Board of Directors

Special Meeting

Date: April 28, 2021

Time: 5:30 p.m.

Location: Virtual Meeting (online)

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NOTICE OF SPECIAL MEETING AND AGENDA

SACRAMENTO MUNICIPAL UTILITY DISTRICT
BOARD OF DIRECTORS MEETING

In accordance with the Governor's Executive Order N-29-20 and the Emergency Board Meeting Procedures adopted by the SMUD Board of Directors, the regular Board meeting and other public meetings are closed to the public to align with state, local, and federal guidelines and social distancing recommendations for the containment of the coronavirus.

Live video streams and indexed archives of meetings are available at:
http://smud.granicus.com/ViewPublisher.php?view_id=16

Members of the public may register to provide verbal comments at an upcoming Board or Committee meeting by e-mailing a request to speak to PublicComment@smud.org. Please include the date of the meeting, name, and topic or agenda item the requestor wishes to speak on. The request may also be submitted while the meeting is in progress during the standard time for the agenda item or topic. **Pre-registration is strongly encouraged by no later than 3:00 p.m. on the day of the meeting.**

Members of the public may provide written public comments on a specific agenda item or on items not on the agenda (general public comment) by submitting comments via e-mail. Comments may be submitted to PublicComment@smud.org and will be placed into the record of the meeting.

Members of the public that are listening to or watching the live stream of a Board meeting and wish to submit written comments on a specific agenda item as it is being heard may submit their comments, limited to 250 words or less, to PublicComment@smud.org, noting the agenda item number in the subject line. The Board President may read comments for items on the agenda into the record, in her discretion, based upon such factors as the length of the agenda or the number of e-mail comments received. General public comment for items not on the agenda will not be read into the record but will be provided to the Board and placed into the record of the Board meeting if it is received within two hours after the meeting ends.

April 28, 2021 – 5:30 p.m.

Zoom Webinar Link: Join SMUD Special Board of Directors Meeting Here
Webinar ID: 161 610 0959
Password: 874904
Phone Dial-in Number: 1-669-254-5252

Call to Order.
a. Roll Call.

1. Approval of the Agenda.

Comments from the public are welcome when this agenda item is called.

Discussion Calendar:

2. Accept SMUD's **2030 Zero Carbon Plan** with the clarifications made in response to public comments.
   Presenter: Scott Martin

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Public Comment:

3. Items not on the agenda.

Dated: April 23, 2021

Nancy Bui-Thompson, President
Board of Directors
Sacramento Municipal Utility District

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Board Committee Meetings and Special Meetings of the Board of Directors are held at the SMUD Headquarters Building, 6201 S Street, Sacramento

The SMUD Board of Directors is currently operating under Emergency Board Meeting Procedures. In response to local, state, and federal directives, the following meetings will be held virtually (online).

May 11, 2021	Strategic Development Committee and Special SMUD Board of Directors Meeting	Virtual Meeting (online)	5:30 p.m.
May 12, 2021	Policy Committee and Special SMUD Board of Directors Meeting	Virtual Meeting (online)	5:30 p.m.
May 18, 2021	Finance and Audit Committee and Special SMUD Board of Directors Meeting	Virtual Meeting (online)	5:30 p.m.
May 19, 2021	Energy Resources & Customer Services Committee and Special SMUD Board of Directors Meeting	Virtual Meeting (online)	5:30 p.m.

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Regular Meetings of the Board of Directors are held at the SMUD Headquarters Building, 6201 S Street, Sacramento

The SMUD Board of Directors is currently operating under Emergency Board Meeting Procedures. In response to local, state, and federal directives, the following meeting will be held virtually (online).

May 20, 2021 Virtual Meeting (online) 5:00 p.m.

Pursuant to Resolution No. 20-06-08 adopted on June 18, 2020, Emergency Board Meeting Procedures are in effect:

Members of the public may make either a general public comment or comment on a specific agenda item by submitting comments via email. Comments may be submitted to PublicComment@smud.org. Comments will be provided to the Board and placed into the record of the Board meeting if it is received within two hours after the meeting ends.

