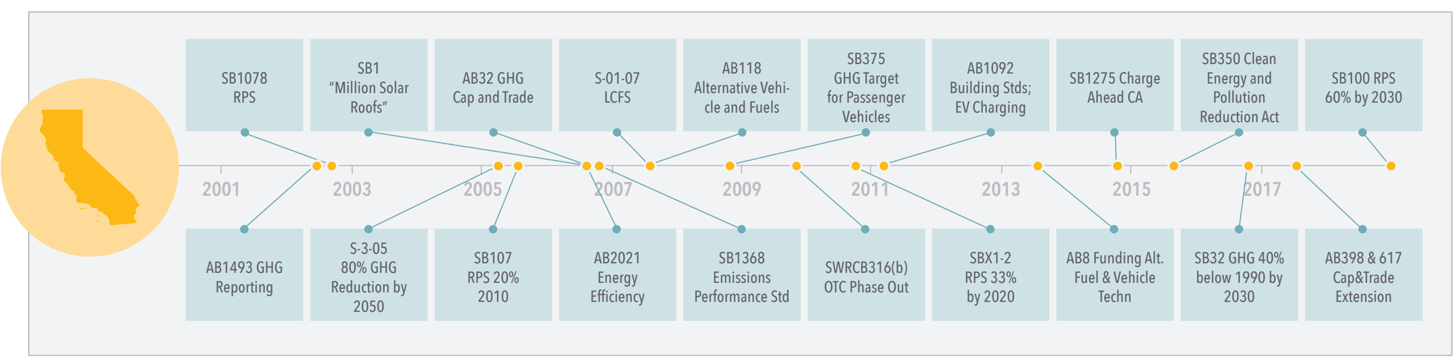
- **SB 100.** Enacted in September 2018, requires SMUD and other load serving entities to meet 60% of electricity demand with eligible renewable energy sources by 2030, and articulated an overall ambition to reach a 100% greenhouse gas free power supply in California by 2045.
- **SB 32.** Enacted in 2016, sets a statewide GHG emissions target of 40% below 1990 levels by 2030.
- **SB 350.** Enacted in 2015, requires SMUD to adopt an IRP and submit it to CEC for review by April 2019 and includes numerous additional provisions.

A more comprehensive discussion of California's policy history and the content of key regulatory and legislative developments is provided in Appendix A.

Figure 9 suggests that numerous policies have a material impact on our resource planning decisions, including energy efficiency goals, renewable procurement requirements and environmental and climate change regulations.

Although some IRP requirements were recently codified in SB 350, SMUD has a long history of integrated resource planning in compliance with all applicable state and federal laws. Our resource planning process is integral in providing customers with reliable, low-cost electric service while balancing regulatory requirements.

Figure 9. California energy policy timeline 2000-2018[7]



[7] See Appendix A for a brief discussion of California energy policy with respect to renewable energy and climate change.

3.2 Economic planning environment

The IRP looks to the future of SMUD's business environment. As in any forecast, our view of future conditions is subject to significant uncertainty and the resource plan that was adopted by SMUD's Board will continue to be evaluated and adjusted over time as market conditions evolve.

The economic situation as well as the demand characteristics in our system could change dramatically because of external changes such as the overall economy, legislation, and federal and state incentives that impact electric demand and technology costs. For example, we expect that under current economic conditions and with the support of SMUD and state policies, the growth of EVs will remain strong. Another example of a policy driver that has a material impact on our system is cannabis. Following the 2016 decision to legalize cannabis consumption and cultivation in California, we expect a surge in electric demand from indoor agriculture operations that move to Sacramento because of SMUD's low rates and the availability of suitable real estate. This section summarizes the key assumptions in our outlook for the 2019-30 period. Section 5 provides additional details on assumptions as they relate to electric demand.

3.2.1 Inflation

Unless otherwise stated, all costs and revenue impacts in this report are provided in constant 2016 dollars.

3.2.2 Targets for renewable energy and greenhouse gas

SMUD's fossil fueled power plants are subject to California's cap-and-trade market for GHG. The California Air Resources Board (CARB) regulates this market and is responsible for establishing, monitoring, and tracking GHG compliance instruments that are used to demonstrate compliance with the cap-and-trade rules (including allowances and offsets). Our Board has adopted a goal to reduce emissions attributable to our power portfolio to 1.35 million MT per year by 2030, equal to a 61% reduction relative to 1990 levels. Our GHG targets are shown in Table 7. Table 7 also shows our annual RPS goals used in the IRP analyses. The new RPS policy under SB 100 that requires a 60% RPS by 2030 was enacted by the legislature after the completion of our analyses but before Board adoption of the IRP. Therefore, even though our analyses do not explicitly include the 60% RPS, SMUD's Board also directed us to adjust the procurement of renewable resources to meet an RPS level of 60%. Our updated RPS procurement plan is included with this report as Appendix B.

Table 7. SMUD's greenhouse gas emissions targets and IRP RPS planning goals

	SMUD Greenhouse Gas Targets 000MT	RPS Procurement Target* % of Retail Sales
2019		31%
2020	2,318	33%
2021		34.8%
2022		36.5%
2023		38.3%
2024		40%
2025		41.7%
2026		43.3%
2027		45%
2028		46.7%
2029		48.3%
2030	1,350	50%

* Used for modeling and scenarios.

3.2.3 Energy storage

AB 2514 was passed in 2010, requiring investor-owned utilities to take on targets for energy storage. The CPUC subsequently set targets for the 3 major investor owned utilities in California, calling for more than 1,300 MW of new energy storage capacity to come online by 2024 at the latest[8]. As a publicly owned utility, SMUD is required to regularly assess the need and cost competitiveness of energy storage and in 2017, we announced a goal of 9 MW by 2020 to be met by a combination of storage technologies on both sides of the customer meter. This is discussed in more detail in sections 5.4 and 7.1.2. As part of our 2018 resource plan, we also expect to add more than 200 MW of new grid-scale battery storage by 2030 to support reliability, integrate renewable energy and serve our customers with continued low rates.

3.2.4 Natural gas market price forecast

The natural gas price forecast used for the IRP is based on a combination of short- and long-term market indicators. In the near term, up to and including 2020, we rely on natural gas futures prices and basis differentials as of early 2018. Long-term natural gas prices were prepared by E3 and are based on a combination of gas futures prices and the long-term outlook provided in U.S. Energy Information Administration's 2017 Annual Energy Outlook. This results in market prices in the 2021-2030 period that are a blend of observed futures prices and the 2017 Annual Energy Outlook. The annual gas price forecast used in the IRP is shown in Table 8.

[8] http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M079/K533/79533378.PDF.

3.2.5 Electricity market price

SMUD is assumed to be a price taker in the California and WECC power markets. This means that we do not expect our resource or trading decisions to influence market clearing prices for electricity. This assumption simplifies SMUD's modeling by taking CAISO market prices as given during the forecast period. For this purpose, we rely on a long-term forecast of hourly power prices developed by E3, which includes the hourly locational marginal price in the day-ahead market for COB, NP-15 and SP-15 as well as ancillary services. The price forecast is consistent with the CA80x50 scenario discussed in section 2.8. The modeling methodology is discussed in more detail in Section 4 of this report.

Key drivers of our long-term power price forecast include:

- Low load growth continues due to continued aggressive focus on energy efficiency in implementing the state's policy of doubling energy efficiency. Energy efficiency gains are counteracted by growth in EV adoption.
- California continues to build solar generation at an aggressive pace (both bulk & rooftop). Despite expanding the use of energy storage and other flexible resources in California, this is expected to continue to periodically result in negative prices throughout the forecast period.
- Northwest and southwest regions of the WECC outside California have limited ability to back down thermal resources, constraining California exports at times of high renewable energy production.
- Under the CA80x50 scenario used for our IRP, California is expected to enact direct policies to ensure that the state's long term GHG reduction goals are reached, leaving CA CO_2 allowance prices at relatively low levels throughout the 2019-2030 period.
- California's RPS is assumed to achieve 50% by 2030 and maintain at least this level henceforth.[9]

As a net importer of power, SMUD is located between two major market hubs: California-Oregon Border (COB) and CAISO's NP-15. The differential between NP-15 and COB is therefore an important driver in the forecast of the source of our future market purchases. Historically COB has generally been a lower cost market than NP-15, even after factoring in greenhouse gas adders associated with importing power into California. However, over time this differential is expected to tighten and eventually reverse during on-peak hours because of continued solar PV expansion in California. This is expected to result in increased procurement of CAISO-sourced power in the 2019-2030 period, compared to historical levels. However, transmission access charges and other CAISO fees are also critical determinants of how attractive purchases from the CAISO will be going forward.

Ancillary Services prices were also developed by E3 for the CAISO area and are driven mainly by wholesale electricity prices.

Based on market research from sources such as NERC, we expect the WECC to be well supplied in terms of generation capacity that can help meet short-term and short duration capacity needs for the purpose of meeting our capacity planning goals. This is one of the reasons why in our IRP we expect to continue partially relying on short-term market purchases of energy and capacity as a part of our balanced and diversified portfolio.[10]

[9] This market price forecast was developed prior to the passage of SB 100, which increased the RPS target to 60% by 2030.

[10] See for example the projected reserve margins in Northwest Power Pool and California/Mexico in NERC's 2018 Assessment: https://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/NERC_LTRA_2018_12202018.pdf.

3.2.6 CAISO transmission access charges

SMUD uses a proprietary forecast of CAISO Transmission Access and Wheeling Access Charges (TAC) developed by Navigant Consulting Inc. for all market sales and purchases between SMUD and CAISO. This forecast is based on the CAISO TAC rate effective July 1, 2017 and includes assumptions regarding effective tax rates, CAISO planned transmission projects and growth in non-ISO approved transmission costs.[11]

3.2.7 Greenhouse gas price forecast

SMUD uses an emissions allowance price outlook that was developed by E3. This outlook reflects existing GHG and RPS policies as well as other drivers that help stimulate development of low/no greenhouse gas emission generation technologies. The forecast reflects a scenario assumption that allowance prices will remain near the CARB floor prices for the entire 2019-2030 period, driven by the assumption that that California will continue to enact policies to ensure that the state remains on a long term trajectory to meet its 2050 goals of reducing CO_2 emissions by 80% compared to 1990 levels. Allowance prices are assumed to continue to increase annually by inflation plus 5%, in line with current regulations.

Table 8. Power, natural gas, TAC and greenhouse gas prices 2019-2030

Nominal	NP-15 \$/MWh(1)	COB \$/MWh(1)	Henry Hub \$/MMBTU(1)	ISO-TAC \$/MWh(2)	Carbon Price \$/MT(1)
2019	18.57	18.99	2.75	12.73	16.28
2020	20.18	21.00	2.77	13.32	17.41
2021	20.94	21.42	2.81	14.41	18.63
2022	22.28	22.58	2.98	15.41	19.92
2023	24.08	24.19	3.15	15.89	21.31
2024	25.36	25.71	3.34	16.19	22.8
2025	26.81	26.94	3.54	16.37	24.39
2026	27.63	28.29	3.74	16.62	26.08
2027	27.82	29.48	3.96	16.94	27.9
2028	27.87	30.66	4.18	17.31	29.84
2029	28.92	34.06	4.42	17.68	31.92
2030	28.35	35.00	4.68	18.03	34.14

(1) Source: E3.

(2) Source: Navigant Consulting Inc.

[11] Being external to the CAISO balancing authority, SMUD pays the WAC and not the TAC, which is paid by loads inside the CAISO. These rates (i.e., WAC and TAC) are nearly identical and therefore TAC can be used to estimate WAC uplifts for price forecasting.

4. IRP modeling methodology

In developing the resource plan described in this report, we modeled SMUD's service territory for the 2019-2030 period using a combination of analytical tools to assess potential scenarios, capacity needs, energy needs, emission reductions, electrification and energy efficiency. Central to our approach is production cost modeling using the PLEXOS modeling platform to determine the cost and feasibility of potential resource portfolios. Our scenarios and potential resource portfolios were developed with the support of a combination of other tools such as the RESOLVE and PATHWAYS models, illustrated in Figure 10. This section explains our modeling approach as well as key assumptions underlying the analyses of the IRP.

Figure 10. IRP modeling framework

Load Forecast

- Electricity demand
- Rate design and demand response
- Electrification and energy-efficiency (PATHWAYS)

Supply options

- New resource options and costs (RESOLVE)
- Effective load carrying capability (RECAP)
- Planning reserve margin
- Operating reserves

Production cost model

- Hourly unit-dispatch (PLEXOS)
- System costs of serving load
- Thermal, physical, environmental, regulatory and economic constraints

4.1 PATHWAYS software overview

The PATHWAYS model is a long-term multi-sector energy and GHG accounting model, utilizing user-defined scenario input assumptions to evaluate changes in total resource costs, electricity demand, and GHG emissions, among other metrics. The PATHWAYS model is used in California by state agencies for scenario planning purposes, including by the California Air Resources Board in California's 2017 Climate Change Scoping Plan.[12] Most recently, the CEC published a report detailing several long-term energy scenarios through 2050 which use E3's PATHWAYS model to evaluate strategies that achieve the state's climate goals.[13]

We used the PATHWAYS model to forecast demand-side electric loads in buildings and the transportation sectors that are consistent with achieving a low-greenhouse gas future in the SMUD service area. SMUD-specific long-term scenarios were developed that are consistent with achieving a 90% reduction in our electricity sector emissions by 2050 and California achieving its long-term goal of an 80% reduction in economy-wide GHG emissions by 2050. The demand-side load is used to develop aggressive energy efficiency, building electrification and transportation electrification forecasts that populate the electric resource planning tools RESOLVE and PLEXOS used by the IRP modeling team.

In working with E3 on this scenario analysis, we identified 4 key strategies that are needed to reduce California GHG emissions by 80% by the year 2050. They are:

1) Energy efficiency and conservation across all sectors of the economy – in buildings, transportation and industry.
2) Electrification of fossil fuel energy applications, and switching to cleaner electricity.
3) Deploying low-greenhouse gas fuels, including sustainable biofuels and renewable electricity.
4) Non-energy and non-combustion sources of GHG emissions must be mitigated, including through the prevention and elimination of methane leaks, fugitive methane, and high global warming potential gases while carbon sequestration in soils and lands must be enhanced.

Electrification of the transportation sector is a critical component of any scenario that meets the state's long-term climate goals. Electrification of buildings will be needed, and electrification of industry may also be needed. The "High Electrification" scenario is one of the 10 mitigation scenarios E3 developed for the CEC and includes a high level of energy efficiency across sectors, renewable electricity and electrification of transportation and buildings. This scenario was used as a basis for developing the electrification assumptions for our IRP.[14] We refer to this scenario in the IRP as the "CA80x50" scenario.

[12] Available at: https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

[13] "Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model", CEC publication number: CEC-500-2018-012. Available at: https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_ Renewables_Future_CEC-500-2018-012-1.pdf.

[14] For the SMUD IRP, the High Electrification scenario was modified somewhat to exclude hydrogen fuel cell cars and trucks, and to instead include more battery-electric vehicles and some electrification of industrial end uses. This modification is intended to reflect the greater confidence in electric vehicle technology relative to hydrogen vehicles, which would also require a large amount of new infrastructure to support centralized hydrogen electrolysis and a fuel distribution network.

4.2 RESOLVE software overview

SMUD contracted with E3 to use the RESOLVE model[15] to develop a generation portfolio to meet the policy goals in each scenario.

RESOLVE is an optimal investment and operational model designed to answer long-term planning questions around renewables integration in systems with high penetration levels of renewable energy. The model is formulated as a linear optimization problem. RESOLVE co-optimizes investment and dispatch for a selected set of days over a multi-year horizon. In this case, it was five-year increments between 2020 and 2040 to identify least-cost portfolios for meeting renewable energy targets and other system goals. RESOLVE also incorporates a representation of neighboring regions to characterize transmission flows into and out of a main zone of interest endogenously. RESOLVE can solve for the optimal investments in renewable resources, as well as supporting resources such as energy storage and demand response subject to multiple constraints:

- An annual constraint on delivered renewable energy that reflects the RPS policy.
- A reserve margin constraint to maintain reliability.
- Simplified unit commitment and dispatch constraints.
- Scenario-specific constraints on the ability to develop specific renewable resources.

RESOLVE is also used by the CPUC for developing its long-term "Reference System Plan" covering California and surrounding areas for the purpose of supporting IRP modeling by load serving entities regulated by the CPUC. E3 and SMUD worked jointly to create a version of the model designed to optimize our future generation portfolio that reflects both SMUD's unique system characteristics and its position as part of the broader electricity system in California and the Western Interconnection.

4.3 RECAP software overview

The Renewable Energy Capacity Planning model (RECAP) is a probabilistic model that assesses generation resource adequacy. RECAP was designed by E3 in 2011 to analyze system reliability planning needs under high renewable penetrations.

The RECAP Model works by comparing probability distribution functions for supply and demand by month, hour, and day type (weekend, weekday) to find the probability that load will be greater than supply in the pertinent time slice. Relevant correlation between variables is enforced using conditional density functions, which requires time-matched load and renewable data. Using a neural network regression, gross load is calculated under present economic and demographic conditions using historical weather years from 1950 to present. The net load module creates a probability distribution function for net load. Relevant correlations between load, wind, and solar are enforced, where significant, using conditional probability distributions. Mathematically, the net load distribution function is a convolution of each of the constituent distributions. Effective Load Carrying Capability (ELCC) is the additional load met by an incremental generator while maintaining the same level of system reliability.

We used RECAP to determine the ELCC capacity values that would be available at the peak demand hour for our solar and wind resources over the planning horizon. Generation profiles for renewables were based on actual historical generation for existing resources, and modeled generation for new resources. Generation profiles generally include at least five-years of data from weather years between 2007 and 2016, inclusive.

RECAP is a publicly available tool that has been used in public studies by organizations including the CPUC and CAISO.

[15] E3 developed RESOLVE as a resource investment model that identifies optimal long-term generation and transmission investments in an electric system, subject to reliability, technical, and policy constraints. See the following link for more details. https://www.ethree.com/tools/resolve-renewable-energy-solutions-model/.

4.4 PLEXOS software overview

For detailed annual and hourly simulations of our existing and projected resources, the PLEXOS model was used. The production cost model PLEXOS is licensed by Energy Exemplar LLC.

We use the platform to simulate economic unit commitment and dispatch for the SMUD balancing area. The hourly model minimizes costs for serving load while considering generating unit characteristics and constraints such as startup/shutdown time, maximum and minimum capacity, heat rate curves, hydrological constraints, emission costs, and operating and maintenance costs. Transmission constraints to and from BANC are also accounted for.

PLEXOS has 3 levels of simulation: a long-term plan for capacity expansion simulations; a medium-term schedule for optimizing hydro storage, fuel supplies, or emissions; and a short-term schedule for chronological unit commitment and dispatch.

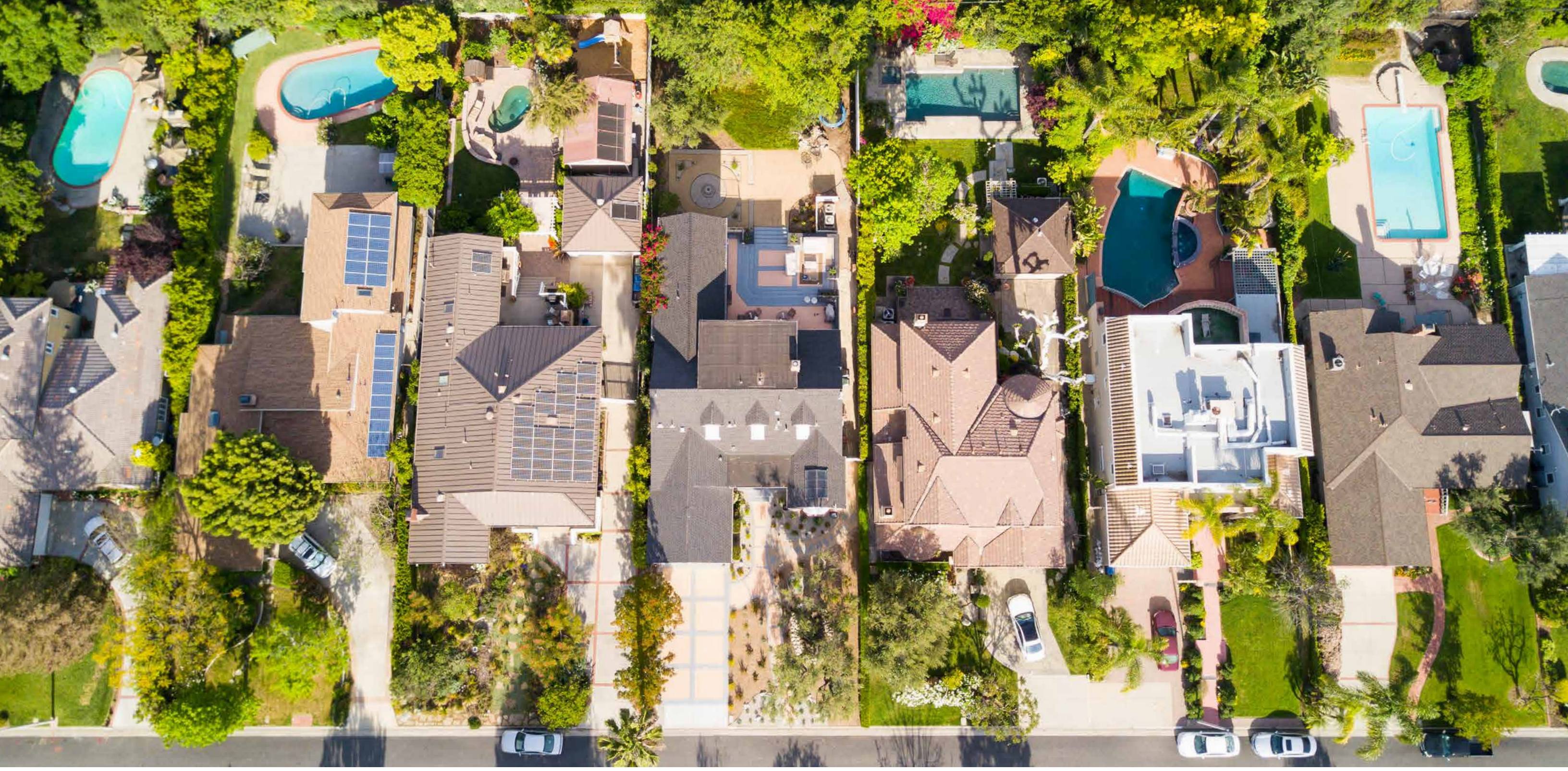
The medium-term schedule was used to develop hourly hydro profiles based on monthly energy requirements. This logic performs the co-optimization of energy and ancillary services for an entire month at the regional level. The outputs of this step are hydro generation profiles that honor the monthly hydro energy constraints.

The unit commitment-economic dispatch logic performs the energy-ancillary services co-optimization by mixed integer programming, while enforcing all resource and operation constraints. The unit commitment-economic dispatch algorithm commits and dispatches resources to balance system energy demand and meet system reserve requirements. The hydro generation profiles developed in the first step are input to this step in the simulation process. The hydro schedules may be modified in this second step to respect chronological hydro unit constraints (e.g., ramp rates) or to respond to price signals.

The resource schedules from the unit commitment-economic dispatch logic are passed to the network application logic. The network application logic solves to enforce the power flow limits (i.e., transmission line or interface limits) and nomograms (i.e., limits based on a specific relationship between generation, load, transmission topology, and/or interface power flows). Thus, the co-optimized solution of energy-ancillary services-power flow is reached.

Input data include:

- The actual load, wind and solar profiles.
- Unit commitment schedules from the day-ahead security-constrained unit commitment process.
- Detailed generator characteristics.
- Contingency reserve, regulation reserve, and flexibility reserve.



5. Electricity demand 2019-2030

This section presents the results of SMUD's IRP electric demand forecast for 2019 to 2030. Our IRP relies on an internally developed forecast of demand that includes several factors that will affect electric demand – all of which are discussed in more detail below. The demand model is based on expected (or normal) weather conditions, also known as a 1 in 2 load forecast. The forecast includes system energy, system peak and customer accounts for SMUD's service territory. We also present and discuss the key drivers of our forecast, including those we expect will help the Sacramento region address climate change challenges, such as electrification of buildings and transportation and energy efficiency improvements. There is only one demand forecast in our IRP, used for all of the options considered, including the Adopted Scenario, and including the effects of significant SMUD investments in demand-side resources such as transportation and building electrification.

We don't use the CEC's electric demand forecast for SMUD. Instead we rely on our own internally developed forecasts, which are discussed in more detail below. By using our internal forecasts, we ensure alignment between the IRP assumptions and assumptions that go into other processes such as transmission and distribution planning, risk management, budgeting, etc. We also don't use external load forecasts for the rest of CA or the WECC directly for our system modeling. Instead, we rely on market price forecasts at nodal interconnection points between BANC and surrounding balancing authorities and use these points as a representation of external markets in our modeling.

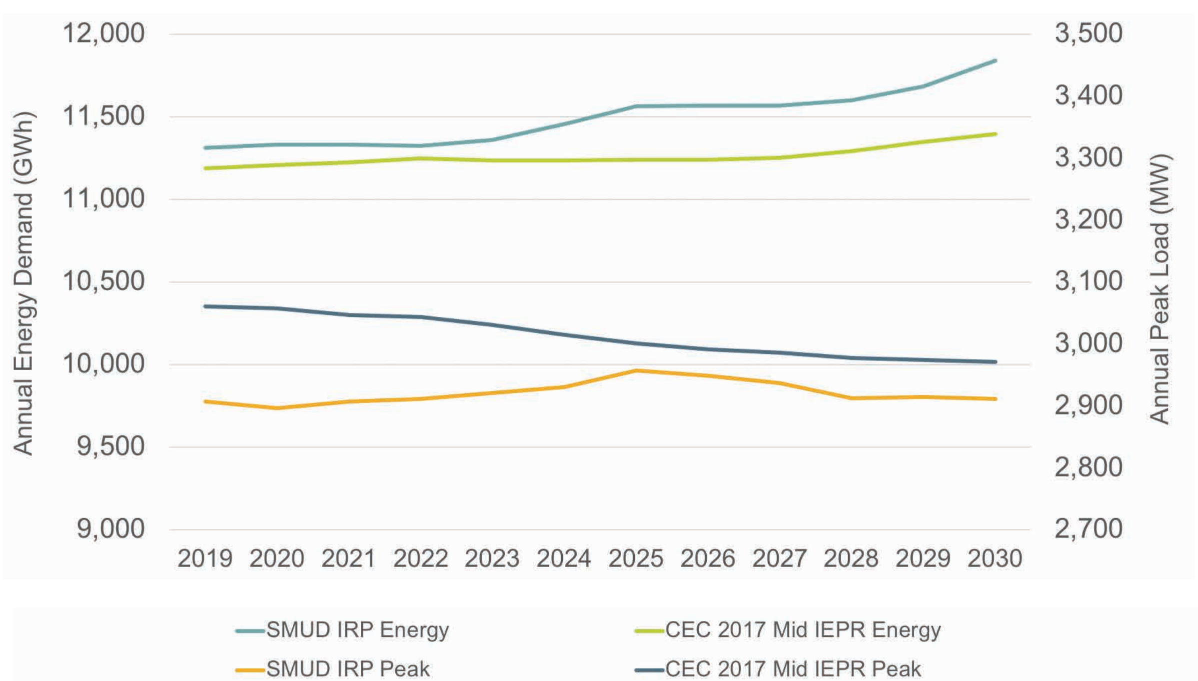
SMUD's electricity demand is forecasted to be relatively flat over the forecast period due to the slow growth in net additions to the housing stock, business activity in the region, SMUD's energy efficiency programs, and the installation of customer-sited solar power and battery storage. The expected increase in the market penetration of electric vehicles and an increasing focus on building electrification are expected to increase electricity demand and offset the impact of otherwise weak load growth. Additional demand from selected key accounts and from indoor cannabis cultivation will also help stimulate demand in the forecast period.

Our residential TOD rate became the standard rate for residential customers in 2019. This rate is designed to shift demand away from peak hours and is also expected to result in modest annual energy demand reductions.

We consider both energy efficiency and electrification to be essential for our long-term mission to reduce greenhouse gas emissions, for our resource portfolio and our community. As part of this effort, our IRP scenarios examine what would be needed from energy efficiency, demand reduction and electrification programs to reduce greenhouse gas emissions (from electric and non-electric sectors) in the Sacramento region to 80% below 1990 levels by 2050.

These efforts, together with conventional growth factors such as economic activity and demographics, are expected to lead to a slight increase of electricity demand in the 2019-2030 period while peak load is expected to remain flat. Figure 11 shows a comparison of our long-term forecast underlying the IRP versus the 2017 IEPR load forecast for the Mid-AAEE case (aka, Mid-Mid). The comparison shows that by 2030 our forecast for electricity demand is about 4% above the CEC's 2017 IEPR forecast while our peak load forecast is about 2% lower than the 2017 IEPR estimated peak load in the Mid-AAEE case.

Figure 11. SMUD versus 2017 IEPR load forecast



The remaining parts of this section provide a detailed overview of each of the key components that are expected to impact demand in the 2019-2030 period. The load forecast that includes all these demand drivers is presented in Section 5.7.

5.1 Load forecast methodology and data

SMUD's forecast models are based on statistical regression techniques which normalize electricity use for variation in temperatures, seasonal use, number of customer accounts and recent trends in electricity use behaviors. The forecast is based on 4 regression models: daily system energy, daily system peak, system hourly loads and the retail class sales models. In each model, loads and retail sales are normalized by customer accounts.

The daily energy and peak models serve as the foundation for the load forecast. These models normalize SMUD's system loads for variations in daily temperatures, weekdays and weekends, months, seasons and holidays. The system hourly load equations provide a daily load shape which is then calibrated to daily energy and peak model estimates while taking maximum peak load limitations and constraints on daily energy use into account.

To forecast retail sales, we use separate regression equations for each major rate class. For a more detailed discussion of the forecast methodology, please see Appendix D. Additional detail is also available in the supporting documentation for our 2017 load forecast filing with the CEC.[16]

[16] https://efiling.energy.ca.gov/GetDocument.aspx?tn=217077-3&DocumentContentId=28501;.

The regression model's retail sales were estimated with data from SMUD's billing system for the period 2006-2017. SMUD billing data includes monthly electricity use and customer accounts by our 21-day cycle reads. The hourly load, daily peak and daily energy models were estimated using hourly load data from SMUD's Energy Management System for its retail service territory for the period Jan. 1, 2006 to Nov. 31, 2017. The historical period used for the demand forecast was selected to provide robust historical data while also reflecting the structure of current demand and demographics.

Forecast parameters for the demand model include population, personal income and employment data, and are listed in Appendix D. Forecasts from the IHS Global Insight Regional Forecast for Sacramento County (June 2017) were used for this purpose. In addition, we used office building vacancy rates from the Sacramento Business Journal for selected publication dates.

A key component in normalizing sales and loads is weather. Both sales and load models use cooling degrees and heating degrees as independent variables in the regression equations. In the load model, daily high temperatures are also used to explain the rapid change in loads during heat storms.

Temperature data is from the National Weather Service's Sacramento City and Executive Airport weather stations. The daily temperatures from these weather stations are averaged to develop a composite temperature index for the Sacramento area. Daily composite temperatures are used to construct cooling and heating degree day variables in the regression's models.

Long term climate change impacts such as changes in high and low temperatures and the duration of heat storms are not directly factored into this long-term forecast (other than in time trends of the parameters used for the forecast) but could potentially further increase long term demand for electricity and impact daily and seasonal demand patterns.

The remainder of this chapter provides an overview of all factors that modify and adjust our load forecast, including the outlook and methodologies for demand response, electrification, distributed behind-the-meter-resources, energy efficiency and time-of-use electric rates.

5.2 Demand response

SMUD currently maintains several load management programs available as capacity during our operations and in reliability planning. In addition, we are continually researching and testing new programs. The forecast used in this IRP represents a strategy that will help continue providing reliable service to our customers, cost-effectively.

Demand response initiatives at SMUD are primarily used for contributing toward our capacity reserves and reserve margin needs. The cost effectiveness was evaluated by program and as a portfolio. As a portfolio, the mix of the various key DR initiatives with significant budgets (PowerDirect, NextGen ACLM and Bring Your Own Device) have a favorable benefit to resource cost ratio (greater than 1.0), using modest capacity values.

In the long run, demand response will also be used to avoid system infrastructure investments for load serving capability and local capacity needs. The benefits of using DR to defer or either avoid system infrastructure investments were not factored into the cost/benefit analysis.

The combined effects of new and existing programs could double our current demand response capacity, from about 86 MW in 2018 to more than 171 MW by 2030. We have highlighted our existing and planned programs below. Table 9 provides an overview of the demand response capacity in the 2019-2030 period. It should be noted that the expected total size of our demand response capacity depends on customer adoption and our plans may therefore need to be adjusted as we learn how successful the programs are over the long term.

Peak Corps Program is a residential air conditioning load management program that provides a summer time resource for in emergency situations if the need arises. Peak Corps also adds value by contributing toward SMUD's reserve margin requirements. Currently, the program has the capacity to reduce demand by 60 MW during a 100% full-shed situation. We are not recruiting new customers to this program and therefore we expect this program to continue to decline by about 7 MW per year due to removal of air conditioning load management (ACLM) devices during HVAC system replacement or simply being removed by the customer. Our NextGen ACLM program is planned to replace our Peak Corps program.

NextGen ACLM is planned to replace the aging Peak Corp program. This program will be based on using two-way smart load control switches that would replace the legacy one-way switch controllers. By 2030, this new initiative is expected to grow to about 40 MW to be utilized for economic use and reliability needs.

PowerDirect Program is an automated demand response program that continues to be an operational resource for reliability and economic purposes. The program is planned to grow and eventually reach a stable level of 30 MW. The program is available for use between June and September, from 2 to 6 pm.

Individual customer agreements: We have curtailment agreements with some of our largest industrial customers that allow us to curtail load for reliability or economic purposes with the potential of up to 6.5 MW within 10 minutes' notice. SMUD can call on these customers all year-long.

Temperature Dependent Rate: We also have customers on our Temperature Dependent Rate. During the summer when outdoor air temperatures exceed 100 degrees Fahrenheit for a certain period, we can notify customers and provide them the option of curtailment or continued service at a higher cost than is specified in the tariff. We currently have about 15 MW of capacity on this non-dispatchable tariff.

Over the next few years, SMUD is planning to launch new demand response initiatives. These new programs are planned to be flexible and available to respond with very short notice. This will help to integrate increasing amounts of intermittent renewable generation on the system.

A **Bring-Your-Own-Device** Program is currently being considered. If successful, the program could grow to more than 90 MW by 2030. The approach for this program is to allow several types of customer-owned devices to participate, including smart thermostats, heat pump water heaters, battery storage and electric vehicle chargers. The goal is to use this capacity for economic or reliability purposes. This program will use currently available control technologies allowing near-real time load adjustments during an event which can be useful in distribution system operations and as general system-wide capacity.

Table 9. Dispatchable Demand Response Programs 2019-2030 (MW)

	Peak Corps	PowerDirect	Agreements	NextGen ACLM	BYOD	Total
2019	59	23	6.5	0.0	8	96.5
2020	52	26	6.5	0.0	16	100.5
2021	45	30	6.5	2.0	24	107.5
2022	38	30	6.5	6.5	32	113
2023	31	30	6.5	11.0	40	118.5
2024	24	30	6.5	15.5	48	124
2025	17	30	6.5	20.0	56	129.5
2026	10	30	6.5	24.5	62	133
2027	3	30	6.5	29.0	70	138.5
2028	0	30	6.5	33.5	78	148
2029	0	30	6.5	38.0	86	160.5
2030	0	30	6.5	42.5	92	171

5.3 Energy efficiency and electrification of transportation and buildings

Energy efficiency, demand reduction and electrification are essential for our long-term mission to reduce greenhouse gas emissions – for our resource portfolio and our community. The importance of these resources is reflected in our existing programs and in our plans to expand these programs. For this IRP, we also looked at what is needed from our energy efficiency and electrification programs to help reduce greenhouse gas emissions in the Sacramento region to 80% below 1990 levels by 2050.

Throughout the spring of 2018 we performed economy-wide modeling to estimate the amount of energy efficiency, building electrification, and vehicle electrification that would be necessary to reduce Sacramento's greenhouse gas emissions to 80% below 1990 levels by 2050 and achieve a net zero greenhouse gas emissions target by 2040 for our resource portfolio. We used the PATHWAYs model, as discussed in section 4.1, to evaluate these goals and identify overall programs levels that would be required to achieve our goals.

In the CA80x50 scenario, we modeled increased investments by SMUD in distributed resources such as storage, energy efficiency and demand response and compounded those investments with the expected impacts of other state and regional policies to support energy efficiency and electrification.

The results of the analysis are a transformation of SMUD's electricity demand over time, where increasing levels of energy efficiency are offset by new electrification loads from transportation, buildings and industry, especially after 2030. This electrification reduces GHG emissions by displacing internal combustion engines with all-electric and hybrid-EVs, and gas space heaters with more efficient electric heat pumps.

As part of our IRP action plan that is outlined in Chapter 14 of this report, we are in the process of developing new metrics for demand-side measures such as energy efficiency and electrification that are focused on GHG impacts. We expect this to help align energy efficiency, demand reduction and electrification programs with our long-term GHG reduction objectives.

The below subsections provide results of the PATHWAYs model compared with existing programs and goals here at SMUD.

All-Electric Smart Homes

SMUD's All-Electric Smart Homes Program brings SMUD customers more future-ready homes that are environmentally friendly, emitting 40% fewer greenhouse gases than an equivalent home powered by natural gas.

The program provides homebuilders attractive incentives to include electric heat pump water heaters, heat pump climate controls and induction cooktops into new homes.

We provide $5,000 incentive for each single-family home and $1,750 for each multifamily unit that declines to install natural gas infrastructure.

5.3.1 Energy efficiency

SMUD's energy efficiency goals are spelled out in the SMUD Board Policy, Strategic Direction-9, Resource Planning.[17] Our energy efficiency programs have consistently delivered innovative programs and savings well beyond the statewide average, including approximately 1,668 GWh of savings over the past 10 years, which is equivalent to 1.5% of the system load each year.

Pursuant to Section 9505(b) of the Public Utilities Code, every four years, each POU is required to identify all potentially achievable cost-effective energy efficiency savings and to establish annual targets for a 10-year period. SMUD's energy efficiency market potential and targets were developed collaboratively with California's publicly owned utilities and submitted to the Energy Commission in May 2017, showing a 2018-2027 cumulative goal of 1,669 GWh.[18]

The modeling performed in support of this IRP suggests that similar energy efficiency goals are achievable, even though we are at the same time also focused on electrification. Our 2019-2030 forecast of energy efficiency includes energy efficiency improvements corresponding to a cumulative total of 1,450 GWh over the 2019-2030 period. The demand forecast presented in Table 15 shows the 2019-2030 outlook for energy efficiency in the IRP. As discussed in Section 2.3, we also have several programs supporting the accelerated adoption of energy efficiency programs.

SB 350 directs the CEC to establish energy efficiency targets that achieve a statewide, cumulative doubling of energy efficiency savings in electricity and natural gas final end uses by 2030, to the extent doing so is cost effective, feasible, and does not adversely impact public health and safety. In Oct. 2017, the CEC released a report describing initial statewide cumulative targets based on current energy efficiency program goals and estimates.[19] The CEC has identified a shortfall of about 3,800 GWh (equivalent) in 2029 assuming aggregation of natural gas and electricity goals and mentions that there is additional market potential from other sectors, such as agriculture and industry, that may make up the shortage. The report does not set a utility-specific target for SMUD, but uses SMUD's adopted 2017 goals as the basis for estimating our contribution to achieving the state-wide doubling target. The additional energy efficiency programs described in the IRP, including electrification, will increase SMUD's contribution to the statewide doubling goal.

Looking ahead, we're working to develop a new GHG and peak load metric that will better align our energy efficiency programs with our GHG goals and electrification initiatives.

By focusing intently on reducing GHG emissions, we believe the energy efficiency programs will be better equipped to reduce such emissions and may help the integration of additional renewable energy capacity by targeting these programs towards the time of day and the seasons when they are most effective at reducing GHG emissions. As a result, we expect to set future energy efficiency goals in terms of GHG emissions intensity and consider GHG abatement costs as a metric for determining the relative cost-effectiveness of energy efficiency measures.

[17] https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2018/Oct/Policy-SD-9.ashx?la=en&hash=EE6661597B8B3DBDD641D03B1106FD2E0DB05E80.

[18] Energy Efficiency in California's Public Power Sector: 11th Edition — 2017, Docket 17-IEPR-06.

[19] Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. Senate Bill 350: Doubling Energy Efficiency Savings by 2030. CEC. Publication Number: CEC-400-2017-010-CMF.

The advantage of this approach is that it will also allow us to cross-compare cost effectiveness from a GHG perspective across both demand increasing (electrification) and demand decreasing (energy efficiency and demand response) programs. Our action plan includes developing this methodology and we expect to update the CEC on this methodology as part of our future demand and energy efficiency forecasts.

5.3.2 Building electrification

SMUD views building electrification as a key component of our energy efficiency strategy. Our electrification efforts to date have focused mainly on the residential sector, which accounts for most of the gas consumption for space and water heating in our region.

Our modeling shows that achieving our greenhouse gas reduction goals will depend significantly on electrifying buildings, and we estimate that over 85% of existing residential and 75% of commercial space and water heating must be converted from gas as a principal fuel source to electricity. This level of electrification assumes that state energy code will mandate that the majority of residential new construction be all-electric by 2030.

The PATHWAYS modeling results also demonstrate that the electrification efforts for buildings are necessary, not only for SMUD's goals, but also for the state to achieve an 80% reduction of GHG emission by 2050. As stated in Executive Order S-3-05 from 2005, or achieve zero GHG emissions from the power sector by 2045 as envisioned in Senate Bill 100 that was passed in 2018.

Electrification of buildings has a long-term impact and also takes time to take root since the turnover of common building energy technologies such as HVAC is typically performed only towards the end of the assets' useful life. Over the forecast period, the impact of our building electrification efforts will accelerate and by 2030, we expect building electrification will lead to an increased demand for electricity by approximately 365 GWh per year by 2030. The GHG emission increases from these efforts are expected to be more than offset by switching fuel from natural gas to electricity and energy efficiency improvements, leading to a net reduction of GHGs from residential and commercial buildings.

SMUD and developer partner to build all-electric homes

SMUD and top national homebuilder D.R. Horton teamed up in October 2018 to build 104 all-electric homes in two new neighborhoods. These "all-electric communities" will include more than 100 homes in the North Natomas area of Sacramento and will be priced for first-time homebuyers. The homes are included in the SMUD Smart Home program and are part of a broader electrification effort by SMUD, the first of its kind in the USA.

5.3.3 Transportation electrification

SMUD has promoted the use of electricity as a transportation fuel since 1990. Transportation electrification helps improve local air quality in our region by reducing criteria pollutants and GHG emissions. The average light duty EV uses approximately 3 MWh of electricity per year and provides a net reduction of GHG emissions of about 2.5 metric tons per year compared to a gasoline car. As of late 2018, there were approximately 9,400 light duty EVs registered in Sacramento County, and the market is growing by approximately 300 vehicles a month.

Medium and heavy-duty EV adoption is beginning to pick up, with electric school buses, transit buses and shuttle buses leading the way. Applications for delivery trucks, utility trucks and some large Class 8 trucks are also beginning to enter the market.

To meet the state's long-term GHG reduction goals, Sacramento regional GHG emissions will need to decline from a forecasted 5.9 million metric tons per year in a business-as-usual-scenario to 1.9 million metric tons per year by 2040. This is equivalent to an average annual reduction of approximately 200,000 metric tons of CO_2e per year from the transportation sector by 2050. To meet this goal, the region will need approximately 1,000,000 light duty EVs by 2050. Our modeling shows that over 230,000 registered electric vehicles are needed in the Sacramento region by 2030 to achieve our long-term GHG targets. Table 10 shows the expected growth of EVs in the Sacramento region that we used in the IRP, consistent with this forecast.

Table 10. Expected growth of electric vehicles in the Sacramento region 2020-2030

Year	Light Duty Vehicles	Annual Energy GWh
2020	14,016	68
2025	78,567	367
2030	232,767	936

5.3.3.1 Light duty electric vehicle programs

At SMUD, we take a holistic approach to climate change and consider it of utmost importance that we do everything we can to cost-effectively reduce GHG emissions in the region. Our strategy to promote the adoption of EVs by removing market barriers through purchase incentives, investments in charging infrastructure and education is therefore an important part of our plan for achieving net-zero GHGs emission by 2040. Our ongoing efforts are discussed in more detail below.

5.3.3.1.1 Electric vehicle and supply equipment incentives

For residential customers we offer a $599 incentive corresponding to about 2 years' EV charging or the opportunity to get a free 240-volt vehicle charger installed. We also have incentives to encourage more installation of charging infrastructure outside of single-family housing locations to address range anxiety, a major barrier to EV adoption. SMUD offers $1,500 incentives for EV chargers at workplaces and multifamily facilities. Until late 2018 SMUD offered a $100,000 DC Fast Charger incentive. Due to customer indifference, these incentives are planned for restructuring in 2019 to align with a new CalEVIP that will fund $14M worth of charging infrastructure in Sacramento County in 2019 and 2020. We will align our incentives with those of CalEVIP to make it easier for customers to apply and get both incentives simultaneously to further incentivize EV adoption.

5.3.3.1.2 Outreach, education and awareness

Marketing research shows general consumer awareness of EVs is low. SMUD runs integrated marketing and advertising campaigns in conjunction with community education and hands-on driving demonstrations to reach customers and raise awareness and provide customers an opportunity to learn about EVs. Our programs for promoting EVs are discussed further in Chapter 2.3, above.

5.3.3.1.3 EV time-of-day rate

Residential customers with EVs are enrolled in our EV Time-of-Day rate that promotes charging after midnight. The rate provides a $0.015/kWh discount for electricity used between midnight and 6 a.m. Approximately 35% of SMUD EV customers had opted into this rate prior to TOD becoming the standard rate for residential customers in 2019.

5.3.3.1.4 Residential grid impacts

SMUD performed a residential EV Grid Impacts study in 2014 and updated the study in 2016. The study showed that the type of charger used by customers has a greater impact on the distribution system than the time of day a vehicle is charged. Level 1 charging at 1.5k W has a relatively low impact on our distribution system. Level 2 charging at power levels above 10 kW show an acceleration of grid impacts.

The current average residential charging level is approximately 3.0 kW. Grid impacts at this level are modest and expected to cost approximately $15 million a year out in the 2030-time frame when light duty adoption exceeds 200,000 vehicles in our service territory.

SMUD is planning for the management of EV grid impacts in several ways. In addition to using residential TOD rates for all EV customers, we are researching smarter managed charging options that could essentially eliminate grid impacts by preventing too many vehicles from charging simultaneously on the same transformer. Costs associated with these new technologies are currently higher than conventional grid reinforcement costs.

We expect that from the early 2020s, smart charging solutions may be competitive with conventional distribution system strengthening measures. As discussed in Section 13.2, our 5-year distribution system investment plan will be updated in 2019 to fully account for expectations reflected in our 2018 IRP.

5.3.3.1.5 Transportation network companies and autonomous vehicles

As of 2018, there were no operators of fleet EVs or EV autonomous vehicles in the Sacramento region. While it is possible that such services may grow quickly and help accelerate the reduction of emissions from the regional transportation sector, our IRP does not anticipate any material impacts to electricity demand or planning from such growth before 2030. We will continue to monitor the development of EV-based and autonomous transportation services in the region and will update our plans as needed to support this development.

5.3.3.1.6 Medium and heavy duty

Growth of electric transportation in the medium and heavy duty EV segments is expected to take significantly longer than the light duty vehicle adoption. Unlike the light duty market, which is driven by consumer preference, the medium and heavy-duty markets are more likely to be motivated by regulatory requirements and financial incentives. This is due in part to the technologies supporting the segment are less mature than in the light duty market, the relatively higher battery costs associated with larger heavier vehicles and generally longer fleet turnover cycles.

We expect public transit and public service fleets will be among the first to electrify, such as public-school bus fleets, refuse trucks and shuttle buses, followed by medium duty delivery and service vehicles. We expect that about 25% of these vehicles will be electrified by 2030.

Transit bus electrification will occur in stages to time with vehicle retirement and therefore have somewhat longer transition cycles. Technologies for large heavy-duty vehicle electrification are also emerging but so far it is unclear whether all applications will be electrified, and in particular long-haul heavy trucks.

Given the lack of market maturity, SMUD does not yet have programs to support medium and heavy-duty electrification. Instead, we conduct research and support research projects such as electric school bus deployment projects in school districts including Elk Grove, Twin Rivers and Sacramento City Unified, to gather data on infrastructure installation costs and energy costs. Based on information gathered from those efforts, we will design programs that meet community needs and stimulate accelerated electrification.

5.3.3.1.7 Commercial EV rates - example

Commercial EV charging is exposed to demand charges because of the characteristics of needing high charging levels and capacity but a relatively low energy use. This has resulted in commercial charging applications typically running at a 5% utilization factor which in turn means that as much as 80% of a customer's electricity bill could be comprised of demand charges. Utilities are just beginning to address this issue and various approaches are currently being tested. For example, Southern California Edison has introduced a 5-year demand charge waiver with a subsequent 5-year phase in. NV Energy is experimenting with a 1-year demand charge waiver followed by a 10% per year phase in of demand charges. At SMUD, we started pilot studies in 2015 using volumetric rates instead of demand charges and will continue to seek solutions that are attractive to customers while providing sufficient cost recovery for SMUD.

5.4 Distributed energy resources behind the meter

We expect the leading energy technologies installed at or behind the customer's meter will be battery storage and solar PV. We expect PV adoption will continue to grow in our service territory because of continued declining costs for installed systems and regulatory mandates such as the required rooftop solar for new buildings in the 2019 Title 24 Building Standards. Through 2017, our customers had installed a total of 157 MW of BTM solar PV, consisting of 19,944 residential and 468 commercial systems (83 MW residential and 74 MW commercial). In addition, there is approximately 1 MW of PV systems installed for low-income multifamily residential customers.

By 2030, we expect behind-the-meter solar installations (new and existing) will increase to over 450 MW, contributing to an annual demand reduction on the grid of more than 800 GWh.

The pace of behind-the-meter solar adoption is driven largely by customer preferences, such as the desire for renewable generation to reduce electricity bills, and net installed costs. The pace could accelerate if costs for new systems fall faster than anticipated or solar PV incentives such as the federal investment tax credit were to be continued beyond its scheduled expiration in 2022.

We will continue to revise and modify SMUD's Rule 21 Interconnection Rules to streamline the application and interconnection construction process and improve efficiency. Our focus is on simplifying the rules and increasing clarity to drive the best possible customer experience during the interconnection process.

The annual BTM PV adoption forecast is converted into annual energy using generation assumptions, such as capacity factor and generation profile. The annual energy is then treated as a decrement to the load forecast.

In response to California's legislation on energy storage under AB 2514, SMUD adopted in 2017 a goal of 9 MW of energy storage to be procured by December 31, 2020. We expect to meet roughly 80% of the target with battery energy storage systems and 20% with thermal energy storage systems. All 9 MW are currently planned behind the-meter with approximately 80% as residential and 20% as commercial and industrial installations. Our load forecast includes the effects of storage on net energy demand and marginal impact on load shapes.[20]

5.5 Dynamic electricity rates (TOD rate)

SMUD encourages energy efficiency and conservation through the residential TOD rate structure that will be fully implemented in 2019, as well as non-residential TOD rates and a variety of programs, such as offering rebates for energy-efficient appliances and heating and cooling systems, and energy-efficient LED lighting. The TOD rate structure encourages customers to conserve energy by rewarding them for reducing their usage during peak hours. There was no rate increase associated with the switch to the TOD rate structure, so customers can save money if they shift or reduce their usage from peak hours. In addition, our TOD rate offers a plug-in EV credit of $0.0150/kWh on all electricity between the hours of midnight and 6 a.m. to encourage EV adoption.

The residential TOD rate structure consists of Peak, Mid-Peak, and Off-Peak periods in the summer months (June through September) and Peak and Off-Peak periods in the non-summer months (October through May) as shown in Table 11 below.

Table 11. Residential TOD rates

Season	Period	2018-2019 Rate ($/kWh)	Notes
Summer (June 1 – Sept 30)	Peak	0.2835	Weekdays between 5 and 8 p.m.
	Mid-Peak	0.1611	Weekdays between noon and midnight except during Peak hours
	Off-Peak	0.1166	All other hours
Non-Summer (Oct 1 – May 31)	Peak	0.1338	Weekdays between 5 and 8 p.m.
	Off-Peak	0.0969	All other hours

[20] For a more detailed discussion of SMUD's energy storage goals, please see https://www.energy.ca.gov/assessments/ab2514_re-eval_reports/smud/AB_2514_Oct_1_2017_Report_UPDATED_91517.pdf.

5.5.1 Load impact of TOD rates

The load impacts from introducing of TOD pricing are based on price elasticity estimates from a SMUD Smart Pricing Option (SPO) pilot conducted from 2012 to 2013. In this study, a randomly-selected group of residential customers was placed on a default TOD rate schedule, but could opt out of the program by contacting SMUD.

One of the important findings from this study was that very few customers opted out of the TOD rate offering.

To calculate the TOD price elasticities, the price elasticities from the SPO study were adjusted to reflect the 2019 TOD prices relative to the 2017 residential electricity prices. In the SPO study, price elasticities were estimated for both standard rates and energy assistance program rates (EAPR). The group elasticity is the weighted average of both rates where the weights are the share of customers on each rate program.

Table 12 shows the derivation of the elasticity estimates based on the price differential discussed above. Net Impact figures are the percentage change in electricity use during each TOD period.[21]

The load forecast presented in Table 15 includes the effect of TOD rates on our electricity demand.

Table 12. Calculation of price elasticities for TOD impacts[22]

	Summer			Winter	
TOD Shares	**Peak**	**Mid-Peak**	**Off-Peak**	**Peak**	**Off-Peak**
Base Price ($/kWh)	0.1291	0.1291	0.1291	0.1128	0.1128
TOD Price ($/kWh)	0.2835	0.1611	0.1166	0.1338	0.0969
Own Price Elasticities					
LN Chn Price	79%	22%	-10%	17%	-15%
Elasticity - Standard	(0.069)	(0.069)	(0.031)	(0.069)	(0.031)
Elasticity - EAPR	(0.011)	(0.011)	-	(0.011)	-
Elasticity - Group	-5.9%	-5.9%	-2.5%	-5.9%	-2.5%
Price Impacts	**-4.6%**	**-1.3%**	**0.3%**	**1.0%**	**0.4%**
Cross Price Elasticity					
Pct change cross price (off-peak impact from a change in on-peak price)		79%	54%		17%
Elasticity - Standard		0.001	0.001		0.001
Elasticity - EAPR		0.013	0.013		0.013
Elasticity - Group (Weighted Average)		0.00316	0.00316		0.00316
Price Impacts		**0.2%**	**0.2%**		**0.1%**
Net Impact (=own price + cross price)	**-4.6%**	**-1.0%**	**-0.4%**	**-1.0%**	**0.4%**

[21] For additional information on SMUD Smart Pricing Option study, see https://www.smartgrid.gov/project/sacramento_municipal_utility_district_smartsacramento.html.

[22] Note that the base prices for 2018 were revised from $0.1291/kWh in 2017 to $0.1310/kWh for the 2018 summer period and from $0.1128/kWh to $0.1145/kWh for the winter period.

5.6 Additional drivers of electricity demand

In addition to the drivers of electric demand discussed above there are three additional drivers that may become increasingly important in the 2019-2030 period. The first is load growth among a few commercial customers that represent a significant portion of our load. The second is electric demand from new commercial activities and the third is electric demand from cannabis cultivation.

5.6.1 Key account commercial customers

Incremental sales are based on the additional sales from current commercial customers who are expected to expand their operations. Our commercial customer accounts staff provided the expected expansion plans for 5 customer accounts. For the incremental load forecast, it is assumed that the full expansion is achieved in 2022 and is constant for the remainder of the forecast period. Table 13 shows the forecast of annual incremental demand.

Table 13. Incremental energy and load

Year	Incremental Energy (MWh)	Peak Impact (MW)
2019	69,515	9
2020	115,475	14
2021	161,033	20
2022	171,383	21

5.6.2 New commercial development

New commercial development loads and sales are based on discussion with SMUD's Economic Development and Commercial Development departments. These groups provided a list of projects for customers who were considering locating in the SMUD service territory which were included in our forecasts. The number of potential projects were evaluated with respect to the trend forecast of customers. The new commercial development sales include the accounts that exceeded our trend analysis for customers with maximum demands greater than 1,000 kW. The net impact of new commercial development is about 46 GWh per year. In the scenario forecast, all projects under consideration began commercial operations on Jan. 1, 2018.

5.6.3 Indoor cannabis cultivation

The sales impacts from indoor cannabis cultivation do not include manufacturing or dispensary operations. Prior to the growing and selling of recreational marijuana in California which became legal on Jan. 1, 2018, SMUD staff received inquiries from potential growers for establishing electrical service. To understand the electrical needs for these customers, SMUD requested that growers submit information on the state license they were applying for on or after Jan. 1, 2018.

California has 3 main license categories for indoor cultivation based on the square footage of the indoor growing space.

A. Specialty: Up to 5,000 sq. ft

B. Small: 5001 to 10,000 sq. ft

C. Medium: 10,001 to 22,000 sq. ft

Table 14 shows the number of projects based on the license category and electrical use assumptions.[23]

[23] The annual MWh is based on the following formula: Annual Use = Max sq. ft per license category * 35 watts per sq. ft * 85% load factor. The indoor cannabis cultivation forecast assumes that each project begins commercial operation on Jan. 1, 2018.

5.7 Load forecast 2019-2030

Table 15 presents our integrated IRP forecast of electricity demand for electricity on our system. The forecast includes the impacts of our energy efficiency programs, electrification, behind-the-meter PV generation, demand response and energy storage programs. Additional forecast adjustments included in the table below are load shifting resulting from our residential TOD rates beginning in 2019, new commercial development, incremental load from new development under construction and indoor cannabis cultivation. The Net Customer forecast includes residential, commercial, agricultural, and streetlight accounts, but it excludes nightlight accounts. Each of these demand drivers are discussed in the sections above.

Table 14. Indoor cannabis cultivation projects and sales and load impacts (2019 - 2030) [24]

License Category	Projects	Average MWh/ year	Annual Sales	Annual Energy (MWh)	Annual Peak (MW)
Class A (Specialty Indoor)	12	1,303	15,637	16,292	2
Class B (Small Indoor)	13	2,606	33,879	35,299	3
Class C (Medium Indoor)	47	5,733	269,471	280,762	27
Total	72		318,987	332,352	32

Table 15. Annual electricity demand, peak demand and customer count 2019-2030

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Unmanaged Load (GWh)	11,211	11,306	11,348	11,399	11,496	11,615	11,701	11,751	11,784	11,865	11,928	12,014
Other Incremental Load (GWh)	450	497	541	552	552	553	552	552	552	553	552	552
Cumulative Energy Efficiency - Committed (GWh)	(213)	(244)	(245)	(243)	(230)	(216)	(215)	(195)	(181)	(156)	(129)	(128)
Cumulative Energy Efficiency - Additional Achievable (GWh)	(16)	(85)	(178)	(276)	(394)	(508)	(612)	(754)	(900)	(1,050)	(1,196)	(1,322)
BTM Solar &Storage (GWh)	(131)	(210)	(237)	(264)	(290)	(314)	(326)	(368)	(416)	(501)	(541)	(571)
TOD Effect (GWh)	(7)	(8)	(7)	(7)	(7)	(7)	(7)	(8)	(8)	(7)	(7)	(7)
Building Electrification (GWh)	3	7	13	24	44	71	104	144	189	240	298	365
Transportation Electrification (GWh)	14	68	98	138	189	259	367	446	548	652	779	936
Managed Load (GWh)	11,311	11,331	11,332	11,322	11,359	11,452	11,563	11,567	11,568	11,596	11,683	11,838
Annual Peak Load (MW)	2,907	2,896	2,907	2,911	2,920	2,930	2,957	2,948	2,936	2,912	2,914	2,911
Number of Customers	633,690	638,554	643,401	648,547	653,801	659,223	666,350	671,641	678,170	684,945	692,261	699,676

[24] NOTE: 35 watts per square foot reported by Xcel Energy, Pg. 7, "Energy Impacts of Cannabis Cultivation," CPUC, April 20, 2017.

Figure 12. Annual energy demand components in 2030 (GWh)

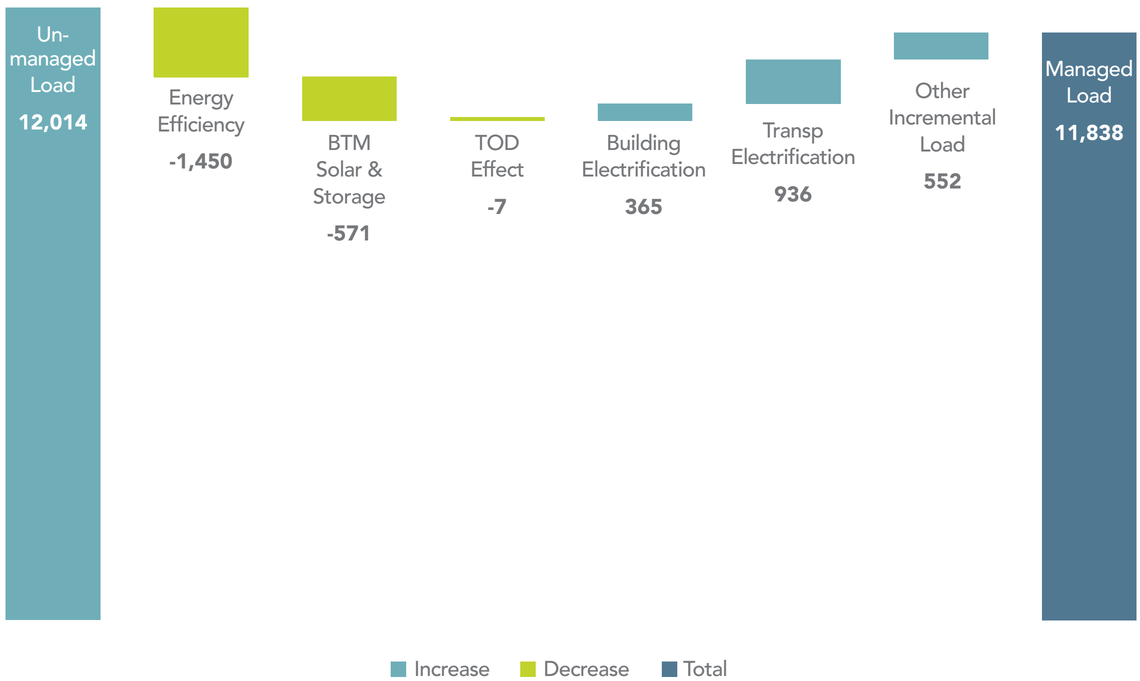


Figure 12 presents the annual energy demand by each of the components in Table 15 for 2030. The figure illustrates the impact of the demand components, suggesting that the largest impacts prior to 2030 will be energy efficiency improvements and behind-the-meter resources, which are counteracted by electrification of transportation.

5.8 Expected load after 2030

After 2030, we expect the momentum for transportation electrification to remain strong and the demand impact of building electrification to accelerate, causing overall demand growth to exceed 1% per year from 2030 to 2040, despite continued increased energy efficiency and growing adoption of demand response measures and programs. However, there is significant uncertainty regarding these long-term expectations since there are numerous factors that could strengthen or weaken long-term demand growth, such as an economic downturn, technological breakthroughs in distributed generation technologies and regional demographics.

For example, the impact of climate change could be more severe than anticipated in our outlook which could increase summer peak loads, decrease winter peak loads, and could also influence seasonal temperature and precipitation patterns, which in turn would impact heating and cooling needs in the Sacramento region.

6. Existing energy supply

SMUD's existing resource portfolio consists of a diversified mix of generation resources, including hydro, natural gas fired combined cycle generators, gas fired peaking capacity, wind, solar and biomass/biogas-based generators. This section describes SMUD's existing generation, contracts, energy resources and transmission resources. Future potential resource additions are discussed, in Chapter 7, and demand resources, including energy efficiency, demand response and distributed resources are discussed in Chapter 5.

6.1.1 Transmission

Our high voltage transmission system connects with surrounding areas at the 230 kV level. Figure 13 provides an overview of our transmission system and how it interconnects with other areas.

Our maximum import capability is limited by resources operating within SMUD's service territory. We have a scheduling limit of over 1,300 MW with the CAISO and own about 500 MW of transmission rights to the California-Oregon Border on the California-Oregon Transmission Project.

We contract for an additional 300 MW of transmission services from WAPA and use short-term transmission services administered by the CAISO for meeting peak energy needs from short-term energy markets as needed.

Figure 13. SMUD transmission overview

6.1.2 Existing generation portfolio

SMUD's power supply portfolio is diversified and includes a wide variety of sources, including hydropower, natural-gas-fired generators, solar, wind, biomass, biogas and geothermal resources. Our goal is a balanced, diversified, reliable and sustainable mix of sources. All our existing owned resources are expected to remain operational throughout the study period and beyond. Some resource contracts are expected to expire during the forecast period, most of which are not assumed to be renewed. The tables below show the net capacity available to serve peak load for thermal and hydro resource and nameplate rating for renewables.

The summer net dependable capacity (NDC) of SMUD's existing thermal generators are summarized in Table 16. These generators are expected to continue to be available for dispatch over the forecast period. We also assume that a portion of the fuel used by the Cosumnes Power Plant will continue to be satisfied by our biomethane supply, which will continue reduce the plant's overall GHG emissions and contribute towards our RPS requirement. Note that even though we assume that our thermal generators are available up to their net dependable capacity during peak demand conditions, we also factor in their historical availability and outage rates, taking into account both typical maintenance schedules and events as well as unplanned (forced) outages in our modeling of these resources.

SMUD owns and operates over 673 MW of large and small hydroelectric resources as part of the Upper-American River Project (UARP). In 2014, SMUD was issued a new FERC license that will allow us to continue operating the UARP for another 50-years.[25] Thus, all hydro resources are expected to remain operational throughout the forecast period. SMUD also has a long-term contract with the WAPA for 336 MW of small and large hydro capacity. In modeling our hydro assets, we base our assumptions regarding availability, typical maintenance, outages, etc on the historical performance of our units.

Table 16. Existing thermal capacity (summer peak NDC MW)

Resource Name	Resource Type	Fuel	NDC (MW)
Campbells	Combined Cycle	Natural Gas	160
Carson	Combined Cycle Cogen	Natural Gas	103
Cosumnes	Combined Cycle	Biogas & Natural Gas	495
McClellan	Gas turbine	Natural Gas	72
Proctor Gamble	Combined Cycle Cogen	Natural Gas	182
Total			**1,012**

[25] FERC's new license order for the UARP can be found here: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/uppramrvr/uarp_ferc_license.pdf.

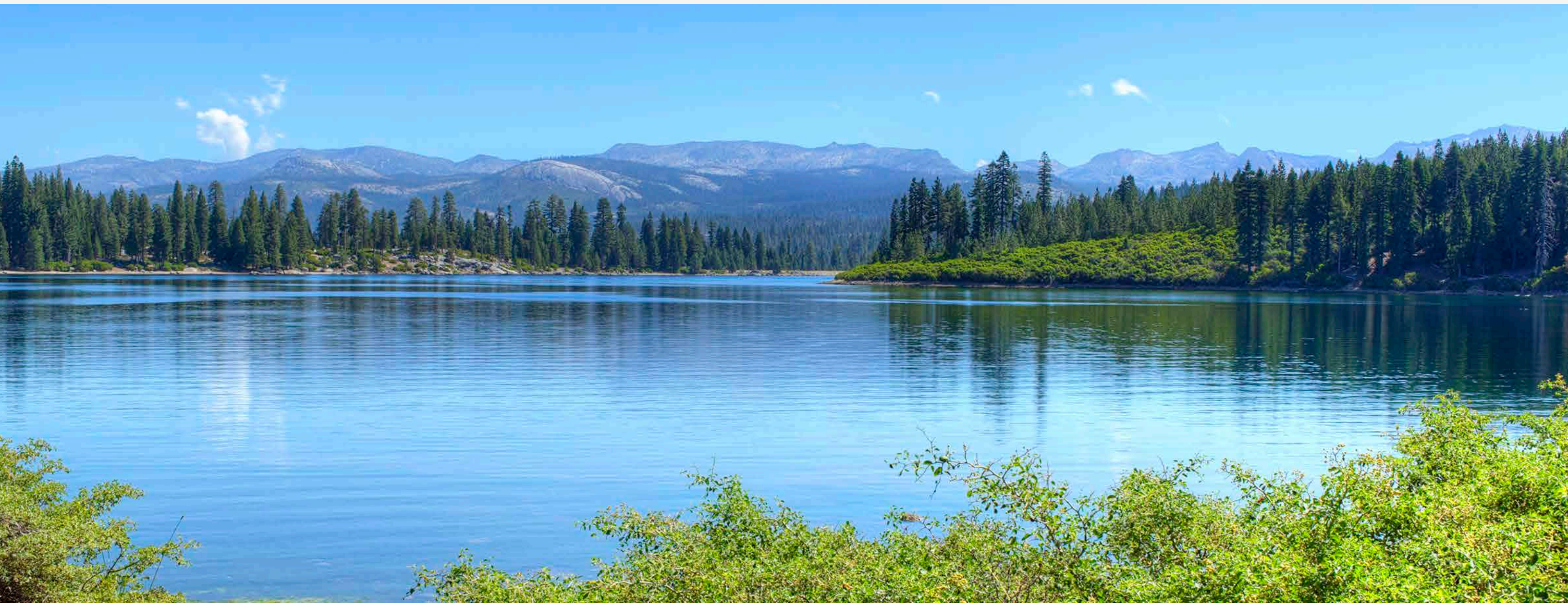


Table 17. Existing hydroelectric capacity (summer peak NDC MW)

Resource Name	Resource Type
UARP	673
Camp Far West	4
WAPA Hydro	336
Total	1,013

Table 18 reports SMUD's renewable energy portfolio comprised of owned and contracted resources.

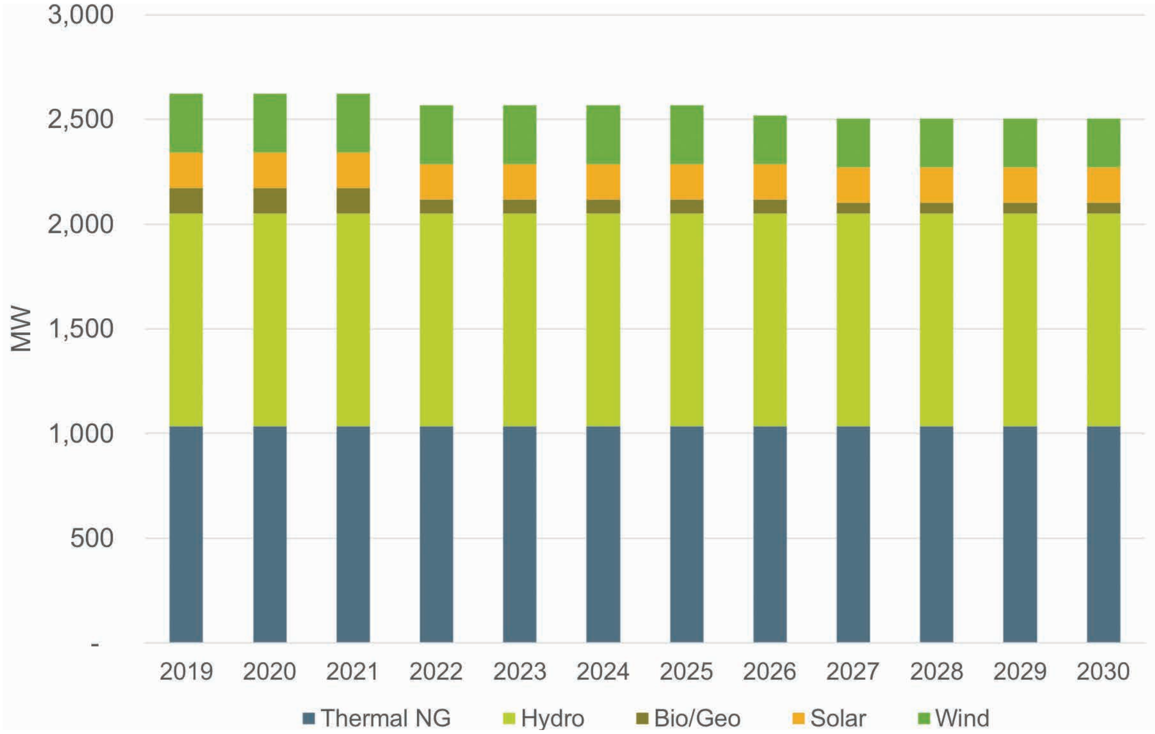
Table 18. Existing renewable energy capacity (Nameplate MW)[26]

Resource Type	Resource Name	Nameplate Capacity (MW)
Biogas/Biomass	Kiefer Landfill	12
Biogas/Biomass	Santa Cruz Landfill	1.4
Biogas/Biomass	Simpson Biomass	55
Biogas/Biomass	Yolo	3.4
Geothermal	Cal Energy	30
Geothermal	Patua	21
Small Hydro	Camp Far West	7.2
Small Hydro	Jones Fork	12
Small Hydro	Robbs Peak	22
Solar	Feed-In Tariff Projects	98
Solar	Rancho Seco PV	11
Solar	Recurrent PV	60
Wind	High Winds	50
Wind	Solano	230
Total		613

[26] Additional RPS-eligible capacity from biogas sources and small solar arrays were not included in this table because of their size or because the gas was consumed in our thermal power plants, including the renewable portion of Cosumnes Power Plant and small dairy digester contracts that total less than 1 MW.

Figure 14 shows SMUD's existing and contracted capacity over the 2019-2030 period. The main reason for the reduction of available capacity over time is the expiration of some wind and biomass contracts over the period.

Figure 14. Existing and contracted capacity 2019-2030 (MW Nameplate)



7. New resource supply options

Over the 2019-2030 period, we expect to add new capacity consisting of solar, wind and battery energy storage. The Adopted Scenario and resource portfolio is shown and discussed in Chapter 9. This section provides an overview of the resource alternatives considered by SMUD in the IRP, including energy storage, wind, solar PV, biomass & biogas and geothermal resources. Distributed resources installed behind-the-meter are discussed in Section 5.4 of this report.

We estimate that between 2019 and 2030, SMUD's non-renewable dispatchable resources together with capacity available in the rest of the WECC will be sufficient to meet our needs for non-renewable capacity. Therefore, our IRP was limited to considering only battery storage, renewable energy alternatives and DERs as candidates for future resource additions. Also, in our modeling and cost assumptions, we expect all potential renewable capacity to be fully deliverable to California and thus qualifying for the RPS as a portfolio content category 1 resource.[27]

Costs of new resource options – discussed further in this section – were estimated based on available industry data from sources such as Lazard, National Renewable Energy Laboratory (NREL), Greentech Media Research and publicly available data published by the CPUC as part of tools and materials supporting CPUC's IRP proceedings. The resource portfolio that was ultimately selected is discussed in more detail in Chapter 9 (Results), taking into account the relative costs and characteristics of the candidate resources and the objectives that the portfolio must meet.

[27] See California Public Utilities Code 399.16 for details on the RPS portfolio categories.

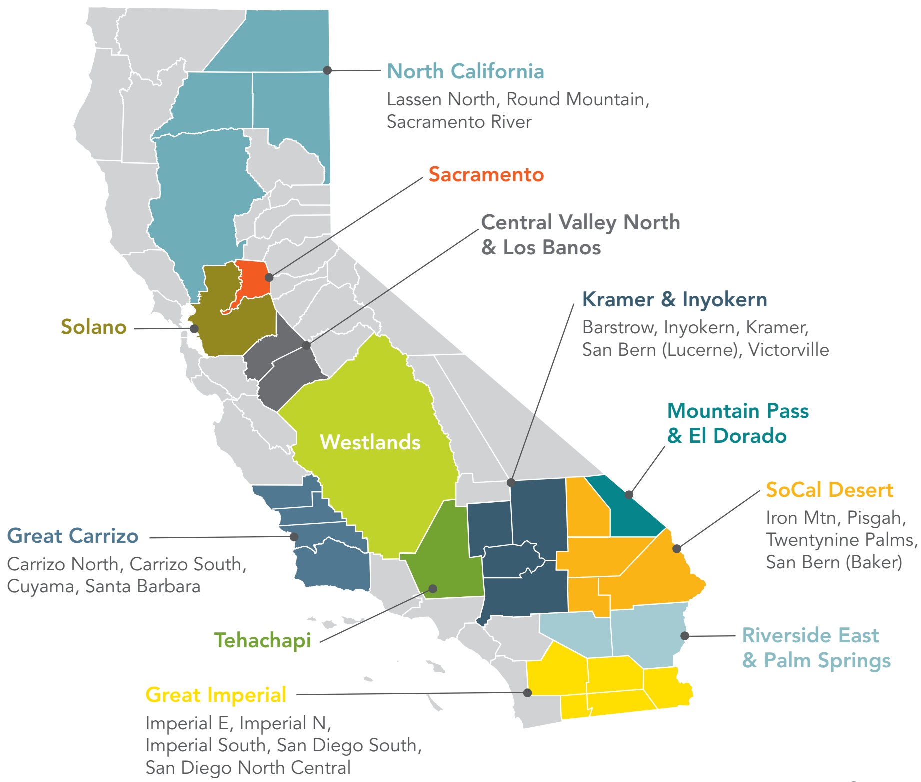
7.1.1 Local vs non-local energy resources

Local energy resources are those that we expect to develop within SMUD's service territory and include solar PV and energy storage. Other potential resources, such as biomass, wind and geothermal resources were not considered for local installation due to cost limitations and/or lack of resource potential within Sacramento County.

Some renewable energy resources have limited resource potential for expansion within California.[28] Therefore, to ensure our IRP does not conflict with or exceed the available potential, we benchmarked our IRP against CPUC's RPS Calculator version 6.2, which provides resource potential estimates for California as well as out-of-state renewable energy sources.

However, it is important to note that the actual resources selected in our IRP beyond those already under development will depend on many factors, including specific procurement objectives, solicitation timing, developer responses and associated costs we receive in resource solicitations. This may in turn also affect the portfolio mix if the relative costs between potential resources were to change compared to our current expectations. For new generic resource additions, SMUD worked with E3's RESOLVE model to select resource types and approximate locations. These resource locations are shown in Figure 15 below for California – in addition we also considered new potential resources in New Mexico and Southern Nevada.

Figure 15. California new resource zones



Source: E3

[28] Based on available capacity listed in version 6.2 of the RPS calculator which can be found on CPUC's RPS website: http://www.cpuc.ca.gov/rps_calculator/.

Using a variety of sources we estimated the potential capacity that could be developed of solar, wind, battery storage, demand response and geothermal resources over the 2019-2030 period, the results of which are shown in Table 19, and discussed in more detail in subsequent parts of this section.

Table 19. Resource potential by resource type considered to be available to SMUD for consideration as future capacity additions

Resource Type	Within SMUD Service Area (MW Nameplate)	In CAISO/WECC (MW Nameplate)
Solar (utility scale)	1,000	Not limited
Wind	0	1,200 (In CA) + 900 Non-CA WECC
Geothermal	0	650
Battery Energy Storage (4h)	560	N/A
Demand Response	180	N/A

7.1.2 Energy storage

Energy storage is a highly flexible resource with a wide range of applications that are dependent on the location and storage technology. The common element across all energy storage systems is the ability to shift energy from one time period to another. This can be done through chemical, thermal or mechanical storage methods. The type of storage is often driven by the specific application need and the space available to site the storage system.

We expect costs of battery storage to continue to decrease over the forecast period, while the comparable cost of conventional thermal power plant capacity will remain constant or possibly increase. In addition, increased penetration of solar capacity across the WECC and CAISO will likely help storage resources become more economic as power price differentials between solar hours and non-solar hours increase. Further, clean flexible resources such as energy storage will be needed to support ever-increasing intermittent renewables while reducing dependence on natural gas.

Even though current battery storage technology isn't a viable alternative for a multi-day energy supply source, it can provide valuable flexibility to meet ramping needs, peak capacity, as well as helping to absorb overgeneration of renewable energy.

Utility-scale energy storage has been the subject of studies and ongoing research at SMUD, including thermal energy storage, pumped hydro storage and battery storage. In response to Assembly Bill (AB) 2514, in 2017 SMUD adopted a target of 9 MW of energy storage to be procured by Dec. 31, 2020.[29] SMUD is currently developing battery and thermal energy storage programs to meet this target. Our 9 MW target is focused on behind-the-meter energy storage systems including lithium-ion batteries and thermal energy storage within SMUD's service territory, with approximately 80% residential and 20% as commercial and industrial installations.

Research and learnings from our current storage program will provide opportunities for expansion if found to be cost-effective and meeting or exceeding expected system benefits. In parallel with SMUD's R&D efforts on storage, we also expect that behind-the-meter battery storage adoption will increase substantially in the 2019-2030 period and could reach as high as 12 MW of behind-the-meter capacity by 2030.

Our analyses suggest that larger scale storage will not be cost-effective for SMUD until 2025 or later. This result is driven by 2 factors: First, storage costs need to decline significantly below today's levels before becoming cost-effective for SMUD in utility-scale applications. Second, our hydro and thermal fleet are flexible enough to manage the expected levels of intermittent load and generation until at least 2030.

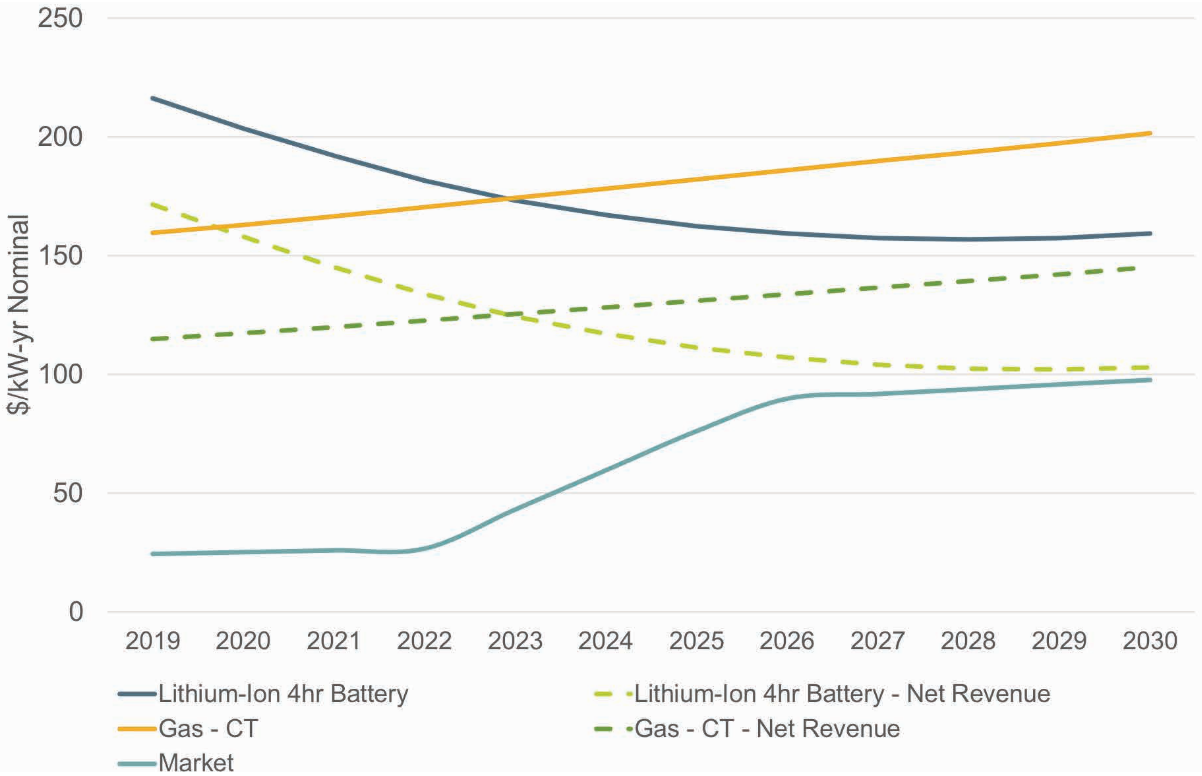
Therefore, prior to achieving cost effectiveness, our efforts will likely be focused on R&D applications, developing interconnection processes, control strategies, communication strategies and the evaluation of infrastructure support opportunities. Success of our early programs will position SMUD well to ramp up energy storage programs and offerings when costs and system needs motivate a wider adoption of storage, currently expected to be around 2030.

Figure 17 shows the expected cost development for 4-hour lithium-ion batteries in utility-scale applications, the most common technology used today. The figure also shows a comparison of costs to conventional gas fired capacity – both these technologies can be utilized to meet capacity needs.

[29] https://www.energy.ca.gov/assessments/ab2514_re-eval_reports/smud/AB_2514_Oct_1_2017_Report_UPDATED_91517.pdf.

While energy storage is not generally cost effective as a new resource for SMUD today, there are niche applications that may cause some of our customers to become early adopters of energy storage. These include solar plus storage to manage onsite power demand and production, which would help minimize demand charges. Other applications may include onsite improvements of power quality and/or power supply security for sensitive operations. We will observe these early adoption applications to continue anticipating further cost declines for storage and the timing for larger scale investments in storage by SMUD.

Figure 16. Expected levelized installed costs of substation-connected 4-hour lithium-ion battery storage 2019-2030 relative to other capacity options



Source: Battery and CT capacity prices based on E3 Price forecasts. Net revenue and market price estimates based on SMUD analysis of current capacity market prices, fixed operating costs of existing CTs and surveys of proprietary market price forecasts.

7.1.3 Solar PV capacity

As shown in Table 18, SMUD currently has 169 MW of local utility-scale solar capacity on our system. By 2021, we are also planning to add over 100 MW of capacity at our local Rancho Seco site, followed by another 100 MW of solar under a long-term contract for solar capacity at the Navajo solar farm in Southern California that is expected to be completed in 2021. These additional solar resources are listed as new resources and included in our Adopted Resource plan listed in Table 21.

7.1.3.1 Local solar PV

In general, solar PV is among the lowest cost renewable technologies, if developed in high solar resource areas. While the Sacramento region may have lower overall solar potential than other parts of California, it is still an attractive area for new solar development. However, suitable land for development of new solar resources within our service territory is somewhat scarce and contributes to limiting the size of any single installation, as well limiting the overall local capacity potential. These factors translate into a local solar cost premium of approximately $7 to $10 per MWh compared to the lowest cost areas in Central and Southern California and in the other southwestern regions.

Another challenge for interconnecting additional solar resources to our system is the need to carry additional operating reserves within the BANC to compensate for the intra-hour variability and uncertainty of the resource. Due to the relatively modest size of BANC, a new solar resource would have a relatively greater impact when interconnected to our system compared to the much larger CAISO system.

The maximum potential for new local utility scale solar PV capacity is estimated to be about 1,000 MW in the Sacramento area. This is based on a high-level analysis of available land in Sacramento County that could be used for ground-mounted solar development and was based on a few simple screening criteria:

- Parcels zoned as industrial or agricultural.
- Parcels located on low-grade agricultural or otherwise disturbed land.
- Minimum parcel-size of 100 acres or contiguous parcels adding up to 100 acres.
- Location within 5 miles of a 69-kV feeder capable of accepting at least 20 MW of PV.

Based on these criteria, we found that 80,000 acres in Sacramento County may be available for additional solar development. We also worked with Sacramento County planning department to apply additional criteria to ensure that these parcels could be feasibly permitted with minimal effort. The parcels were limited to candidate sites that have been identified as deteriorating industrial-zoned parcels or vacant land. The additional criteria resulted in 6,000 acres of potential sites for solar development which is estimated to be able to host up to 1,000 MW of solar PV. Expected costs for local and non-local solar PV resources over the 2019-2030 period are shown in Figure 17.

7.1.3.2 Non-local solar

We also considered the procurement of solar energy resources from other balancing areas, including the CAISO and out-of-state resources. The best resource potential for solar PV development is in Southern California and in the desert southwest due to high irradiation while still within the WECC and in proximity of California. Acquiring solar resources from this area allows SMUD to cost-effectively reduce greenhouse gas emissions and achieve our RPS targets. However, the challenge with procurement of resources from other balancing areas is that transmission and wheeling costs can be prohibitive. Non-local solar resources also don't help to improve our regional air quality or provide economic opportunities in the Sacramento region.

Based on resource potential estimates by the CPUC published in its RPS calculator, up to 180 GW of solar resources could be developed elsewhere throughout the WECC and delivered to the CAISO. This includes approximately 110 GW within California and 70 GW out-of-state.

For modeling purposes, we assume all new projects to be fixed tilt monocrystalline silicon panels with 180-degree azimuth (south facing) and a horizontal tilt between 20 and 35 degrees, depending on the latitude of the site. Further, we assumed a DC:AC ratio of 1.3 and an inverter efficiency of 96%. This results in an average annual capacity factor ranging from 25 to 35% depending on location.

Solar energy production was modeled using NREL tools. The System Advisor Model was used to produce 5-minute and hourly electric system output.[30] Weather and irradiance data was sourced from the National Solar Radiation Database for years 2007 through 2016, as available.[31] We also assumed that development and capital cost would be levelized over 20 years. Figure 17 shows the expected levelized costs for new solar PV resources in the 2018-2030 period based on publicly available data sources.

[30] https://sam.nrel.gov/ NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC. SAM is developed by the National Renewable Energy Laboratory (NREL) with funds from the U.S. Department of Energy. SAM collaborates with Sandia National Laboratories for the photovoltaic models and has collaborated with the University of Wisconsin's Solar Energy Laboratory for the concentrating solar power models.

[31] https://maps.nrel.gov/nsrdb-viewer.

7.1.4 Wind

SMUD owns and operates a significant amount of wind generation in Solano County, near Rio Vista. Energy from these wind resources are delivered into the CAISO and occasionally wheeled to SMUD. The IRP includes our plan to repower and expand capacity in this area in the future.These capacity additions are included as new resources in Section 9: Results. Due to a combination of limited additional available land in the Solano area and the area's limited wind resource rating, we expect that additional wind resources will be developed outside of the Solano wind area.

Until recently, wind resources have been the lowest cost renewable resource available in California. While there are still some wind resource areas available for development in California, most of the major wind resource areas, such as Solano County or the Tehachapi area are nearly fully developed. This means that any future resources in these areas would need to be done through brown-field repowering rather than new greenfield development which will lead to higher costs compared to other areas in the WECC. Therefore, we expect the best areas for future wind energy development to be in Wyoming and New Mexico.

There is also a vast amount of offshore wind potential off the Pacific coast. However, the development of these resources is challenged by the depth of sea floor (which would necessitate floating applications) and the lack of transmission to areas with the best wind conditions. There are also a host of other considerations that will likely need to be addressed, including environmental concerns and aesthetic impacts. Therefore, offshore wind was not considered as a potential resource for the IRP.

We estimate that in-state wind potential available to SMUD is limited to about 1,200 MW of new resources. An additional 900 MW of out-of-state wind resources are also estimated to be available for development and procurement by SMUD with using existing transmission. NREL's Wind Integration National Dataset Toolkit wind datasets were used to produce 5-minute and hourly generation profiles for locations in Wyoming, New Mexico, and California, corresponding to the locations considered in our IRP. This dataset represents wind power production time series, and simulated forecasts created using the Weather Research and Forecasting Model run on a 2-km grid over the continental United States at a 5-min resolution over the years 2007 through 2013.[32 33]

We also assumed that development and capital cost would be levelized over 20 years.

7.1.5 Geothermal

We estimate that about 650 MW of new geothermal resources from out-of-state regions (Pacific Northwest and Southern Nevada) could be available for SMUD in the 2019-2030 period. Geothermal is assumed to be a must-take baseload resource operating at a capacity factor range of 80 to 84%. As one of the few resources that is both essentially GHG-free and available to serve baseload needs, geothermal resources can be an attractive future resource option. However, lead times for new developments are often long and the underlying production potential of the steam source can be uncertain. In addition, the long-term levelized cost of geothermal resources is often significantly higher than wind and solar resources (even after considering the integration costs of wind and solar).

Therefore, we did not add any new geothermal capacity to our resource portfolio as part of the IRP until after 2030. However, if new or existing geothermal resources were to be offered at competitive prices compared to other renewables (e.g. during resource solicitations), or if the need for additional GHG-free baseload resource arises, we may consider geothermal resources sooner than reflected in our IRP.

32 Draxl, C., B.M. Hodge, A. Clifton, and J. McCaa. 2015. "The Wind Integration National Dataset (WIND) Toolkit." Applied Energy 151: 355366.
33 https://www.nrel.gov/grid/wind-toolkit.html.

7.1.6 Biomass and biogas

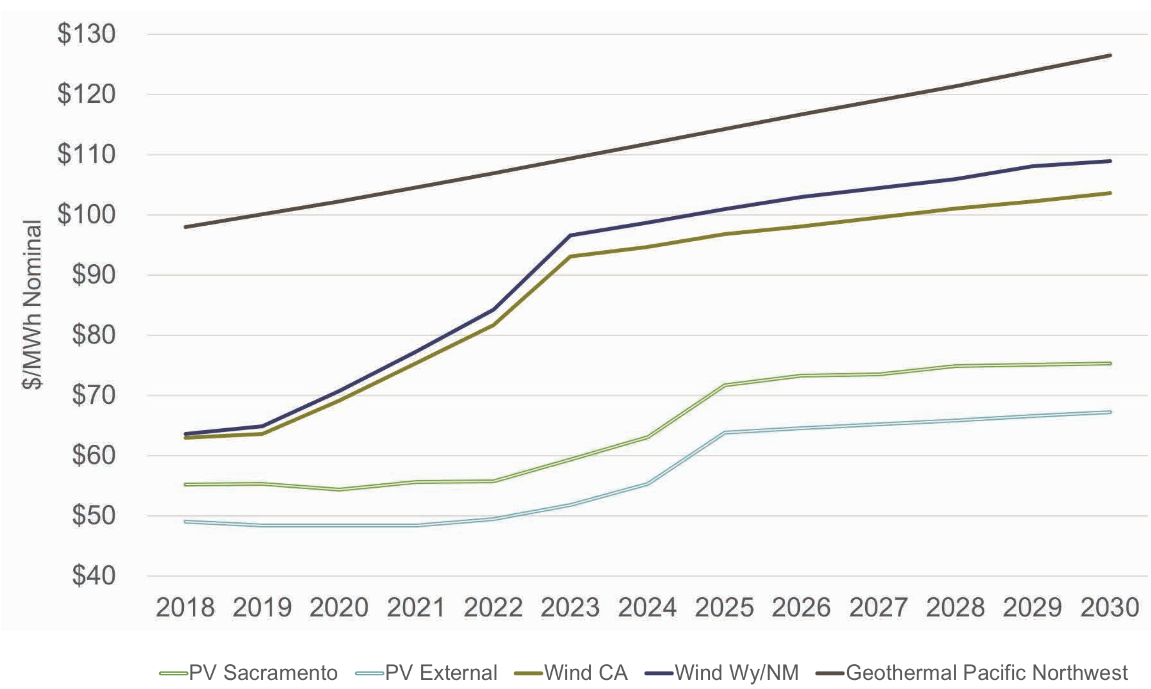
SMUD has a long history of supporting research and development of new, local bioenergy projects, including dairy digesters and landfill gas projects. Our existing resource portfolio includes about 57 MW of biogas and biomass projects. The energy from these resources is delivered under long-term power purchase agreements, some of which will expire in the 2019-2030 period. We do not include these resources in the IRP beyond the expiration of existing contract terms but will consider keeping them in the portfolio if the terms of renewed agreements are competitive with other resource supply options or if the baseload nature of the generation is desirable.

Our IRP portfolio does not include any new biomass or biogas resources. The reasons include relative resource availability, regulatory risk and high resource costs. We have found that the overall resource potential is relatively limited and constrained – especially regarding new biogas contracts and the regulatory constraints upon it, the size of each individual project is often small and the levelized costs of energy is far higher than for other potential resources.

7.1.7 Unspecified resource purchases

As part of our long-term resource portfolio, SMUD plans to also partially rely on market purchases from the CAISO and the rest of the WECC to complete our energy and capacity needs while allowing flexibility to account for uncertainty of future demand as well as year-to-year and month-to-month fluctuations of intermittent generation, hydroelectric generation and load. Depending on the overall developments of market prices and resource availability in the WECC, we may include additional capacity resources into our resource portfolio as needed. For example, if the cost of battery storage were to undercut capacity market prices sooner than expected, SMUD may decide to build battery storage in place of buying capacity from the market.

Figure 17. Levelized costs for new potential resources delivered at the busbar ($/MWh)



Source: E3

8. System and local reliability

As a utility and as the operator of BANC, we safeguard reliability, not only for our customers but also for the 5 other member utilities of BANC. BANC operations are subject to regulations and reporting requirements to FERC, NERC and the CEC. We conduct a rolling 10-Year Transmission Assessment Plan that focuses on grid reliability and necessary system improvements. Section 13 (T&D) below discusses our expectations with respect to transmission and distribution and the needed investments and upgrades over the next several years. This section is limited to reliability assumptions and constraints that are directly considered in modeling our IRP portfolios. The discussion in this section therefore includes our planning assumptions regarding reserve margin, operating reserves, ancillary services, flexible ramping and load following resources that are needed to maintain a balanced system in the long term. It also describes the overall balancing responsibilities performed by BANC and future potential improvements expected by joining the Energy Imbalance Market.

8.1 Planning reserve margin

SMUD ensures its long-term ability to serve electricity demand under all conditions by following federal, state, and NERC requirements for reliability and operations. For planning purposes, we plan to have sufficient resources to meet 1-in-2 peak load conditions plus a 15% planning reserve margin to account for extreme weather, operating reserves and unexpected outages. This level is consistent with WECC's planning criteria and matches the system resource adequacy requirements used by the CAISO and CPUC for resource adequacy.

In addition to ensuring that sufficient capacity and reserves are available for the annual and monthly peak load, evaluation of energy adequacy is increasingly important as capacity of installed intermittent renewable resources increases on the customer side of the meter as well as on the grid. This is particularly important in the long term when we may not only see more renewables but also higher levels of energy-limited battery storage.

As discussed in Section 2.7, we determined that a SMUD system without the support of thermal generation is not a viable resource plan given current battery storage costs and technology that falls short of meeting today's reliability standards. We don't expect battery storage to be a suitable replacement of our entire thermal fleet during the 2019-2030 forecast period covered in this report. However, SMUD will continue studying this possibility in future IRP studies.

8.1.1 Local reliability and capacity needs

Within SMUD's service territory we do not have any meaningful transmission constraints that would warrant separate local reserve requirements to support local reliability. SMUD relies on imports to serve load and to ensure sufficient capacity reserves are available at all times. In order to ensure that our transmission ties remain fully available, we must also maintain local generation operating at all times.

Within our service territory we have more than 1,000 MW of installed thermal capacity that is capable of serving this need, which significantly exceeds the capacity needed for securing import capabilities to our service territory. In addition, there are generators within the BANC Balancing Authority area that further bolsters our local capacity reserves. We therefore do not model any local constraints in the IRP.

8.2 Operating reserves and NERC reliability standards

In our system modeling approach, operating reserves can be split into 2 categories: NERC reliability-related reserves, including contingency and frequency response, and other operating reserves.

For contingency reserves, the system must maintain sufficient reserves to mitigate an unexpected system change like the sudden loss of a generating unit, load or transmission. Currently, these requirements are based on the NERC BAL-002-WECC-2a standard, which sets the amount of contingency reserve equal to the greater of (1) the amount equal to the loss of the most severe single contingency in the balancing area, or (2) the sum of 3% of hourly integrated load plus 3% of hourly integrated generation. At least half of this contingency reserve must be spinning and responsive to frequency deviations.

Frequency response must, on average, meet the minimum requirement set forth in the NERC BAL-003-1.1 standard. This requirement is in MW/0.1Hz. The requirement for SMUD is about 10 MW/0.1 Hz and is expected to be covered through the 50% spinning requirement of the contingency reserve requirement.

Note that in preparing the IRP, we do not perform detailed transmission and reliability modeling. Instead, we rely on modeled operating reserves intended to ensure that all reliability needs are met. This approximation is validated by performing other studies that are focused exclusively on reliability, such as our annual 10-Year Transmission System Assessment update that evaluates the reliability of the SMUD transmission system in the near and long-term planning horizons across a variety of system conditions following a wide range of contingencies. The assessment, which also follows and complies with the NERC TPL-001-4 Reliability Standard, evaluates the reliability of the transmission system by measuring the system performance following various contingencies against all applicable NERC, WECC, and SMUD performance criteria.

Operating reserves modeled in this study include hour-ahead flexibility and regulation reserves as follows:

- **Regulation Reserve** – These are spinning, synchronized capacity available for deployment within a second to minutes timeframe, up to the re-dispatch interval of the system. These resources must be on automatic generation control since it's assumed that there is no other mechanism to command generation changes in this timeframe.
- **Hour-Ahead Flexibility Reserves** – Flex or flexibility reserves are held to cover larger unpredicted changes in net load outside the regulation timeframe primarily due to uncertainty in forecasts of wind and solar but may also include load forecast uncertainty. The timeframe for these reserves is from the system re-dispatch interval to when replacement reserves can be activated and online. A portion of these reserves may be met by spinning and synchronized units if the reserve amounts necessary require starting up longer-start units (units with 2 to 6-hour start times).

Our IRP models used dynamic reserve requirements that change with time and are based on present or anticipated system conditions. This is opposed to static reserve requirements that are the same for all periods and/or are independent of changing system conditions. The methodology for this approach was developed by the Electric Power Research Institute (EPRI).[34]

According to EPRI, dynamic reserve requirements take advantage of information that the variability or uncertainty may be greater or lesser for the period in question, such that the requirements for operating reserves can be adjusted accordingly. Too little reserve can lead to greater risk or lower reliability. Too much reserve can lead to excessive costs that have little reliability benefit. Although dynamic reserve requirements have not been widely adopted, EPRI sees this as an emerging state-of-art approach for operational scheduling.[35]

[34] An Enhanced Dynamic Reserve Method for Balancing Areas. EPRI, Palo Alto, CA: 2017. 3002010941.

[35] Reserve Determination Methods for Sacramento Municipal Utility District. EPRI, Palo Alto, CA: 2018. 3002012932.

Table 20. Operating reserve assumptions for production cost model (MW)

	Regulation				Hour Ahead Flex			
Reserve Type	Mean Up	Mean Down	Max Up	Max Down	Mean Up	Mean Down	Max Up	Max Down
2019-2020	14	14	31	31	31	33	80	83
2021-2024	15	16	33	33	38	44	129	139
2025-2030	16	17	35	36	43	50	161	172

Table 20 provides a snapshot of the operating reserves that are modeled to capture reliability in our IRP modeling.

8.2.1 Simplifying assumptions for the RESOLVE model

We used RESOLVE for part of our modeling, as discussed in Chapter 4. This model simplifies the electricity system to 37 representative days and therefore does not allow for the use of dynamic reserves. To capture NERC balancing requirements, the following assumptions were made:

Regulation up and down

- 1% of load in every hour.
- Does not scale or vary with renewable penetration (functionality does not exist in RESOLVE).

Hour Ahead Flex up and down

- 2% of load in every hour plus incremental needs driven by new renewables.
- For solar, incremental needs based on regression from SMUD's flexible reserves assumptions.
- For wind, incremental needs assumed to be 5% of installed capacity.

Spinning reserves

- 3% of load in every hour.

8.3 Energy Imbalance Market

The EIM is a market for imbalance energy operated by the CAISO. It is an automated, real-time energy wholesale market that matches the lowest cost electricity supply with demand every 15 minutes and dispatches every 5 minutes. EIM participants must submit balanced load and resource schedules (including ramping ability) to the CAISO for each market cycle, using the EIM only for the last-minute unbalanced portion of load and resources. SMUD as a member of BANC, will join the EIM in April 2019.

We expect that joining the EIM will provide improved flexibility in our operations and help to integrate renewable energy on our system as well as provide greater access to regional markets which could offer opportunities for cost savings that would benefit our customers. Studies performed by the CAISO show that so far, the EIM has provided more than $500M of savings for its members, of which $100M+ were achieved in 2018.[36]

[36] https://www.westerneim.com/Documents/ISO-EIMBenefitsReportQ3-2018.pdf.

9. Results

The results of SMUD's 2018 IRP, as presented in this report, are framed in the context of satisfying CEC's review guidelines and to inform policy direction on our long-term GHG reduction targets. Details that are presented here include information and data through 2030. Additional high-level results that extend through 2040 are included to support policy discussions related to long-term GHG reduction strategies and are also available in the Board-adopted IRP that is enclosed in Appendix C to this supplemental report.

Because the primary focus of this IRP cycle was to examine GHG reduction strategies, our scenarios are all focused on exploring alternative GHG targets and clean sources of supply or demand reduction. These results presented in this section are based on the scenarios that were described in Chapter 2.7 of this report. We present results on our Adopted resource scenario as well as on the alternative GHG scenarios that were considered by our Board.

9.1 Adopted Scenario

The Adopted Scenario represents the resource portfolio and overall GHG reduction roadmap adopted by the SMUD Board on Oct. 18, 2018 and that is highlighted in the updated Strategic Directive 9 (See Figure 8 for details). The Adopted Portfolio was selected following Board discussions and stakeholder interactions that spanned several of the Board's meetings between May and October, 2018.

9.1.1 Resource portfolio

The Adopted resource portfolio is focused on reducing SMUD's direct emissions from its operations to 1 MMT of GHG by 2040 while at the same time contributing to significant electrification in the Sacramento region.

Taken together, this is expected to result in emission reductions in other sectors of the economy that will serve to offset our greenhouse gas emissions, thus creating a net-zero greenhouse gas emissions result.

For this scenario, we used RESOLVE as a capacity expansion model to determine the least cost portfolio of new resources. The model was constrained to reduce our greenhouse gas emissions to 1 MMT by 2040. As mentioned in Section 7, the resource options were constrained to GHG-free resources, battery storage and market capacity purchases.

For our Adopted Portfolio, we expect that SMUD will continue to rely on market purchases from the CAISO and Northwest power markets to complement our capacity needs and ensure that planning reserve margin levels are maintained. Over the forecast period, we expect these market purchases will decline from an estimated 907 MW in 2020 to 403 MW in 2030 as a result of our investments in energy efficiency, demand response, new renewable energy and battery storage. We use market purchases of capacity mainly because market-available capacity has so far been relatively inexpensive and while overall capacity prices are expected to increase over the forecast period, we still expect capacity prices to remain below the cost of building new capacity at least until towards the end of the next decade.

By 2030, the cost of 4-hour battery storage is expected to be competitive with capacity markets and construction of conventional thermal capacity, which is born out in the capacity expansion results that add over 240 MW of grid connected 4-hour battery storage in 2030. Utility-scale storage is expected to look even more favorable post-2030 as its cost continues to decline and conventional capacity markets tighten. Note, however, that we see a need for adding significant battery capacity in 2030, we may also spread the capacity procurement over several years to facilitate implementation and fine-tune the supply to our needs.

Table 21: New supply and demand response resources for the Adopted Scenario (MW)

Units=MW	Capacity(1)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Biogas/Biomass	NDC	7	7	7	-	-	-	-	-	-	-	-
Small Hydro	NDC	3	3	3	3	3	3	3	3	3	3	3
Wind	Nameplate	200	200	200	200	268	268	268	268	268	503	554
	NDC	32	32	32	32	69	69	69	101	130	144	166
Solar	Nameplate	0	100	100	100	100	100	100	100	100	153	200
	NDC	0	60	58	56	55	54	51	68	73	71	81
Solar SolarShares℠	Nameplate	143	143	155	167	179	189	202	217	234	249	264
	NDC	11	73	77	82	85	88	91	96	100	105	109
Battery Storage 4hr	NDC	-	-	-	-	-	-	-	-	-	-	246
Demand Response	NDC	116	124	130	136	143	149	153	159	170	185	197
Market Purchases	NDC	907	798	842	850	818	859	853	787	720	694	403
Total	NDC	1,076	1,539	1,604	1,626	1,721	1,778	1,791	1,798	1,798	2,108	2,223

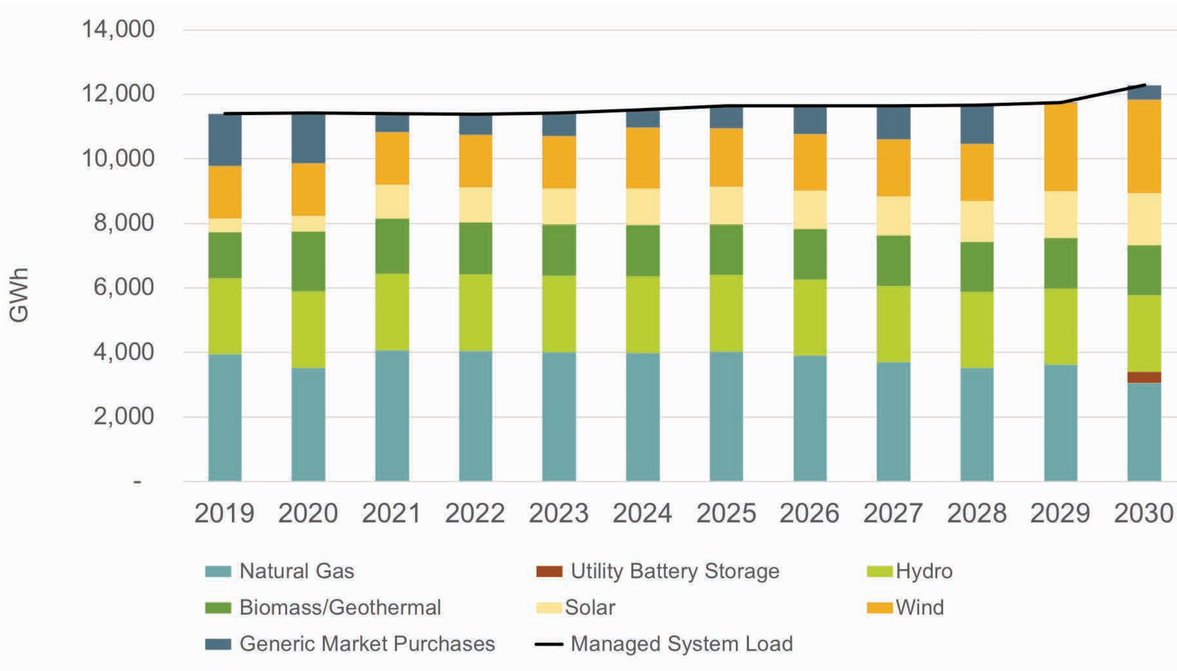
(1) NDC= Net dependable capacity at the coincident summer peak load conditions. NDC for solar and wind are ELCC; Nameplate = rated maximum generation (AC) capacity.

9.1.2 Energy balance and capacity accounting

System load, or our net energy for load, is forecasted to increase from 11,300 GWh in 2020 to just under 12,000 GWh in 2030.[37] Modeling results show that our annual portfolio continues to transition away from GHG-emitting sources to GHG-free resources, such as renewables and hydro. Over this forecast period, GHG-free resources increase from 51% of system load in 2019 to 69% by 2030 (equivalent to an increase from 54% to 74% of retail sales). Figure 18 shows our annual energy balance, i.e. what resources will be used to meet our demand for electricity in the 2019-2030 period.

Given the limited geographical region SMUD covers, most of our renewable procurement that's needed to meet RPS requirements occurs outside our service territory. The energy from these resources will be delivered into either the CAISO wholesale market or delivered to SMUD for serving load, depending on the CAISO dispatch locational marginal price, CAISO TAC and REC value. Allowing delivery of CAISO renewables to load during low market price periods reduces the need to curtail solar generation, particularly in Southern California. Simulated deliveries of renewables delivering to the CAISO are included with net market purchases in Figure 18.

Figure 18. Annual energy balance



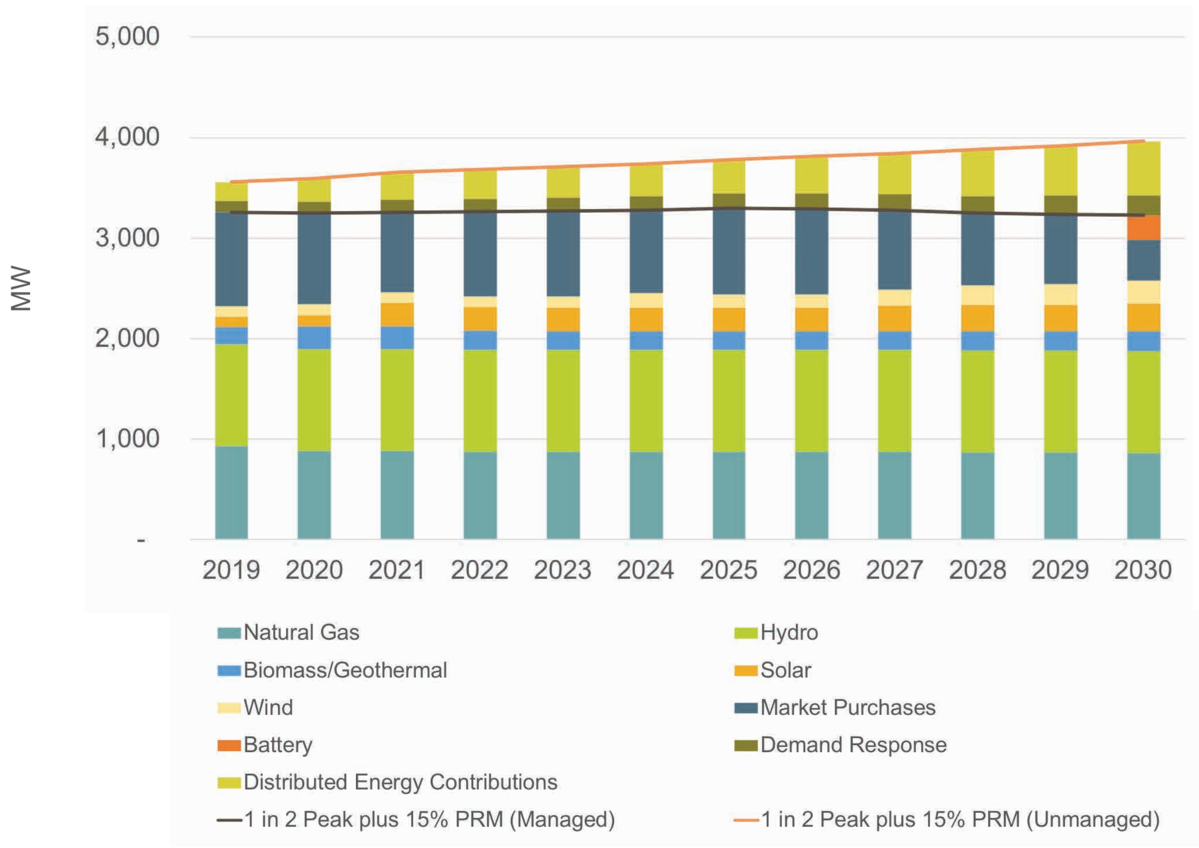
37 These system loads differ slightly from the load forecast presented in other sections of this report. System loads include contributions from battery storage (charging load), bulk transmission line losses, and effects of distributed energy resources and demand response programs.

SMUD plans to a reserve margin of 15% of managed load, accounting for contributions from distributed resources and demand response programs. SMUD thermal and hydro resources are expected to be available up to their net-dependable capacity during the peak month.[38] The contributions of renewables were based on the effective load carrying capability of the resources. With the inclusion of market purchases of capacity, SMUD's plan meets or exceeds our planning reserve requirements for all years of the study. Figure 19 shows the estimated capacity balance by resource type for the 2019-2030 period.

The distributed energy resources in our plan include customer-side solar and storage, energy efficiency, and building and vehicle electrification. Taken together these demand-side resources reduce our system peak, as shown in Figure 21. DERs are expected to reduce our system peak by 189 MW in 2019 and 538 MW in 2030. Most of these impacts come from energy efficiency and customer-installed solar. Our demand response plan is expected to reduce our system peak by 101 MW in 2019 and 171 MW in 2030.[39]

The energy balance of Figure 18 and the capacity balance of Figure 19 demonstrate that the Adopted Scenario represents a diversified mix of short term and long term resources as well as a mix of conventional and renewable energy and capacity. Market capacity resources are expected to be purchased from the CAISO or the Pacific Northwest depending on market prices, import costs and carbon content of the potential power that would be delivered under such capacity purchases.

Figure 19. Annual capacity balance 2019-2030 (MW)



[38] See also section 6.1.2 for more discussion of our existing thermal and hydro capacity and their expected availability.

[39] The demand response here is grossed up by 15% to account for direct demand reductions, which also reduce our need to carry additional planning reserves.

9.1.3 Net demand during summer peak hours

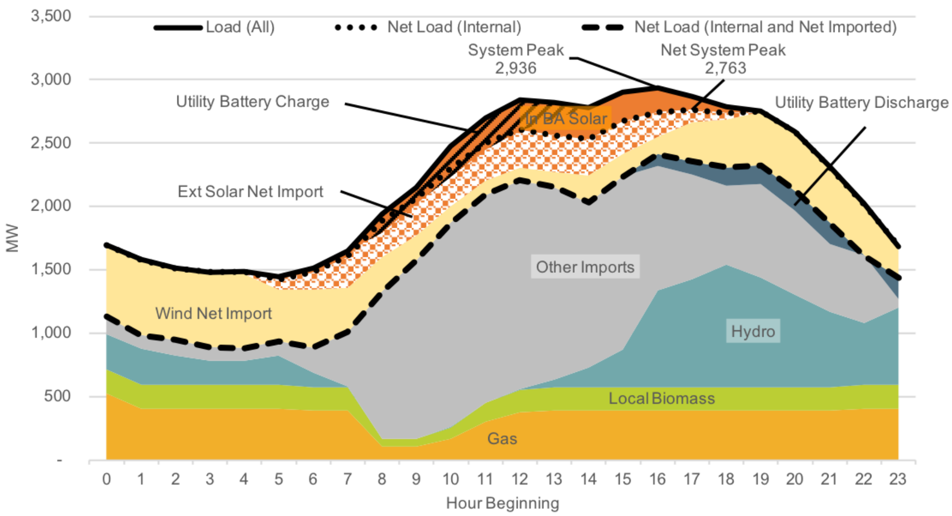
Figure 20 shows an example of how our resource portfolio is used to meet demand for a 24-hour period of a high demand summer day in 2030, including a breakdown of each resource by hour on the demand side and on the supply side.

Today, our peak load generally occurs between 4 and 6 p.m. during the summer. Over time, as the level of energy efficiency, building electrification, and vehicle charging loads increases, our load shape begins to flatten and by 2030 this results in a load shape that varies only by 10% between 12 and 7 p.m., with a peak of net demand at 7 pm. During these peak load conditions, and for a several hours prior, the CAISO NP-15 market price forecast is generally low due to an abundance of solar generation, which means that the lowest cost power available for our system is imports from the CAISO (Shown in Figure 20 as "Imports"). The example also suggests that batteries charge between 8 a.m. and 1 p.m., absorbing low-cost market power for use during higher priced hours.

By 2030, the Adopted Scenario includes over 250 MW of grid-scale solar capacity within SMUD's service territory. The total capacity of intermittent resources within SMUD's territory shifts our net system peak out to hour 19, from hour 16. Here, net system peak is the system peak minus contributions from intermittent resources directly serving our load. The net system peak is relatively flat from hours 16 to 19.

Figure 20 also shows how our thermal power plants are dispatched in response to market signals while maintaining minimum levels to safeguard system reliability and meet operational constraints. Unspecified market purchases, under the market price forecast used in this analysis, are expected to peak at 1,500 MW. As market prices increase, our hydro assets ramp up and along with battery storage discharge power, fill in the need for power at the time of our net system peak. This allows for our natural gas thermal output to remain flat while our market purchases decline. Our geothermal and biomass resources generate as baseload resources and therefore are not assumed to be flexible load following resources.

Figure 20. Resource contributions to the 2030 peak and net peak load[40]



[40] Net Market Purchases includes unspecified procurement and sales from/to the CAISO and the Pacific Northwest as well as specified renewable procurement from resources delivering power to the CAISO.

9.1.4 Net demand during spring low-load and peak hydro conditions

Besides summer peak load conditions, increasing penetration of renewable energy can also result in challenging conditions during low load periods. For SMUD, this is particularly true during springtime when solar output is often strong, hydro runoff is at its peak and overall demand is modest. As an example, we evaluated the performance of our Adopted Portfolio for a Sunday in April of 2030. Figure 21 provides an example of the hourly resource supply in this situation.

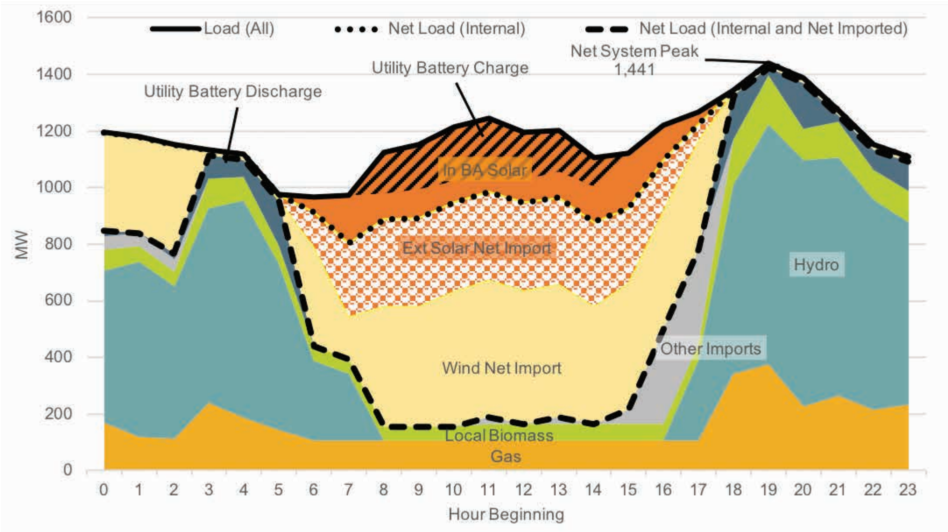
Under these forecasted market conditions in 2030, the CAISO market prices are negative from 8 a.m. through 4 p.m. Additionally, Pacific Northwest market prices at COB are also negative from 8 a.m. to 10 a.m. For this day, SMUD's utility storage is dispatched to meet internal load and reduce or increase net imports based on external market signals from COB and CAISO. To maximize the economic value, the batteries are dispatched during multiple periods during the day (see Figure 21).

In the morning and evening, the batteries dispatch such that SMUD's load is met with hydro, batteries, renewables and gas fired generation operating at or near minimum operational levels except to meet ramping needs and overnight demand. Imports are primarily traced back to renewable resources delivering energy to the CAISO.

Our hydro generation is minimized when the CAISO NP-15 and the COB energy prices drop to negative values and instead market purchases are maximized. Reducing our hydro generation may result in the need to spill at Slab Creek to comply with minimum flow requirements on the American River under certain conditions. Otherwise, the simulated system appears flexible enough to store run-off until needed in the shoulder periods.

The relative "lumpiness" of the system load is directly related to the load swings from battery charging. Total system loads increase by as much as 150 MW when the battery transitions from discharging to charging.

Figure 21. Example of low-load and high-hydro conditions in 2030



In the evening, as our solar contracts cease to deliver energy, our hydro assets and contracted resources are capable of ramping quickly to absorb most of the need. On this day, we see a maximum 3-hour ramp of 840 MW starting at 4 p.m. (hour beginning 16), that is part of a 5-hour ramp of over 1,200 MW starting at 3 p.m. Our hydro assets are dispatched in the simulation to absorb the bulk of the 3-hour ramp and the remaining ramping needs are easily met with the Cosumnes Power Plant, however, due to the negative market prices, the simulation chooses to import unspecified power before ramping Cosumnes.

The ramping and potential over-generation from solar PV does not cause operational concerns for our system. Instead, SMUD, by using the flexibility of our system can increase imports and thereby help alleviate overgeneration issues in the CAISO market while at the same time reducing our costs for serving load. Our analyses show that even during conditions with low-load coupled with high renewable and hydro energy we expect to be able to import the vast majority of our contracted solar and wind generation in the CAISO, thereby contributing to mitigating curtailment impacts for other resources in the CAISO market. We have found that there is a slight risk of curtailment, primarily during the spring run-off months in the 2025-2029 period prior to the planned addition of large-scale battery storage in our portfolio. However, even under these challenging conditions the risk of curtailment of our resources is estimated to be less than 0.7% of the annual energy from our CAISO-interconnected wind and solar resources.

9.1.5 Local net zero

The Adopted Scenario has a goal of limiting our annual generation portfolio emissions to 1 MMT by 2040, while we also drive the transformation of Sacramento's economy to a low-carbon future through electrification and other SMUD programs. This requires significant investments in programs, customer education and incentives that will benefit the local community by reducing emissions associated with fossil fuel combustion including both greenhouse gases and criteria pollutants, particularly in disadvantaged communities.[41]

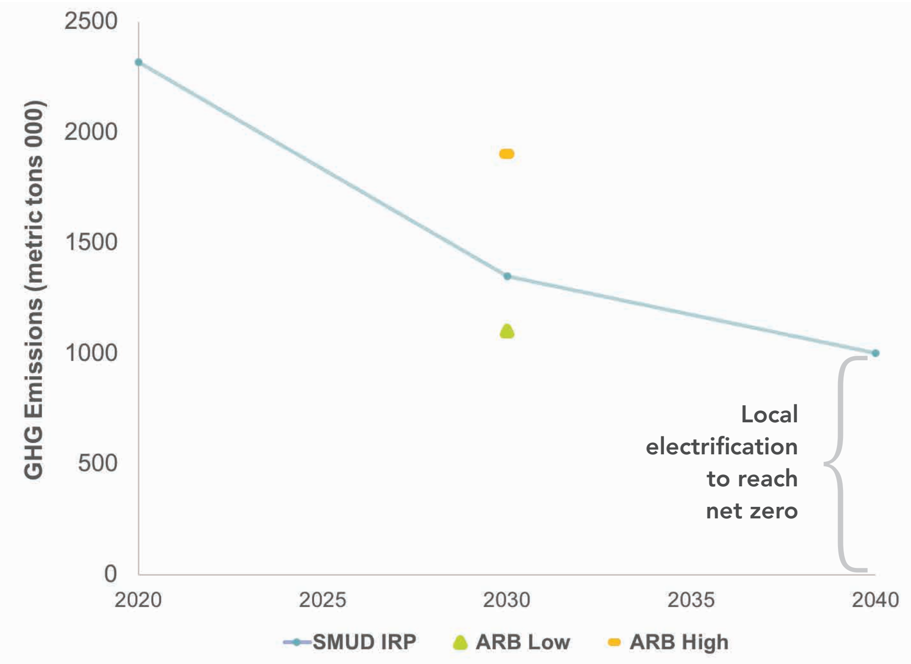
[41] See https://doi.org/10.5194/acp-18-4817-2018

SMUD has an important role in facilitating state-wide greenhouse gas reductions. The Sacramento region will need to undergo a significant transformation to achieve the State's climate goals. In our Adopted Scenario, we consider not only direct emission reductions from our own operations and energy efficiency, but also the indirect effects that result from our support of regional electrification of buildings and transportation. With this approach we focus more of our efforts locally, bringing both economic and environmental benefits to the region.

Under the Adopted Scenario, investments will significantly lower Sacramento area overall GHG emissions. However, absent the substantial, new renewable investments reflected in our IRP, SMUD's own emissions would increase because of continued electrification of transportation and buildings. Our focus on renewable energy supply in combination with cleaner and more energy efficient demand is therefore key to our resource plan.

Figure 22 illustrates the GHG emissions gap that we need to fill for our net emissions to get to net zero through emission reductions in other sectors because of electrification. One challenge of this net zero approach is measuring the impacts of local measures relative to other statewide and regional efforts to reduce GHG emissions through electrification of transportation and building uses. Quantifying SMUD's effect on the adoption rate of EVs and heat pumps will require understanding of how effective programs are at enabling and driving customer adoption and influencing customer choice. This will require future studies of consumer preferences and program effectiveness. Performing these studies over the next few years is an important component of our IRP action plan. Our preliminary high-level analyses suggest that the electrification we envision will more than close the one million metric ton gap in 2040, as illustrated in Figure 23.

Figure 22. SMUD's long term greenhouse gas goals and ARB greenhouse gas planning targets by 2040



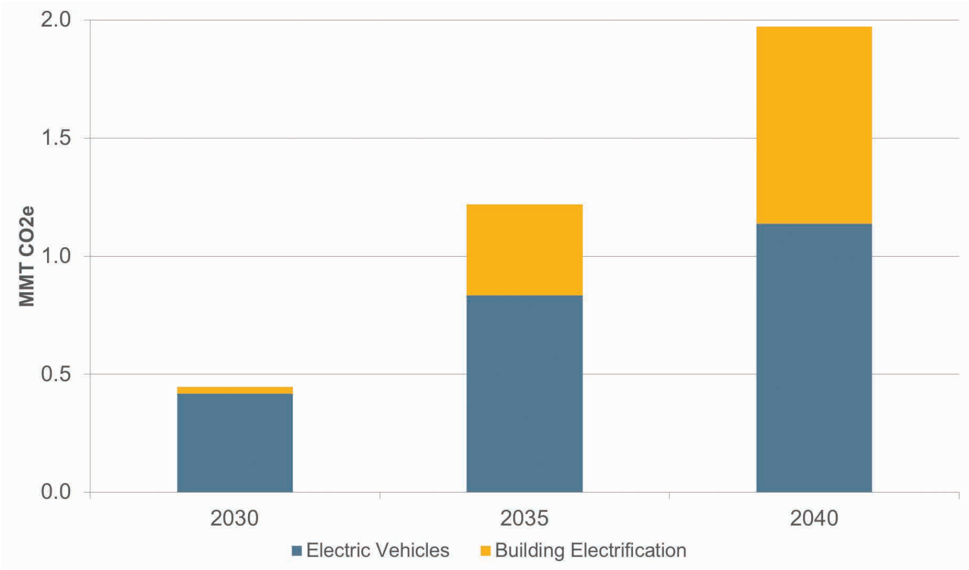
It is estimated that for every additional EV on the road in SMUD's service territory, 2 to 5 MT of CO_2e from gasoline consumption are avoided each year. Similarly, displacing natural gas appliances in buildings with electric appliances such as heat pumps can reduce overall household emissions by between 1 and 3 MT CO_2e per year. As planned, SMUD's own GHG emissions would continue to decline as we aggressively pursue low-emission or zero emission power.

Avoidance of natural gas for heating, clothes drying, and cooking and displacement of gasoline use in the transportation sectors are the primary sources for emissions reductions due to electrification in Sacramento as shown in Figure 23. This figure shows the estimated GHG emission savings in Sacramento resulting from the high building and vehicle electrification trajectory in our Adopted Scenario, relative to a business-as-usual electrification scenario.[42] As shown in the figure, avoided GHG emissions through SMUD's efforts, programs and incentives to electrify buildings and transportation are expected to achieve almost 2 MMT of GHG emissions annually by 2040 under our Adopted Scenario.

SMUD's local investments in support of decarbonization of transportation and buildings creates significant reductions in local GHG emissions. Accounting for these reductions toward offsetting our GHG footprint, we plan to achieve a net-zero portfolio by 2040. This study finds that the investments SMUD plans to make in local GHG reductions coupled with the significant efforts to increase renewables and decarbonize its own electricity supply while maintaining local reliability expected by SMUD's customers, will allow SMUD to achieve a net zero greenhouse gas portfolio by 2040.

GHGs mentioned earlier, quantification of emissions savings that can be attributed to our actions will be challenging. Also, given the uncertainty of adoption rates and preferred technology choices in the future, we may look at other means of GHG reductions to meet any shortfall in electrification emission reductions including purchasing additional renewables or using voluntary greenhouse gas offsets.

Figure 23. GHG emissions avoided in the Sacramento region due to local electrification under the Adopted Scenario



[42] These emission reductions were estimated relative to a business-as-usual scenario wherein there is no new electrification of buildings and vehicles but still assuming continued improvements in efficiency for gasoline vehicles and natural gas furnaces over time.

9.2 Alternative scenarios

In addition to the Adopted Scenario, we also considered additional resource plan scenarios to achieve deeper resource decarbonization through additional investments in non-local renewable resources. We considered 3 additional scenarios resulting in SMUD emissions of 750K, 500K, and 350K metric tons of carbon dioxide emissions by 2040. The main difference in results among these scenarios is the level of investments in solar and wind resources and energy storage. The resource build for these cases are shown in Table 22 below.

Table 22: Resource portfolio for alternative scenarios

Units=MW	2020	2025	2030	2020	2025	2030	2020	2025	2030
	750k			500k			350k		
Biomass	7	-	-	7	-	-	7	-	-
Small Hydro	3	3	3	3	3	3	3	3	3
Wind	200	268	624	200	268	652	200	268	669
Solar	-	330	330	-	369	369	-	394	394
Solar SolarShares℠	143	189	264	143	189	264	143	189	264
Battery Storage 4hr	-	-	231	-	-	219	-	-	211
Demand Response	116	149	197	116	149	197	116	149	197
Short-Term RA	907	833	400	907	826	400	907	823	400
Total	**1,376**	**1,772**	**2,049**	**1,376**	**1,804**	**2,104**	**1,376**	**1,826**	**2,138**

All scenarios reflect meeting a 15% planning reserve margin. Table 23 shows the peak load contributions from each of the resources under the alternative scenarios for 2030. The firm capacity shown for hydro and thermal resources is based on net dependable capacity in July. Storage is assumed to be fully available for dispatch during the system peak. Variable renewable contributions are based on their effective load carrying capability.

The alternative scenarios were designed to deliver different greenhouse gas trajectories for 2040. Therefore, when looking at these scenarios at 2030, the differences are relatively minor. However, even though the alternative scenarios lead to deeper greenhouse gas reductions, none of these additional reductions occur locally and therefore do not help to reduce local emission or provide economic opportunities. For a comparison of rate impacts and revenue requirements under the Adopted Scenario and the alternative scenarios, please see Section 12 of this report.

Table 23: 2030 planning reserve margin peak demand results for alternative scenarios

	Unit	750k	500k	350k
1 in 2 Peak Demand	MW	2,712	2,712	2,712
Planning Reserve Margin	MW	517	517	517
Peak Capacity Needs	**MW**	**3,229**	**3,229**	**3,229**
Firm Capacity	MW	2,075	2,075	2,075
Storage	MW	231	219	211
Renewable ELCC	MW	479	498	505
Market Purchases	MW	444	437	438
Total Capacity	**MW**	**3,229**	**3,229**	**3,229**
Expected Reserve Margin	%	15%	15%	15%

9.3 Senate Bill 100

SB 100 went into effect Jan. 1, 2019, requiring electric utilities to achieve a 60% RPS by 2030. Our IRP modeling and scenarios did not account for a 60% RPS by 2030 since this legislation was passed after our modeling was completed. However, the SMUD Board's resolution that adopted the IRP also recognizes that our future resource procurement also needs to ensure that we get to a 60% RPS by 2030.

Our Adopted Scenario is expected to deliver more than 50% of our energy needs from RPS-eligible renewable resources but falls short of a 60% RPS by 2030. Following the passage of SB 100, we analyzed the additional RPS requirements necessary to meet a 60% RPS and determined that with relatively minor additional costs, the IRP can achieve SB 100 mandates through a mixture of compliance measures allowed under the RPS rules.[43]

To achieve the SB 100 RPS mandate, additional RPS procurement may be needed as early as 2025, relative to our IRP. These additional resource needs will likely be met with solar and wind in the Central Valley and Southern California. However, as RPS mandates continue to increase, SMUD may also consider other options not included in our IRP modeling, such as firmed-and-shaped products and REC-only transactions. Our updated RPS procurement plan provides more detail on how we plan to comply with our IRP-driven renewables and the additional need for renewable energy credits resulting from SB100 (See Appendix B).

9.3.1 Moving toward zero greenhouse gas emissions – an example for 2040

SB 100 includes declaratory aspirations that 100% of all retail electric load be served by carbon-free resources by 2045. SMUD looks forward to working with state agencies to assess these aspirations to ensure implementation maintains safety, environmental and public protections, affordability, and system and local reliability.

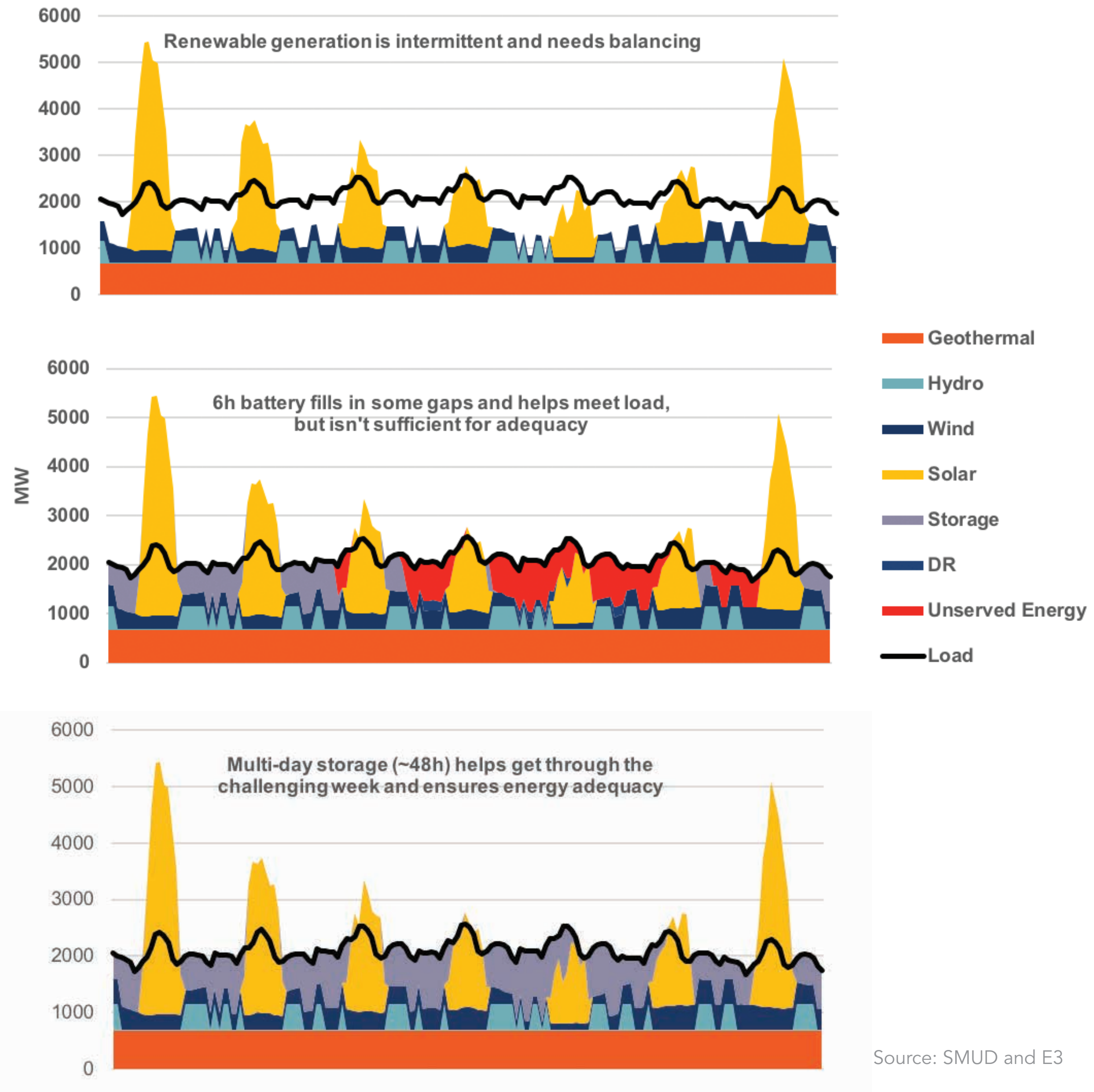
As part of our IRP analyses we studied a scenario with an absolute zero greenhouse gas emission goal for 2040, wherein we retire all our gas-fired plants by 2040. Because our analysis quickly revealed that this would have a dramatic impact on rates, we didn't evaluate this scenario in detail.

The portfolio chosen for this zero-emission scenario assumes that SMUD would procure all available potential geothermal capacity (650 MW) from the Pacific Northwest. The scenario would also require an over-procurement of solar and wind resources to an equivalent of a 137% RPS. In addition, our analysis suggests that multi-day energy storage would be necessary to maintain reliability – technologies that are cost-prohibitive today.

In a "worst-week" analysis, we found that unless a carbon-free resource portfolio includes long-term (multi-day) storage, it would not be able to serve load if the system is stressed by pervasive multi-day cloud cover, drought conditions or low wind speeds. In the future, new technologies may emerge to help solve this challenge. However, in the absence of such technologies, a resource portfolio that is completely free of gas-fired capacity would be prohibitively expensive for our customers and would jeopardize reliability. Figure 24, illustrates the balancing needs and risk of not being able to serve load unless the system is supported by batteries that can provide energy for at least 48 hours. Batteries of this scale have not yet been demonstrated as feasible.

[43] The 350K scenario results shown in Tables 22-23 reaches 2030 RPS levels that are close to the SB100 requirement of 60% and can be seen as a proxy for cost impact by 2030.

Figure 24. Example of a capacity challenge in 2040 if all resources were fossil fuel free.



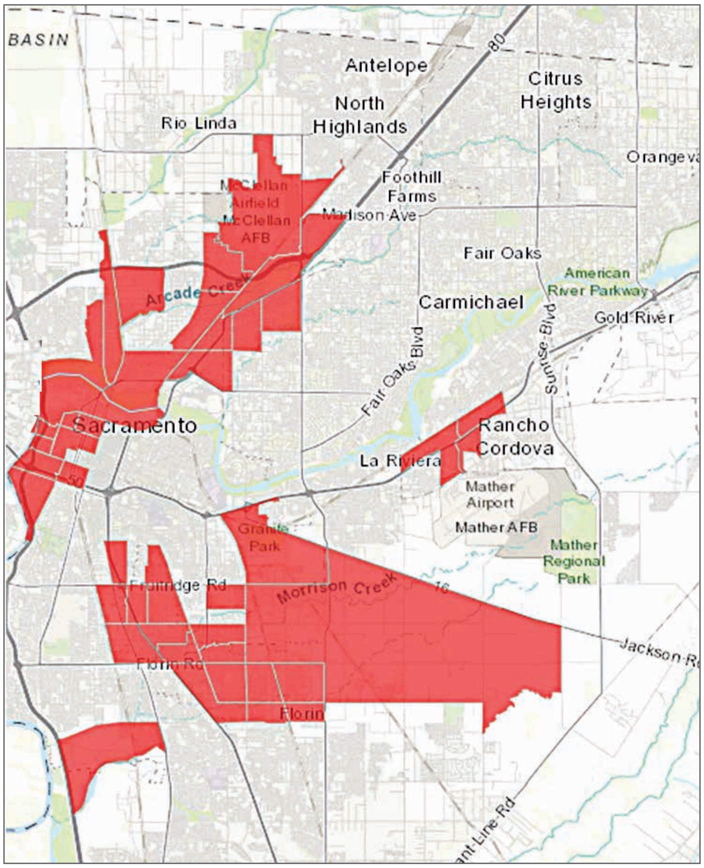
Source: SMUD and E3

Considering the challenges for the electricity system to function and provide affordable energy without support of thermal generation, we consider approaches like our net zero approach discussed in this IRP to be a better alternative. By focusing not only on our own emissions but taking a broader view of overall GHG emission reduction across the economy, we believe that utilities will continue to be key contributors in supporting a state-wide decarbonization.

10. Localized air pollutants and disadvantaged communities

Pursuant to Senate Bill 535, disadvantaged communities (DACs) are communities designated by CalEPA, using the California Communities Environmental Health Screening Tool ("CalEnviroScreen"), based on a combination of economic and environmental factors. Figure 25 illustrates the disadvantaged communities within SMUD's service territory using the CalEnviroScreen tool to identify the top 25% highest scoring census tracts in SMUD's service territory.

Figure 25. Disadvantaged communities within SMUD service territory



Source: CalEnviroScreen 3.0

The CalEnviroScreen defines disadvantaged communities based on 20 indicators that cover pollution-related data such as toxic waste, particulate matter, diesel particulates and ozone, as well as population characteristics such as poverty level, cardiovascular disease, housing, unemployment, asthma, etc. According to the tool, 190,843 people reside in the disadvantaged communities within our service territory.

We have a long track record of community-focused programs and outreach that benefit vulnerable communities within our service territory. Our IRP also includes a significant expansion of local renewable energy sources as well as support for electrification of transportation and buildings, both of which will contribute to a reduction of emissions in the Sacramento region.

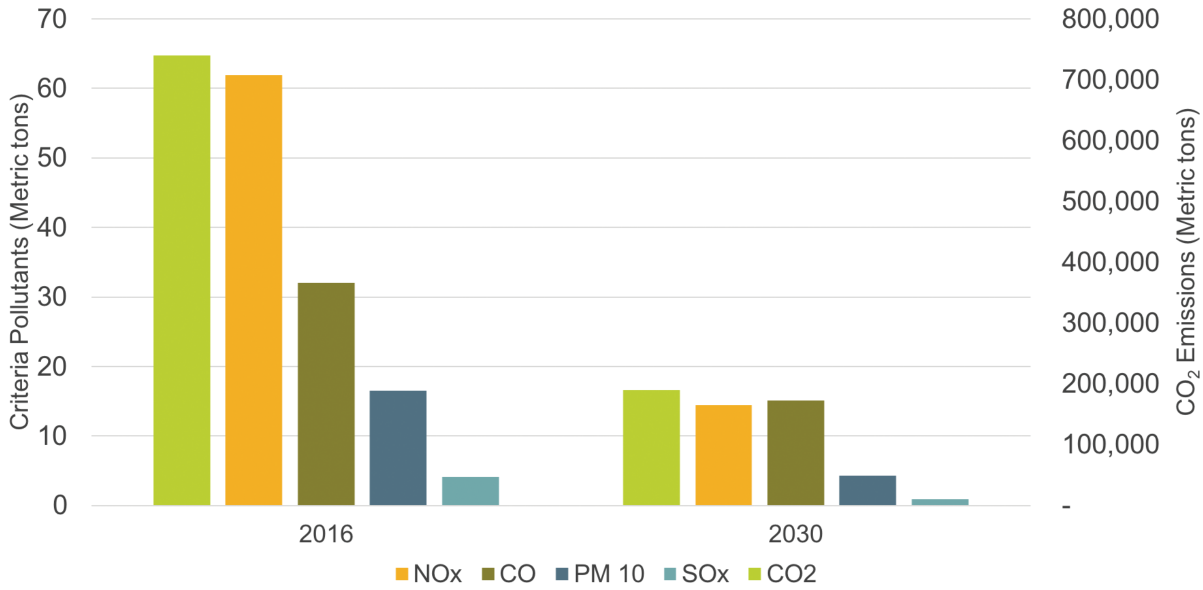
10.1.1 Emissions from production of electricity in disadvantaged communities within SMUD's service territory

There are 3 natural-gas power plants within SMUD's service territory that fall within the state's defined disadvantaged communities.[44] We plan to continue relying on these plants to maintain system reliability and provide local capacity when needed.However, over time utilization of these plants is expected to decline because of our increasing focus on renewable energy and the expected availability of power from markets outside SMUD's service territory. Consequently, projected criteria air pollution emissions from these plants also decline under our IRP.

Two of SMUD's power plants located in DACs are cogeneration facilities that supply useful steam to nearby customers for process heat in addition to generating electricity. The contractual steam demands of these customers can require power plant operation even when market prices suggest that power plant operation is uneconomic. To reduce the operations of these facilities, and hence emissions in the surrounding community, SMUD has recently added ancillary equipment to reduce the steam need of one customer and provide for an alternative steam source for another.

[44] Disadvantaged Communities are defined by California Environmental Protection Agency as California communities that are disproportionately burdened by, and vulnerable to, multiple sources of pollution. More information is available at: https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30.

Figure 26. Expected reductions of criteria pollution and GHGs from SMUD electricity generation in DAC areas



As discussed in Section 5, we expect electrification of the Sacramento region to substantially increase SMUD's electricity demand compared to a situation with less electrification initiatives. Despite this increase, electrification is an important contributor to improving air quality in the region by reducing emissions from buildings and from traffic. Electrification and energy efficiency improvements in the region are also likely to create jobs that benefit disadvantaged communities. For example, recent studies indicate that investments in energy efficiency programs can result in 5 to 10 job-years per million dollars spent.[45 46]

SMUD funding for transportation electrification is expected to add over 230,000 electric vehicles to the roads in Sacramento by 2030. Removing gas-powered vehicles will reduce local air pollution from the transportation sector, particularly along freeway corridors which tend to run through disadvantaged communities. By 2030, we expect electric vehicle deployment to reduce annual mobile source emissions of NOx by 49 metric tons and particulate matter by 1.17 metric tons.[47]

[45] A job-year is defined as one full-time job for one year.
[46] More information can be found at the following links
http://edfclimatecorps.org/sites/edfclimatecorps.org/files/the_growth_of_americas_clean_energy_and_sustainability_jobs.pdf
http://www.energy.ca.gov/2009publications/CEERT-1000-2009-022/CEERT-1000-2009-022.PDF
http://www.labormarketinfo.edd.ca.gov/contentpub/GreenDigest/CaliforniaGreenEconomy-070910.pdf
https://www.epa.gov/statelocalenergy.
[47] Based on results from the Energy Commission's Light-Duty Plug-In EV Energy and Emissions Calculator, as modified with inputs consistent with SMUD's electric vehicle forecast. https://efiling.energy.ca.gov/getdocument.aspx?tn=224889.

SMUD Sustainable Communities team will strengthen our support for disadvantaged communities.

We recently added a new dedicated Sustainable Communities group at SMUD. The objectives of their work is to make an impact in our community where it's needed most. Our sustainable communities actions include aligning with regional partners to create more sustainable and healthy communities through economic development, workforce development, jobs creation, environmental stewardship and climate change leadership. Our first step is to develop a baseline of the existing disparity gap within SMUD's service area and start to better leverage existing SMUD programs in a cross-functional way to ensure a sustainable positive impact to communities in need.

The collaboration with regional communities and governments was a critical step in defining our strategy for enhancing the quality of life for all our customers and enhancing the vitality for all communities by focusing on improved transportation access, contributing to a healthy environment, focusing on social wellbeing, and catalyzing economic prosperity opportunities within communities of need. These efforts will have their most significant impact in disadvantaged communities.

We have developed formal relationships with key external community partners and we are contributing $2.3 million over the next 3 years with 38 local organizations to work on projects aligned with our Sustainable Communities initiative. One example is our partnership with Mutual Housing to provided funding for electric vehicle infrastructure at their low-income apartment complexes. In addition, we're offering program support to improve/replace HVAC units in 168 apartments. With partnerships like these, we are able to leverage our budget for community programs to do more focused work in communities of need in the Sacramento region.

10.1.2 SMUD actions and programs impacting disadvantaged communities

We have a low-income program for our customers who are at or below 200% of the federal poverty level. In 2017 our Board approved a restructuring of our Energy Assistance Program Rate (EAPR) program to help customers who need it the most. We changed our EAPR qualifications from usage-based to Federal Poverty Level-based. Qualified customers with household income between 0% and 100% are receiving the largest discount. The discount is lower for customers with income above 100% of the Federal Poverty Level, but below 200%. Customers' discounts will be based on the household size and income provided at the time of the application.

Table 24. EAPR eligibility guidelines (effective June 1, 2018)

Persons in Household	Maximum month income
1	$2,023
2	$2,743
3	$3,463
4	$4,183
5	$4,903
6	$5,623
Each additional member	$720

The programs we provide are for all low-income customers in our service territory. Many of our low-income customers live in DACs and are encouraged to participate in one of our energy saver programs.

In addition to the EAPR and the Grid Alternatives program (right) and the-low income programs mentioned in Section 2.3, we also offer the following programs that are open to all customers, but that could benefit customers in disadvantaged communities, especially the Energy Saver bundles. We recruit customers who are the most likely to benefit from the following bundles via mail and email.

- **Energy Saver Deep Retrofit** focused on homeowners. This includes weatherization upgrades such as a free HVAC system if a customer meets the criteria. Energy efficiency education is included in the program.
- **Energy Saver House Bundle** focused on renters. Participants can get energy efficiency-related items such as a free smart thermostat, weatherization upgrades, a smart strip and some LED light bulbs. Energy efficiency education is included.
- **Energy Saver Apartment Bundle** that includes an energy-efficient Dyson fan, smart strip, LED bulbs and energy efficiency education.

We also provide benefits to our community through many additional programs, including weatherization for homeowners and working with property management organizations like the Sacramento Housing and Redevelopment Authority and the Salvation Army to offer energy efficiency incentives for customers living in low-income housing. These projects include efficiency improvements such as HVAC replacement, LED light fixtures and new refrigerators.

In 2019 we also began a new multifamily program for property owners. Any location that has primarily low-income tenants could receive 25% more in incentive dollars for energy efficiency upgrades such as electric induction stoves.

Solar power for low-income customers

In 2016 we developed a partnership with Grid Alternatives to install solar for EAPR customers who lived in a DAC. We recruited the customers based on the CalEnviroScreen, and Grid Alternatives provided the offer of free solar while we offered free weatherization measures to improve the energy efficiency of the home for years to come.

GRID Alternatives is a national nonprofit focused on making renewable energy technology and job training accessible to underserved communities.

Interested customers contact GRID directly to continue the process and potentially receive a free solar electricity system. The systems are funded by California Climate Investments, a statewide program that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, particularly in disadvantaged communities. Typical systems meet 75-90% of customers' electricity needs.

10.1.3 Other SMUD Programs impacting disadvantaged communities and low income customers.

Through a variety of funding sources we have pursued, and continue to seek development of, programs for low income and disadvantaged communities. We look for external funding where possible for these programs since it helps to mitigate bill and rate impacts for our customers. For example, using funding from sources such as the American Recovery and Reinvestment Act and revenues from AB32 Allowances, we have pursued deep energy retrofit programs in multifamily homes, electrifying local truck stops to reduce idling and thereby also reducing harmful diesel pollution in disadvantaged communities.

Regional Service Delivery and Cross-Cutting One-Stop Shop: We coordinate with multiple low-income agencies in the Sacramento area. For example, we have a Memorandum of Understanding with the City of Sacramento that allows "auto-enrollment" of SMUD's EAPR customers in the City's low-income discounts for city utilities (water, sewer, etc.) and the automatic credit of the City's utility users tax that SMUD collects. We also have partnership agreements with Sacramento Metropolitan Air Quality Management District (SMAQMD), Sacramento Housing and Redevelopment Agency (SHRA), local water districts, Sacramento Food Bank, local school districts, and many non-profit agencies. We fund a monthly Network Connections meeting for low-income agencies that is administered by the Sacramento Food Bank.

SMUD's Energy HELP program provides qualified low-income customers with immediate financial assistance to keep their lights on. The program is voluntarily funded by our customers. SMUD is also implementing additional programs and examining how well they will work in pilot demonstrations. For example:

- We have a partnership with the state's Community Services and Development Department's Low Income Weatherization Program (LIWP) and Grid Alternatives to install deep energy retrofits and weatherization measures and support the installation of solar. SMUD sends direct mailings to eligible customers (e.g., EAPR customers in disadvantaged communities). Interested customers can get a deep home energy efficiency retrofit (including heating/cooling upgrades, attic insulation, refrigerator replacement, weather-stripping and light-emitting diode (LED) lighting) along with rooftop solar funded by LIWP. Customer roofs must be adequate for solar installation. SMUD also has a new partnership with Habitat for Humanity to repair roofs that are not adequate so that the LIWP/Grid Alternatives partnership can be considered.
- SMUD is partnering with SMAQMD and SHRA to directly establish an EV car sharing program in DACs.
- We partner with local school districts in disadvantaged areas to demonstrate the benefits and feasibility of electrifying school buses in Elk Grove, Twin Rivers and Sacramento City Unified school districts.
- We recently launched a new Community Development program called "Shine" in which matching grants will be targeted at local non-profits and neighborhoods to improve the environmental, economic and cultural life of our communities. Grants will range from $10,000 to $100,000 dollars.
- Environmental Justice Resiliency Programs: SMUD is an active member of the Capital Region Climate Readiness Collaborative, which has a focus on Environmental Justice via identifying climate adaptation risks and assisting with projects to protect the most vulnerable people in the region.

- Training and Education: SMUD is active in training programs for disadvantaged communities. Our Power Pathways program is a partnership with PG&E and American River College to provide electric job training in a pre-apprentice program for military veterans. Ten graduates of the program used their training to help land jobs at SMUD.
- Low income energy efficiency: In 2019 we also began a new multifamily program for property owners. Any location that has primarily low-income tenants could receive 25% more in incentive dollars for energy efficiency upgrades such as electric induction stoves.

10.1.3.1 DAC renewable energy program pilot example

SMUD continually works to enhance and improve the cost-effectiveness of our community programs. One example is our pilot program called the North Franklin Community Energy Project that's being developed to test whether community-owned, customer-shared solar projects on urban infill sites can provide economic and environmental benefits to low-income neighborhoods and marginal small businesses in disadvantaged communities without requiring cross-subsidies from other ratepayers.

This pilot project entails partnering with a local nonprofit to develop, own and operate a 3 MW solar farm located within a DAC, and sell the output to SMUD for resale to 1,000 low-income customers within the surrounding zip codes, with the priority going to neighboring DACs.

Customers who qualify for this pilot project will also receive support from our low-income weatherization program to increase the energy efficiency and comfort of their homes. This should result in a more predictable electric bill month-to-month, with a smaller total annual amount.

Pairing community solar with co-located demand side measures will increase the effective capacity and reliability of the solar production by reducing local peak loads and enabling dynamic dispatch of customer loads to support the grid. This value is in addition to the T&D costs and losses avoided by siting the solar locally and the value of hedging against future market uncertainty. The current plan calls for customer marketing and recruitment in 2019, with the solar farm coming online in 2020.

If evaluation results produced in 2021 prove successful, this model could be offered to additional neighborhoods to increase access to solar energy by lower income customers, providing bill stability and reducing customer energy bill burden.

11. Greenhouse gas emissions

SMUD's GHG emissions fluctuate from year to year, sometimes significantly, due to varying availability of hydroelectric generation from our Upper American River Project hydroelectric system and the GHG-free generation we buy from WAPA and the Pacific Northwest.

In 2017, our GHG emissions were 1.99 MMT, reflecting an abundance of low-cost, low-carbon power that was available in the WECC markets. Going forward, the availability of low-cost low-carbon power is uncertain as other WECC-utilities strive to reduce their GHG footprint.

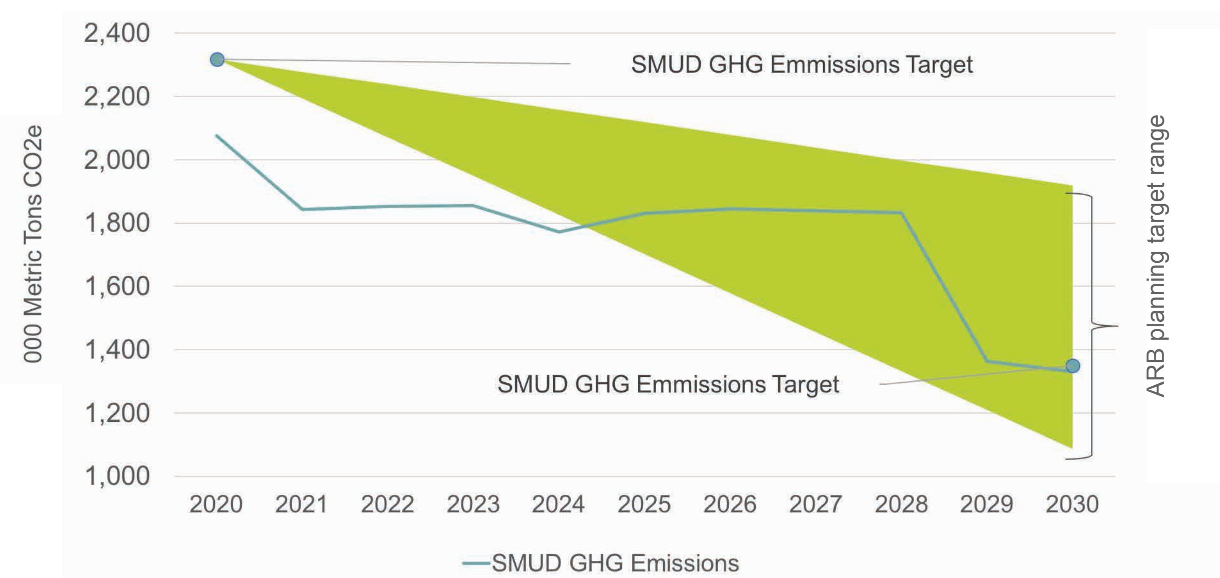
Our IRP sets a high bar for both SMUD and the region as it commits to an even more ambitious transformation, reducing regional GHG emissions by 65%, improving air quality, supporting economic growth and encouraging innovation over the next 20 years. By 2040, SMUD's goal is to continue reducing our GHG footprint while driving reductions throughout the Sacramento region. To achieve this goal, we plan to expand and develop new programs to achieve the following objectives:

- Remove barriers to local EV adoption including expanding charging infrastructure.
- Electrify new and existing buildings.
- Increase our portfolio of renewable power supplies.
- Make our community more resilient and sustainable through new distributed energy and storage solutions.

CARB has established GHG emission targets for SMUD for 2030 that range between 1.1 and 1.9 MMT per year. Our IRP achieves a 1.3 MMT GHG emissions level for 2030 which is in the lower range of the CARB targets. Figure 27 shows our expected GHG emissions from power plants relative to the CARB targets. In this figure we also see the impact of increased renewable energy procurement and storage in the 2020-2021 and 2029-2030 periods as we direct our procurement away from CAISO market purchases and instead increase the use of renewable energy and storage.

As discussed earlier, we plan to reduce our GHG footprint through a combination of grid-scale renewable energy sources, energy efficiency and electrification. These efforts will not only result in GHG emission reductions, but also in reductions of criteria pollutants from our power plants and emission reductions resulting from from electrification of transportation and buildings.

Figure 27. SMUD IRP GHG emissions 2020-2030



11.1 Voluntary GHG reduction programs & research

Most of our existing customer and research programs – energy efficiency, electrification, renewables, storage and EVs – will ultimately reduce GHG emissions by helping to conserve energy or expand low-greenhouse gas sources of energy supply. Other SMUD programs, including Greenergy, SolarShares, Shade Trees, energy efficiency and EV incentive programs continue to support a more sustainable region.

In 2018 alone, SMUD invested more than $28 million in energy efficiency, electric transportation and shade trees. Our programs are also focused on ensuring our disadvantaged communities benefit from our investments.

SMUD also develops research projects and pilot demonstration projects to support the region and to prepare our organization for deeper decarbonization. These efforts are voluntary and currently don't receive specific carbon credits. However, the programs address specific climate vulnerabilities and create new opportunities for customers who are motivated to accelerate reduction of their carbon footprint. Highlights of some of these current and proposed projects and programs include:

- **Natural Refrigerant Incentive Program:** Beginning in 2015, SMUD conducted a survey of significant regional short-lived climate pollutants (with very high global warming potential) to understand which of them might be the best opportunities for reduction via our established energy efficiency rebate programs and relationships with commercial and industrial customers.

  The research revealed a significant opportunity within commercial refrigerants. A pilot Natural Refrigerant Incentive Program, based on kWh and GHG reduction, was launched in March 2017 and provides incentives that can help offset the incremental first cost of purchasing and installing a natural refrigerant system, which helps avoid the use of chemicals with extremely high global warming potential.

SMUD testing mobile EV chargers

SMUD is partnering with FreeWire Technologies to test flexible and mobile chargers that may make it easier and more convenient for electric vehicles owners to charge their cars.

FreeWire's Mobi Gen and Mobi EV chargers are suited for situations that require flexibility and when installing permanent infrastructure is not feasible.

The units deliver high-performance EV charging capabilities beyond the confines of fixed infrastructure. They should help us expand our EV power service offerings and give SMUD customers a new way to enhance EV ownership and improve air quality, with the hope of increasing EV adoption.

The program offers additional incentives for small or medium-sized business customers with projects located in disadvantaged communities. This bonus incentive is intended to assist independent grocers with new refrigerant regulations and preventing possible closures of fresh food grocers in areas that lack healthy food options already.

- **SMUD Living Future Project Accelerator:** The International Living Future Institute (ILFI) is a worldwide leader in regenerative building techniques. Its Building & Community Challenges are ambitious certification programs addressing energy, water, waste and livability in the building environment. Sacramento is the home of Arch Nexus, an architectural firm that created California's first certified Living Building, which was also the first certified Adaptive Reuse project in the world.

  SMUD partnered with Arch Nexus and ILFI to develop the SMUD Living Future Project Accelerator supporting local projects to achieve certification under the ILFI Living Building Challenge. Our goals are to activate more ILFI projects in the region, assist them in moving from concept through certification, and study and showcase them as examples of advanced, all-electric buildings. The Accelerator included:

  - Education, tours and discussion of leading-edge buildings in the region.
  - Engagement, technical assistance and expert coaching directly with ILFI, Arch Nexus and SMUD staff.
  - Financial assistance with project registration, certification fees and certification documentation.
  - Development of Living Future Building Block summaries for building types most relevant for the Sacramento region.

- **Land-based Carbon Storage:** We are investigating ways to store greenhouse gas in soil and vegetation that can restore natural systems, protect agricultural, rangelands and wildlife habitat, and support new business opportunities in and around our service territory. With partners Sacramento Area Council of Governments, Environmental Council of the States and The Nature Conservancy we recently completed a first-of-its-kind assessment of the technical potential for greenhouse gas storage within Sacramento County, recognizing existing and projected land uses and development patterns. Subsequent public-private partnerships (with land trusts, open space conservancies or private landowners, for example) could leverage greenhouse gas offset protocols and create new revenue streams and other incentives to preserve and expand land-based greenhouse gas storage opportunities.

  We are currently exploring a demonstration project involving local ranchers, "climate beneficial" fiber and textile producers and a unique local textile manufacturer that could catalyze a regional "farm to fashion" economy. We are also planning a feasibility study of the greenhouse gas storage potential of SMUD-owned land at our Solano Wind facility.

- **Greenhouse gas Offset Protocol Research Demonstrations:** SMUD has supported research and demonstration projects designed to result in approved greenhouse gas offset protocols for promising sequestration and GHG reduction projects relevant to our geographic area and of likely interest to our customers. These include:

  - **Delta Wetlands Carbon Sequestration.** We partnered with the Sacramento San Joaquin Delta Conservancy, The Nature Conservancy, and others to develop a GHG methodology for wetlands and rice farming in California. Technical sequestration potential of the SF Bay Delta has been estimated at approximately 380 million tons of CO_2e.

- **Placer Forest Sustainability Initiative.** With the Placer County Air Quality Management District and other partners, we supported the development of a GHG offset protocol for forest fuel management activities that reduce the impacts of catastrophic wildfire and black greenhouse gas emissions.

- **Regional Heat Pollution Reduction Initiative:** The Sacramento region already experiences an excess of California averages in heat-related illness and death. Recent CalEPA research identifies the areas within the region that experience the most intense urban heat island effect, a phenomenon influenced by the prevailing wind pattern in the area which is expected to be exacerbated by increasing average temperatures in the future. In the Fall of 2016 the members of the Capital Region Climate Readiness Collaborative (CRCRC), including SMUD, launched an initiative to address this pressing health and economic concern.

  Through our climate research and development program, we also researched improving compliance with existing shade ordinances and expanding education and outreach with other Collaborative members. Staff are also chartering a new project that will assess impacts to SMUD, our outdoor workforce and our customers more specifically. This work will enable mitigation and safety measures (cool roofs and pavements and urban greening) to be more effectively placed to reduce heat pollution and energy use for cooling.

- **Climate Readiness Updates and Operational Plan:** We monitor scientific literature and new findings related to the long-term physical impacts of climate change and evaluate them for impact on our service territory, the locations in which we purchase, generate or transmit electricity and procure critical equipment. Prior assessments led to new research projects detailing risk to infrastructure related to flooding and wildfire. An updated scientific assessment and operational action plan was completed in November 2016 and the next full review is planned for 2020. In accordance with California's policy direction, adaptation measures that also include a mitigation benefit are prioritized.

- **Hazard Mitigation & Carbon Reduction:** In late 2018, we were notified by the California Governor's Office of Emergency Services that 3 concept proposals we submitted for Federal Emergency Management Agency Hazard Mitigation Grant Program funding consideration were approved for the next phase of review. These project concepts all combine community risk reduction and greenhouse gas reduction. They are:

  - **Cool Roof & Community Resilience Program.** This program will offer an ambitious cool roof rebate to home, multifamily and small business property owners located within specified high heat and social vulnerability zones within Sacramento County.

  - **Farm-Based Flood Control & Carbon Storage.** Localized flood risk and greenhouse gas storage will both be addressed using demonstrated carbon farming practices such as windbreak and shelterbelt installation, riparian area restoration, silvopasture establishment and other methods.

  - **Urban Greening for Heat Pollution Reduction.** SMUD will work with local partners the Sacramento Tree Foundation and the Environmental Justice Coalition for Water to implement a community-led green infrastructure development project that will maximize long-term heat reduction potential in multiple frontline neighborhoods.

12. Retail rates

We have a long history as a leader in providing opportunities for customers to reduce energy usage through energy efficiency programs, transparency in rate structure and allocating costs equitably across all customer categories. We continue to maintain rates that are below PG&E rates and among the lowest in California (See also section 2.4 for a description of our Board strategic directives regarding rates). Keeping rates just and affordable while meeting RPS obligations and GHG reduction targets were the focus areas of this IRP study. This section describes the rate impact study we conducted as part of the IRP analysis.

For each scenario that we considered, SMUD's overall revenue requirement and average annual retail rates were estimated.

The revenue requirement included costs in several categories, such as costs associated with maintaining our existing generation resources and transmission and distribution systems, customer cost and public goods charges. In addition to these costs, the revenue requirement includes the fixed costs of new investments in generation, transmission and distribution as well as the costs to operate our system.

To achieve the 2040 goals laid out by the SMUD Board in its IRP directives and IRP adoption, we expect that most of the necessary resource additions will occur after 2030. However, additional expenditures for local, clean distributed resources, including vehicle and building electrification efforts, will begin in the early 2020's and continue to increase until about 2030 after which annual investments in local resources level off.

In all scenarios, we expect regional electrification to provide strong load growth that would moderate impacts on the system average rate.

A comparison of the scenarios up to 2030, shows that the Adopted Scenario results in the lowest rate increase over the forecast period. The main drivers of rate increases up to 2030 across all scenarios are local electrification investments that take place before the load effects associated with electrification materializes.

Note that the rate impacts shown in Table 25 consider only the incremental impacts of investments in the IRP and do not include other factors that could potentially impact rates, such as changes in O&M costs, distribution and transmission investments, inflation, etc. The difference in rate impacts and electricity bill impacts for customers grows over time and becomes more pronounced after 2030. This was one of the reasons why the Board, despite relatively small differences among cases before 2030, preferred to minimize customer impacts by selecting the lowest cost portfolio while at the same time focusing on local environmental improvements in the region through electrification.

Customer electric bills are expected to rise in part because of our decarbonization efforts in the Sacramento economy and reinvestments in SMUD's electric supply, which will increase both electricity costs and customer electricity usage.

However, we expect increases will be more than offset by savings from reduced consumption of natural gas and transportation fuels in households that choose to electrify.

As an example, our current all-electric single-family residential customers with EVs have average monthly single-family residential electricity bills that are nearly 63% higher than electricity bills for our single-family residential customers with a natural gas/electric mix. However, the overall energy bill impact when accounting for savings in gasoline and natural gas costs, is expected to result in savings of 10-15%. This illustrates that electrification may have a significant impact on electric bills, but we also note that offsetting reductions in customers' gasoline and natural gas costs, together with improvements in energy efficiency, are expected to result in net savings for customers that electrify. Future bills will also be affected by technological change and efficiency as well as future rate design and strategy. While final impacts to customer bills will be determined by a combination of factors, it's likely there will be relatively larger electric bill increases because of electrification and decarbonization, which will be offset by lower natural gas and gasoline costs.

Table 25. Customer rate impact (real 2016 $)

		2020	2025	2030
	Total Retail Sales (GWh)	10,876	11,098	11,362
Adopted Scenario	Total Resource Cost ($MM)	$1,410	$1,497	$1,631
	Average System Rate (Cents/kWh)	12.96	13.49	14.36
750k MT	Total Resource Cost ($MM)	$1,410	$1,500	$1,641
	Average System Rate (Cents/kWh)	12.96	13.52	14.45
500k MT	Total Resource Cost ($MM)	$1,410	$1,503	$1,649
	Average System Rate (Cents/kWh)	12.96	13.55	14.51
350k MT	Total Resource Cost ($MM)	$1,410	$1,505	$1,656
	Average System Rate (Cents/kWh)	12.96	13.57	14.57

13. Transmission and distribution plans

SMUD has a long history of performing detailed planning for its system to ensure reliability for customers and to meet requirements from the state, NERC and FERC. There are no reliability concerns over the 2019-2030 period for the transmission and distribution systems. However, our transmission and distribution plans include significant new investments to ensure continued high reliability while integrating more DERs. Our grid modernization plans also include a focus on visibility, control and data that will help prepare for a more decentralized two-way flow of energy on our distribution system.

Our transmission plans cover up to 10 years ahead and our distribution system plans provide a 5-year outlook. This section summarizes our most recent transmission and distribution plans and provides an overview of how the IRP resource plan is integrated with transmission and distribution plans.

13.1 Bulk transmission system

The SMUD transmission system consists of a network of 115 kV and 230 kV overhead and underground lines and cables that are interconnected to the adjacent PG&E and WAPA transmission systems via numerous 230 kV interties and one shared 230 kV substation. The 115 kV portion of the transmission system is used primarily to serve customer load in the downtown area of Sacramento while the 230 kV portion is used to serve the remainder of our service territory.

We have generation resources directly connected to our transmission system, namely hydroelectric power plants that are part of the Upper American River Project in the Sierra Nevada and the 5 thermal power plants in the Sacramento Valley. The combined NDC summer capacity of the hydro and thermal units are 673 MW and 1,012 MW respectively. We don't have any existing renewable resources directly connected to our transmission system.

Though we own 230 MW of the Solano Wind Farm that is directly connected at the 230 kV (transmission) voltage level, it is connected to PG&E's 230 kV transmission system with an interconnection point situated such that location does not impact the reliability of the SMUD transmission system.

With a local generation capacity of 1,685 MW (excluding all distributed resources) and forecasted 1-in-10 peak demands that range from 3,216 to 3,336 MW across the 10-year planning horizon, SMUD relies on our transmission system to reliably serve customer load during peak demand scenarios.

13.1.1 Transmission system reliability

The reliability of our transmission system is evaluated annually as part of the BANC Planning Coordinator's 10-Year Transmission System Assessment. The annual assessment evaluates the reliability of the SMUD transmission system in the near- and long-term planning horizons considering a variety of system conditions factoring in a wide range of contingencies. The assessment, which also follows and complies with the NERC TPL-001 Reliability Standard, evaluates the reliability of the transmission system by measuring the system performance following various contingencies against all applicable NERC, WECC, and SMUD performance criteria.

The assessment includes various power system analyses, such as steady state, voltage stability, transient stability, short circuit, and spare equipment unavailability analyses, to ensure the reliability of the transmission system and to comply with the standard.

The 10-Year assessment is primarily performed with the General Electric Positive Sequence Load Flow (PSLF) software, which is an industry standard tool is widely used throughout the WECC region. The PSLF system models that are used as assessment inputs are updated to reflect the expected generation dispatch, the real and reactive load forecasts, the changes to existing facilities, and any new planned facilities. SMUD uses our 1-in-10 demand forecast for peak scenarios to produce the most severe results and to better identify potential system deficiencies.

The 2018 10-Year Transmission System Assessment demonstrated that SMUD's transmission system meets all required NERC, WECC, and SMUD performance criteria. No system deficiencies or criteria violations were identified and, as such, there were no corrective action plans developed as a result of the assessment.

In addition to the 10-Year assessment, we performed a steady state contingency analysis on our transmission system model on scenarios that represented a stressed transmission system using loads and generation resources forecasted for 2040. The model was developed using the summer peak model developed as part of the 10-Year Transmission assessment as base case. The selected scenarios represent the stressed transmission system in terms of import levels, high reliance on solar generation and batteries in the state of charge and discharge. The study findings did not reveal any deficiencies in meeting NERC, WECC and SMUD performance criteria.

However, the study concluded that additional reactive power support, such as shunt capacitors, dynamic reactive power sources or batteries, will be required for the proposed level of renewables. This additional reactive power requirement is to maintain steady state stability, and to keep bus voltages within acceptable limits under contingency conditions. Although some transmission lines and transformers were found to be overloaded during high import conditions in this stress-test analysis, we expect these conditions to be possible to mitigate with system adjustments such as generation re-dispatching.

13.1.2 Transmission system upgrades

While SMUD meets all performance requirements, we continuously evaluate reliability enhancing options and over the past year we approved several projects that will increase the reliability of the transmission system. These projects are listed in Table 26 and include new 230 kV bus shunt capacitors for voltage support and transmission line reconductor projects to mitigate potential thermal overloads at high demand levels. For additional detail on planned transmission upgrades, please see the 2018 transmission assessment that is available on the SMUD open access same time information system site.[48]

[48] http://www.oasis.oati.com/woa/docs/SMD1/SMD1docs/SMUD_2018_Ten_Year_TPL-001-4_Assessment_Report_Final_20181219.pdf

Figure 28. SMUD distribution system profile

Load growth:
1.23%
per year since 2013

Substations:
207
at voltage levels of **69kV, 21kV, 12kV** and **4kV.** All the **69kV** and **21kV** substations have supervisory control and data acquisition (SCADA) functionality.

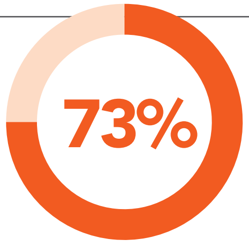
Peak Load in 2018:
2,960 MW

Record Peak Demand:
3,299 MW
ON
JULY **2006**

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

10,178 MILES
of sub-transmission distribution lines

Automation and control:



of our **12kV**

substation transformers have SCADA functionality while 80% of the circuits have some sort of automation.

Distribution system connected Solar: **290 MW** as of September 2018, equating to 6% penetration level at system peak.

Table 26. Transmission system upgrades to improve the reliability of the bulk transmission system

Project Name	Description	Expected In-service Date
Natomas 230 kV Bus Shunt Capacitor Project	Install 50-MVAR bus shunt capacitor at Natomas 230 kV.	Winter 2019
Hurley-Procter 230 kV Line Reconductor Project	Reconductor the 6.5-mile-long Hurley-Procter transmission line with a higher ampacity conductor and upgrade terminal equipment.	Spring 2020
Foothill 230 kV Bus Shunt Capacitor Project	Install 50-MVAR bus shunt capacitor at Foothill 230 kV.	Spring 2020
Hurley 230 kV Bus-tie Breaker	Install a bus-tie breaker to reduce risk of station clearing outage.	2022

13.2 Distribution

SMUD's distribution planning criteria requires that facilities do not exceed 100% of their rated capacity during normal operating conditions. Additionally, we require that the system has sufficient capacity to serve 100% of the load during (N-1) operating conditions. These two criteria are key for modeling distribution system reliability and for determining the need for new investments in the distribution system.

Our 5-Year Distribution System Plan provides a road map of capital projects and expected investments over the next 5 years to ensure our distribution system continues to have the capacity to serve existing and demand forecasts in a reliable, safe and cost-effective manner. The plan evaluates past performance and anticipates future system needs based on a wide-array of criteria in alignment with our vision and goals.

The plan discusses drivers of load growth in subsections of the system, such as the current resurrection of the local housing market and the strong growth of indoor cannabis cultivation operations.

The Golden 1 Center is one example that is heavily influencing major downtown Sacramento development including new hotels, residential towers and commercial buildings, which is in turn affects utilization of the facilities that serve the downtown Sacramento area.

The 2019-2023 distribution plan includes many projects and upgrades: 103 Line projects are proposed through 2023, adding approximately 85 miles in new distribution lines (69-, 21- and 12 kV). The plan also includes 31 substation projects that will add approximately 834 MVA in transformer capacity. For more detail, SMUD's 5-year distribution plan is available upon request.

13.2.1 Grid modernization and integration of DERs

One-way power flow starting at central station generation (like from SMUD's Cosumnes Power Plant) through the transmission and distribution wires to customers is increasingly supplemented with DERs such as rooftop solar, utility scale solar and storage, EVs, fuel cells and customer-owned "micro grids." For SMUD, this means we need to update our system to safely and reliably operate in and orchestrate distributed, 2-way power flow.

In addition to the distribution line and substation capital investments discussed above, we see the following 3 initiatives as key in our efforts to transform the distribution system to a bi-directional grid that facilitates increasing penetration of DERs.

The first is to implement an advanced distribution management system, which is a foundational step to help the distribution operators optimize all grid connected resources. This project is underway and scheduled for completion in 2020.

The second is to expand substation automation and line automation to provide remote visibility and control for distribution system operators. SMUD will continue to retrofit remaining distribution substations having multiple feeders with full supervisory control and data acquisition (SCADA) functionality. The smaller substations (approximately 30) with single feeders will be retrofitted with smart meters to provide near real-time remote monitoring for the distribution operators and engineers. All new distribution substations will be installed with full SCADA functionality.

We're also installing automated switches to provide real-time remote monitoring and control for the distribution operators, including voltage regulators on our 21kV and 12kV system to address potential power quality issues and prepare the system for higher levels of DER penetration.

The third key initiative is to continue to reinforce infrastructure to support the physical integration of DERs. For a more detailed discussion of SMUD's distribution system plan, our 2018 5-year plan is available upon request.

13.3 Integrating expected IRP impacts on the transmission and distribution systems

The IRP calls for nearly 400 MW of new grid-connected utility-scale solar PV in the 2019-2030 period, of which about 100 MW is local capacity in active development. The near-term capacity is already modeled in the most recent transmission system assessment to identify any adverse impacts that may result from the interconnection of these resources. A system impact study was also performed to identify any adverse impacts outside of the planning process.

We update our transmission and distribution plans annually. Due to the concurrent development of the IRP, the transmission plan and the distribution plan, our transmission and distribution plans will not reflect the IRP capacity and demand outlook until 12-14 months after the completion of the IRP. However, any near-term projects expected in the next 1-4 years are typically already under review and assessment from a T&D perspective through separate project-specific processes around the interconnection of a new project.

Going forward, as we approach the expected online dates for new capacity or start to experience the impact of behind-the-meter demand and generation growth, our transmission and distribution plans will be updated well before impacting the system, thus ensuring that the system is ready for new generation and demand as expected in the IRP. Since the IRP is forward-looking and subject to significant uncertainty, we also expect to adjust all planning in accordance with how SMUD's business environment develops.

14. Action plan and next steps

Any long-term market outlook carries significant uncertainty and there are many factors that could cause us to need to re-evaluate and adjust the IRP. For example, a downturn in the economy may slow down load growth as well as customers' willingness to invest in energy efficiency or electric vehicles and electric buildings or appliances. Similarly, if costs for battery storage, solar PV or other technologies decline faster than currently expected, there may be cause for SMUD to accelerate investments in these technologies. However, our current expectations are that we will not need to procure additional capacity until the end of the 2020s beyond what we already have under development – and then mainly focusing on solar, wind and battery storage, as discussed earlier.

Our IRP anticipates that California and the broader WECC region will be relatively well supplied with both conventional and renewable energy resources until at least 2024 when PG&E's Diablo Canyon nuclear plant retires. The relatively abundant supply of resources in western power markets means that capacity and energy are expected to be available at costs that are significantly below the cost of building new power plants or energy storage. We therefore expect to continue to rely on short to medium term procurement of resources to serve capacity and energy needs while also meeting or exceeding the mandated RPS levels that will bring our RPS portfolio to 60% and our overall power supply portfolio to be almost 80% percent carbon free by 2030.

Our initial actions therefore are focused on developing and expanding customer programs that will support growth of electrification, energy efficiency, distributed renewable energy sources and programs that benefit disadvantaged communities. Table 27 summarizes our action plan for key areas of the IRP that are discussed in other parts of this report. Our updated plan for procurement of renewable energy is also available in Appendix B.

A key action item for us is to develop an accounting methodology to address how our electrification efforts translate into local GHG savings. We plan to develop a methodology for how our electrification efforts contribute to our net zero carbon goals articulated in this report and will work collaboratively with state and regulatory bodies to identify a workable approach that address emission reductions across different sectors.

Table 27. IRP action plan

Resource Plan Component	Anticipated Actions	Approximate Timing	Key uncertainties that may accelerate of decelerate actions
IRP Update	Refresh IRP based on needs and market conditions.	Annually	• N/A
	Update IRP fundamentals and assumptions for consideration by Board, stakeholders and submission to the CEC.	2022-2024	
Capacity and Reserves	Near term procurement of capacity in WECC power markets until prices or reliability needs justify new storage or other capacity investments.	Ongoing	• Changing Resource Adequacy regulatory requirements • Capacity prices • CA fossil fueled unit retirements • Cost of storage
	Continuous assessment of demand for capacity and reserves as well as local load serving capabilities to ensure reliability.	Ongoing	
	Grid scale storage procurement.	See below	
Reliability	Evaluate and plan reliability in transmission, distribution and electric operations.	Annually	• Changing codes/ regulations
Energy Supply	Balance energy and capacity needs with market purchases until capacity and/or energy costs in markets increase to warrant local development and operations.	Ongoing	• Wholesale power prices • Market prices for capacity • Natural gas prices • Cost of storage • State/Federal incentives for new resources
Renewable Energy Procurement	Implement RPS Procurement Plan.	See Appendix B	• See Appendix B • Customer demand/ preferences
	Expand SolarShares program to provide opportunities for residential customers.	2019 onwards	
	Identify suitable sites for local utility scale solar.		
Energy Storage	Identify suitable sites for utility scale storage in the Sacramento region.	2019	• Market prices for capacity • Cost of storage • State/Federal incentives for storage and renewables
	Permitting and development for potential sites within SMUD service area.	Ongoing	
	Issue RFP/RFO for multi-MW grid-connected energy storage.	2026-2028	
	Launch Smart Water Heater energy storage incentives as part of SMUD's 9MW of behind-the-meter energy storage goal for 2020.	In progress	
	Streamline permitting processes for behind-the-meter storage to facilitate customer adoption of battery storage and other DERs.	Ongoing	
Energy Efficiency and Demand Response	Implement TOD rates.	2019	• Change in code and regulations for buildings, appliances/equipment and energy efficiency
	Issue call for inputs on "Bring-Your-Own-Device" demand response.	2019-2021	
	Launch next generation ACLM program.	2021	
	Define new efficiency goals using greenhouse gas impact and greenhouse gas costs as a metric.	2019	
	Expand efficiency programs through new and existing programs to meet the State's "doubling of energy efficiency by 2030" objective.	Ongoing	
Electrification, DERs and DACs	Develop electrification impact protocols to recognize GHG emission reduction resulting from electrification and energy efficiency investments.	2019-2020	• EV cost trends • Regional economy and demographic trends • Local and State Policy accelerating local electrification
	Streamline SMUD Rule 21 for interconnection of DERs.	Ongoing	
	Continue collaboration with regional and state governments and businesses to create programs for fleet electrification.	Ongoing	
	North Franklin DAC renewable energy pilot.	2019	
	Expand programs for all-electric new homes and launch incentives for existing buildings.	2019-2020	

For us to reach our ambitious goal of net-zero greenhouse gas emissions by 2040, we plan to launch several programs supporting electric transportation and buildings. We must also work on the leading edge of research to experiment with new technologies, programs and customer service programs to move towards lower overall greenhouse gas emissions in the Sacramento region that will offset the remaining emissions from our natural gas fired generation by 2040. Further, it will take a coordinated effort across all local agencies focused on transportation and buildings to accelerate electrification in the region.

We also expect regulatory changes will provide support for electrification through tightening requirements for electrical applications for overall fuel and emissions efficiency. However, despite launching ambitious customer programs to support electrification of transportation and buildings, we expect this to take time. Therefore, the impact of programs launched in the next few years may not be fully realized until after 2030.

Under our existing Board directives, we update our resource plan annually and will adjust the action plan outlined above as needed based on direction from our Board, our customers' preferences, economic development, technological advancements and changes in regulatory requirements. Finally, the IRP was approved prior to the passage of SB 100 that requires utilities to meet at least 60% of their retail electric sales demand with eligible renewable energy by 2030. The updated RPS procurement plan includes our plan for closing the RPS gap between this IRP and the 60% RPS requirement.

14.1 IRP risks and barriers

Our resource plan lays out an ambitious road map to decarbonize the Sacramento region. At the same time, it's important to recognize long-term projections and assumptions are subject to significant uncertainty and our assessment includes numerous assumptions and expectations regarding the future business environment for SMUD. Key uncertainties in our outlook that will need to be monitored closely include:

- **Renewable resource costs:** Solar and wind costs have steadily decreased in recent years to historic lows, but may increase with increased renewable goals for all utilities in California. These resource costs are susceptible to land value, incentive expiration (ITC/PTC), political climate, environmental regulations and the cost of material to create them. Resources such as battery storage used to balance renewables are projected to decrease significantly over the next 10 years which would allow for lower cost deployment of these valuable balancing resources when needed.
- **New technology advancements:** New technology will likely emerge that could make deeper decarbonization easier and less costly.
- **Regulatory uncertainty:** California environmental regulations are continually evolving as the state pursues its low-carbon goals which in turn could have a significant impact on our costs of generating and distributing power. For example, RPS goals through 2030 have been revised higher to 60% by SB 100 just after passage of an increase in RPS from 33% to 50% by 2030, set under SB350 in 2015.

- **Regional economic growth and demographics:** An economic downturn or a slower than expected growth in regional jobs and population could cause a delay in the implementation of this IRP. A change of relative costs of goods and services could warrant adjustments of our resource plan.

- **Market uncertainty:** Higher than forecasted market prices could create upward pressure on costs and rate projections and dampen the adoption of transportation and building electrification. Market value of renewables in the CAISO may decline with increasing solar penetration along with increasing charges and tariffs.

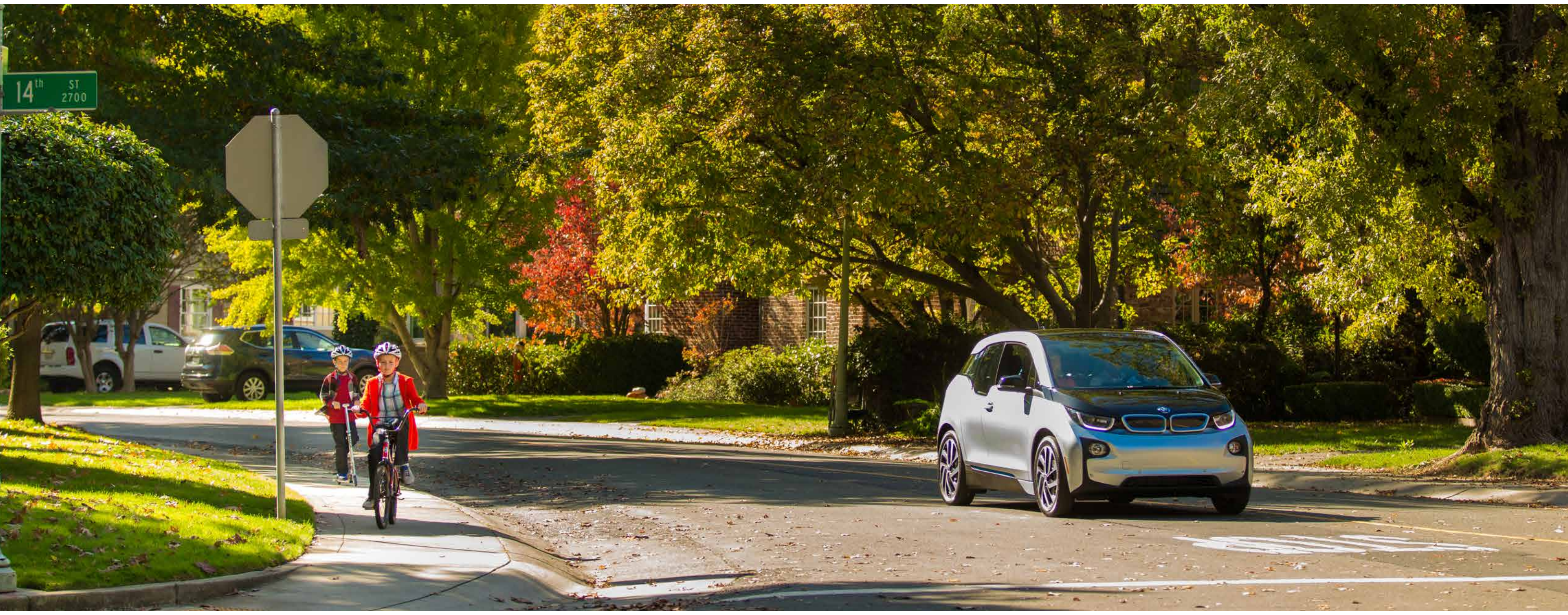
- **Pace of electrification adoption:** Decarbonization of transportation and buildings in the Sacramento region will require significant collaboration across a wide range of stakeholders locally and statewide. While SMUD's investments in electrification will be significant, regulatory policy will also drive the pace of electrification adoption which at this point is thinly defined and uncertain.

- **DER incentives:** Customer adoption of distributed resources and electric transportation will, to a significant degree, depend on local, state and federal incentives, such as the LCFS incentives to provide customers the necessary motivation to electrify their energy use while keeping electricity and capital costs reasonable.

- **Retail sales:** Despite SMUD's existing and planned programs to support electrification, there is significant uncertainty regarding how fast our load will grow because of our efforts and those of other supporting local and state agencies. Lower or higher than expected load growth will change the expected rate impact and costs detailed in this resource plan.

- **Behind-the-meter generation and storage:** Our resource plan assumes increasing electric sales that will offset our electrification spending. However, a higher adoption of net-metered renewable generation capacity could reduce sales and increase the burden on retail rates of our electrification initiatives.

We will periodically update the resource plan as technology, markets and regulations evolve. Following our annual resource planning process with SMUD's Board, we may update our GHG emissions reduction goals in Board Strategic Direction-9, Resource Planning, as necessary to deliver resources at a reasonable cost and manageable risks to maintain our core commitments to customers (safety, cost, reliability and environmental stewardship).



15. Glossary

Additional Achievable Energy Efficiency (AAEE): Energy efficiency savings that are not included in SMUD's budget plan but likely to occur, including impacts from future updates of building codes and appliance standards and SMUD's efficiency programs expected to be implemented to meet internal targets.

California-Oregon Border (COB): Trading hub for the transfer of power from the Pacific Northwest and California.

California-Oregon Transmission Project (COTP): Transmission project connecting the Balancing Area of Northern California with the California-Oregon Border trading hub.

Committed Energy Efficiency: Energy Efficiency savings from programs included in current budget plan and existing building codes and appliance standards.

Effective Load Carrying Capability (ELCC): The ability to effectively increase the generating capacity available to a utility without increasing the utility's loss of load risk, quantified as the amount of new load that can be added to a system after capacity is added by a generator without increasing the loss of load probability or expectation.

Market price: The price at which supply equals demand for the day-ahead or hour-ahead markets. Market-based pricing is set in open market systems of supply and demand under which prices are set solely by agreement as to what buyers will pay and sellers will accept. Such prices could recover less or more than full costs, depending upon what the buyers and sellers see as their relevant opportunities and risks.

Net Energy for Load: Energy demand from retail sales, transmissions and distribution system losses, pumping and battery storage loads, and other utility loads that must be met with generation plus energy receipts minus energy deliveries.

Net System Peak: System peak less generation from intermittent solar and wind resources.

Planning Reserve Margin: Additional reserve margin for long-term planning equal to 15% of SMUD's unmanaged load.

System Peak: Maximum annual energy demand within SMUD's service territory.

Transmission Access Charge: A charge for each megawatt hour of power delivered via CAISO's high voltage transmissions system and is used to recover transmission revenue requirements. SMUD pays the TAC when wheeling power from the CAISO.

15.1 Acronyms

AAEE: Additional achievable energy efficiency

ACLM: Air conditioning load management

Adopted Scenario: Integrated Resource Plan scenario adopted by SMUD's Board as the preferred plan for achieving our strategic directions and environmental goals.

BANC: Balancing Authority of Northern California

Board: SMUD's seven-member Board of Directors.

BTM: Behind the meter or the customer-side of the meter.

CA80x50: PATHWAYs scenario results consistent with California's long-term goal of reducing statewide greenhouse gas emissions by 80% below 1990 levels by 2050

CAISO: California Independent System Operator

CalEPA: California Environmental Protection Agency

CalEVIP: California Energy Commission EV Infrastructure Program

CARB: California Air Resources Board

CEC: California Energy Commission

CO_2: Carbon dioxide

CO_2e: Carbon dioxide equivalent

COB: California Oregon Border

CPUC: California Public Utilities Commission

DAC: Disadvantaged Communities

DER: Distributed energy resources, including solar and wind power, energy efficiency, demand response, electric vehicles and building electrification.

DR: Demand Response

E3: Energy and Environmental Economics, Inc.

EAPR: Energy Assistance Program Rate

EIM: Energy Imbalance Market

EPRI: Electric Power Research Institute

EV: Electric vehicles

FERC: Federal Energy Regulatory Commission

GHG: Greenhouse gas

GWh: Gigawatt-hour

HVAC: Heating, ventilation, and air conditioning

IEPR: Integrated Energy Policy Report

ILFI: International Living Future Institute

IRP: Integrated resource plan

JPA: Joint Powers Authority

km: kilometer

kV: kilovolt

kWh: Kilowatt-hour

LCFS: Low Carbon Fuel Standard

LD PEV: Light-duty plug-in electric vehicle

LED: light-emitting diode

MM: Million metric

MMT: Million metric tons

MT: Metric ton

MW: Megawatt

MWh: Megawatt-hour

NDC: Net dependable capacity

NERC: North American Electric Reliability Corporation

NP-15: CAISO market north of WECC Path 15

NREL: National Renewable Energy Laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy.

PG&E: Pacific Gas and Electric

PRC: Public Resources Code

PSLF: Positive Sequence Load Flow

PUC: Public Utilities Code

PV: Photovoltaic

RECs: Renewable energy credits

RPS: Renewables Portfolio Standard

SB: Senate bill

SCADA: Supervisory control and data acquisition

SD: Strategic direction

SMUD: Sacramento Municipal Utility District

SP-15: CAISO market south of WECC Path 15

Title 24: The California Building Standards Code, California Code of Regulations Title 24

TOD: Time-of-day

UARP: Upper American River Project

WAPA: Western Area Power Administration

WECC: Western Electricity Coordination Council

16. **Appendix A:** Overview of California's clean energy policy development

Over the course of the last 15 to 20 years, California has passed a variety of laws and regulations that have established a complex set of requirements for investor and publicly owned utilities to plan for system reliability in the long term, while simultaneously meeting numerous environmental and energy policy goals. Laws have required increasingly higher amounts of renewable procurement to supply electricity, emphasized the importance of procuring demand-side resources such as energy efficiency, and fostered a cleaner transportation system – including electric transportation increases that must be met by electric utilities. The Table below outlines the most significant legislative bills addressing California's environmental and energy policies relevant to integrated resource planning.

Table 28. California energy legislation and executive orders 2002-2018

Date	Legislation	Description
Sept. 10, 2018	**Senate Bill 100** (DeLeon, Chapter 312, Statutes of 2018)	SB 100 accelerated and increased California's RPS to 60% by 2030. The bill also stated that it is a policy of the state that eligible renewable energy resources and zero-carbon resources supply 100% of retail sales of electricity to California end-use customers by December 31, 2045.
July 26, 2017	**Assembly Bill 617** (Christina Garcia, Chapter 136, Statutes of 2017)	**Companion to Cap-and-Trade** Extension Establishes a groundbreaking program to measure and reduce air pollution from mobile and stationary sources at the neighborhood level in the communities most impacted by air pollutants. Requires the Air Resources Board to work closely with local air districts and communities to establish neighborhood air quality monitoring networks and to develop and implement plans to reduce emissions. The focus on community-based air monitoring and emission reductions will provide a national model for enhanced community protection.
July 25, 2017	**Assembly Bill 398** (Eduardo Garcia, Chapter 135, Statutes of 2017)	**Cap-and-Trade Extension** Extends and improves the Cap-and-Trade Program, which will enable the state to meet its 2030 emission reduction goals in the most cost-effective manner. Furthermore, extending the Cap-and-Trade Program will provide billions of dollars in auction proceeds to invest in communities across California.
Sept. 19, 2016	**Senate Bill 1383** (Lara, Chapter 395, Statutes of 2016)	**Short-lived Climate Pollutants** Establishes statewide reduction targets for short-lived climate pollutants.
Sept. 8, 2016	**Senate Bill 32** (Pavley, Chapter 249, Statutes of 2016)	**GHG emission reduction target for 2030** Establishes a statewide GHG emission reduction target of 40% below 1990 levels by 2030.
Oct. 7, 2015	**Senate Bill 350** (De León, Chapter 547, Statutes of 2015)	**Clean Energy and Pollution Reduction Act of 2015** Establishes targets to increase retail sales of renewable electricity to 50% by 2030 and double the energy efficiency savings in electricity and natural gas end uses by 2030.

Date	Legislation	Description
Sept. 21, 2014	**Senate Bill 1275** (De León, Chapter 530, Statutes of 2014)	**Charge Ahead California Initiative** Establishes a state goal of 1 million zero-emission and near-zero-emission vehicles in service by 2020. Amends the enhanced fleet modernization program to provide a mobility option. Establishes the Charge Ahead California Initiative requiring planning and reporting on vehicle incentive programs and increasing access to and benefits from zero-emission vehicles for disadvantaged, low-income, and moderate-income communities and consumers.
Sept. 28, 2013	**Assembly Bill 8** (Perea, Chapter 401, Statutes of 2013)	**Alternative fuel and vehicle technologies: funding programs** Extends until Jan. 1, 2024, extra fees on vehicle registrations, boat registrations, and tire sales to fund the AB 118, Carl Moyer, and AB 923 programs that support the production, distribution, and sale of alternative fuels and vehicle technologies and air emissions reduction efforts. The bill suspends until 2024 ARB's regulation requiring gasoline refiners to provide hydrogen fueling stations and appropriates up to $220 million, of AB 118 money to create a hydrogen fueling infrastructure in the state.
Sept. 28, 2013	**Assembly Bill 1092** (Levine, Chapter 410, Statutes of 2013)	**Building standards: EV charging infrastructure** Requires the Building Standards Commission to adopt mandatory building standards for the installation of future EV charging infrastructure for parking spaces in multifamily dwellings and nonresidential development.
April 12, 2011	**Senate Bill X1-2** (Simitian, Chapter 1, Statutes of 2011)	Senate Bill X1-2 increased California's RPS requirement to 33% by 2020. The new RPS goals applies to all electricity retailers in the state including publicly owned utilities (POUs), investor-owned utilities, electricity service providers, and community choice aggregators.
Sept. 29, 2010	**Senate Bill 2514** (Skinner, Chapter 469, Statutes of 2010)	SB 2514 required the CPUC to determine and adopt appropriate storage targets, if any, for each load-serving entity under its jurisdiction. The bill also required the governing board of a local publicly owned electric utility to determine and adopt appropriate storage targets, if any. Storage target information must be provided to the CPUC, for a load-serving entity, or to the Energy Commission, for a local publicly owned electric utility.
Sept. 30, 2008	**Senate Bill 375** (Steinberg, Chapter 728, Statutes of 2008)	Sustainable Communities & Climate Protection Act of 2008 requires Air Resources Board to develop regional GHG emission reduction targets for passenger vehicles. ARB is to establish targets for 2020 and 2035 for each region covered by one of the State's 18 metropolitan planning organizations. For more information on SB 375, see the ARB Sustainable Communities page.

Date	Legislation	Description
Oct. 14, 2007	**Assembly Bill 118** (Núñez, Chapter 750, Statutes of 2007)	**Alternative Fuels and Vehicles Technologies** AB 118 created the Alternative and Renewable Fuel and Vehicle Technology Program, to be administered by the Energy Commission, to provide funding to public projects to develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies.
Sept. 29, 2006	**Assembly Bill 2021** (Levine, Chapter 774, Statutes of 2006)	AB 2021 requires the Energy Commission to develop a statewide estimate of all potentially achievable cost-effective electricity and natural gas efficiency savings and establish statewide annual targets for energy efficiency savings and demand reduction over 10 years. The bill also requires local publicly owned electric utilities establish efficiency and demand targets over 10 years, and report the targets and background information (programs, expenditures, cost-effectiveness, and results) to the Energy Commission.
Sept. 29, 2006	Emissions Performance Standards **Senate Bill 1368** (Perata, Chapter 598, Statutes of 2006)	SB 1368 limits long-term investment by the State's utilities in baseload generation to only those resources that meet emissions performance standards set by CEC and CPUC. The emissions performance standards have been a driving force behind phasing out of long-term contracts that California utilities have for coal-fired generation and have played a key role in decreasing GHG emissions in the electricity sector.
Jan. 18, 2007	**Executive Order S-01-07**	The LCFS requires that fossil fuel distributors reduce the carbon intensity of transportation fuels for use in the California (or purchase LCFS credits from other participating companies that produce low carbon fuels) and increase the production of low-carbon alternative and renewable fuels. LCFS credits trade in their own standalone market. As of late 2018 they were trading at $180 per metric ton, more than 10 times the stationary emissions allowances enacted by AB32 (see below). The LCFS credit market is assumed to be available throughout the planning cycle to reduce SMUD's cost of our vehicle electrification programs.
Sept. 27, 2006	**Assembly Bill 32** (Núñez, Chapter 488, Statutes of 2006)	California Global Warming Solutions Act of 2006. AB 32 requires the Air Resources Board (ARB) to adopt a statewide GHG emissions limit equivalent to the statewide GHG emissions levels in 1990 to be achieved by 2020. AB 32 also gave CARB the option of setting up a market-based compliance program, authorizing the Cap-and-Trade program. See more information on AB 32 at ARB.

Date	Legislation	Description
Sept. 26, 2006	**Senate Bill 107** (Simitian, Chapter 464, Statutes of 2006)	SB 107 directs California Public Utilities Commission's Renewable Energy Resources Program to increase the amount of renewable electricity (Renewable Portfolio Standard) generated per year, from 17% to an amount that equals at least 20% of the total electricity sold to retail customers in California per year by December 31, 2010.
Aug. 21, 2006	**Senate Bill 1** (Murray, Chapter 132, Statutes of 2006)	California's Million Solar Roofs plan is enhanced by PUC and CEC's adoption of the California Solar Initiative. SB 1 directs PUC and CEC to expand this program to more customers and requiring the state's municipal utilities to create their own solar rebate programs.
Sept. 29, 2005	**Senate Bill 1037** (Kehoe, Chapter 366, Statutes of 2005)	SB 1037 requires the California Public Utilities Commission and the Energy Commission to identify all potentially achievable cost-effective electricity efficiency savings and requires that procurement plans aim to first acquire all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible. The bill also requires each local publicly owned electric utility to report annually to its customers and to the Energy Commission, its investment on energy efficiency and demand reduction programs.
June 1, 2005	**Executive Order S-03-05**	Sets a long-term goal for California to reduce GHG emissions by 80% by 2050 compared to 1990 levels. Directs Cal/EPA to coordinate efforts and provide progress updates to Governor and Legislature
Sept. 12, 2002	**Senate Bill 1078** (Sher, Chapter 516, Statutes of 2002)	This bill establishes the California Renewables Portfolio Standard Program, which requires electric utilities and other entities under the jurisdiction of the California Public Utilities Commission to meet 20% of their renewable power by December 31, 2017 for the purposes of increasing the diversity, reliability, public health and environmental benefits of the energy mix.
July 22, 2002	**Assembly Bill 1493** (Pavley, Chapter 200, Statutes of 2002)	The "Pavley" bill requires the registry, in consultation with the State Air Resources Board, to adopt procedures and protocols for the reporting and certification of reductions in GHG emissions from mobile sources for use by the state board in granting the emission reduction credits. The bill also required the state board to develop and adopt, by Jan. 1, 2005, regulations that achieve the maximum feasible reduction of GHGs emitted by passenger vehicles and light-duty trucks. For more information on AB 1493 Pavley I, see the ARB Clean Car Standards page.

Source: https://www.climatechange.ca.gov/state/legislation.html, with subtractions and additions.

In response to and in addition to legislation, the governor and the energy agencies in California lay out energy and environmental policy for the state. The primary energy agencies are the CEC, the California Public Utilities Commission. For environmental aspects of energy use including GHG emissions – the California Air Resources Board. SMUD is not directly regulated by the CPUC, but is regulated by the CEC through the renewable portfolio standard regulation and the IRP reporting requirements described in detail below.

The energy agencies have often collaborated to propose new energy policy recommendations. In 2003, the energy agencies came out with an Energy Action Plan that contained specific recommendations about increasing demand response, renewables requirements, ensuring reliability, promoting distributed generation, etc. This plan was updated in 2005 and 2008. The CEC also produces Integrated Energy Policy Reports every two years (with updates in the intervening years) that contain recommendations for California Energy Policy. In many cases these recommendations have been incorporated in California law by the bills listed above and others.

PU Code §9615 calls for all utilities to follow the state's loading order and prioritize acquiring all available energy efficiency, DR and renewables that are cost effective, reliable and feasible (SB 1037, statues of 2005). This provision is complemented by a body of law and regulatory policy around the importance of energy efficiency, such as AB 2021, which requires regular reporting from POUs on energy efficiency and DR targets (currently set at every four years).

Other related statutory guidance to POUs provides that POU boards shall initiate a process to develop storage targets that are updated every 3 years (PU Code §2836) and that cost-effective storage can be used to meet resource adequacy needs. State law does not provide enforceable storage procurement goals for POUs, in contrast to investor owned utilities (PU Code § 2839).

California governors also guide energy policy by directions to state agencies and by executive orders. Important Governor Executive Orders include:

Executive Order S-3-05 signed by Governor Arnold Schwarzenegger: Established GHG targets of reducing GHG emissions to 2000 levels by 2010, 1990 levels by 2020, and 80% below 1990 levels by 2050. AB 32 codified the 2020 goal, and SB 32 established a new GHG level for 2030, on the path to the 2050 goal, of 40% below 1990 emissions.

Executive Order B-30-15 signed by Governor Jerry Brown: Identified actions in 5 key climate change strategy "pillars" necessary to meet California's ambitious climate change goals:

- Reducing today's petroleum use in cars and trucks by up to 50%.
- Increasing from one-third to 50% our electricity derived from renewable sources.
- Doubling the efficiency savings achieved at existing buildings and making heating fuels cleaner.
- Reducing the release of methane, black carbon, and other short-lived climate pollutants.
- Managing farm and rangelands, forests, and wetlands so they can store greenhouse gas.

This executive order became the driving force behind SB 350 and SB 32. Executive Order B-30-15 extended the goals of AB 32 and set a 2030 goal of reducing emissions 40% from 1990 levels.

Executive Order B-48-18 Signed by Governor Jerry Brown: Established a goal of at least 5 million zero-emission vehicles on the California roads by 2030.

Executive Order B-55-18 Signed by Governor Jerry Brown: Established a new statewide goal of achieving greenhouse gas neutrality as soon as possible, and no later than 2045, and achieve and maintain net negative emissions thereafter.

SB 350 goals and integrated resource planning

SB 350 (de Leon, Statutes of 2015) included many provisions enhancing the major elements of California's clean energy strategy, including additional investments in electric transportation, a plan to double energy efficiency savings, and extending the RPS in California to 50% by 2030. Most relevant to this document, SB 350 also established in law for the first time a requirement for an integrated resource planning process that acts to connect a variety of diverse planning guidance from previous legislation and energy agency policies. In particular, SB 350 created a new requirement for the largest 16 POUs to adopt IRPs and submit them to the CEC for "review."

With respect to these IRPs, SB 350 contains 14 provisions requiring that the IRPs developed, adopted and provided to the CEC by POUs address particular topics. Arguably, the 2 most important requirements from SB 350 are contained in Section 9621(b) (1) and (2), which state that an IRP should demonstrate that the POU's procurement plan:

(1) Meets the GHG emissions reduction targets established by CARB, in coordination with the commission and the Energy Commission, for the electricity sector and each local publicly-owned electric utility that reflect the electricity sector's percentage in achieving the economywide GHG emissions reductions of 40% from 1990 levels by 2030.

(2) Ensures procurement of at least 50% eligible renewable energy resources by 2030 consistent with Article 16 (commencing with Section 399.11) of Chapter 2.3.

In July 2018, CARB adopted a planning target range for GHG reduction by 2030 for the electricity sector and for each of the utilities that SB 350 required to file IRPs. SB 100 passed in September 2018 and changed the RPS target to 60% by 2030. Our updated RPS procurement plan reflects this latest state policy development.

In addition to the above main goals, SB 350 requires IRPs to meet the following additional 6 state policy goals (Section 9621(b)(3)).

a. Enable each POU to serve its customers at just and reasonable rates.

b. Minimize impacts on customers' bills.

c. Ensure system and local reliability.

d. Strengthen the diversity, sustainability, and resilience of the bulk transmission and distribution systems, and local communities.

e. Enhance distribution systems and demand-side energy management.

f. Minimize localized air pollutants and other GHG emissions, with early priority on disadvantaged communities.

And, SB 350 requires SMUD planners to address the following 5 resource topics in the IRP:

1. Energy efficiency and demand response.
2. Energy storage requirements.
3. Transportation electrification.
4. A diversified procurement portfolio consisting of both short and long-term electricity, electricity-related, and demand response products.
5. Resource adequacy requirements.

Subsequently, Senate Bill 338 (Skinner, Chapter 389, Statutes of 2017) requires POU IRPs to consider existing renewable generation, grid operational efficiencies, energy storage, and distributed energy resources, including energy efficiency, to meet their energy needs during peak demand hours.

All of the above topics and goals have been included in our resource planning processes in the past, prior to the passage of SB 350. Each year, SMUD staff develops resource plans and presents these in summary fashion to our Board of Directors for approval. This resource planning activity is required by the Board's Strategic Directive on Resource Planning. With the passage of SB 350, SMUD's resource planning process includes the development and filing of an IRP document at the CEC.

Finally, SB 350 requires the "Renewable Procurement Plan" pursuant to the RPS law (PUC Section 399.30) to be incorporated in the IRP. The initial RPS requirements established for POUs by SBx1-2 required development of a renewable procurement plan and a compliance enforcement plan. SMUD developed and adopted those plans in 2013. There was no requirement to update these plans on an ongoing basis, but SB 350 will require an update of SMUD's original renewable procurement plan so that it is consistent with the proposed resources in the IRP and reflective of subsequent legislation that expanded and extended the RPS (SB 350 and SB 100). Our updated RPS procurement plan is attached to this document as Appendix B.

17. **Appendix B:** Renewable energy procurement plan

RESOLUTION NO. 19-04-04

WHEREAS, by Resolution No. 13-11-09, adopted November 21, 2013, this Board approved and adopted the SMUD **Renewable Energy Resources Procurement Plan (RPS Procurement Plan)**; and

WHEREAS, Public Utilities Code section 399.30(a) requires each publicly owned utility (POU) to adopt and implement a renewable energy resources procurement plan that ensures procurement from eligible renewable energy resources pursuant to requirements set forth in in Public Utilities Code section 399.30; and

WHEREAS, Section 3205(a) of the California Energy Commission (CEC) *Enforcement Procedures for the Renewables Portfolio Standard for Local Publicly Owned Electric Utilities (CEC RPS Regulations)*, includes additional requirements applicable to POU renewable energy resources procurement plans; and

WHEREAS, due to new RPS regulations, the **RPS Procurement Plan** requires updating; and

WHEREAS, staff has developed an updated **RPS Procurement Plan**, substantially in the form of **Attachment B**, that meets the statutory requirements of Public Utilities Code section 399.30 and the *CEC RPS Regulations*; and

WHEREAS, the updated **RPS Procurement Plan** incorporates portions of the Clean Energy and Pollution Reduction Act of 2015 (SB 350, De Leon), and The 100 Percent Clean Energy Act of 2018 (SB 100 De Leon) that extend the RPS targets through 2030 and increases those targets to 60% by 2030; and

WHEREAS, the updated **RPS Procurement Plan** also incorporates certain of the renewable resource commitments and provisions of SB 350 that have not yet been included in the *CEC RPS Regulations*; and

WHEREAS, Public Utilities Code section 399.30(f) and the *CEC RPS Regulations* require the SMUD Board of Directors to provide the public with notice, in accordance with the Ralph M. Brown Act, Government Code section 59450, et seq., and provide the public and the CEC with certain information, whenever it deliberates in public on its **RPS Procurement Plan;** and

WHEREAS, SMUD provided such notice on March 29, 2019, and April 19, 2019; **NOW THEREFORE,**

BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE SACRAMENTO MUNICIPAL UTILITY DISTRICT:

The Board hereby approves and adopts the updated **Renewable Energy Resources Procurement Plan (RPS Procurement Plan)**, substantially in the form of **Attachment B.**

Approved: April 25, 2019

INTRODUCED: DIRECTOR SANBORN				
SECONDED: DIRECTOR KERTH				
DIRECTOR	AYE	NO	ABSTAIN	ABSENT
TAMAYO	X			
ROSE	X			
BUI-THOMPSON	X			
FISHMAN	X			
HERBER	X			
KERTH	X			
SANBORN	X			

SMUD Renewable Energy Resources Procurement Plan

(RPS Procurement Plan)

April 2019

Table of Contents

Section 1: Introduction

The Sacramento Municipal Utility District (SMUD) is committed to the development and procurement of renewable energy for our customers. In order to grow renewable energy supplies for its customers, SMUD voluntarily created three separate programs: a green pricing program called “Greenergy,” a shared solar program called “SolarShares,” and a Renewables Portfolio Standard (RPS) Program (prior to legislation mandating the program).

In 1997, SMUD began Greenergy, which allows participating residential customers to select a 100% renewable product to serve 100% or 50% of their monthly electricity demand, respectively, in addition to their regular electricity bill. Commercial Greenergy customers pay an additional amount per kWh of electricity usage to serve 100% or 50% of their monthly electricity demand using renewables, on top of their regular rates. Commercial Greenergy customers can also purchase 1 MWh blocks of a 100% renewable product. SMUD has significantly expanded Greenergy in the last few years and is planning to revise the program structure in the near future,

In 2008, SMUD launched a pilot program called SolarShares, which allowed customers to receive a portion of their electricity usage from an off-site solar system. Participants saw a SolarShares charge, and a credit associated with the solar generation. The initial 1 MW pilot was fully subscribed quickly. Since then the program has grown and now includes options for large commercial customers as well. In 2016, SMUD significantly expanded the SolarShares program by extending the pilot SolarShares program to large commercial customers, signing agreements to deliver 150 MW. SMUD plans to roll out a residential SolarShares expansion and a new SolarShares option for new residential construction in the future.

These two voluntary programs result in SMUD customers engaging in renewable procurement beyond the RPS mandates in place. State law (SB 350) recognizes this additional procurement by allowing electricity sales to these customers that are supported by specific renewable resources to be excluded from overall retail sales prior to calculating SMUD’s RPS obligation.

In 2001, SMUD established its initial RPS goals, and by 2008 had established goals of procuring 20% of its retail electricity sales from eligible renewable energy resources by 2010 and 33% by 2020 (SMUD’s RPS goals). In 2002 (and in later statutes modifying the initial law), the State of California established an RPS for retail sellers of 20% of retail sales served with electricity from eligible renewable energy resources by December 31, 2010. The RPS statutes at that time did not specifically obligate local publicly owned electric utilities (POUs) such as SMUD with percentage goals and deadlines, nor did the state law require POUs to satisfy state eligibility rules for renewable energy resources to count toward their RPS goals. Nevertheless, POUs were required to consider and implement an RPS that met the “intent of the Legislature”.

Senate Bill 2 in 2011 (SBX1-2) established an RPS goal of 33% by 2020 for local publicly-owned electric utilities (POUs) as well as retail sellers. SMUD achieved the 20% RPS in 2010, with resources meeting the state eligibility rules, and is on target to achieve the required 33% RPS by 2020. Senate Bill 350 (SB 350, 2015) modified provision of the RPS and set a 2030 RPS target of 50%, which was further modified by Senate Bill 100 (SB 100, 2018) to establish a 60% RPS target by 2030 and a planning goal of serving 100% of retail sales with zero carbon resources by 2045.

SMUD's RPS policy is stated in SMUD Board Strategic Direction (SD) 9. SD9 includes the RPS goals of 20% by 2010, 33% by 2020, and 60% by 2030[1], and also sets policies for energy efficiency goals, clean distributed generation, and greenhouse gas reduction. Staff strives to reach the policy goals in SD9 in the most effective and efficient way practicable. SMUD balances the multiple policies in SD9 with other Board policies including those established for high levels of reliability (SD4), competitive rates (SD2), access to capital markets (SD3), and the local environment (SD7). SMUD also undertakes research, development and demonstration (RD&D) activities (SD10) that contribute to the RPS and other SD9 goals. Balancing the achievement of SMUD's RPS and other policies involves an integrated resource planning (IRP) process.

As required by Public Utilities Code (PUC) § 399.30 (a), and by the *Enforcement Procedures for the Renewable Portfolio Standard for Local Publicly Owned Utilities (CEC RPS Regulations)*, Section 3205(a), SMUD adopted a renewable energy resources procurement plan in 2013. Given the legislative changes to RPS requirements from SB 350 and SB 100, as well as the passage of time since the initial plan adoption, SMUD is adopting a revised procurement plan – this document – describing how it will achieve its RPS procurement requirements for each compliance period established by law through 2030.

In December 2011, SMUD's Board approved SMUD's RPS Enforcement and Compliance (Enforcement) Plan, pursuant to SBX1-2. In November 2013, SMUD's Board adopted a revised Enforcement Plan to ensure compliance with the *CEC RPS Regulations*. The Enforcement Plan confirms SMUD's commitment to comply with the *CEC RPS Regulations.*

Section 2: Renewable Procurement and RPS Compliance

SMUD has met its RPS compliance obligations for the first (2011 – 2013) and second (2014 – 2016) compliance periods and is well under way to meeting the established targets for the third (2017 – 2020) compliance period, per *CEC RPS Regulations*, Section

[1] SMUD's SD-9 goal was most recently revised on October 18, 2018 to reflect the latest 60% requirement enacted in SB 100. This revision also established "Net-zero" goals for SMUD in 2040 and 2050, whereby investments to reduce transportation and building GHG emissions locally "zero-out" remaining GHG emissions from SMUD's power plants.

3204)[2,3]. Table 1 illustrates the RPS compliance targets for 2017 through 2030, as provided in PUC § 399.30 (c)(2). The targets in Table 1 for years not specifically identified (interim targets) in PUC § 399.30 (c)(2) are based on a straight-line interpolation between the targets for the years specified (2020, 2024, 2027, & 2030). The CEC has not yet incorporated updated targets to reflect a 60% RPS by 2030, and therefore the interim targets are SMUD's current best estimates.

Table 1: RPS Compliance Targets

	Compliance Period 3				Compliance Period 4				Compliance Period 5			Compliance Period 6		
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
RPS Target (% of Retail Sales)	27%	29%	31%	33%	35.8%	38.5%	41.3%	44%	46.7%	49.3%	52%	54.7%	57.3%	60%

Table 2 shows the expected procurement from contracted and planned eligible renewable contracts as well as owned resources that can be allocated and retired for SMUD's RPS compliance. This estimate is based on SMUD's December 2018 load forecast[4]. Note that this renewable energy procurement shows our estimated availability of resources but does not indicate that the associated Renewable Energy Certificates (RECs) will all be retired for the RPS. Most of these contracts reflect projects that are on-line and generating electricity, or contracts that have been executed with an expected commercial online date. The table excludes generation from resources that are allocated to meet SMUD's Greenergy and SolarShares retail sales. For resources that may be used to serve multiple programs, any generation not used to meet RPS requirements is excluded from Table 2. The values in Table 2 incorporate a geothermal project that includes capacity buildout through 2020, a new wind project scheduled online in 2019, and 2 new solar projects expected online in 2021 and 2022.

SMUD expects to retire RECs from existing and planned resources to fully achieve compliance in the compliance periods through 2024. SMUD plans to extend contracts and/or contract for new resources to achieve compliance in subsequent compliance periods (see RPS Deficit – Additional Resources Needed). Table 2 shows adequate eligible renewable procurement to enable this compliance with the addition of new resources after 2024.

SMUD's currently procured renewable energy resources are predominately Portfolio Content Category (PCC) 0 and PCC 1 RECs. SMUD has procured some PCC 3 RECs from our customers' distributed generation systems under SB 1. SMUD is developing a strategy to optimize our renewables portfolio and is actively pursuing contracts for PCC 2 RECs and considering additional PCC 3 RECs and alternative uses of biomethane to maximize value and meet compliance period requirements subject to *CEC RPS*

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[2] For historical compliance in the first and second compliance periods, see CEC reports on POU RPS compliance.

[3] SMUD notes that the CEC has not yet changed the *CEC RPS Regulations* to implement provisions of SB 350 and SB 100, but believes that any changes established will have minimal impact, if any, on compliance in the third compliance period.

[4] Note that this load forecast is more recent than and updated from the forecast that underlaid the modeling in SMUD's overall Integrated Resource Plan. This is in keeping with the general concept that IRPs are not "set in stone" but will be revised to reflect updated information.

Regulations, Section 3204 (c). As this strategy is considered and potentially implemented, the PCC procurement shown in Table 2 will change, but SMUD will remain in compliance with the portfolio balance requirements.

Table 2: SMUD's Renewable Resources and Compliance Requirements

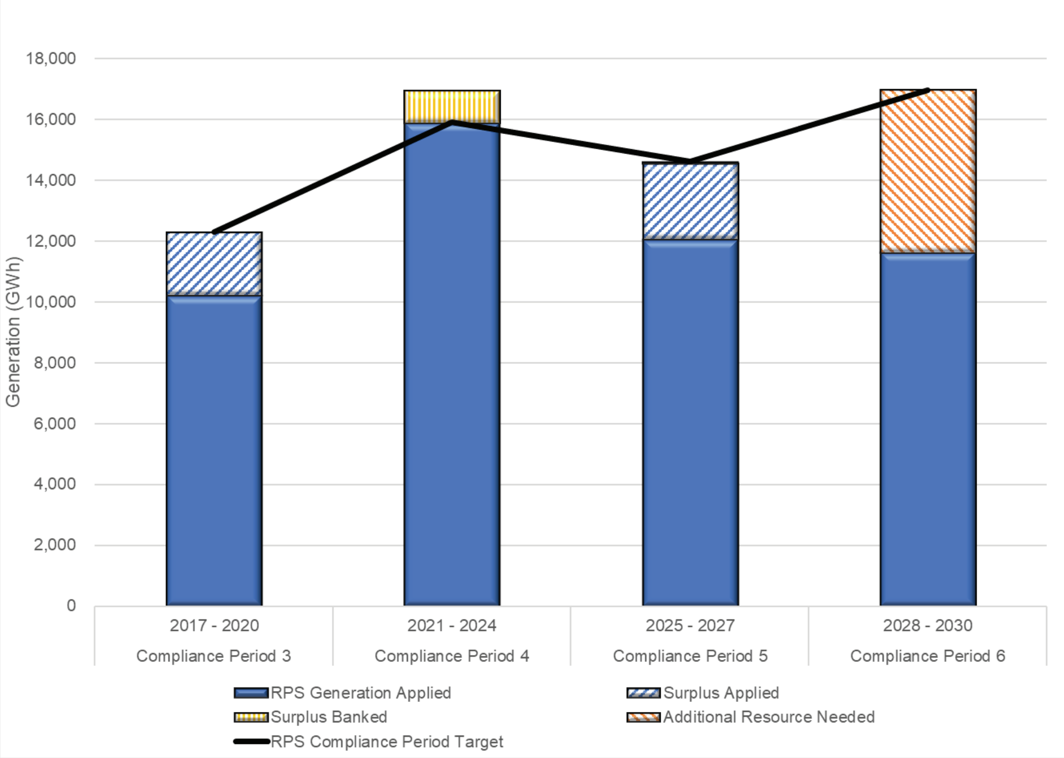
	Compliance Period 3 2017 - 2020	Compliance Period 4 2021 - 2024	Compliance Period 5 2025 - 2027	Compliance Period 6 2028 - 2030
RPS Compliance Period Target (GWh)	**12,298**	**15,910**	**14,610**	**16,973**
Category 1 Minimum	75%	75%	75%	75%
Category 3 Maximum	10%	10%	10%	10%
Procurement by Technology (GWh)				
Biomass/Biogas /Biomethane	4,171 GWh	5,126 GWh	3,657 GWh	3,628 GWh
Geothermal	1,004 GWh	1,471 GWh	1,085 GWh	1,071 GWh
Solar	543 GWh	2,227 GWh	1,530 GWh	1,214 GWh
Wind	3,963 GWh	7,679 GWh	5,439 GWh	5,381 GWh
Eligible Hydro < 30MW	520 GWh	450 GWh	337 GWh	337 GWh
Total Generation	**10,202 GWh**	**16,953 GWh**	**12,048 GWh**	**11,631 GWh**
Surplus Applied	2,097 GWh	0 GWh	2,500 GWh	0 GWh
Total Applied to RPS Target	**12,298 GWh**	**15,910 GWh**	**14,610 GWh**	**16,973 GWh**
RPS Deficit - Additional Resources Needed	0 GWh	0 GWh	61 GWh	5,341 GWh
Surplus Banked	*0 GWh*	*1,043 GWh*	*0 GWh*	*0 GWh*
Procurement by Portfolio Content Category (GWh)				
Category 0 RECs	4,134	4,486	1,997	1,970
Category 1 RECs	5,781	12,048	9,738	9,348
Category 2 RECs	0	0	0	0
Category 3 RECs	245	377	283	283
Pre-June 1, 2010 Category 3 RECs	41	41	31	31
Total	**10,202**	**16,953**	**12,048**	**11,631**
Long-Term Contracts				
Percentage of Long-Term RECs	>99%	>99%	>99%	>99%

Note: Values in this table are subject to change.

Table 2 shows the PCC 0, PCC 1 and PCC 3 RECs, that SMUD expects from currently committed eligible renewable resources. The majority of procurement from contracts/agreements signed after June 1, 2010 are PCC 1, sufficient to exceed the portfolio balance requirements specified in PUC § 399.16 (c) and in the *CEC RPS Regulations*, Section 3203 (c)-(e) with regards to procured electricity products for compliance with RPS requirements. SMUD intends to retire RECs within 36 months of generation to fully meet the portfolio balance requirements. Figure 1 illustrates SMUD's compliance through 2030 utilizing compliance period generation and banked resources, along with any surplus and additional resource needs.

SBX1-2 permitted POUs to accumulate excess procurement in one compliance period for use in a subsequent compliance period. Under these original excess procurement rules, only RECs from long-term contracts and owned resources could count in the excess procurement calculation. This meant that any RECs from short-term contracts were subtracted out before a POU could determine if it had any excess procurement. These original excess procurement rules will remain in place until the end of Compliance Period 3. SMUD has banked excess procurement from Compliance Periods 1 and 2 for use in subsequent periods, pursuant to these existing excess procurement rules, which are currently implemented in *CEC RPS Regulations*, Section 3206 (a)(1).

Figure 1: SMUD RPS Resources and Compliance



SB 350 significantly amended the excess procurement rules, allowing a POU to calculate its excess procurement without first subtracting out RECs from short-term contracts. Under these new excess procurement rules, only PCC 1 and PCC 0 RECs may be carried forward as excess procurement. This means that if a POU has excess PCC 2 or PCC 3 RECs, those RECs will not be able to be banked and carried forward. While these new excess procurement rules will become mandatory starting in Compliance Period 4, a POU may use these new excess procurement rules in Compliance Period 3 if the POU meets the 65% long-term procurement requirement specified in PUC § 399.13 (b). SMUD notes that the CEC has not yet updated the *CEC RPS Regulations* to incorporate the revised treatment of excess procurement enacted in SB 350. However, SMUD's procurement practices and Procurement Plan apply these new excess procurement rules, based on the updated provisions in PUC § 399.13 (a)(4)(B).[5] Pursuant to the additional provisions in SB 350, SMUD elects to apply the new excess procurement provisions starting in

[5] See section entitled" Excess Procurement" at the end of this plan for more detail. If the CEC's eventual implementation differs from what SMUD is expecting herein, procurement will be adjusted to reflect the final regulations.

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Compliance Period 3. SMUD's banked excess procurement as of the end of Compliance Period 2 was 3,551,599 RECs. SMUD also had historic carryover that was completely retired and used to meet our Compliance Period 2 obligations. SMUD's total historic carryover balance, as approved by the CEC, was 2,666,104 RECs.[6]

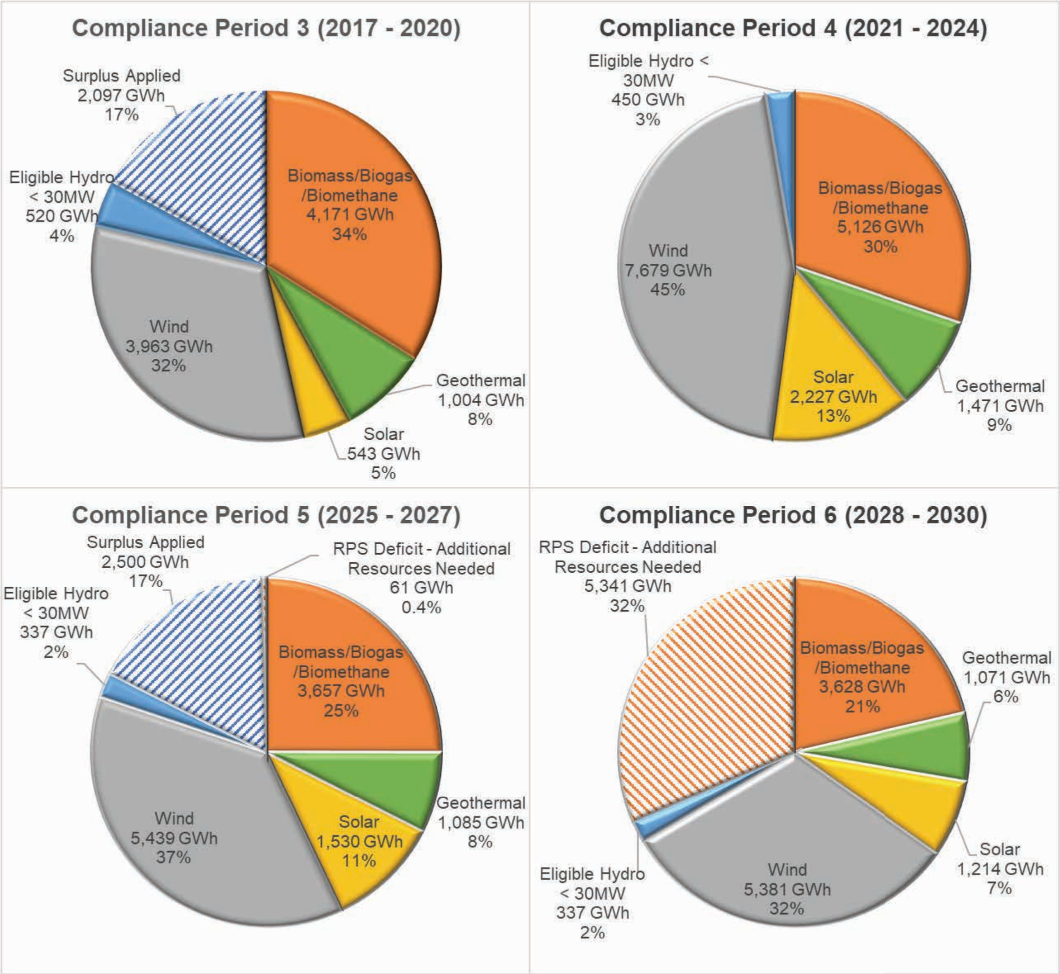
SMUD's 2018 IRP reflects a need for additional renewable procurement starting in Compliance Period 5 (2025 – 2027), which under the IRP is met with additional solar and wind resources. SMUD intends to procure these resources earlier than the need shown in the modelling, to ensure compliance under the increased RPS requirements from SB 100. The IRP analysis and modelling were completed prior to the passage of SB 100, and therefore was based on a 50% RPS by 2030. However, SMUD's SD 9 goal and this procurement plan have been updated to reflect meeting the mandated 60% RPS by 2030. The RPS compliance period targets in Table 2 reflect SMUD's latest load forecast, as of December 2018. Meeting the State's current 60% RPS will require SMUD to procure additional resources starting in Compliance Period 5 (2025 – 2027).

SMUD is continuing to pursue additional renewable resource options not included in Table 2 and will continue to evaluate new options to ensure compliance through 2030 and in preparation for compliance beyond 2030. SMUD's continued efforts to optimize our renewables portfolios and procurement value to our customers, will likely alter the timing of additional resource procurements. SMUD will closely monitor resource availability relative to compliance obligations and will strategically assess when to pursue new resources through solicitations, direct contract with developers and marketers, and building our own. Figure 2 provides an estimate of SMUD's RPS resource mix through 2030.

Note that all tables and figures are based in part on expected generation through 2030. Actual generation and resource mixes may change as SMUD procures additional resources or resources generate differently than expected. SMUD's projected compliance may also be affected by the difference between the current forecast retail sales and actual sales through 2030. The market response to SMUD's investments in electrification, along with the uncertain technological changes in that market may lead to increases or decreases in actual sales from those forecast. In addition, changes in customer demand for our Greenergy and SolarShares programs, and in the resources used to supply those programs, can impact the "net" sales used to calculate SMUD's RPS obligations.

[6] Historic carryover balance was verified by the CEC as part of the Compliance Ceriod 1 verification and compliance determination process. The verification report was adopted by the CEC in January 2017, and the compliance determination was issued by the CEC's executive director in June 2017.

Figure 2: SMUD RPS Compliance Resource Mix



Section 3: Procurement Process

The SMUD Board of Directors (Board) establishes all RPS goals and SDs and considers them in short and long-term renewable resource investment decisions. As mentioned above, the SDs include policies for environmental performance, power reliability, carbon emissions reductions, financial objectives, and renewables RD&D and procurement. SMUD's IRP process helps ensure SMUD achieves its long-term goals and SDs, at a reasonable cost. The IRP process helps develop balanced recommendations that support renewable procurement and development actions and other SMUD SDs.

SMUD owns and operates eligible renewable energy resources, with the resulting electricity products used for RPS compliance. SMUD owns a number of small hydro, wind, and solar PV facilities, which are listed in Appendix A.

SMUD also procures eligible renewable electricity resources by contract through formal solicitation processes and unsolicited offers. These proposals and offers are evaluated based on benefits, costs and overall value to SMUD's customer/owners.

Section 4: Historic Carryover

Since the Board approved an RPS goal in 2001, SMUD has actively procured renewable energy. In order to ensure meeting its annual RPS goals and, specifically, the 2010 target, SMUD procured renewable energy exceeding the annual targets established in the *CEC RPS Regulations*. Per the *CEC RPS Regulations*, "Historic carryover" means a POU's procurement that satisfies the following criteria:

1. The procurement is for electricity and the associated renewable energy credit generated in 2004-2010 by any eligible renewable energy resource that met the Commission's RPS eligibility requirements in effect when the original procurement contract or ownership agreement was executed by the POU.
2. The original contract or ownership agreement was executed by the POU prior to June 1, 2010.
3. The procurement is in excess of the sum of the 2004-2010 annual procurement targets defined in section 3206 (a)(5)(D) and was not applied to the RPS of another state or to a voluntary claim.

Through the CEC's verification process, SMUD received 2,666,104 RECs of historic carryover from renewable energy consistent with these criteria. SMUD applied all its historic carryover towards the requirements for Compliance Periods 2.

Section 5: Portfolio Content Category 0 Resources

SMUD has some of its current renewable supply procured pursuant to contracts or ownership agreement executed before June 1, 2010 from resources that met the CEC's eligibility requirements when the resources were procured. Pursuant to PUC § 399.16 (e) as implemented in *CEC RPS Regulations, Section 3202 (2),* the electricity product from these "grandfathered resources" are counted in full toward the RPS requirements. The CEC reporting forms refer to these resources as PPC "0" resources.

SMUD has modified or extended some of these contracts and as a result has changed the status of the resources from the date of modification from PCC 0 to PCC 1. See Appendix A for a listing of SMUD's resources.

Section 6: Additional Committed Category Resources

SMUD continued to develop and procure renewable supply after June 1, 2010. SMUD's Feed-In Tariff (FIT) solicitation in 2009 resulted in nearly 100 MW of solar PV systems that have since been constructed under the FIT. SMUD expanded its Solano Wind Facility in the Rio Vista area in 2012, by completing construction of Solano Phase III, which added 128 MW of capacity. In 2013, SMUD supported the construction of several local dairy digestor projects in SMUD's service territory. Some of SMUD's dairy digester resources have experienced operational issues and are currently offline.

SMUD also has 3 "grandfathered" common carrier biomethane contracts that are certified to provide renewable biomethane to the Cosumnes Power Plant (CPP), along with a biogas cleanup facility near the Sacramento Regional County Sanitation District's (SRCSD) wastewater treatment plant that began injecting the cleaned biogas into SMUD's dedicated pipeline for combustion at CPP in 2011. This SRCSD biogas was previously combusted at SMUD's Carson power plant, and may still be combusted there when combustion at CPP is infeasible (due to planned or unplanned outages). SMUD is considering maximizing the value of these resources and may use them for purposes other than the RPS (in which case other RPS resources will be procured for compliance as needed).

SMUD has also added, or extended, the following contracts since the procurement plan was last updated:

- Patua 1 – 29 MW geothermal & solar PV facility began deliveries at the end of 2013.
- Rancho Seco PV – 10.9 MW solar PV facility started delivery at the end of 2015.
- Kiefer I – SMUD signed a new 8.3 MW contract that allowed SMUD to continue receiving biogas generation from this facility in 2016.
- Kiefer 2 – SMUD signed a new 5.7 MW contract that allowed SMUD to continue receiving biogas generation from this facility in 2016.
- CalEnergy – 30 MW geothermal facility started deliveries of the first 10 MW in 2017, with the remaining 20 MW to be phased in through 2020.
- Great Valley Solar (Recurrent) – 60 MW solar PV facility began delivering to SMUD at the end of 2017.
- Highwinds Extension – SMUD extended the contract with this 50 MW wind facility in 2016.

SMUD currently has some PCC 3 resources through the implementation of the SB-1 solar roof-top incentive program. The amount of PCC 3 generation represented is a fraction of the PCC 3 maximum in the CEC regulations. SMUD has not used PCC 2 resources for RPS compliance in the past, but as mentioned earlier, is actively pursuing strategic procurement of PCC 2 as part of optimizing our overall renewables portfolios and anticipates adding PCC 2 resources in the near future. See Appendix A for a listing of SMUD's resources.

Section 7: Future Procurement

Since meeting its RPS goal for 2016, SMUD continues to conduct activities to procure renewable energy to meet future obligations. Activities include the following:

- SMUD staff will continue to seek additional renewables resources to address the current RPS resource shortfall forecast in Compliance Period 5 and beyond. As part of SMUD's ongoing efforts to optimize its overall renewables portfolio, including the addition of PCC 2 and PCC 3 resources, when SMUD will need additional resources is expected to shift. SMUD plans to closely monitor any changes to when additional resources are needed and ensure that requests for proposals for new projects are available well in advance of expected shortfalls, or that other means of identifying, negotiating, and contracting for new resources take place. SMUD will consider both in-state and out-of-state resources and will continue to look at the potential to develop new renewable resources within SMUD's service territory.
- SMUD continually reviews existing renewable contracts set to expire within the next few years to examine the possibility of extending and/or modifying these contracts.
- SMUD is developing a new small hydro facility near the current Slab Creek project that is scheduled to be online by the middle of 2019.
- A contract for a new 200 MW wind facility scheduled to begin delivery in June 2019.
- An agreement to purchase generation from new 13 MW solar PV facility located in SMUD's service territory, which is expected to begin operations starting in 2020. RECs from this facility are expected to be used for SMUD's voluntary renewable programs, with any surplus available to meet RPS requirements.
- SMUD is working on developing a new 160 MW solar PV facility located at SMUD's Rancho Seco site which is expected to be online in 2021. RECs from this facility are expected to be used primarily for SMUD's voluntary renewable programs, with any surplus available to meet RPS requirements.
- A contract for a new 100 MW solar PV facility located in Southern California that is scheduled to be online in 2022. RECs from this facility may be used for SMUD's voluntary renewable programs, with any surplus available to meet RPS requirements.
- SMUD is looking into repowering the early phases of our existing Solano Wind facility, in addition to adding a phase 4 to SMUD's Solano project (potential net addition of up to 77 MW). SMUD's Board has not made any decisions yet whether to proceed with this project.
- SMUD staff has supported development of new local dairy digester projects and continues to look for opportunities to economically expand this resource in SMUD's service territory.

- As SMUD's SolarShares and Greenergy Programs are expected to expand, staff continues to look for solar and renewable projects to supply these programs.

Some of the resources used to serve SMUD's voluntary renewable programs are listed here since any excess generation not used to serve load from those programs will be used to meet RPS obligations. However, this plan and any requirements or provisions herein, apply to procurement to serve SMUD's RPS obligations, notwithstanding the provisions of Section 8 of this plan.

These planned activities and other future procurement may also contribute to meeting SMUD's RPS compliance requirements, along with existing resources and committed projects. In addition, they will add to SMUD's renewable fuel diversity and contribute toward SMUD's longer term carbon reduction goals.

Section 8: PUC § 399.30 (c)(4) – Retail Sales Exclusion for Voluntary Green Pricing and Shared Renewable Programs

Starting in Compliance Period 2, and pursuant to PUC § 399.30 (c)(4), the SMUD Board adopts rules permitting SMUD to exclude from its retail sales the kWh generated by an eligible renewable energy resource that is credited to a participating customer pursuant to a voluntary green pricing program, subject to the following additional requirements:

- Any exclusion shall be limited to electricity products that do not meet the portfolio content criteria set forth in PUC § 399.16 (b)(2) or (3).
- Any RECs associated with electricity credited to a participating customer shall not be used for compliance with the RPS procurement requirements and shall be retired on behalf of the participating customer, and shall not be further sold, transferred, or otherwise monetized for any purpose.
- To the extent possible for generation that is excluded from retail sales under this provision, SMUD shall seek to procure those eligible renewable energy resources that are located in reasonable proximity to program participants.

The CEC has not yet implemented PUC § 399.30 (c)(4) in the currently effective *CEC RPS Regulations*. However, pursuant to PUC § 399.30 (c)(4)SMUD has excluded certain green pricing and shared renewable load served by eligible renewable energy resources (qualifying as PCC 1 or PCC 0) from its total retail sales for purposes of determining RPS compliance obligation in Compliance Period 2. SMUD will continue to apply the exclusions allowed by this provision in future compliance periods for eligible renewable energy resources that are located within a reasonable proximity of program participants, to the extent possible as specified by this section.

Section 9: PUC § 399.13 (b) as referenced by PUC § 399.30 (d)(1) – Long-Term Procurement

Pursuant to PUC § 399.30 (d)(1), the SMUD Board adopts procurement requirements consistent with PUC § 399.13 (b), as follows:

- Beginning January 1, 2021, at least 65% of the procurement SMUD counts toward the renewables portfolio standard requirement of each compliance period shall be from its contracts of 10 years or more in duration or in its ownership or ownership agreements for eligible renewable energy resources.

SMUD's procurement strategy shall ensure that SMUD continues to comply with the provisions of PUC § 399.13 (b), as referenced in PUC § 399.30 (d)(1). SMUD currently procures (or owns) greater than 99% of our RPS resources through long-term contracts (greater than or equal to 10 years), and intends to continue procuring all PCC 1 resources to meet RPS compliance from long-term contracts (with limited exceptions, and ensuring the 65% requirement is met). SMUD may procure PCC 2 and PCC 3 resources through short-term contracts, but will ensure that at least 65% of all RECs applied to meet any compliance period obligation are from long-term contracts.

Furthermore, as provide by PUC § 399.13 (a)(4)(B)(iii), as referenced in PUC § 399.30 (d)(1), SMUD hereby provides notice of its intent to comply with the provision of PUC § 399.13 (b) for the compliance period beginning in January 1, 2017 (Compliance Period 3), and thereby applying the provisions of PUC § 399.13 (a)(4)(B)(i) and (ii) to Compliance Period 3.

Section 10: PUC § 399.13 (a)(4)(B) as referenced in PUC § 399.30 (d)(1) – Excess Procurement

As described in Section 1 above, SB 350 made modifications to the excess procurement requirements in PUC § 399.13 (a)(4)(B), and no longer requires subtraction of short-term contracts in calculating excess procurement. The CEC has not yet implemented these new excess procurement rules into the *CEC RPS Regulations*. However, SMUD incorporates these new rules into this plan and will use the updated provisions of this section in calculating excess procurement.

As stated in Section 9, SMUD has elected to comply with the long-term procurement requirements of PUC § 399.13 (b) early, and as permitted by PUC § 399.13 (a)(4)(B)(iii), the new excess procurement rules will apply to SMUD starting in Compliance Period 3 (2017 – 2020).

Pursuant to PUC § 399.30 (d)(1), and consistent with SMUD's election to meet the long-term procurement requirements of PUC § 399.13 (b) early, the SMUD Board adopts procurement requirements consistent with PUC 399.13 (a)(4)(B), as follows:

For Compliance Period 1 and 2, the following rules shall apply:

- SMUD may apply excess procurement in one compliance period to a subsequent compliance period, subject to the following limitations:
  - Electricity products that exceed the maximum limit for PCC 3, as specified in PUC § 399.16 (c), must be subtracted from the calculation of excess procurement.
  - Electricity products procured under contracts of less than 10 years in duration shall be subtracted from the calculation of excess procurement, unless the electricity product meets the grandfathering requirements of PUC § 399.16 (d).
- SMUD may begin accruing excess procurement as of January 1, 2011.
- Excess procurement meeting these requirements may be applied to any future compliance period and shall not expire.

For Compliance Period 3 and all subsequent compliance periods, the following rules shall apply:

- SMUD may apply excess procurement in one compliance period to a subsequent compliance period, subject to the following limitations:
  - Electricity products that are classified as PCC 2 or PCC 3 may not be counted as excess procurement.
  - Electricity products that exceed the maximum limit for PCC 3, as specified in PUC § 399.16(c), must be subtracted from the calculation of excess procurement.
- Excess procurement meeting these requirements may be applied to any future compliance period and shall not expire.

Appendix – SMUD RPS Resources

Existing Resources

Resource	Technology	PCC	Short/Long	Capacity		Termination
CPP	Biomethane	PCC 0 & 1	Long			Post 2030
Solano Phase 1 & 2	Wind	PCC 0	Long	102		Post 2030
Solano Phase 3	Wind	PCC 1	Long	128		Post 2030
Camp Far West	Small Hydro	PCC 0	Long	8		Post 2030
Kiefer 1	Biogas	PCC 1	Long	8.3		2025
Kiefer 2	Biogas	PCC 1	Long	5.7		2026
Highwinds	Wind	PCC 1	Long	50		2025
Yolo Landfill	Biogas	PCC 0	Long	3.4		2026
Santa Cruz (GRS, Landfill)	Biogas	PCC 0	Long	1.9		2024
Simpson/Tacoma Biomass	Biomass	PCC 0	Long	55		2021
Loyalton Cogen (SB 859)	Biomass	PCC 1	Short	4.2		2023
Cal Energy	Geothermal	PCC 1	Long	30		Post 2030
Patua 1	Geothermal	PCC 1	Long	21		Post 2030
Robbs Peak	Small Hydro	PCC 0	Long	29		Post 2030
Jones Fork	Small Hydro	PCC 0	Long	11.5		Post 2030
Slab Creek #	Small Hydro	PCC 1	Long	2.7		Post 2030
RanchoSeco PV *	Solar PV	PCC 1	Long	10.9		Post 2030
Great Valley Solar *	Solar PV	PCC 1	Long	60		Post 2030
FIT **	Solar PV	PCC 1	Long	100		Post 2030
WAPA CVP	Small Hydro	PCC 0	Long	13.5		Post 2030
New Hope Diary #	Biogas	PCC 1	Long	0.4		Post 2030
Van Warmerdam Diary	Biogas	PCC 1	Long	0.6		Post 2030
Van Steyn Dairy	Biogas	PCC 1	Long	0.2		2025
Cal Expo	Solar PV	PCC 0	Long	0.4		2020
Commercial PV (SB-1, PCC 3)	Solar PV	PCC 3	Long			Post 2030

Future Resources - Contracted/Under Development

Resource	Technology	PCC	Short/Long	Capacity	Online	Termination
South Fork Powerhouse	Small Hydro	PCC 1	Long	1.9	2019	Post 2030
Grady	Wind	PCC 1	Long	200	2019	Post 2030
Biomass Resource	Biomass	PCC 1	Short	2.7	2019	2024
Wildflower Solar I *	Solar PV	PCC 1	Long	13	2020	Post 2030
Rancho Seco PV II *	Solar PV	PCC 1	Long	160	2021	Post 2030
NTUA ***	Solar PV	PCC 1	Long	100	2022	Post 2030

Future Resources - Planned/Under Consideration

Resource	Technology	PCC	Short/Long	Capacity	Online	Termination
Solano Wind Phase 4	Wind	PCC 1	Long	77	2022	Post 2030

\# These facilities are currently offline.

* These resources will be used primarily to serve load from SMUD's SolarShares programs and not available for RPS compliance needs. However, any excess generation not needed to serve SolarShares loads may be applied to SMUD's RPS compliance needs.

** Generation from the FIT resources will be used to serve SMUD's voluntary programs on occasion as needed (i.e. unexpected fluctuations in loads, delay in solar/renewable resource development, etc.)

*** The NTUA agreement specifically identifies the use of generation from this resource may be used to meet RPS requirements or to serve load from our voluntary renewable programs (SolarShares, Greenergy).

All RECs from these facilities are tracked in WREGIS and retired into the appropriate retirement accounts (compliance or voluntary program) to ensure no double counting between programs occurs.

18. **Appendix C:** Board resolution and IRP adoption documents

RESOLUTION NO. 18-10-11

WHEREAS, SMUD has a long history of environmental leadership in our resource planning and procurement activities and has adopted greenhouse (GHG) reduction goals that exceed those set by the State of California; and

WHEREAS, California enacted the Clean Energy and Pollution Reduction Act of 2015 (SB 350, De Leon) to set new objectives in clean energy and pollution reduction for 2030 and beyond; and

WHEREAS, those objectives include an increase from 33 percent to 50 percent by 2030 in the procurement of renewable energy from eligible renewable resources, as well as achievement of carbon reduction targets established by the California Air Resources Board (CARB) for large local publicly owned electric utilities; and

WHEREAS, SB 350 requires SMUD to adopt an **Integrated Resources Plan (IRP)** by January 1, 2019, to ensure that SMUD achieves those objectives, including:

- Meeting the GHG reduction target range established by CARB for SMUD of between 1.089 million to 1.919 million metric tons (MT) by 2030;
- Ensuring procurement of at least 50% eligible renewable energy resources by 2030;
- Meeting specific state policy goals, including minimizing impacts on ratepayers' bills, ensuring system reliability, and minimizing emissions of localized air pollutants in disadvantaged communities; and

WHEREAS, California recently enacted SB 100 (DeLeon, 2018), which accelerates renewable energy procurement to 60% by 2030 and directs further study of how electric utilities like SMUD can ultimately supply 100% of their annual sales of electricity from zero carbon resources by 2045; and

WHEREAS, SB 350 requires SMUD to adopt a process to update its **IRP** at least once every 5 years to ensure that SMUD is meeting those objectives; and

WHEREAS, it is a core value of SMUD to provide our customers and community with a sustainable power supply through the use of integrated resource planning; and

WHEREAS, staff has analyzed multiple, long-term carbon reduction scenarios and summarized key findings and recommendations in the attached **SMUD IRP** to determine how to achieve those objectives; and

WHEREAS, SMUD conducted a lengthy public process to review the SMUD IRP and held public meetings on April 4, 2018, June 6, 2018, August 1, 2018, September 5, 2018, October 2, 2018, and October 18, 2018, and received extensive public input; and

WHEREAS, staff has proposed a scenario that reduces GHG emissions to 1.35 million metric tons by 2030 through investments in vehicle and building electrification, energy efficiency, clean distributed resources, RPS eligible renewables, large hydro generation and biogas, consistent with its Strategic Direction (SD-9) goal of reducing local GHG emissions equivalent to the remaining 1.0 million metric tons from SMUD power plants by 2040 ("Net Zero in 2040"); and

WHEREAS, in order to achieve Net Zero in 2040, the **SMUD IRP** provides that SMUD will make aggressive investments in energy efficiency programs and electrification that will lower transportation and building emissions within our local community; and

WHEREAS, over the next three years, SMUD expects to spend tens of millions of dollars on transportation electrification and programs to promote fuel-switching for water and space heating in both residential retrofit and new construction; and

WHEREAS, Net Zero in 2040 preserves flexibility to integrate and balance new supplies of renewables using internal SMUD resources as well as the resources of the regional grid in order to achieve the lowest cost carbon reductions for our customers; and

WHEREAS, Net Zero in 2040 will prioritize procurement of local, clean resources to minimize localized air pollutants and GHG emissions on low-income and disadvantaged communities in the Sacramento region; and

WHEREAS, Net Zero in 2040 provides a roadmap for SMUD's ongoing environmental leadership through aggressive carbon reductions in the Sacramento region; **NOW, THEREFORE,**

BE IT RESOLVED BY THE BOARD OF DIRECTORS OF THE SACRAMENTO MUNICIPAL UTILITY DISTRICT:

Section 1. This Board adopts the **SMUD Integrated Resources Plan (SMUD IRP)** substantially in the form set forth in **Attachment H.**

Section 2. This Board adopts a process for updating the SMUD IRP at least once every five years, substantially in the form of Appendix I to the **SMUD IRP.**

Section 3. This Board adopts revisions to **Strategic Direction SD-9, Resource Planning**, to, among other things, reflect a greenhouse gas emissions (GHG) target of 1.35 million metric tons (MT) in 2030 and a GHG target of Net Zero in 2040, substantially in the form set forth in **Attachment I**.

Approved: October 18, 2018

INTRODUCED: DIRECTOR BUI-THOMPSON				
SECONDED: DIRECTOR KERTH				
DIRECTOR	AYE	NO	ABSTAIN	ABSENT
FISHMAN	X			
ROSE	X			
BUI-THOMPSON	X			
SHIROMA			X	
KERTH	X			
TAMAYO		X		
SLATON	X			

Attachment H

SMUD IRP

Scenarios Summary Report

September 2018

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Appendices

Attachment A – August 1, 2018, Presentation at Energy Resources & Customer Services Committee and Special SMUD Board of Directors Meeting

Attachment B – September 5, 2018, Presentation at Energy Resources & Customer Services Committee and Special SMUD Board of Directors Meeting

Attachment C – October 2, 2018, Presentation at the Finance & Audit Committee and Special SMUD Board of Directors Meeting

Attachment D – October 18, 2018, Presentation at the SMUD Board of Directors Meeting

Attachment E – SMUD Process for Update of the Integrated Resource Plan

1 Introduction

Sacramento Municipal Utility District (SMUD) is a community-owned, not-for-profit electric utility. Our purpose is to enhance the quality of life for our customers and community.

SMUD's Integrated Resource Plan (IRP) is a living document that is intended to guide efforts to supply reliable electricity in an environmentally responsible and cost-effective manner through the study of planning strategies that achieve high-level policy goals. SMUD's IRP is updated annually to address staff recommendations for additional study and to reflect legislative, regulatory, market and technology changes.

In 2015, California enacted the Clean Energy and Pollution Reduction Act (Senate Bill 350, SB 350) that imposed new requirements on both investor-owned and publicly-owned electric utilities. SB 350 directs SMUD to adopt an IRP by January 1, 2019 that meets specific RPS procurement and GHG reduction goals, while considering other state policy goals, such as reliability, ratepayer impacts, and effects on disadvantaged communities, and submit the plan to the California Energy Commission (CEC) for review and comment. SB 350 also requires SMUD's Board to adopt a process to refresh the IRP every five years to ensure the utility meets the state's goals. This IRP will be approved by our Board of Directors following a public process and be the basis for an IRP filing with the California Energy Commission by April 30, 2019 that meets the CEC's very specific guidelines.

This IRP relies on numerous planning assumptions that help model SMUD's electricity system under various scenarios. While these assumptions and scenarios are plausible and simulated using the best available modeling techniques, the results are illustrative, not deterministic of near-term budgets and plans, and show how different planning targets affect operations, revenues, reliability, and costs from a policy perspective.

Given the policy-level approach of an IRP, staff emphasizes that this study is not forecasting or predicting outcomes. Periodically, staff will update SMUD's IRP to reflect market trends allowing for careful determination of resource planning investments during shorter-term decision-making windows.

SMUD's IRP process informs long-term strategic development by the various business units within SMUD and efforts are made to ensure the assumptions align with short-term 5-year and 3-year plans as well as SMUD's annual budget and enterprise metrics. The IRP should not be treated as a business plan, budget recommendation, customer program choice or design, or as a commitment to procure any immediate resource. Rather, an IRP provides broad direction and goals that guide the strategies developed and implemented by staff with specific program design and project implementation done during 1-year, 3-year, and 5-year planning cycles.

1.1 Purpose: Advancing SMUD's Environmental Leadership

It is a core value of SMUD to provide our customers and community with a sustainable power supply through the use of an integrated resource planning process. A sustainable power supply is currently defined in Strategic Direction-9 (SD-9) as one that reduces SMUD's net long-term greenhouse gas (GHG) emissions to serve retail customer load to 350,000 metric tons (MT) by 2050 (equivalent to a 90% reduction below 1990 levels), while assuring reliability of the system, minimizing environmental impacts on land, habitat, water quality, and air quality, and maintaining a competitive position relative to other California electricity providers. SD-9 was established by SMUD's Board of Directors in 2004 and has provided the road map for SMUD's ongoing environmental leadership. The GHG emission reduction target was established in 2008 with refinements to the policy continuing over the years based on market and regulatory conditions.

As mentioned above, in 2015 California imposed new regulatory conditions applicable to SMUD's GHG emission reduction targets and other resource choices. SB 350 requires SMUD's IRP to ensure that SMUD:

1. Meets the GHG reduction target range established by the California Air Resources Board (CARB) for SMUD of between 1.089 million to 1.919 million metric tons by 2030;
2. Procures at least 50% eligible renewable energy resources by 2030;
3. Meets the following state policy goals:
    a. Enable each POU to serve its customers at just and reasonable rates;
    b. Minimize impacts on ratepayers' bills;
    c. Ensure system and local reliability;
    d. Strengthen the diversity, sustainability, and resilience of the bulk transmission and distribution systems, and local communities;
    e. Enhance distribution systems and demand-side energy management; and
    f. Minimize localized air pollutants and other GHG emissions, with early priority on disadvantaged communities.

SB 350 also requires SMUD planners to address the following resources in the IRP:

1. Energy efficiency and demand response;
2. Energy storage requirements
3. Transportation electrification;
4. A diversified procurement portfolio consisting of both short and long-term electricity, electricity-related, and demand response products; and
5. Resource adequacy requirements.

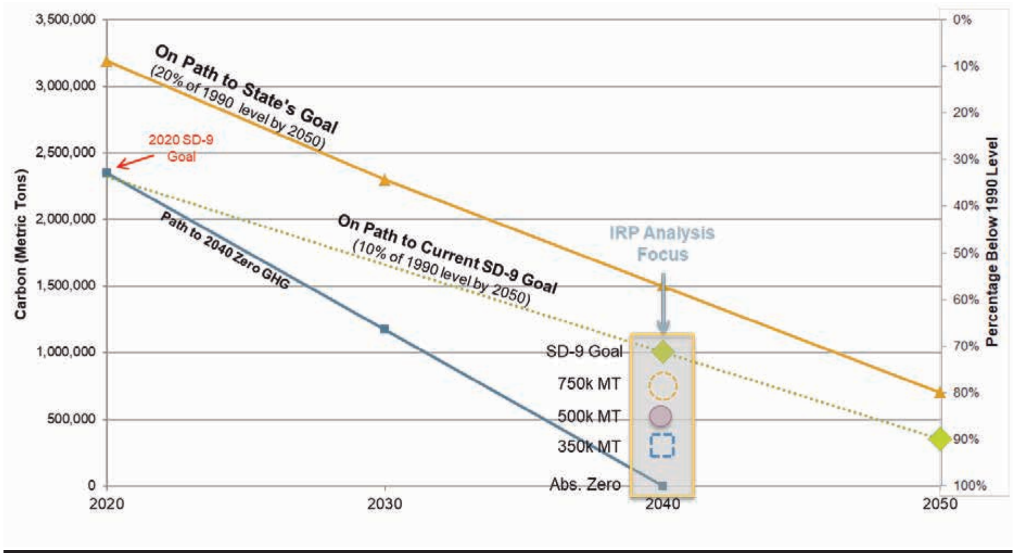
Finally, SB 350 requires the "Renewable Procurement Plan" pursuant to the RPS law (PUC Section 399.30) to be incorporated in the IRP. This will require an update of SMUD's original renewable procurement plan, adopted in 2013.

Subsequently, Senate Bill 338 (Skinner, Chapter 389, Statutes of 2017) requires POU IRPs to consider existing renewable generation, grid operational efficiencies, energy storage, and distributed energy resources, including energy efficiency, to meet their energy needs during peak demand hours.

In addition, California just enacted SB 100 that accelerates renewable energy procurement to 60% by 2030.[1] SB 100 also directs further study of how utilities may ultimately supply 100% of annual retail sales of electricity from zero-carbon resources by 2045. SMUD's SD-9 GHG emission reduction target of 90% below 1990 levels by 2050 is consistent with the 2030 target carbon emissions range set under SB 350.

SMUD's Board of Directors has directed staff to use this planning cycle to study additional steps to advance SMUD's environmental leadership through aggressive GHG reductions. Accordingly, SMUD staff looked at various GHG trajectories out to 2040 as illustrated in Figure 1. These scenarios included SMUD's current SD-9 goal path to reduce GHG emissions 90% below 1990 levels by 2050, and an absolute zero emissions scenario in 2040.

Figure 1: Current policy benchmarks and scenario targets



[1] This report predated passage of SB100. The analysis in this report reflects the SB350 RPS requirements including the 50% RPS by 2030 and a GHG footprint of 1.65 million metric tons. After this report was issued in July, SMUD studied the impact of SB100 and determined with the higher 60% RPS by 2030, SMUD's new GHG footprint would be about 1.35 million metric tons.

3 | Page

Consistent with SB 350's requirements, the objectives of this planning cycle are to analyze the maximum level of grid de-carbonization achievable at just and reasonable rates without sacrificing reliability, while ensuring system and local reliability, and examining economy-wide carbon savings. Key questions include the long-term role of SMUD's existing thermal fleet, how quickly SMUD can achieve GHG reductions both within the electric sector and across the local economy, and the overall cost of various alternatives.

As a community-owned utility, SMUD is uniquely positioned to holistically consider and balance both utility-specific carbon reductions plus SMUD investments in local community measures that may achieve greater carbon reductions overall. This study focuses on procuring renewable generation and accelerating local vehicle and building electrification to achieve significant carbon reductions over the planning horizon. These strategies-- renewable generation and electrification -- are most directly within SMUD's core competencies and represent promising areas to achieve additional GHG reductions above and beyond efforts that SMUD, or other state actors, are already undertaking. These broad strategies also include targeted energy efficiency and demand reduction programs, investments in disadvantaged communities, and other customer renewables and storage resources.

The key metrics used to evaluate these options within SMUD's IRP include impacts on:

- SMUD's resource portfolio
- System reliability and reserves
- Costs and rate impacts

SMUD contracted with Energy and Environmental Economics, Inc. (E3) to use their California PATHWAYS model to develop a long-term, carbon reduction scenario. This scenario is designed to be consistent with other state plans and California's long-term climate goals and estimate SMUD's contribution to community-wide carbon reductions.

SMUD worked with E3 to develop and evaluate plausible carbon reduction scenarios using the PATHWAYS model. Through this model, electric vehicle adoption, building electrification, and other economy-wide carbon reduction strategies were modeled for each year between 2020 and 2050, such that SMUD would achieve a minimum 90% reduction in electricity sector GHG emissions by 2050, while supporting high levels of energy efficiency and electrification economy-wide.

This report is a summary of key findings and includes recommendations for how to achieve GHG reductions by 2030 consistent with SB 350. SMUD's preferred scenario identifies options and aggregate costs to achieve this 2040 carbon reduction plan. The planning targets adopted pursuant to this Draft IRP by SMUD's Board will be used to develop an SB 350-compliant IRP document for submittal to the California Energy Commission in April 2019.

While the planning horizon for this IRP is 2040, it recognizes SMUD's current SD9 goal for 2050, is based in part on the Statewide 80 percent by 2050 scenario modeling done by E3, and is also targeted to meet the 2030 IRP requirements established by SB 350 and SB 338. The following Draft Requirements Table indicates this IRP's connection to the 2030 IRP requirements.

Draft Requirements Table

IRP Requirement	SMUD Action
Is consistent with the 2030 GHG reduction target range established by CARB: Below 1.086 million to 1.919 MMT	SMUD IRP target for 2030 is 1.35 MMT[2]
Procures at least 50% eligible renewable energy resources by 2030	SMUD IRP plans for 60% renewables by 2030, consistent with the new SB 100 target[3]
Serve customers at just and reasonable rates	SMUD IRP includes discussion of rate impacts of various scenarios, and rejects scenario with unreasonable rate impacts
Minimize impacts on ratepayers' bills	SMUD IRP minimizes bill impacts while balancing other goals
Ensure system and local reliability; reflect resource adequacy requirements	SMUD IRP includes added resources to ensure reliability, rejects scenario that may cause reliability concerns
Strengthen the diversity, sustainability, and resilience of the bulk transmission and distribution systems	SMUD IRP document will discuss projects to address transmission needs and the resilience of the distribution system
Enhance distribution systems and demand-side energy management; Consider energy efficiency and demand response	SMUD IRP includes demand-side energy management; SMUD IRP Document will include significant discussion of these programs and the distribution system
Minimize localized air pollutants and other GHG emissions, with early priority on disadvantaged communities	SMUD IRP includes plans to electrify transportation, which should cause significant reductions in localized air pollutants; SMUD IRP document will discuss in detail
Consider energy storage	SMUD IRP includes investments in storage resources through several scenarios; rejects scenario with most expensive storage
Consider/Discuss transportation electrification	SMUD IRP envisions significant investments in transportation electrification
Include a diversified procurement portfolio of both short and long-term electricity, electricity-related, and demand response products	SMUD IRP includes consideration of short and long-term procurement of both demand and supply side products

[2] See footnote 1.
[3] See footnote 1.

IRP Requirement	SMUD Action
Consider existing renewable generation, grid operational efficiencies, energy storage, and distributed energy resources, including energy efficiency, to meet energy needs during peak hours	SMUD IRP document will include discussion of resources to meet needs during peak demand hours
Include latest Renewable Procurement Plan	SMUD will update its Renewable Procurement Plan to reflect chosen scenario and provide in IRP document

2 Decarbonization Scenario Analysis in PATHWAYS

The PATHWAYS model is a long-term economy-wide energy and GHG accounting model, taking user-defined scenario input assumptions to evaluate changes in total resource costs, electricity demand, and GHG emissions, among other metrics. The PATHWAYS model is used in California by state agencies for scenario planning purposes, including by the California Air Resources Board in California's 2017 Climate Change Scoping Plan.[4] Most recently, the California Energy Commission published a report detailing several long-term energy scenarios through 2050 which use E3's PATHWAYS model to evaluate strategies that achieve the state's climate goals.[5]

2.1 SMUD's Climate Commitment and California's Climate Goals

SMUD has committed to achieving a 90% reduction in our electricity portfolio GHG emissions by 2050, relative to 1990 levels. In addition, SMUD is also committed to help the Sacramento region more broadly reduce GHG emissions outside of the electricity sector.

California, through Executive Orders S-3-05 and B-30-15, established a policy goal of reducing total statewide GHG emissions to 80% below 1990 levels by 2050 ("80x50"). Senate Bill 32 (Pavley, 2016) subsequently required CARB to ensure that statewide GHG emissions be reduced to at least 40% below 1990 levels by 2030. These ambitious goals are commensurate with the intent of the 2015 Paris Agreement aiming to limit global mean climate change to less than 2°C.

SMUD's programs that contribute to reducing GHG emissions outside of the electric sector include investments in energy efficiency and electrification, cross-agency efforts

[4] Available at: https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm
[5] "Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model", CEC publication number: CEC-500-2018-012. Available at: https://www.ethree.com/wp-content/uploads/2018/06/Deep_Decarbonization_in_a_High_Renewables_Future_CEC-500-2018-012-1.pdf

to mitigate high global warming potential gases, and tree planting and land stewardship to increase the sequestration of carbon in trees and soils.

Reducing GHG emissions in the Sacramento region will require transformation of the local energy economy in ways that expand beyond current state policies and mandates. SMUD is poised to enable and facilitate critical pieces of this transition. Furthermore, SMUD expects to be a major partner, with other local, regional and state players in ensuring that Sacramento is on a path to achieving the state's ambitious climate goals.

2.2 Greenhouse Gas Emissions in Sacramento and the SMUD Service Territory

Today, GHG emissions in the Sacramento region are highest in the transportation sector. Cars, trucks and other vehicles represent approximately 45% of the total regional GHG emissions. Direct emissions from homes and businesses represent about 19% of total regional GHG emissions, while the electricity sector, including imports used to serve SMUD's load, represents about 18% of the region's total, which was about 2.5 million metric tons (MMT) in 2015. Industry and agricultural emissions make up the remaining 17%. [6]

Overall in the Sacramento region, GHG emissions are estimated at approximately 14 MMT of CO_2-equivalent in 2015, or about 3% of the statewide total. With a population of 1.5 million people in 2015, this means that the per capita emissions in Sacramento are 9.5 MT. This is slightly lower than the statewide average (11 MT per capita), largely due to the lower prevalence of industry, as well as SMUD's lower GHG emissions intensity of electricity.

To achieve an 80% reduction in GHG emissions by 2050, emissions in the Sacramento region must fall to 2.6 MT per capita by 2040 and 1.3 MT per capita by 2050. This dramatic reduction in GHG emissions is reflected in the SMUD IRP analysis, as well as SMUD's role in enabling this transition.

2.3 SMUD's Role in Meeting Climate Goals and Benefits to the Sacramento Community

SMUD is making significant investments to reduce GHGs on many fronts across our service territory. SMUD is investing in energy efficiency programs in both commercial and residential buildings to reduce electricity and natural gas consumption. SMUD and our customers are investing in renewable generation, including community and rooftop solar PV. To further reduce GHG emissions in buildings, SMUD has recently launched a gas-to-electric conversion incentive program through our Home Performance Program. This first-in-the-state program is particularly beneficial to SMUD's customers with

[6] As estimated in the PATHWAYS model.

rooftop solar PV and is likely to be expanded in the coming years to enable higher levels of building electrification and greater carbon savings in buildings.

SMUD is also helping to achieve carbon reductions in the transportation sector through our electric vehicle programs and by investing in vehicle charging infrastructure. Finally, SMUD is working with city and county agencies on many fronts. We are partnering to phase out and replace equipment capable of emitting high global warming potential gases. We are also working to increase soil and tree carbon sequestration through better stewardship of our region's lands and forests tree planting programs.

Reducing GHG emissions in Sacramento through energy efficiency, electrification and renewable energy will also improve local air quality, reduce criteria pollutant emissions and improve local health. Sacramento sits at the crossroads of some of California's major interstates (Highways 99 and 50 and Interstates 80 and 5), and as a result is impacted by the local air pollution and criteria air pollutants associated with vehicles and trucking along these interstates. Electrification of the transportation sector will reduce both GHG emissions as well as local air pollution, improving health outcomes in Sacramento communities in tangible ways. By reducing or eliminating the combustion of natural gas in buildings, electrification in buildings will improve both indoor air quality and safety, in addition to the potential for bill savings and improved comfort.

2.4 The California PATHWAYS model

To incorporate an economy-wide perspective on GHG mitigation in the SMUD IRP process, E3 used their California PATHWAYS model to develop a SMUD-specific outlook for a long-term, carbon reduction scenario that is consistent with achieving a 90% reduction in SMUD's electricity sector emissions by 2050, and an 80% reduction in economy-wide GHG emissions in the region.

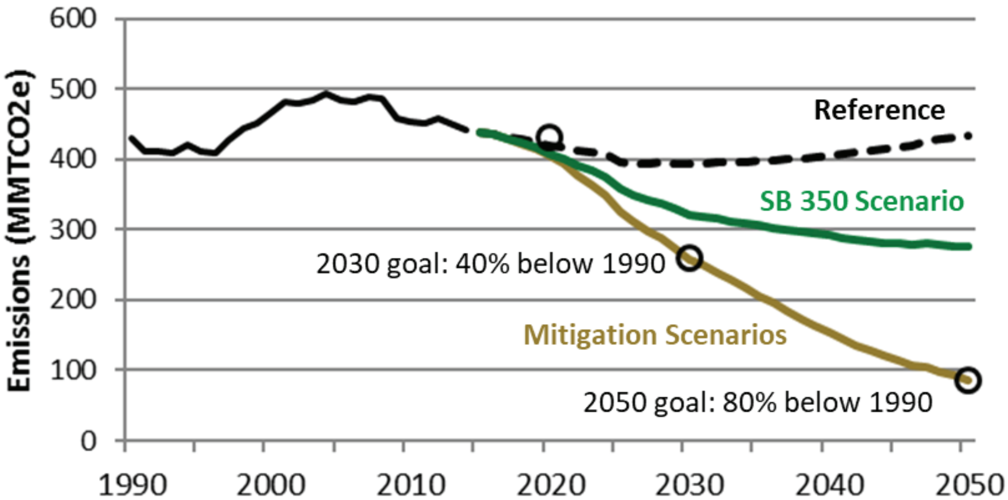
Within the context of SMUD's IRP, the PATHWAYS model is used to forecast demand-side electric load assumptions in buildings and the transportation sector that are consistent with achieving a low-carbon future in the SMUD service area. The load assumptions are used to populate the electric resource planning tools RESOLVE and PLEXOS used by the IRP modeling team.

E3 analyzed three kinds of scenarios (Figure 2):

- "Reference" or business-as-usual scenario,
- Senate Bill 350 scenario incorporating most existing policy commitments through 2030 and excluding the effects of cap-and-trade, which is not directly modeled in PATHWAYS, and
- Mitigation scenarios that achieve the State's 2030 and 2050 goals.

E3 found that large emission reductions, either from cap-and-trade or other complementary policies, will be needed beyond those achieved by existing policies in the Senate Bill 350 scenario. This gap, between current policy and the state's climate goals, is illustrated by the difference in GHG emissions in the green "SB 350 Scenario" line and the gold "Mitigation Scenarios" line shown in Figure 2. SMUD is planning for a future along the gold "Mitigation Scenarios" line but getting there is not a foregone conclusion. Achieving this low-carbon future will require significant new efforts at the local, regional and state level and can be facilitated and helped by SMUD's own actions and programs, as discussed below.

Figure 2: California GHG emissions, historical and projected in PATHWAYS



2.5 The California 80x50 Scenario

Through their scenario analysis, E3 has identified four "pillars," or key strategies that are needed to reduce GHG emissions across the economy. These include:

1) Energy efficiency and conservation across all sectors of the economy -- in buildings, transportation and industry.
2) Electrification of fossil fuels, and switching to cleaner electricity, while
3) Deploying low-carbon fuels, including sustainable biofuels and low-carbon, renewable electricity.
4) Non-energy and non-combustion sources of GHG emissions must be mitigated, including through the prevention and elimination of methane leaks, fugitive methane, and high global warming potential gases while carbon sequestration in soils and lands must be enhanced.

Electrification of the transportation sector is a critical component of any scenario that meets the state's long-term climate goals. Electrification of buildings will be needed, and electrification of industry may also be needed. The "High Electrification" scenario is one of the 10 mitigation scenarios E3 developed for the CEC and includes a high level of energy efficiency across sectors, renewable electricity, and electrification of transportation and buildings. This scenario was used as a basis for developing the electrification assumptions for the SMUD IRP.[7] We refer to this scenario here as the "California 80x50" scenario.

The California 80x50 scenario entails profound transformations of how energy is consumed and generated across all sectors, as illustrated in Figure 3. Notable landmarks include:

- 100% of new car sales are zero-emission vehicles (ZEV) by 2035. This represents a level of ZEV adoption that likely exceeds Governor Brown's ambitious goal in Executive Order B-48-18 to get 5 million ZEVs on the road by 2030.
- 100% of new water and building space heater sales are electric heat pumps by 2040. This represents a fundamental change from the current practice in the state and the Sacramento region where natural gas water and space heating continue to represent the majority of equipment sales.
- 74% of electricity is generated from zero-carbon resources by 2030 and nearly 100% is zero-carbon by 2050. This is in-line with, if not more aggressive than, state goals and mandates.

For Sacramento to achieve this 80x50 scenario, SMUD, as well as state, local and regional partners, will have critical roles in enabling and speeding the adoption of electric vehicles, building electrification and renewable electricity. It is not a foregone conclusion today that these ambitious climate goals will be achieved absent significant new de-carbonization efforts and investments by many stakeholders.

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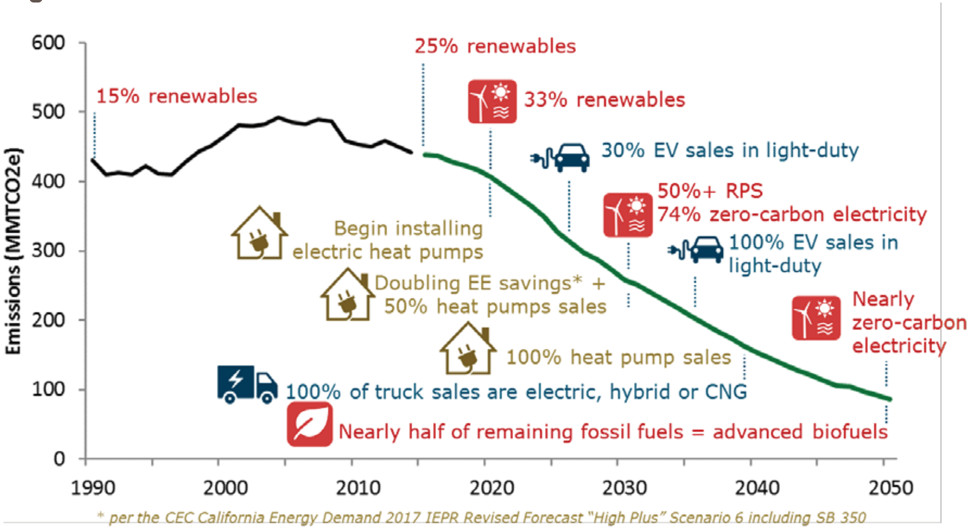
[7] For the SMUD IRP, the High Electrification scenario was modified somewhat to exclude hydrogen fuel cell cars and trucks, and to instead include more battery-electric vehicles and some electrification of industrial end uses. This modification is intended to reflect the greater confidence in electric vehicle technology relative to hydrogen vehicles, which would also require a large amount of new infrastructure to support centralized hydrogen electrolysis and a fuel distribution network.

Figure 3: Timeline of GHG Reduction Measures in the California 80x50 Scenario



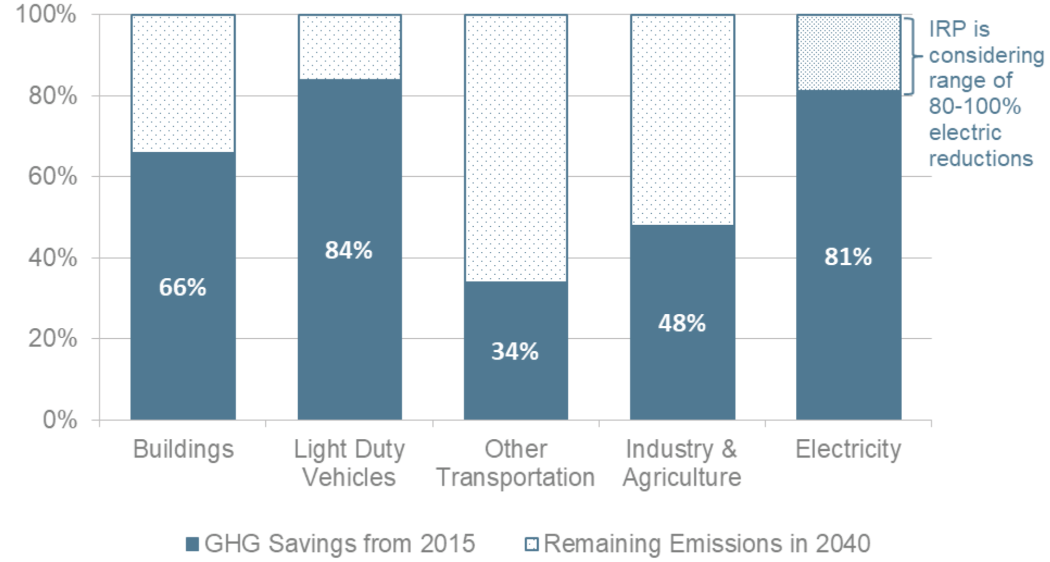
Note: SB 100 changed the 2030 50% RPS noted in the chart above to a 60% level.

2.6 GHG Emissions and Savings in Sacramento and the SMUD Service Territory

For SMUD's IRP, the statewide California 80x50 scenario was downscaled to SMUD's service territory using SMUD-specific energy demand data and building stock information. When SMUD-specific information was not available, scaling factors were applied based on SMUD's share of the Sacramento region's population, households, commercial square footage, and vehicle miles traveled. The resulting present-day GHG emissions were benchmarked to the Sacramento County 2005 GHG emissions inventory and found close agreement with emissions modeled for 2015 in PATHWAYS. The future trajectory of GHG emissions reflects the SMUD territory's contribution to the state's 80x50 goals.

The model results indicate that by 2040, the largest share of emissions reductions in Sacramento would come from new renewable electricity and the electrification of light-duty vehicles. In this scenario, 100% of light duty vehicle sales are zero-emission by 2035. In the 80x50 scenario, Sacramento area GHG emissions from electricity and light duty vehicles are both reduced by over 80% relative to 2015 levels by 2040. The next largest source of emissions savings are expected to come from energy efficiency and electrification in buildings. In this scenario, direct GHG emissions from buildings are reduced by over 65% relative to 2015 by 2040 (Figure 4).

Figure 4: Sacramento Region GHG Savings, Percent Reduction below 2015 Levels by Sector in 2040



2.7 Implications for SMUD Demand-Side Programs

The levels of increasing energy efficiency and electrification in the 80x50 scenario contemplates a significant increase in SMUD-led investments in energy efficiency and other distributed energy resources. These investments would benefit both SMUD customers as well as the environment, and would use SMUD funding to leverage private investment in clean energy resources. For example, a SMUD incentive to install a high-efficiency electric water heater can encourage a customer to also bring their own investment dollars to the table, reducing both carbon emissions and their energy bills over the long-run.

In the California 80x50 scenario, total incremental SMUD investments in clean-energy distributed energy programs are assumed to increase nearly ten-fold between 2020 and 2040, expanding from $10 million per year in 2020 to nearly $100 million per year by 2040 as part of an effort to unlock deeper levels of carbon savings through 2040.

In this scenario, starting in 2020, an increase of $10 million per year SMUD investment in distributed energy resources is assumed to be split nearly evenly between energy efficiency, building electrification, and transportation electrification programs. This mix, as well as the total level of SMUD-driven distributed clean energy investments (DER), is assumed to change over time through 2040, as SMUD's DER programs support higher levels of carbon reductions across the region.

Also in this scenario, by 2040, nearly 65% of this estimated $100 million per year investment would fund energy efficiency programs, including incentives for building upgrades in homes and businesses. Approximately 20% of these investments are assumed to fund building electrification efforts across the SMUD service territory, including incentives to replace natural gas space heating and water equipment with high efficiency electric alternatives.[8] The remaining 15% of these investments are assumed to be used to enable and encourage the electrification of vehicles across the Sacramento region, above and beyond the levels of vehicle electrification funded with Low Carbon Fuel Standard credits.

2.8 Implications for SMUD: Electricity Demand

Electrification in the transportation and building sectors will lead to higher electricity demand in the Sacramento region, necessitating additional procurement of renewable resources to meet increasing loads consistent with the mandates of SB 350, SB 32 and SB 100. SMUD's IRP analysis is designed to reflect and incorporate these effects on both loads and resource procurement needs, consistent with meeting or exceeding the state's RPS and climate goals and SMUD's Strategic Directions.

In the California 80x50 scenario, SMUD's investments in DERs combined with the potential impacts of other state and regional policies to support energy efficiency and electrification result in a significant transformation of SMUD's electricity demands over time. High levels of energy efficiency are offset by new electrification loads from transportation, buildings and industry, especially after 2030 (Figure 5). This electrification reduces GHG emissions by displacing internal combustion engines with electric and hybrid-electric vehicles, and gas space heaters with more efficient electric heat pumps.

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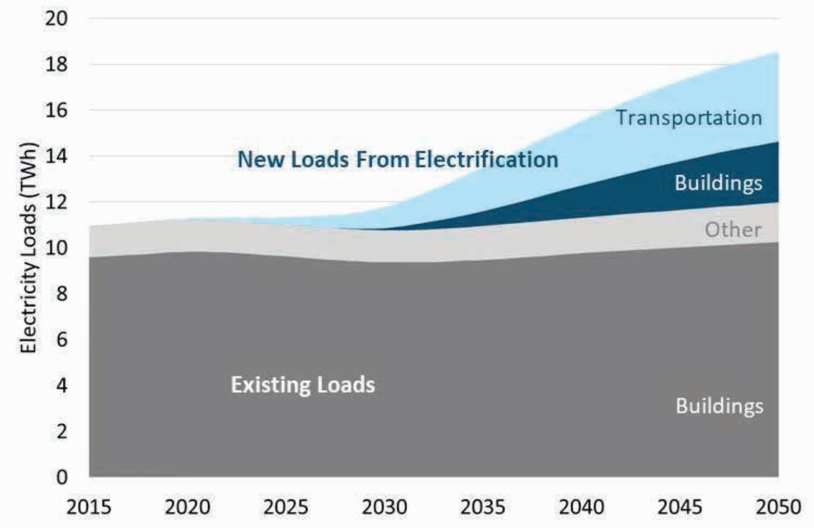
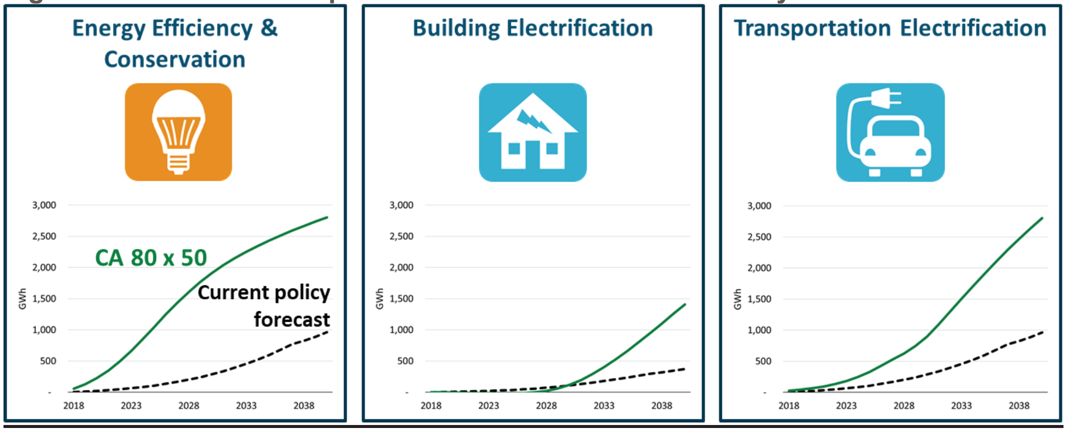
[8] Funding in this category will be dependent on the implementation of local and state codes that are consistent with electrification as a fuel substitution. If the code changes are not made, the investment share will need to be greater.

Figure 5: SMUD total electricity loads projected in PATHWAYS 80x50 Scenario



Electric load modifiers from the California 80x50 scenario are used in the IRP electric generation portfolio analysis described in the next section. Relative to current projections, large increases in energy efficiency, building electrification, and transportation electrification are necessary to meet the 80x50 goal. The annual energy demand projections from these load modifiers are illustrated in Figure 6.

Figure 6: Load modifiers provided to RESOLVE for electricity sector simulations



The “current policy forecast” in Figure 6 also illustrates the levels of energy efficiency savings and electrification in buildings and vehicles that might be achieved with current policies and programs, as they existed before passage of SB 100 in 2018[9]. This "current policy forecast" is unlikely to be sufficient to achieve the California 80x50 scenario or the state's long-term carbon goals. In order to accelerate the transition to a significantly lower carbon future, SMUD is planning for a more ambitious deployment of energy efficiency, building electrification and transportation electrification in Sacramento, driven by SMUD programs and new local, regional, and state policies and programs. This accelerated deployment of energy efficiency and electrification is represented by the California 80x50 trajectories in Figure 6.

3 SMUD Electricity Portfolio Optimization Analysis

To further examine SMUD's role in facilitating a deep decarbonization future for our customers and community and to link the state's decarbonization goals to our IRP, SMUD undertook a detailed analysis of its long-term generation portfolio options, at a level consistent with achieving the SB 350 planning target by 2030, and a minimum of 90% reductions by 2050, relative to 1990 levels, as articulated in SD-9. To explore the investments needed to decarbonize our electricity supply, as well as the associated costs and average customer retail rate impacts, SMUD developed a range of long-term scenarios tied to future GHG reduction goals. The analysis of these scenarios provides SMUD's customers and the Board with actionable information on the relative viability of potential electricity sector GHG emissions goals, in the context of a high energy efficiency and high electrification future.

3.1 Scenarios Analyzed

SMUD examined multiple scenarios representing a range of long-run, electricity sector GHG trajectories and infrastructure goals. Each of these scenarios is consistent with the California 80x50 scenario, including high levels of energy efficiency and electrification. These scenarios included:

- SD-9 Goal Scenario: a scenario that is consistent with SMUD's existing SD-9 GHG goal of 350,000 MT by 2050. This scenario achieves GHG emissions equal to 1.0 MMT by 2040 while preserving SMUD's existing gas generation resources, and is consistent with a trajectory to achieve a 90% reduction in GHGs (or 350,000 MT) by 2050, relative to 1990 levels.
- SD-9+ Scenarios: a range of scenarios exceeding the SD-9 trajectory that test meeting alternative GHG reduction targets— ranging from 350,000 to 750,000 MT in 2040—while preserving SMUD's gas generation resources.
- Absolute Zero Scenario: a scenario that requires SMUD to retire all existing gas generation resources and to serve its load exclusively with carbon-free resources.

[9] See footnote 1.

The key assumptions that define each of these scenarios are shown in Table 1. Each of these scenarios is consistent with a future in which SMUD, the Sacramento region, and the state as a whole are assumed to undertake a significant new effort to enable higher levels of energy efficiency, building electrification and vehicle electrification. These demand-side assumptions are represented in the table below as "80x50" on the Distributed Energy Resources category.

Table 1: Key Scenario Assumptions in 2040

	SD-9 Goal	SD-9+ Scenarios			Absolute Zero
	1,000k MT	750k MT	500k MT	350k MT	
GHG Emissions (MT)	1,000,000	750,000	500,000	350,000	—
RPS+ Level*	86%	91%	96%	98%	137%
Distributed Energy Resources	80x50	80x50	80x50	80x50	80x50
Existing Gas Generation	Maintained	Maintained	Maintained	Maintained	Retired
Balancing	Internal/ Market	Internal/ Market	Internal/ Market	Internal/ Market	Internal

** The shorthand reference to "RPS+" used in this report represents the share of SMUD's retail sales served by RPS-eligible renewable generation and carbon-free large hydro resources.

In the SD-9 and SD-9+ scenarios, SMUD's thermal fleet continues to operate through 2040 and provides needed energy and capacity for system and local reliability. The Absolute Zero scenario stands apart from the other scenarios not only because of its lower GHG target, but also because of the stringent exclusion of thermal gas-fired generation resources in the portfolio. All other scenarios allow SMUD significantly more flexibility in its effort to integrate incremental renewables while ensuring system and local reliability. The SD-9 Goal and SD-9+ scenarios allow SMUD to maintain its existing natural gas generation resources with existing levels of biomethane use to meet reliability needs, with minimal impacts on ratepayers' bills. The SD-9 Pathway and SD-9+ scenarios also allow SMUD to continue to import low cost, unspecified power from wholesale markets to meet reliability needs —thus taking advantage of a broader, more diverse pool of loads and resources—whereas the Absolute Zero scenario functionally islands SMUD from these wholesale markets, requiring SMUD to supply and balance carbon-free electricity in all hours throughout the year. These two factors significantly drive differences between the Absolute Zero scenario and the others considered in this IRP.

3.2 Modeling Methodology

E3 used RESOLVE to develop a generation portfolio to meet the policy goals in each scenario. RESOLVE is designed to inform long-term electricity system planning when high penetrations of renewable generation are considered. RESOLVE co-optimizes investment and dispatch—in this case, between 2020 and 2040 solving for the optimal investments in renewable resources as well as complementary resources such as energy storage and demand response subject to multiple constraints:

- An annual constraint on delivered renewable energy that reflects the RPS policy;
- A resource adequacy constraint to maintain reliability;
- Simplified unit commitment and dispatch constraints; and
- Scenario-specific constraints on the ability to develop specific renewable resources

RESOLVE is also used by the California Public Utilities Commission (CPUC) for development of its long-term “Reference System Plan” for the service area covered by the utilities regulated by the CPUC. E3 and SMUD worked jointly to create a version of the model designed to optimize SMUD’s future generation portfolio that reflects both SMUD’s unique system characteristics and its position as part of the broader electricity system in California and the Western Interconnection.

3.3 Key Assumptions

The following assumptions are common to all scenarios:[10]

- SMUD’s demand forecast is consistent with a transition towards California’s “80x50” climate goals (discussed in Section 2), which include high levels of energy efficiency as well as building and transportation electrification;
- DER costs assume new local and state mandates are enacted consistent with the state’s long-term objectives and that Low Carbon Fuel Standard (LCFS) incentives continue;
- Wholesale market prices in the California Independent System Operator (CAISO) and at the California-Oregon Border are based on fundamentals modeling of the loads and resources within each region; [11]
- Natural gas prices reflect market forward curves in the near term (through 2021), then linearly transition to the fundamentals forecast of Energy Information Administration’s 2017 Annual Energy Outlook by 2040;[12]
- SMUD’s existing resource portfolio is assumed to remain online throughout the course of the modeling analysis while taking into consideration expiring renewable contracts;[13]
- Renewable supply costs and projections of CAISO charges and tariffs; and
- Operational reserves assumptions for load and variable renewables.

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[10] Planning assumptions and technology costs will change over time and need to be monitored closely and revised in future IRPs.
[11] Fundamentals models develop market clearing prices based on optimal dispatch and operation of resources (e.g. thermal, hydro, renewables) to serve hourly load forecasts.
[12] https://www.eia.gov/outlooks/archive/aeo17/
[13] The Absolute Zero scenario, which assumes the retirement of all of SMUD’s existing gas resources by 2040, is an exception to this assumption.

Optimized portfolios in each scenario are constructed by adding new resources to SMUD's existing resource base. The resources considered in the optimized portfolio include:

- **Solar:** The study assumes 1,000 MW of local solar could be built in SMUD territory, and up to 180 GW of solar resources could be developed elsewhere throughout the state of California and delivered to the CAISO.
- **Wind:** In-state wind potential available to SMUD is limited to 1,200 MW. An additional 900 MW of out-of-state wind resources are included as potential wind resource options.
- **Geothermal:** The study assumes approximately 650 MW of geothermal resources from out-of-state regions (Pacific Northwest and Southern Nevada) were available for SMUD.
- **Energy Storage:** Battery storage has been added to absorb renewable oversupply. The maximum contribution toward SMUD's capacity need is 560 MW based on a "rule-of-thumb" assessment of SMUD's load shape. Future technology advancement may increase the maximum level of support battery storage could provide for local renewable integration.
- **Demand Response:** the study relies upon SMUD's forecast for available DR in SMUD territory, which starts at 85 MW in 2018 and increases to 179 MW by 2040.
- **Unspecified Capacity Resource Purchases:** As available, market resource adequacy purchases are made to meet SMUD's reliability targets. Local capacity resources could be added if cost effective or required.

Cost and performance assumptions for each resource option were determined from a combination of sources, including:

- Public technology cost estimates used in the California Public Utilities Commission 2017 IRP proceeding; [14]
- National Renewable Energy Laboratory's 2017 Annual Technologies Baseline; [15]
- Internal SMUD forecasts; and
- Energy storage costs were updated based on Lazard's Levelized Cost of Storage 3.0 analysis. [16]

[14] Page 34 http://cpuc.ca.gov/uploadedFiles/CPUCWebsite/Content/UtilitiesIndustries/Energy/EnergyPrograms/ElectPowerProcurementGeneration/irp/RESOLVE_Inputs_Assumptions_2017-09-15_redlines.pdf

[15] https://atb.nrel.gov/

[16] https://www.lazard.com/perspective/levelized-cost-of-storage-2017/

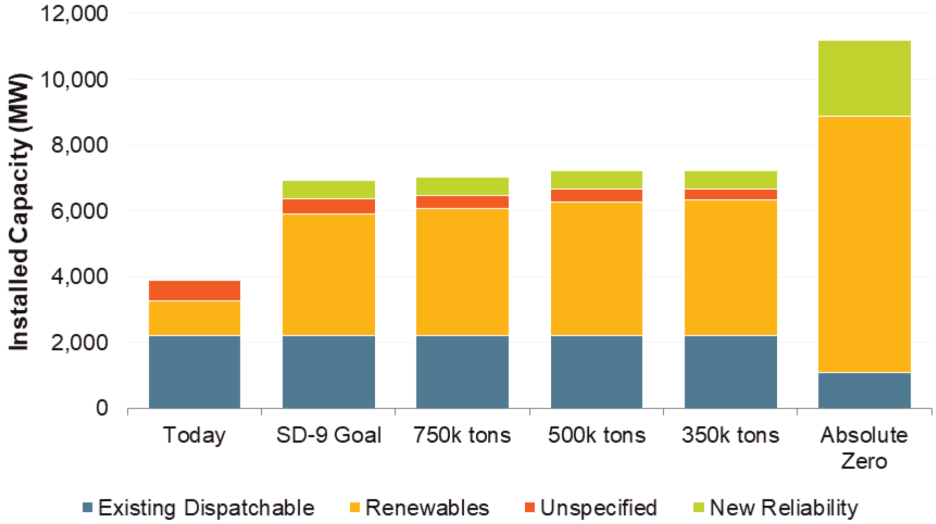
4 Portfolio Analysis

RESOLVE was used to create a portfolio of resources to meet the specific emissions targets for each scenario. The existing and new resources were categorized into one of four broad categories:

- SMUD existing dispatchable generation, including SMUD's existing natural gas resources, the UARP hydro resource, and SMUD's long-term contract for WAPA hydro;
- SMUD renewable generation, including all existing and new renewable resources;
- Unspecified capacity, representing generic capacity needed to meet reliability needs that may be supplied through market purchases or development of new capacity resources; and
- Additional reliability resources, which includes both energy storage capacity and demand response.

The selected resource portfolios for each scenario are shown in Figure 7.

Figure 7: Snapshots of 2040 SMUD resource portfolios in each scenario



Several observations can be made for these portfolios:

- Meeting SMUD's SD-9 goal by 2040 under the high levels of energy efficiency and electrification needed in the California 80x50 scenario will require significant investment in additional renewable generation capacity, including a mix of wind, solar, and geothermal resources. Whereas SMUD's existing portfolio includes roughly 1,000 MW of renewable generation capacity, a total of roughly 3,700 MW of renewable capacity is needed by 2040 to maintain a trajectory towards achieving the SD-9 goal in 2050.

- Incremental reductions in SMUD's GHG footprint in the SD-9+ scenarios can be achieved with limited additions of renewable generation capacity beyond those needed to achieve the SD-9 goal.
- The Absolute Zero scenario requires substantial investments to double the renewable capacity and more than three times the storage capacity relative to the SD-9 goal and SD-9+ scenarios. In addition, the duration of storage resources needed in the Absolute Zero scenario is substantially longer (48 hours) than the storage resources in the other scenarios (4 hours). This very long duration is added to mitigate reliability risks in the absence of SMUD's existing dispatchable gas resources.

4.1 System and Local Reliability Implications

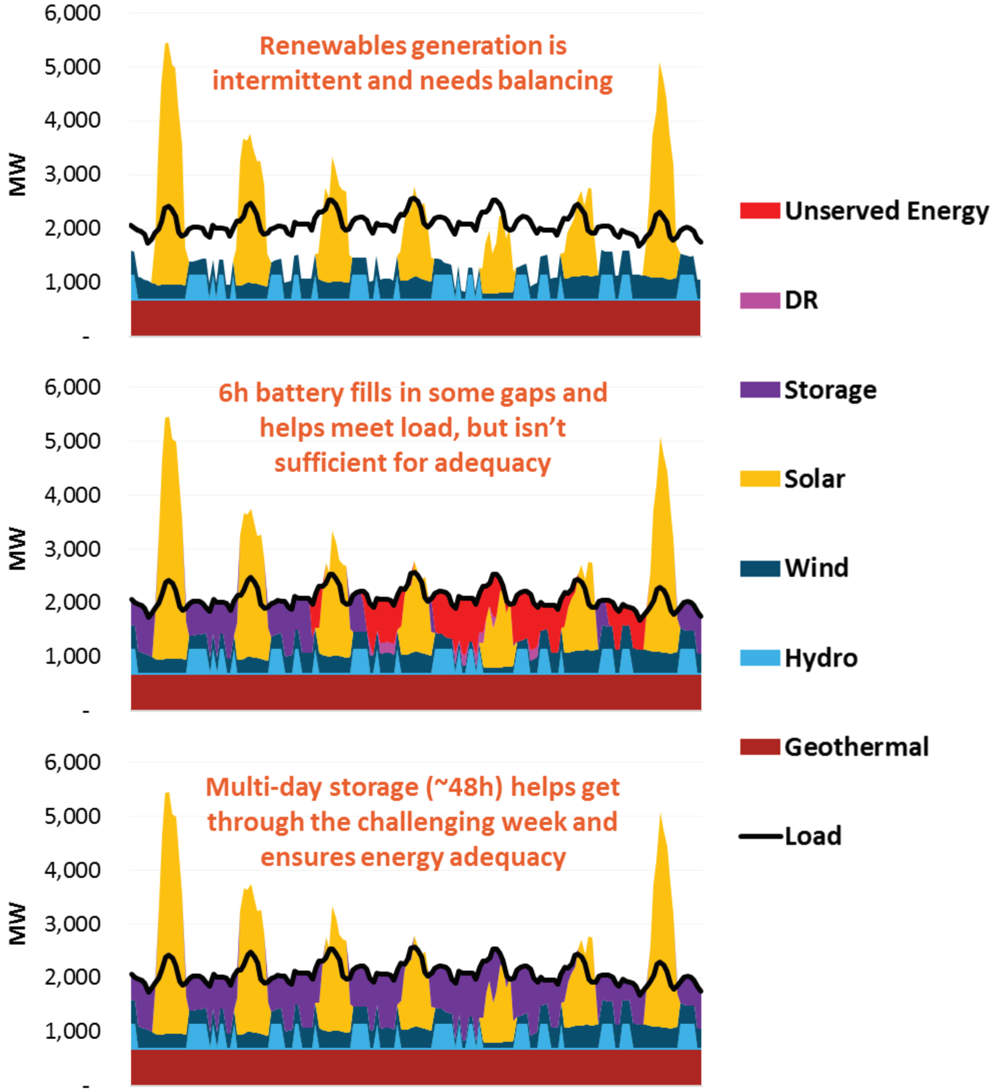
SB 350 requires SMUD to adopt an IRP to ensure that it meets system and local reliability. Each portfolio in this analysis is designed to achieve the high standard of system and local reliability expected by SMUD's customers. In the SD-9 Goal and SD-9+ scenarios, SMUD satisfies its reliability obligations by adding capacity resources to meet annual peak demand plus a 15% planning reserve margin to account for extreme weather, operating reserves, and unexpected outages.

In the Absolute Zero scenario, a 15% planning reserve margin is not sufficient to ensure that load can be met during all hours. Evaluation of energy adequacy becomes increasingly important in portfolios that rely upon renewables and storage resources to meet reliability needs, as the capability of energy storage to meet demand across extended periods of need is limited by its duration and is dependent on availability of surplus system power to charge.

In systems with a high penetration of intermittent renewables and little to no dispatchable generation, the ability of storage to contribute to reliability is contingent on intermittent renewable energy production. In extended periods with low solar and wind production, ensuring we meet our customers' energy needs becomes challenging despite large investments in additional amounts of renewables and storage on the system. The problem is addressed in the Absolute Zero scenario by adding multi-day energy storage (48+ hours) at considerable cost to the system since battery technologies that are commercially available today are sized to meet a 4 to 6 hour need. This phenomenon and the need for substantial storage capacity to meet reliability needs are shown in Figure 8. In addition, this example doesn't cover the array of different anomalous weather events that SMUD's system currently experiences. Even the substantial additional investment in 48-hour storage would be insufficient to ensure reliability during anomalous weather events. Consequently, it is doubtful that SMUD could meet our customers' reliability expectations under certain anomalous circumstances.

In the future, new technologies may emerge to help solve this challenge, however, in the absence of such technologies this scenario becomes prohibitively expensive for our customers and calls into question our ability to meet SMUD's reliability metrics.

Figure 8: Resource adequacy analysis for a challenging period in the Absolute Zero scenario.



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4.2 Cost & GHG Impacts

For each scenario, SMUD's overall revenue requirement and average annual retail rates were estimated. The revenue requirement includes costs in a number of categories. Across the scenarios, it was assumed that a number of costs would remain constant in real terms.[17] These include costs associated with maintaining SMUD's existing generation resources and transmission and distribution systems, customer costs, and public goods charges. In addition to these costs, the revenue requirement includes the fixed costs of new investments in generation, transmission, and distribution as well as the costs to operate SMUD's system, comprising fuel and variable costs and the costs and revenues associated with market purchases and sales. The revenue requirement is also used to calculate an average retail rate in each scenario. These metrics are summarized in Table 2.

Table 2: Portfolio cost metrics across scenarios[18]

	SMUD 2018 Budget	2040 Scenarios Results				
		SD-9 Goal 1000k MT	750k MT	500k MT	350k MT	Absolute Zero
Revenue Requirement (2016 $B)	$1.36	$2.04	$2.07	$2.10	$2.12	$5.13
Average Retail Rate (2016 cents/kWh)*	12.8	13.6	13.9	14.1	14.2	34.4
Average Residential Monthly Bill Impacts** (2016 $)	$103	$178	$182	$185	$186	$451

*Average bills may rise faster than rates because of increasing loads from electrification and the costs associated with decarbonizing SMUD's electric supply and the Sacramento economy.
** Average Residential Monthly Bills compare current average monthly bill for a single family gas/electric customer with potential future average monthly bill for all electric single family residential customer with an EV.

For the SD-9 and SD-9+ scenarios, revenue requirements increase as SMUD reduces its GHG emissions. Emissions reductions to achieve the SD-9 emissions pathway are achieved mainly through a combination of distributed resources, new renewables, and local reliability investments. Emissions reductions to achieve the SD-9+ scenarios are assumed to be achieved through the addition of new renewable generation. To achieve the 2040 goals for SD-9, new renewables and reliability investments mostly occur after 2030 while additional expenditures for local, clean distributed resources, including vehicle and building electrification efforts, begin in the early 2020's and continue to increase until about 2030 after which annual investment in local resources levels off.

Under the 80x50 scenario load forecast, achieving SD-9 (with incremental GHG reductions beyond 2018) means revenue requirements increase by more than $600

[17] The IRP analysis does not incorporate non-IRP related costs that are likely to increase, and would result in potentially higher rate increases than those reflected in the analysis. Rate and bill impacts will be higher due to additional costs necessary for normal SMUD operations, which typically require some level of annual rate increases to cover increases in operating costs and fund investments.
[18] All dollars are in 2016 values throughout this report. Costs shown do not include impacts of inflation. Assuming 2% inflation, a multiplier of 1.6 would apply to convert to 2040 values.

million over the 22-year period. While that is a modest average increase of about 1.75% per year, with increasing loads due to electrification of transportation and buildings customer bills may rise by a higher amount each year. Customer bills may increase faster due to greater electricity demand per customer.

For illustrative purposes, SMUD's current all-electric single family residential customers with EV's have average monthly single family residential bills that are nearly 63% higher than SMUD's current single family residential customers with a natural gas/electric mix. This illustrates that customer electric bills are likely to rise as a result of deep decarbonization of the Sacramento economy and SMUD's electric supply, which will both increase SMUD costs and customer electricity usage. Offsetting this increase to electric bills will be a reduction to customers' gasoline costs and natural gas bill as well as significant expansion of our investments in energy efficiency. Future bills will also be affected by technological change and efficiency as well as future rate design and strategy. Specific rate design, cost allocation, and customer retail rate strategy are the subject of rate proceedings not the IRP. While final impacts to customer bills will be determined by a combination of factors, it's likely there will be relatively larger electric bill increases because of electrification and decarbonization, which will be offset by lower natural gas and gasoline costs.

In addition, reducing SMUD's GHG footprint from the SD-9 goal to 350,000 MT requires an additional $80 million of spending in 2040, which equates to an average abatement cost of $123/ MT. In the SD-9 and SD-9+ cases, emissions reductions are achieved at lower cost relative to the Absolute Zero case due to the preservation of SMUD's gas fleet and the addition of low cost regional renewables to achieve the lower net emissions.

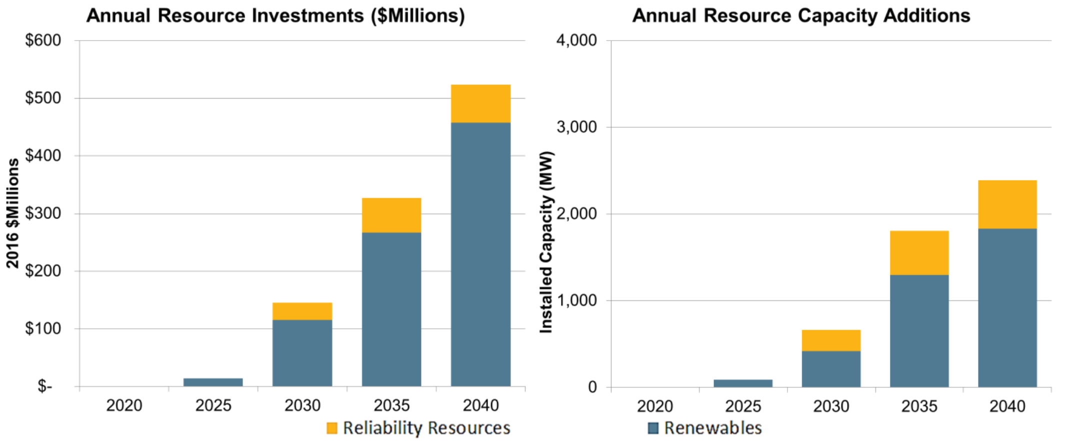
In all scenarios except absolute zero, significant increases in electric sales in the 80x50 scenario moderate impacts on the system average rate. For the Absolute Zero scenario, costs increase dramatically due to the retirement of existing gas resources and the need to overbuild renewable and storage resources to meet reliability needs as discussed previously in section 4.1.

4.3 SD-9 Goal Path is Aggressive

This analysis indicates that SMUD's current Strategic Direction to reduce emissions beyond the state's goals will require numerous investments by SMUD. Additionally, enabling the greater Sacramento region to transition to a low-carbon future will also require SMUD commitments and investments that are not limited to SMUD's generation portfolio, such as consumer incentives and distribution system upgrades.

Shown below in Figure 9 (right) are the capacity additions in new renewables and local reliability resources to achieve an SD-9 pathway. Figure 9 (left) shows the annual costs of these additional resources. Together, new investments in renewables and reliability resources add over $500 million to the revenue requirement in 2040.

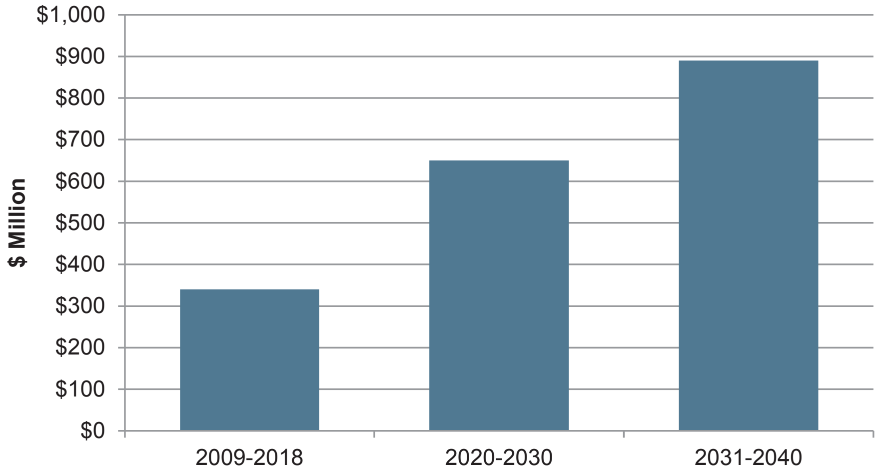
Figure 9: Annual resource capacity and investments



Renewable capacity additions to follow the SD-9 pathway require a tripling of SMUD's 2020 renewable portfolio. Expansion of local capacity to support the increase in renewable generation represents the largest local capacity expansion since the construction of Cosumnes Power Plant in 2006. Much of the increase to renewable capacity is required to continue to reduce SD-9 emissions in the face of significantly increased loads caused by electrification of transportation and buildings. Continuing along the SD-9 emissions pathway in the face of a nearly 50% expected increase in electric sales represents a far greater commitment to GHG reduction than was envisioned when the SD-9 goal was originally adopted in 2008.

In addition to renewable and capacity expansions, SMUD is also making very significant investments in local electrification and distributed resources over this time frame. Figure 10 shows the planned local expenditures for building and vehicle electrification every ten years through 2040. These local investments coupled with the new renewable and reliability capacity represent substantial, new spending to achieve a lower GHG footprint for both the local economy and for SMUD's electric portfolio. From 2020 to 2040, investments total over $1.5 billion in electrification and energy efficiency to achieve the 80x50 goal and represent a tripling of the spending SMUD made on these efforts from 2009-2018.

Figure 10: Building and Vehicle Electrification and Energy Efficiency 10-year Program Costs



As rates and customer bills rise to achieve decarbonization goals, there is a crucial balance that SMUD must consider in its resource planning, procurement, and long-term strategy development. If rates and bills rise too quickly, higher costs for SMUD's customers will begin to undermine the economic viability of much of the electrification foundation to achieving local and state economy-wide decarbonization. Recent consumer surveys have found that fuel cost savings is just as important as other factors (such as local or home charging, $7,500 tax rebate, state EV rebates, and battery warranties) in supporting the purchase or lease of an electric vehicle. On the other hand, low rates and bills will support and encourage the rapid transition necessary toward electrification envisioned in the IRP scenarios. Keeping rates affordable and competitive to ensure there is a strong local incentive to switch to clean, low carbon electricity benefits the local economy and ensures SMUD can support and enhance the region's efforts to significantly reduce local GHG emissions.

Finally, California's 80x50 goal is not a requirement on any local entity and there are no mandates in place to achieve these targets economy-wide. High levels of electrification sales in the California 80x50 scenario will need support from local and state policies and regulations. Early action by SMUD can help the Sacramento region successfully achieve these targets without overly burdening the community. SMUD's resource plan will need to be frequently reviewed and updated to insure investments and strategies remain cost-effective and prudent in an uncertain and competitive market. However, achieving the SD-9 pathway in conjunction with the local electrification investments made to achieve the 80x50 objectives will significantly reduce GHG emissions in the local community and support decarbonization of the local economy and transportation networks.

5 Achieving 80x50, a Local Net Zero Approach

While the cost to achieve a portfolio that adheres to the standards of the Absolute Zero scenario would be prohibitively expensive to SMUD's customers, an alternative is to look at SMUD's role in enabling economy-wide carbon reductions. The economy within the greater Sacramento region will need to undergo a significant transformation to achieve the State's climate goals, as discussed in Section 2: Decarbonization Scenario Analysis in PATHWAYS. State and regional mandates alone may not be sufficient to enable this market change. Local incentives and infrastructure investment will also be needed. Under this paradigm, SMUD may consider targeting local, economy-wide emissions reductions through investments enabling the decarbonization of buildings and transportation. A Net Zero approach would consider the emissions reductions associated with SMUD's investments in decarbonization of buildings and transportation as a strategy to reduce the emissions associated with an SD-9 pathway.

Within this strategy, SMUD can reduce emissions in Sacramento through investments in emissions reductions in other sectors, including local investments in decarbonization of transportation and buildings. These local investments to support the State's decarbonization pathway will significantly lower Sacramento area overall GHG emissions. However, absent the substantial, new renewable investments envisioned in this IRP and articulated in Section 4.3, SMUD's own emissions would increase as a result of continued electrification of transportation and buildings. SMUD's investments to support a transformation of local transportation and building use, coupled with the significant expenditures and resource growth to maintain an SD-9 pathway in the face of electrification, together significantly reduce local GHG emissions. A Net Zero approach would both recognize the investments SMUD is making to achieve an SD-9 emissions pathway along with the investments SMUD is making to reduce Sacramento area emissions overall. One challenge of the Net Zero approach will be measuring the impacts of local measures relative to other statewide and regional efforts to reduce GHG emissions through electrification of transportation and building uses.

5.1 Local Net Zero

As proposed, "Local Net Zero" would complement SD-9 emissions reductions with the emissions reductions associated with transportation and building electrification. SMUD's investments in local electrification, taken together, would be targeted toward reducing Sacramento's local GHG emissions by an amount equivalent to SMUD's SD-9 pathway emissions by 2040. For the SD-9 scenario, SMUD determined that local investments in electrification required to achieve the 80x50 scenario can result in a Net Zero portfolio for SMUD.

It is estimated that for every additional electric vehicle on the road in SMUD's service territory, 2 to 5 metric tons of CO_2e from gasoline consumption are avoided each year. SMUD's own GHG emissions increase because of producing the electricity for the electric vehicle, but these increased emissions are expected to be much smaller than the avoided emissions from gasoline due to the greater efficiency of electric drivetrains and the lower emissions intensity of electricity. Similarly, displacing natural gas appliances in buildings with electric appliances such as heat pumps can reduce overall household emissions by between 1 and 3 MT per year. However, SMUD does not currently count emissions reductions from transportation or building electrification within SD-9, despite the significant investments SMUD makes to encourage local electrification efforts.

For the purposes of this IRP and the SD-9 scenario discussed in this report, SMUD is assumed to invest in enough additional new renewables to reduce SD-9 GHG levels to offset the additional electric sector emissions caused by electrification of transportation and buildings assumed in the 80x50 pathway. SMUD's investment in renewables to offset the emissions associated with transportation and building electrification was not reduced to reflect the local emissions reductions from electrifying transportation or buildings. If SMUD were to count these local emissions reductions, SMUD can achieve a "Local Net Zero" portfolio by 2040 through our local investments made in transportation and building electrification. These SMUD investments would significantly benefit the local community by reducing emissions of harmful co-pollutants associated with fossil fuel combustion, particularly in disadvantaged communities, which are disproportionately exposed to these co-pollutants.[19]

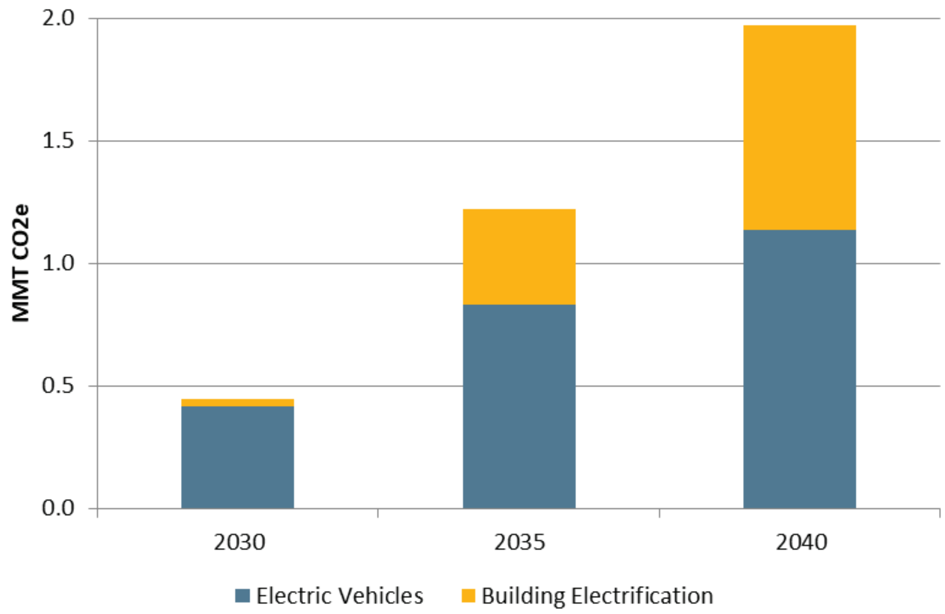
Avoidance of natural gas for heating, clothes drying, and cooking and displacement of gasoline use in the transportation sectors are the primary sources for emissions reductions due to electrification in SMUD as shown in Figure 11. This figure represents an estimate of the GHG emission savings in the SMUD region associated with the high building and vehicle electrification trajectory, relative to zero electrification, in the California 80x50 scenario. As shown in the figure, avoided GHG emissions through electrification of transportation and buildings reach almost 2 million MT of GHG emissions annually by 2040.

These emission reductions were estimated relative to zero electrification of buildings and vehicles, assuming continued increases in efficiency for gasoline vehicles and natural gas furnaces over time.

To enable this market transformation, SMUD must invest in projects and programs designed to enable and encourage adoption of these new technologies. These include, but are not limited to, distribution system upgrades, electric vehicle charging infrastructure, education and outreach, and customer incentive programs.

[19] See https://doi.org/10.5194/acp-18-4817-2018

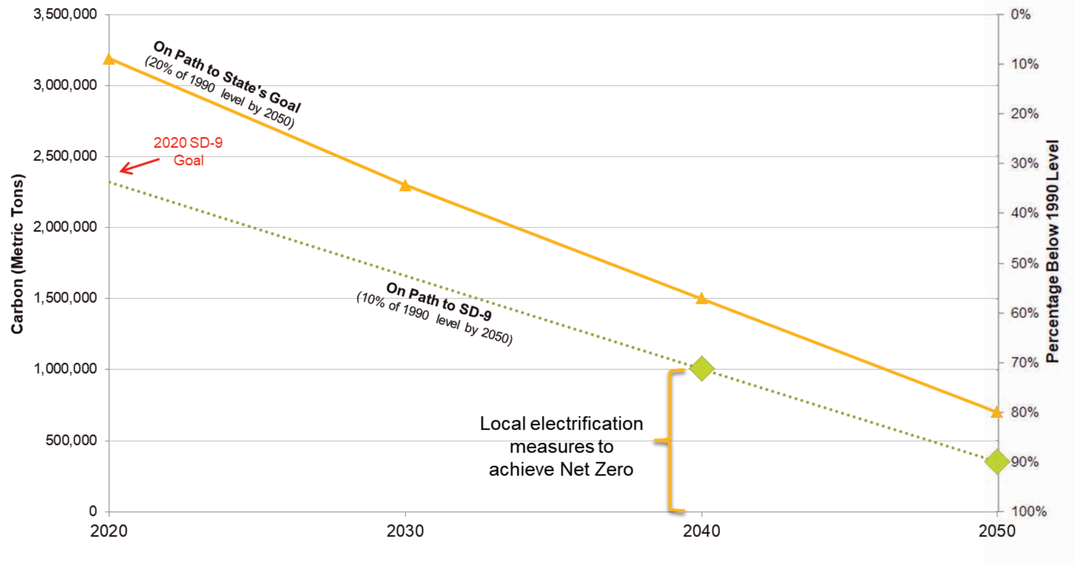
Figure 11: Maximum GHG Emissions Avoided in the Sacramento Region due to Local Electrification



Quantifying SMUD's effect on the adoption rate of electric vehicles and heat pumps, relative to statewide efforts, will require understanding of how effective programs are at enabling customer adoption and influencing customer choice. This is an initial attempt to assess the magnitude of the local GHG reductions associated with SMUD's electrification efforts. As part of implementing this IRP, SMUD plans to create an accounting methodology to address how our electrification efforts translate into local GHG savings. The State and its regulatory bodies do not currently have an approach that adjusts the utility GHG footprint for the GHG savings associated with carbon reductions in transportation or buildings, despite the State needing significant support and investment from utilities to encourage this transformation. The California Air Resources Board conducts the Low Carbon Fuel Standard (LCFS) program that provides incentives for emissions reductions in the transportations sector, but does not directly address GHG emissions increases associated with increased loads in the electric sector due to electrification nor does the LCFS program credit electrification GHG reductions against a utility's GHG footprint. Additionally, **the** California Air Resources Board, as part of its AB398 proceedings, is currently considering additional allowance allocations to Electrical Distribution Utilities to account for increased carbon obligations resulting from transportation electrification. SMUD will develop a methodology to count emission reductions from electrification and will work with the State and regulatory bodies to recognize our approach.

SMUD's local investments in support of decarbonization of transportation and buildings creates significant reductions in local GHG emissions. If these reductions are counted toward offsetting SMUD's SD-9 GHG footprint, SMUD could potentially achieve a Net Zero portfolio as early as 2040. This study finds that the investments SMUD plans to make in local carbon reductions coupled with the significant efforts to increase renewables and decarbonize its own electricity supply while maintaining local reliability expected by SMUD's customers, will allow SMUD to achieve a Net Zero carbon portfolio by 2040 as show in Figure 12.

Figure 12: SD-9 Pathway with Local Net Zero emissions in 2040.



5.2 Accelerating Regional Net Zero to 2035 and 2030

In addition to the Net Zero options considered by 2040, the Board directed staff to consider accelerating the 2040 carbon reduction target to 2035 or 2030. Based on an initial assessment by E3, staff is able to provide a high-level assessment of the minimum costs to achieve these goals.

- Using local measures only (including transportation and building electrification) will require early retirement/turnover of vehicles and building appliances which substantially increases the costs to achieve a Net Zero GHG goal earlier than 2040.
- Annual costs to accelerate achievement of a Local. Net Zero is estimated to be on the order of $500 million per year if achieved by 2030 or $200 million per year by 2035. These cost estimates reflect a conservative assessment of carbon

reductions available to be achieved and measures to achieve carbon reductions through early adoption of electrification (available at a higher cost than achieving 80x50). Expenditures to maintain a net-zero portfolio would decrease over time as SMUD's resource mix includes more carbon-free resources.

- Retail rate impacts for these scenarios were not analyzed in this study, however, they are expected to be higher than the SD-9 case due to the need for additional dollars to pay for early retirements.
- Along with additional costs of moving Net Zero to 2030 or 2035, there is also concern about the pace of achieving the Net Zero goal as it would require reaching 100% adoption of electric vehicles and heat pumps in this time frame. It is unclear whether this will be enough time to allow complete market transformation in these two sectors. By focusing on a 2040 timeframe to achieve net zero, technologies will have longer to mature and become more widely adopted as well as, allow for natural turnover of appliances (avoiding early retirement). This will make achievement of the goal less risky and less expensive for SMUD and its customers.
- Future technology performance and costs are uncertain and will evolve over time. Over the next five to 10 years, more information will be available about costs and market acceptance for zero-carbon building technologies and zero-carbon vehicles within SMUD's service territory. Staff plans to continue to assess technology options as they emerge to further reduce GHG emissions over time.

6 Discussion

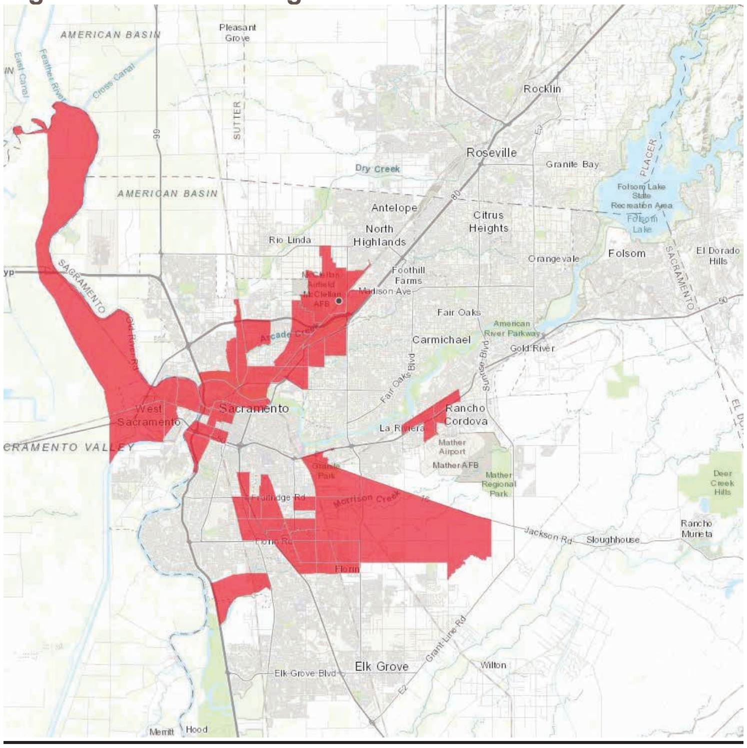
The findings of this study indicate that SMUD will need to increase spending significantly to achieve any target adopted by SMUD's Board, including maintaining the existing SD-9 pathway with significant load growth associated with electrification. Staff took a high-level look at the effect of these scenarios on power plant operations in disadvantaged communities and the potential for new jobs in Sacramento's clean-energy economy.

6.1 Economic Development and Disadvantaged Communities

SB 350 requires that utilities look at programs targeting not just low-income communities, but disadvantaged communities. CalEPA used the CalEnviroScreen 3.0 tool to inform the designation of these communities. [20] Figure 13 illustrates the disadvantaged communities within SMUD's service territory.

[20] See the following for more information: https://oehha.ca.gov/calenviroscreen/sb535

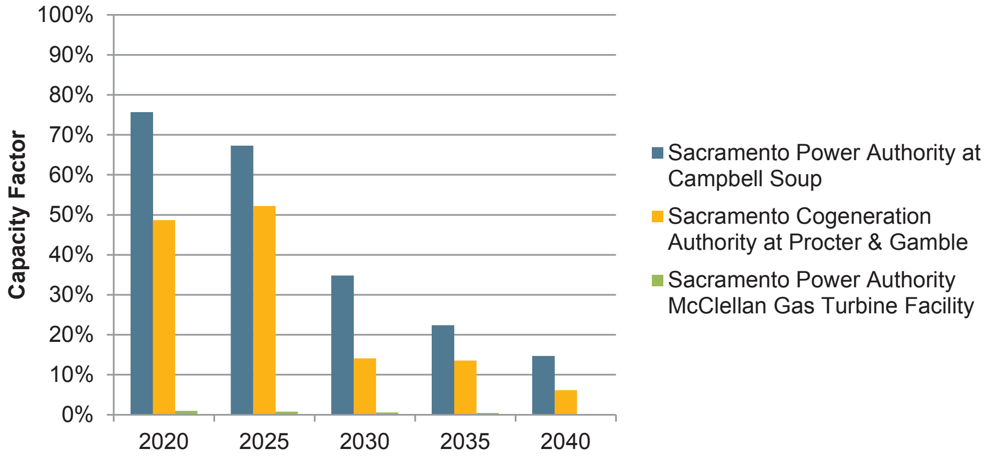
Figure 13: Disadvantaged Communities within SMUD service Territory



There are three thermal natural-gas power plants within SMUD's service territory that fall within the state's defined disadvantaged communities. [21] This analysis assumed that these plants would continue to be utilized to maintain system reliability. In all cases, reliance on these plants declines due to increased renewables and other economic factors. Consequently, criteria air pollution emissions from these plants are also expected to decline. See Figure 14 for details.

[21] Disadvantaged Communities are defined by California Environmental Protection Agency as California communities that are disproportionately burdened by, and vulnerable to, multiple sources of pollution. More information is available at : https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-30

Figure 14: Change in dispatch of Power Plants in SMUD's Disadvantaged Communities



SMUD currently provides incentives to low-income residential customers, including energy efficiency upgrades and discounted electricity rates. While program design was beyond the scope of this study, SMUD will continue to develop and administer programs targeting low-income customers, including initiatives needed to achieve SMUD's SD-9 goals to support sustainable communities and insure that all customers benefit from SMUD's local investments in carbon reduction.

Under each of the scenarios, funds are spent to increase building efficiency and enable electrification of vehicles and buildings. These efforts will deliver environmental and health benefits to the Sacramento region. As previously stated, building electrification can provide indoor air quality improvements. Vehicle electrification can help improve Sacramento's overall air quality, particularly in disadvantaged communities located near freeway corridors. Furthermore, it is likely that money spent on program incentives will encourage job growth/creation in the local economy. Recent studies indicate that investments in energy efficiency programs can result in 5 to 10 job-years per million dollars spent.[22] [23]

[22] A job-year is defined as one full-time job for one year.
[23] More information can be found at the following links
http://edfclimatecorps.org/sites/edfclimatecorps.org/files/the_growth_of_americas_clean_energy_and_sustainability_jobs.pdf
http://www.energy.ca.gov/2009publications/CEERT-1000-2009-022/CEERT-1000-2009-022.PDF
http://www.labormarketinfo.edd.ca.gov/contentpub/GreenDigest/CaliforniaGreenEconomy-070910.pdf
https://www.epa.gov/statelocalenergy

6.2 Risks and Uncertainties in the Decarbonization Strategy

As mentioned previously, the analysis demonstrates the relative viability of achieving a deep decarbonization future for the Sacramento region. It is important to recognize that the projections and assumptions are many years in the future with significant uncertainty. Cost assumptions could diverge substantially as technology advances or new mandates and regulations are adopted. For this reason, the findings and recommendations are intended to provide an initial roadmap for SMUD policy makers and planners.

Some examples of key assumptions that will need to be monitored closely to mitigate potential risks include:

- Renewable costs: Solar and wind costs have steadily decreased in recent years to historic lows and may increase with renewable goals for all utilities in California. These resource costs are susceptible to land value and environmental regulation. Resources such as battery storage used to balance renewables are projected to decrease significantly over the next 10 years which would allow for lower cost deployment of these valuable balancing resources when needed.
- New technology advancements: New technology will likely emerge that could make deeper decarbonization easier and less costly.
- Regulatory uncertainty: Environmental regulations in California are continually evolving as the State pushes towards its low-carbon goals. Higher than forecasted carbon prices would drive up cost and rate projections, even in low-carbon systems. RPS goals through 2030 have just been revised higher by SB 100. Mandates to procure baseload renewables, such as biomass and geothermal, would replace assumed procurement of the lower cost renewable resources.
- Market uncertainty: Higher than forecasted increases in market prices will drive up cost and rate projections beyond those assumed and dampen the adoption of transportation and building electrification. Market value of renewables in the CAISO may decline with increasing solar penetration along with increasing charges and tariffs.
- DER program implementation: Converting the Sacramento region to electric transportation and space heating will require significant collaboration statewide and locally.
- DER costs: The cost of distributed resources will require local and state mandates and LCFS incentives to provide customers the necessary motivation to convert to electric and keep utility costs reasonable.
- Retail Sales: The timing and magnitude of future sales influenced by transportation and building electrification has the ability to offset infrastructure investments costs. However, electrification is still highly speculative and the magnitude of load increases is uncertain. Additionally, if load does not increase

as expected, investment costs will be applied to a smaller sales base, magnifying the retail rate impact.

- Third-party competition for sales: The plan assumes increasing electric sales to cover growing costs of electrification. However, with new policy mandates, improving technology and expanding rooftop solar beyond those assumed in our analysis would dampen sales and could increase retail rates.
- Stranded investments: Ensure that appropriate off-ramps exist in the project review, approval, and implementation processes before significant capital outlays or commitments are made in case the project economic benefits erode, or the associated benefits are placed at risk.

SMUD will need to frequently update its IRP action plan as technology, markets, and regulations evolve. SMUD will likely need to update its SD-9 goals in the future to deliver resources at a reasonable cost and manageable risks, in order to maintain its core commitments to customers (safety, cost, reliability, and environmental stewardship).

7 Staff Recommendations

SMUD has a long history of strong environmental leadership in its resource planning and procurement activities. This includes voluntary programs, such as Greenergy and SolarShares, early renewable adoption, strong energy efficiency mandates, and existing GHG reduction goals that exceed the state's aggressive goals.

RESOLVE analysis indicates that SMUD's SD-9 goal of reducing GHG emission to 1.0 MMT by 2040, while more aggressive than the state's goals when the analysis was performed, is still achievable at a reasonable cost to customers. In 2018, average rates are estimated to be 12.8 cents per kWh and expected to increase to an estimated 13.6 cents per kWh in 2040, or 6.3% over SMUD's 2018 rates (in 2016 dollars and in real terms), under the SD-9 scenario. This assumes that, compared to SMUD's portfolio today, in an 80x50 world, SMUD will need to increase its renewable generation portfolio by 270% and invest in distribution system upgrades to allow for a significant increase in DERs. While rate impacts are shown to be relatively modest under the SD-9 scenario, the significant amount of new capacity investment necessary to achieve the 80x50 goal as depicted in Figure 7 should not be discounted. As noted above there is considerable uncertainty around the technology, market and policy environment.

In addition, if higher electricity sales fail to materialize as assumed in this analysis, average annual rates could increase more quickly than shown in this report. While it is expected that rates will increase at a moderate pace, with increased costs offset somewhat due to increases in sales, customer bills could increase at a faster pace as a result of increased sales and increased costs associated with decarbonization. Overall, Customer energy costs, including natural gas and gasoline, are anticipated to be lower, despite increases in electric bills. This is based on the significant efficiency improvements of electrification technologies compared to incumbent transportation and heating solutions. Bill impacts will depend on the pace of technology change, cost allocation and rate design strategy over the next 20 years, all of which will be the subject of future rate proceedings and to Board consideration and approval.

The analysis also indicates that additional carbon reductions beyond the SD-9 goal appear to be feasible. Achieving a carbon goal of 350,000 MT in 2040 results in a 2040 average system rate increase of up to 11% over SMUD's 2018 rates (in real terms). Achieving a "local net zero" emissions target is also feasible with additional investment in local measures such as incremental local electrification or renewables. This analysis shows that SMUD is making significant early investments that support the transition to the State's 80x50 objectives. This not only helps the State achieve its carbon reduction goals but it also represents a significant reduction to local GHG emissions. If these emission reductions are counted to offset electric sector emissions along the SD-9 pathway, SMUD can achieve a Local Net Zero emissions target by 2040.

From a reliability perspective, maintaining a variety of options for renewable balancing, including CAISO, BPA purchases and internal SMUD resources within a large regional grid is a key to low-cost carbon reductions. Fewer balancing options will require less efficient dispatch of SMUD resources – such as running multiple thermal generators at minimum operational level and may require new, significant local investments in flexible resources. Also based on this study, staff notes that meeting load entirely with renewables, hydro and storage is prohibitively expensive with current technology and may not be reliable during long-duration adverse weather events. Retaining gas generation ensures reliability and moderates cost increases and rate impacts under all of the SD-9 scenarios, allowing SMUD to pursue lower carbon scenarios without causing undue reliability obstacles. [24]

In summary, SMUD's SD-9 goal is already more aggressive than California's economy-wide GHG reduction policy. This results in SMUD being a strong contributor to California's low-carbon energy market. SMUD's environmental leadership thus far has set the groundwork for decarbonizing the Sacramento region. Sacramento's regional GHG emissions savings modeled by PATHWAYs, as shown in Figure 4, demonstrates that SMUD, as a provider of low-carbon electricity, will be a key player in reducing GHG emissions in the building and transportation sectors. While loads are expected to increase, SMUD's portfolio emissions are expected to decline.

The current SD-9 policy is focused on decarbonizing SMUD's portfolio without considering how SMUD can enable a similar transformation of Sacramento's economy. This study has demonstrated that there are opportunities for utility action outside traditional resource procurement decisions. SMUD investments in DER-enabling technologies will lower economy-wide carbon emissions while maintaining SMUD's current approach to reducing portfolio emissions and maintaining system reliability. These investments will also have beneficial effects on jobs, the environment, and disadvantaged communities. Local reductions in emissions with electrification of

[24] Does not apply to the Absolute Zero scenario. Albeit, under the SD-9 scenarios, SMUD's utilization of gas-fired generation declines over time.

transportation and buildings can offset the SD-9 emissions remaining in SMUD's GHG footprint to achieve a Net Zero portfolio by 2040.

Based on this study and the findings presented here, SMUD staff recommends the following language be adopted and added to Strategic Direction- 9, Resource Planning:

It is a core value of SMUD to provide its customers with a sustainable power supply through the use of an integrated resource planning process. A sustainable power supply is defined as follows:

- *2020 GHG emissions goal: 2.318 million metric tons*
- *2030 Power Supply GHG emissions goal: 1.35 million metric tons*[25]
- *2040 Power Supply GHG emissions goal: 1.0 million metric tons offset by investments to achieve Net Zero*
- *2050 GHG emissions goal: 350,000 metric tons offset by investments to achieve Net Zero*

Beginning in 2040, SMUD will achieve a Net Zero GHG footprint. A Net Zero footprint is defined as achieving emissions reductions that offset SMUD's 2040 and 2050 GHG emissions. GHG reductions may come from vehicle and building electrification, energy efficiency, clean distributed resources, renewables, large hydro, biogas, and offsets. Local resources will have priority over regional resources while assuring reliability of the system, minimizing environmental impacts on land, habitat, water quality, and air quality, and maintaining competitive rates.

To guide SMUD in its energy efficiency evaluation and investment, SMUD shall achieve Energy Efficiency equal to 15% of retail load over the next 10-year period. On an annual basis, SMUD will achieve energy efficiency savings of 1.5% of the average annual retail energy sales over the three-year period ending with the current year. To do this, SMUD will acquire as much cost effective and reliable energy efficiency as feasible through programs that optimize value across all customers. SMUD shall support additional energy efficiency acquisition by targeting one percent (1%) of retail revenues for above market costs associated with education, market transformation, and programs for hard to reach or higher cost customer segments. The market value of energy efficiency will include environmental attributes, local capacity value and other customer costs reduced by an efficiency measure.

To guide SMUD in its renewable procurement, SMUD will procure renewable resources to meet 33% of SMUD's retail sales by 2020, and 60%[26] *of its retail sales by 2030, excluding additional renewable energy acquired for certain customer programs. In acquiring renewable resources, SMUD shall emphasize local and regional environmental benefits.*

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[25] See footnote 1.
[26] See footnote 1.

7.1 Next Steps

Following Board direction on revisions to SD-9, staff will complete the development of the 2018 Integrated Resource Plan for filing with the CEC in April 2019.

SB 350 requires a statewide doubling of energy efficiency achievements by 2030, including savings resulting from utility programs as well as building codes and standards and other state energy efficiency programs. SB 350 directs the California Energy Commission to set energy efficiency targets based on a doubling of the additional achievable energy efficiency contained in the *California Energy Demand Updated Forecast, 2015-2025,*[27] extrapolated to 2030. While the CEC has provided their view of a statewide shortfall, work remains to be done on creating a fuel substitution carbon accounting mechanism.

This analysis incorporates SMUD's initial understanding of how to account for these savings, however, questions remain, and therefore staff is not recommending an update to SD-9 energy efficiency targets at this time. Implementation of the doubling goal requires a new accounting methodology that incorporates both traditional energy efficiency programs and energy efficiency resulting from building electrification. Staff will develop this methodology, along with the methodology for accounting for electrification reductions driven by SMUD investments in electrification, and recommend updates to SD-9 in the spring of 2019.

In addition, there have been numerous updates and changes to the options and scenarios discussed in this report. Please see the attached appendices for more information.

[27] Jones, Melissa, Michael Jaske, Michael Kenney, Brian Samuelson, Cynthia Rogers, Elena Giyenko, and Manjit Ahuja. 2017. Senate Bill 350: Doubling Energy Efficiency Savings by 2030. California Energy Commission. Publication Number: CEC-400-2017-010-CMF.

Exhibit to Agenda Item #14

SMUD Board of Directors Meeting
Thursday, October 18, scheduled to begin at 9:00 a.m.
Customer Service Center, Rubicon Room

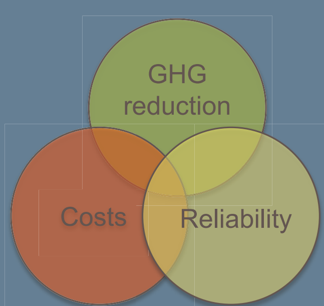
Attachment D

Powering forward. Together.

SMUD

IRP Strategic Objectives

- Strategic objective was to establish long-term (2030, 2040 & 2050) carbon targets while balancing:
  - Environmental Leadership
  - Cost and Customer Impacts
  - Reliability
  - Local benefits



- IRP will be reassessed every 5 years to capture critical industry changes
  - IRP will be filed with the CEC
  - IRP includes an appendix with the process and schedule for preparing the next IRP, which will be filed with the CEC in April 2024
  - Monitor progress on IRP annually as part of SD-9 reporting

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SMUD

2018 IRP process recap

1st Board meeting April 4
- IRP objectives and scenarios
- Board/public comment

2nd Board meeting June 6
- High level scenario results
- Board /public comment

3rd Board meeting Aug. 1
- Detailed scenarios results and staff recommendation
- Public report released
- Board/ public comment

4th Board meeting Sept. 5
- Evaluate new Option 3 and address Board questions
- Board/public comment

5th Board meeting Oct. 2
- Evaluate new Option 4 and address Board questions.
- Draft SD-9 language
- Board/public comment

- IRP studied many options for setting new long-term GHG objectives while ensuring SMUD meets specific State and Board policy goals and planning targets, minimizes costs and customer rate impacts, ensures system reliability, and minimizes local emissions with early priority in disadvantaged communities.
- Board meeting Oct. 18 to approve SMUD's 2018 IRP

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Final Options Considered

Option	(a) Cumulative Electrification & EE Spend (2016 $B)	(b) Cumulative Renewable/ Reliability Spend (2016 $B)	(c) Cumulative Offsets Spend @ $40/MT (2016 $B)	(a) + (b) + (c) Cumulative Total Spend (2016 $B)	2040 Sac Area GHG Emissions (MMT)	2040 Avg Electric Bill Increase over 2020 ($/Month)
1 1 MMT	$1.7	$4.8	$0.0	$6.5	4.9 (64% below 2020)	$76 (74%)
2 750k MT	$1.7	$5.1	$0.0	$6.8	4.9	$79 (77%)
2 500k MT	$1.7	$5.4	$0.0	$7.1	4.9	$82 (80%)
2 350k MT	$1.7	$5.6	$0.0	$7.3	4.9	$83 (81%)
4 350k MT Offsets	$1.7	$4.8	$0.2	$6.7	4.9	$78 (76%)

- Emissions in Option 2 are offset by non-local renewables
- Offsets in Option 4 produce same non-local GHG reduction as Option 2 but at much lower cost
- Sacramento area emissions stay at 4.9 MMT in 2040
- Long-term commitments to non-local renewables limit options for reducing bill impacts
  - Less local electrification investments would be primary means of mitigating bill impacts

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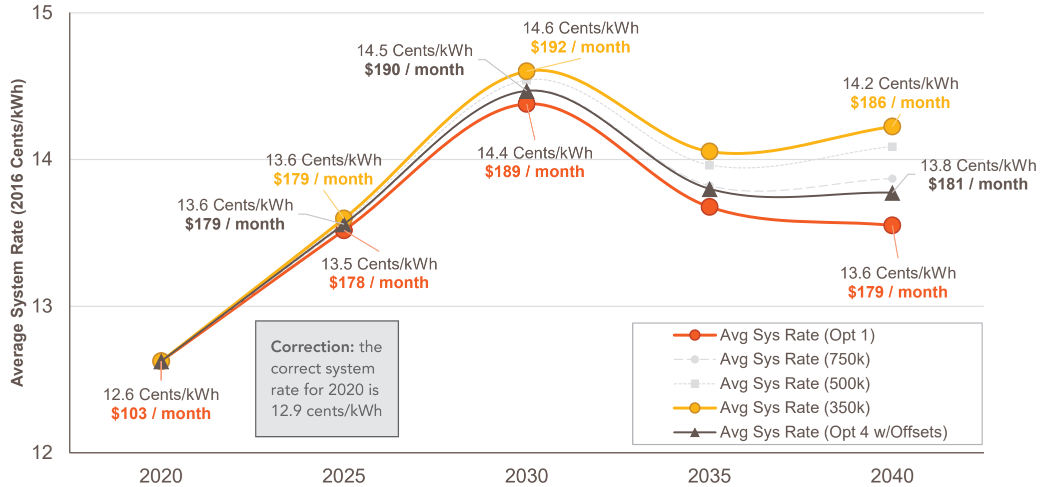
Rate and Bill Impacts



- Rate/bill impacts could be greater if renewable investments are needed earlier
- Prior to 2030, most customers will not have converted to electric transportation and building use and will see the rate increases but not the bill increases depicted on this chart
- Does not include rate impacts from other increased costs or investments

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SMUD

Key findings

2018 IRP: Key findings

- Carbon reduction
  - Use of natural gas generation is significantly reduced although natural gas capacity is still required for reliability
  - 57% reduction in SMUD emissions from 2020 to 2040
- Renewable expansion
  - Tripling of SMUD's current renewable portfolio with ~2,600 MW of new renewables
  - Addition of ~1,500 MW local solar PV
  - Addition of ~500 MW of local reliability resources
- Electrification
  - Local transportation and building electrification exceeds current State policy
  - Emissions from electrification loads are offset by additional renewables
  - Aggressive electrification reduces local GHG by ~65% and improves local air quality in Sacramento
- Costs and customer Impacts
  - Maintaining low rates encourages more transportation/building electrification
  - Local focus improves the Sacramento economy
  - Disadvantaged communities benefit from lower emissions
  - Cumulative spending will be $6.5 to $7.3 billion through 2040

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SMUD

Public input

Key themes

- Appreciation that SMUD studied more aggressive GHG goals
- Support for more aggressive SMUD goals
  - Work toward zero carbon in 2040 and retire natural gas generation
  - Do more earlier
  - Lead the country in addressing climate change
  - Cost is secondary to GHG reduction
  - General support for Option 2 350k MT or Option 4 350k MT
- GHG and customer impacts
  - Consider additional subsidies for low income families
  - GHG is driving climate change
  - Local emissions create health concerns

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SD-9 Options

- **Option 1** – $6.5 B total costs
  - 1.35 Million MT by 2030
  - Net Zero in 2040
- **Option 2** – $6.8-$7.3 B total costs
  - 1.35 Million MT by 2030
  - Net Zero in 2040
    - Additional GHG reduction of 250/500/650k MT from investments in non-local renewables
- **Option 4** – $6.6 - $6.7 B
  - 1.35 Million MT by 2030
  - Net Zero in 2040
    - Additional GHG reduction of 250/500/650k MT from purchasing offsets

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Staff Recommendation – Option 1

- Launches a substantial electrification effort in Sacramento resulting in a significant reduction in local GHG emissions
  - Maximizes local impact and benefits
- Leads the State's plan for decarbonizing the economy
- Moderates rate increases
  - Encourages more electrification
- Ensures local reliability
  - Significant reduction in natural gas plant operations which lowers emissions in disadvantaged communities
  - Utility scale battery storage investments
- Expands renewable investments above State goals
  - Maximizes use of local renewables
- Maintains flexibility without over committing

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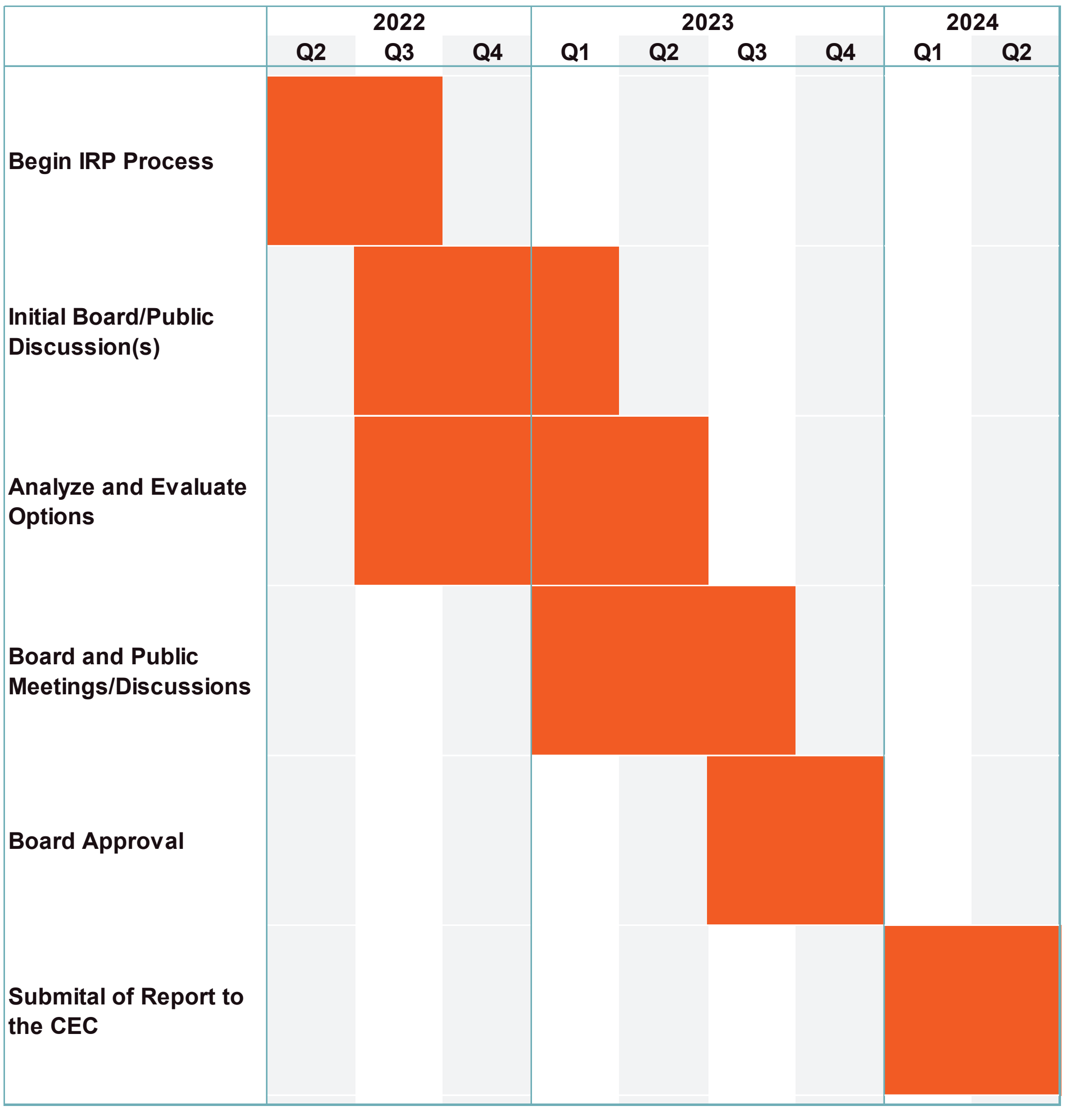
Attachment E

SMUD Process for the next Update of the IRP



The Table above describes the process and schedule that SMUD plans to follow for the next update of this IRP. SMUD plans to follow a similar process and timeline at least once every five years thereafter.

Attachment I

SMUD BOARD POLICY

Category: **Strategic Direction**		Title: **Resource Planning**
		Policy Number: **SD-9**
Adoption Date:	**May 6, 2004**	Resolution No. **04-05-11**
Revision:	**May 6, 2004**	Resolution No. **04-05-12**
Revision:	**September 15, 2004**	Resolution No. **04-09-11**
Revision:	**May 17, 2007**	Resolution No. **07-05-10**
Revision:	**December 18, 2008**	Resolution No. **08-12-15**
Revision:	**November 19, 2009**	Resolution No. **09-11-08**
Revision:	**May 6, 2010**	Resolution No. **10-05-03**
Revision:	**May 19, 2011**	Resolution No. **11-05-05**
Revision:	**December 20, 2012**	Resolution No. **12-12-12**
Revision	**October 3, 2013**	Resolution No. **13-10-09**
Revision:	**September 17, 2015**	Resolution No. **15-09-11**
Revision:	**October 20, 2016**	Resolution No. **16-10-14**
Revision:	**October 18, 2018**	Resolution No. **18-10-11**

It is a core value of SMUD to provide its customer-owners with a sustainable power supply through the use of an integrated resource planning process. A sustainable power supply is defined as one that reduces SMUD's net long-term greenhouse gas (GHG) emissions to serve retail customer load to Net Zero by 2040. Net Zero is achieved through investments in vehicle and building electrification, energy efficiency, clean distributed resources, RPS eligible renewables, large hydro, and biogas. SMUD shall assure reliability of the system, minimize environmental impacts on land, habitat, water quality, and air quality, and maintain a competitive position relative to other California electricity providers.

To guide SMUD in its resource evaluation and investment, the Board sets the following interim goal:

Year	Net Greenhouse Gas Emissions (metric tons)
2020	2,318,000
2030	1,350,000
2040	Net Zero
2050	Net Zero

In keeping with this policy, SMUD shall also achieve the following:

a) SMUD's goal is to achieve Energy Efficiency equal to 15% of retail load over the next 10-year period. On an annual basis, SMUD will achieve energy efficiency savings of 1.5% of the average annual retail energy sales over the three-year period ending with the current year.

To do this, SMUD will acquire as much cost effective and reliable energy efficiency as feasible through programs that optimize value across all customers. SMUD shall support additional energy efficiency acquisition by targeting one percent (1%) of retail revenues for above market costs associated with education, market transformation, and programs for hard to reach or higher cost customer segments. The market value of energy efficiency will include environmental attributes, local capacity value and other customer costs reduced by an efficiency measure.

b) Provide dependable renewable resources to meet 33% of SMUD's retail sales by 2020, 44% by 2024, 52% by 2027, and 60% of its retail sales by 2030 and thereafter, excluding additional renewable energy acquired for certain customer programs.

c) In meeting GHG reduction goals, SMUD shall emphasize local and regional environmental benefits.

d) SMUD will continue exploring additional opportunities to accelerate and reduce carbon in our region beyond the GHG goals in this policy.

e) Promote cost effective, clean distributed generation through SMUD programs.

Monitoring Method: GM Report
Frequency: Annual

19. **Appendix D:** Load forecast methodology and data sources

SMUD's forecast models are based on statistical regression techniques which normalized electricity use for variation in temperatures, seasonal use, number of customer accounts, and recent trends in electricity use behaviors. The forecast is based on 4 regression models: daily system energy, daily system peak, system hourly loads (24 separate equations), and retail class sales models. In each model, loads and retail sales are normalized by customer accounts.

The daily energy and peak models serve as the foundation for the load forecast. These models normalize SMUD's system loads for variations in daily temperatures, weekdays and weekends, months, seasons and holidays. The system hourly load equations provide a daily load shape which is calibrated to daily energy and peak model estimates with the following restrictions:

- Maximum of estimated hourly loads for day "i" = estimated peak for day "i" for each day of the forecast year.
- Sum of the estimated hourly estimate loads for day "i" = estimated daily energy for day "i" for each day of the forecast year.

The predicted values from these models are:

- kwh/day/account,
- peak kW/day/account, and
- kW/hour/account.

These initial predicted values are based on a system estimation of individual accounts that is subsequently rolled up to provide electric demand by rate class as discussed further below. The retail sales model includes separate regression equations for each of the major rate classes (rate codes in parentheses) which include:

- Residential Electric Space Heat (Rate Codes RSE, RSC, RWE, RWC)
- Residential Non-Electric Space Heat (RSG, RWG)
- Small General Services with maximum demands below 20 kW (GSN)
- Small General Services with maximum demands between 20 and 299 kW (GSS)
- Small General Service Time of Use with maximum demands between 300 and 499 kW (GSTOU3)
- Medium General Service Time of Use with maximum demands between 500 and 999 kW (GSTOU2)
- Large General Service Time of Use with maximum demands greater than 1,000 kW (GSTOU1)
- Other includes Agricultural (AGR), Street (ST and TF) and Night Lighting (NL) accounts.

The dependent variable for the sales models is kWh/customer per billing period. The regression model normalized class sales for variations in monthly use, temperature conditions (monthly heating and cooling degree days), and for recent sales trend with a binary variable. For the small general service classes (under 299 kW maximum demands), commercial vacancy rates were included in the regression equation to explain the recent trends in economic activity.

For residential customer accounts, the ITRON Statistically Adjusted End-Use (SAE) modeling framework is used to simulate end-use saturations and efficiency standards. This model is applied separately to residential customer with electric and non-electric space heat. The SAE modeling framework incorporates energy end-use, appliance saturations and appliance efficiencies to develop heating, cooling and "other" appliances end-use indices. The indices are used as independent variables in a regression model where the dependent variable is electricity sales per account. Simulation of energy use is based on the indices, which change over time to incorporate marginal saturation rates and improvements in efficiency standards. For the residential model, saturations are based on the SMUD 2013 Residential Appliance Saturation Survey (RASS) results.

19.1 Load and sales projections

The monthly retail sales forecast for each rate class is derived by multiplying the forecasted sales per customer with the forecasted number of customers for each rate class. The resulting total unmanaged retail sales forecast shown in Table 15 of this report is the sum of the rate class sales forecast. For system energy, peak and hourly loads, the forecast is based on the estimated loads per account times the net customer forecast (total customers minus nightlight customer accounts). System energy, peak and hourly loads are calibrated to the unmanaged sales forecast after adjusting for line and voltage distribution losses (i.e. system energy = 1.0419*unmanaged sales forecast).

19.2 Economic and demographic data

The primary driver for the sales and load forecasts is the customer account forecast. Table 29 presents the customer account forecast for the major customer classes.

Table 29. SMUD customer account forecast

Year	Residential	Small GS	Medium GS	Large GS	Other	Net Customers.
2018	557,839	64,781	252	161	5,448	628,481
2019	562,510	65,262	254	163	5,501	633,690
2020	566,774	65,803	256	165	5,557	638,554
2021	570,979	66,386	259	167	5,610	643,401
2022	575,416	67,040	262	169	5,660	648,547
2023	579,893	67,764	265	170	5,709	653,801
2024	584,524	68,500	268	172	5,758	659,223
2025	589,864	69,233	271	174	5,807	665,350
2026	595,383	69,952	274	176	5,856	671,641
2027	601,113	70,697	277	177	5,906	678,170
2028	607,061	71,467	280	179	5,957	684,945
2029	613,528	72,258	283	181	6,011	692,261
2030	620,083	73,059	286	183	6,065	699,676
Annual Growth Rate						
	0.89%	1.01%	1.07%	1.07%	0.90%	0.90%

Notes:

Residential includes both electric and non-electric space heat accounts.

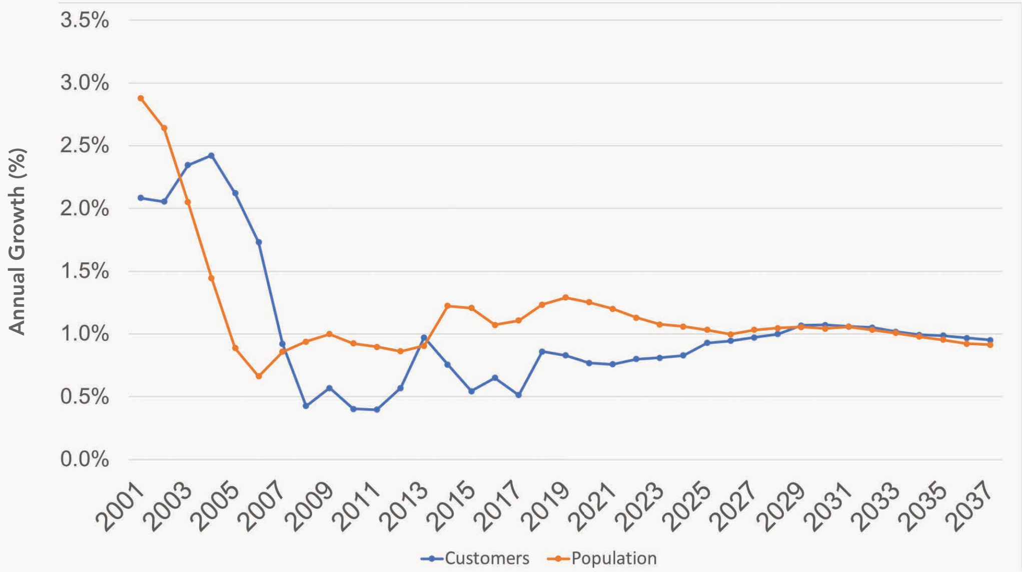
Small General Service (GS) includes accounts on rate schedules GSN (0-20 kW maximum demands), GSS (20-299 kW maximum demands), and GSTOU3 (300 to 499 kW maximum demands).

Medium GS includes customers on rate schedule GSTOU2 (500-1,000 Maximum Demands).

Large GS includes customers on rate schedule GSTOU1 (Maximum Demand >=1,000kW).

Other includes customers on the Agriculture, street lighting and traffic signals rate schedules.

Figure 29. Sacramento County population and residential customer annual growth



The forecast for residential customer accounts is based on the population forecast for Sacramento County. Figure 1 shows the historical and forecasted growth rates for the Sacramento County's population and SMUD's residential customer accounts.

During the last residential building cycle, Sacramento county population acted as a leading indicator for new residential customer growth. For the forecast period, however, we do not forecast cyclical economic developments and therefore long-term residential customer growth is expected to keep pace with population growth.

The forecast for Small General Service accounts are based on economic drivers such as employment and gross county product. The Medium General Service accounts (between 500 and 1,000 kW maximum demands) and Large General Service accounts (greater than or equal to 1,000 kW maximum demands), and other customer accounts (Agriculture and Lighting) are based on their historical growth rates.

19.3 Sacramento weather

A key component in normalizing sales and loads is weather. Both sales and load models use cooling degrees and heating degrees as independent variables in the regression equations. In the load model, daily high temperatures are also used to explain the rapid change in loads during heat storms.

Temperature data is from the National Weather Service's Sacramento City and Executive Airport weather stations. The daily temperatures from these weather stations are averaged to develop a composite temperature index for the Sacramento area. Daily composite temperatures are used to construct cooling and heating degree day variables in the regression models.

Table 30 and Table 31 present the normal temperatures and degree days used in forecast based on temperature data from 1981 to 2010. The average daily temperature is the average of the daily high and low temperatures. The High and Low temperatures are the maximum and minimum daily temperatures, respectively, for each month. The cooling degree (CDD65) and heating degree (HDD65) variables are the sum of the daily cooling and heating degrees for the calendar month with 65 degrees Fahrenheit as the base temperature. The SumCdd65 and SumHdd65 are the sum of the cumulative degree days for the previous 30 days for each day during the month. The Sumcdd65 and SumHdd65 are used to reflect the number of degrees days over the billing month period.

Table 30. Normal average daily temperatures

	Avg. Daily	Avg. High	Avg. Low	High	Low
January	48	55	40	65	32
February	52	61	43	72	33
March	56	67	45	79	34
April	62	76	49	89	41
May	67	81	53	97	45
June	74	90	58	104	51
July	78	95	60	106	54
August	76	93	60	105	55
September	73	88	58	101	51
October	65	78	52	93	44
November	55	65	44	77	34
December	47	55	40	65	30

Table 31. Normal cooling and heating degree days per month

	CDD65	HDD65	SumCDD65	SumHDD65
January	-	542	-	18,275
February	-	361	-	13,886
March	2	277	18	10,813
April	25	165	313	6,975
May	112	52	2,072	3,425
June	239	6	5,355	804
July	362	-	10,142	61
August	339	-	11,369	4
September	240	5	9,407	56
October	69	65	5,069	799
November	1	318	734	5,507
December	-	551	4	14,432

19.3.1 Variability of load forecast: extreme temperature scenarios

The normal temperature scenario is referred to as the "1 in 2" load condition scenario. That is, there is a 1 in 2 chance of this weather scenario occurring. Because the Sacramento area often experiences extremes in temperatures during the summer months, extreme temperature scenarios are used to examine these changes in system peak loads. Table 32 below presents the extreme temperatures for each load condition scenario.

Table 32. Extreme temperature scenarios

Load Condition Scenario	Daily High Temperature
1 in 2	106
1 in 5	108
1 in 10	110
1 in 20	112
1 in 40	114

The peak load forecasts under extreme conditions are estimated using the parameter estimates from the daily peak model.

19.4 Forecast errors

Table 33, Table 34 and Table 35 present the annual errors (actual versus predicted values) for the retail sales, system peak, and customer forecasts, respectively.

Table 33. Retail sales errors (mwh)

Years	Actual	Forecast	% Error
2007	10,913,372	10,940,472	-2.6%
2008	10,959,168	11,238,188	-2.6%
2009	10,757,807	10,358,626	0.2%
2010	10,389,858	10,560,255	2.5%
2011	10,459,022	10,527,298	1.9%
2012	10,519,497	10,513,856	0.0%
2013	10,480,762	10,432,362	0.7%
2014	10,585,750	10,572,551	-0.1%
2015	10,523,765	10,548,236	-0.5%
2016	10,530,677	10,628,118	0.9%
2017	10,519,686	10,348,905	-1.7%

Note: Retail sales based on SMUD's 21-day cycle read billing data

Table 34. System peak errors

Years	Actual	Forecast	% Error
2007	3,099	3,124	0.8%
2008	3,086	3,062	-0.8%
2009	2,848	3,038	6.7%
2010	2,990	2,976	-0.5%
2011	2,840	2,979	4.9%
2012	2,953	2,974	0.7%
2013	3,014	2,946	-2.3%
2014	3,003	2,987	-0.5%
2015	2,956	3,008	1.8%
2016	2,972	2,998	0.9%
2017	3,157	3,006	-5.0%

In general, the peak model does not perform as well as the retail sales mode where the sales errors range from -2.6 to 2.5 % with an average error of about 0.01%. The peak model errors range from -5.0% to 6.7% with an average error of .6%.

Table 35. Customers account forecast errors

Years	Actual	Forecast	% Error
2007	572,107	595,130	1.2%
2008	590,607	598,717	1.4%
2009	593,971	594,838	0.1%
2010	596,367	593,975	-0.4%
2011	598,730	599,098	0.1%
2012	602,141	600,904	-0.2%
2013	607,997	605,887	-0.3%
2014	612,592	614,694	0.3%
2015	615,930	618,560	0.4%
2016	619,882	626,243	1.0%
2017	623,119	627,000	0.6%

The remainder of the report presents the following historical SMUD statistics: historical retail sales, system energy, system peak and net customers (Table 36), sales by retail rate class (Table 37), customer accounts by retail sales classes (Table 38), bill determinants by rate schedule (Table 39), and historical and projected population, non-farm employment, and personal income for Sacramento County (Table 40).

Table 36. Retail sales, system energy, peak, and customer accounts

Year	Sales(GWH)	System Energy (GWH)	System Peak (MW)	Net Customers	System Load Factor
2000	9,578	10,269	2,688	513,644	43.6%
2001	9,406	9,781	2,484	524,348	44.9%
2002	9,485	10,094	2,779	535,118	41.5%
2003	9,955	10,583	2,809	547,667	43.0%
2004	10,206	10,894	2,672	560,937	46.5%
2005	10,604	11,133	2,959	572,832	42.9%
2006	10,892	11,688	3,280	582,745	40.7%
2007	10,913	11,643	3,099	588,107	42.9%
2008	10,959	11,718	3,086	590,607	43.3%
2009	10,758	11,448	2,848	593,971	45.9%
2010	10,390	11,085	2,990	596,367	42.3%
2011	10,459	11,193	2,840	598,730	45.0%
2012	10,519	11,239	2,953	602,141	43.4%
2013	10,481	11,378	3,014	607,997	43.1%
2014	10,586	11,259	3,003	612,592	42.8%
2015	10,525	11,251	2,956	615,930	43.4%
2016	10,477	11,246	2,972	619,934	43.2%
2017	10,930	11,598	3,157	623,119	41.9%
Annual Growth	0.78%	0.72%	0.95%	1.14%	

Table 37. Sales by retail classes

Year	Residential	C&I Small	C&I Medium	C&I Large	Other	Total
2000	4,126	3,192	761	1,358	141	9,578
2001	4,019	3,193	744	1,307	142	9,406
2002	4,087	3,260	709	1,286	143	9,485
2003	4,362	3,319	773	1,363	138	9,955
2004	4,404	3,362	799	1,495	147	10,206
2005	4,557	3,482	814	1,610	140	10,604
2006	4,742	3,536	779	1,694	141	10,892
2007	4,631	3,524	821	1,790	147	10,913
2008	4,690	3,478	828	1,806	157	10,959
2009	4,704	3,340	793	1,770	151	10,758
2010	4,500	3,222	755	1,768	144	10,390
2011	4,600	3,224	717	1,776	142	10,459
2012	4,644	3,243	680	1,799	153	10,519
2013	4,635	3,236	655	1,804	151	10,481
2014	4,660	3,233	647	1,883	162	10,586
2015	4,638	3,165	621	1,952	146	10,524
2016	4,678	3,157	587	1,920	136	10,477
2017	4,996	3,217	581	2,007	127	10,930
Annual Growth	1.13%	0.05%	-1.57%	2.32%	-0.60%	0.78%

Table 38. Average monthly customer accounts by class

Year	Residential	C&I Small	C&I Medium	C&I Large	Other	Total
2000	455,455	53,055	293	130	4,712	513,644
2001	464,909	54,306	291	128	4,715	524,348
2002	474,293	55,682	289	126	4,728	535,118
2003	485,858	56,656	304	125	4,725	547,667
2004	497,969	57,743	320	130	4,775	560,937
2005	508,760	58,832	315	131	4,794	572,832
2006	517,369	60,099	307	136	4,834	582,745
2007	521,300	61,452	330	141	4,883	588,107
2008	522,819	62,353	332	149	4,955	590,607
2009	525,784	62,686	331	155	5,016	593,971
2010	528,065	62,781	316	156	5,049	596,367
2011	530,104	63,064	294	154	5,114	598,730
2012	533,318	63,238	291	152	5,142	602,141
2013	538,863	63,510	282	157	5,185	607,997
2014	543,177	63,784	264	149	5,217	612,592
2015	546,383	63,856	254	155	5,282	615,930
2016	549,980	64,163	248	158	5,334	619,882
2017	552,897	64,412	249	157	5,405	623,119
Annual Growth	1.15%	1.15%	-0.96%	1.13%	0.81%	1.14%

Table 39. 2017 billing determinates by rate schedule

Rate Class	Description	Customers	Avg. kWh/mth	Annual GWh	Share of Total Sales
Residential	Electric Space Heat	123,809	831	1,235	11%
Residential	Non-Electric Space Heat	429,088	731	3,762	34%
GSN	Max kW <=20	55,936	1,157	777	7%
GSS	21 to 299 Max Kw	7,999	19,326	1,855	17%
GSTOU3	300 to 499 Max Kw	477	102,338	586	5%
GSTOU2	500 to 999 Max Kw	249	194,703	581	5%
GSTOU1	>=1000 Max Kw	157	1,062,447	2,007	18%
AGR	0 to 499 Max Kw	2,430	2,413	70	1%
Street/Traffic		70,222	63	53	0%
Nightlights		4,563	66	4	0%
Total		694,929		10,930	100%
Net Customers		690,367			

Table 40. Sacramento County economic and population history and forecast

Year	Population	Non-Farm Employment (1,000)	Personal income ($Mil)
2000	1,235,492	570,837	36,273
2001	1,271,059	580,217	39,495
2002	1,304,626	589,833	41,016
2003	1,331,368	591,928	43,406
2004	1,350,629	598,831	46,184
2005	1,362,610	616,765	48,166
2006	1,371,641	629,951	50,965
2007	1,383,397	630,986	52,725
2008	1,396,379	618,058	54,773
2009	1,410,321	587,249	53,826
2010	1,423,361	572,818	54,665
2011	1,436,131	568,930	57,494
2012	1,448,504	581,092	59,784
2013	1,461,631	593,742	61,654
2014	1,479,513	606,317	65,392
2015	1,497,371	620,974	69,872
2016	1,513,423	633,312	73,112
2017	1,530,179	646,482	76,550
2018	1,549,046	656,837	80,822
2019	1,569,014	667,237	85,411
2020	1,588,677	675,587	89,770
2021	1,607,744	682,161	94,387
2022	1,625,925	689,389	99,098
2023	1,643,434	697,056	103,994
2024	1,660,853	704,673	109,144
2025	1,678,009	711,845	114,443
2026	1,694,734	718,389	119,913
2027	1,712,229	725,772	125,763
2028	1,730,144	733,937	131,910
2029	1,748,416	742,530	138,304
2030	1,766,639	751,727	144,899

19.5 Data and sources

The regression models retail sales were estimated with data from SMUD's billing system for the period 2007-2017. This period is reflective of the post-recession demographics and economic development in the Sacramento region. SMUD's billing data include monthly kWh and customer accounts. Hourly load, daily peak and daily energy models were estimated using hourly load data from SMUD's Energy Management System (EMS) for its retail service territory for the period 1-1-2006 to 11-31-2017.

The population, personal income, and employment data is from the IHS Global Insight Regional Forecast for Sacramento County (June 2017).

Office building vacancy rates are from the Sacramento Business Journal, On Real Estate Section, selective publication dates.

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