Members of the public that are listening or watching the live stream of a Board meeting and wish to comment on a specific agenda item as it is being heard, may submit their comments, limited to 250 words or less, to PublicComment@smud.org. The Board President may read the comments into the record, in her discretion, based upon such factors as the length of the agenda, the number of email comments received, and whether the Board is in danger of losing a quorum. Comments will be provided to the Board and placed into the record of the Board meeting if it is received within two hours after the meeting ends.

Members of the public may register to provide verbal comments at an upcoming Board or Committee meeting by emailing a request to speak to PublicComment@smud.org. Please include the date of the meeting, name, and topic or agenda item the requestor wishes to speak on. The request may also be submitted while the meeting is in progress during the standard time for the agenda item or topic. Pre-registration is strongly encouraged by no later than 3:00 p.m. on the day of the meeting.

ADA Accessibility Procedures: Upon request, SMUD will generally provide appropriate aids and services leading to effective communication for qualified persons with disabilities so that they can participate equally in this virtual meeting. If you need a reasonable auxiliary aid or service for effective communication to participate, please email Toni.Stelling@smud.org, or contact by phone at (916) 732-7143, no later than 48 hours before this virtual meeting.

2

SSS No.	BOARD AGENDA ITEM STAFFING SUMMARY SHEET	Committee Meeting & Date N/A
CGS&OO 21-005		Board Meeting Date April 28, 2021

TO		TO	
1.	Lora Anguay	6.	Stephen Clemons
2.	Scott Martin	7.	Tracy Carlson
3.	Gary King	8.	
4.	Frankie McDermott	9.	**Legal**
5.	Jennifer Davidson	10.	**CEO & General Manager**

Consent Calendar		**Yes**	X	**No** *If no, schedule a dry run presentation.*	**Budgeted**		**Yes**	X	**No** *(If no, explain in Cost/Budgeted section.)*

FROM (IPR)	DEPARTMENT	MAIL STOP	EXT.	DATE SENT
Scott Martin	Resource and New Business Strategy	B205	6872	04/22/21

NARRATIVE:

Requested Action: Accept SMUD's 2030 Zero Carbon Plan with the clarifications made in response to public comments.

Summary: Staff will provide a brief presentation outlining the public process and public comment received with regard to SMUD's 2030 Zero Carbon Plan, which identifies a flexible Pathway for SMUD to eliminate carbon emissions from its power supply by 2030. The Plan includes clarifications based on feedback and comments received. The Board is invited to discuss the Plan, provide comment and accept the 2030 Zero Carbon Plan with the clarifications made in response to public comment.

Board Policy: *(Number & Title)* Strategic Direction SD-9, Resource Planning; Strategic Direction SD-10, Innovation

Benefits: Discuss and review culmination of input and information to-date on industry-leading new policy and goals to reduce SMUD's greenhouse gas emissions from its electricity production to zero.

Cost/Budgeted: N/A

Alternatives: Do not accept the plan or take no action.

Affected Parties: All SMUD Departments, Customers and Communities in SMUD's Service Territory

Coordination: All SMUD Departments

Presenter: Scott Martin, Interim Chief Grid Strategy and Operations Officer

Additional Links:

SUBJECT	ITEM NO. *(FOR LEGAL USE ONLY)*
SMUD's 2030 Zero Carbon Plan	**2**

ITEMS SUBMITTED AFTER DEADLINE WILL BE POSTPONED UNTIL NEXT MEETING.

DRAFT
March 2021

2030 Zero Carbon Plan

SMUD's flexible road map to eliminate carbon emissions from our power supply by 2030.

Draft 2030 Zero Carbon Plan

Table of contents

Table of Figures

Table of Tables

Executive summary

SMUD's goal to eliminate carbon emissions from our power supply by 2030 is more ambitious than already aggressive state mandates and is ahead of virtually all other utilities in the United States. Our 2030 Zero Carbon Plan is a flexible road map to achieve our zero carbon goal while ensuring all customers and communities we serve reap the benefits of decarbonization.

For more than a half century, SMUD has focused on growing the amount of carbon-free electricity we provide to the Sacramento region. Construction of our Upper American River Project (UARP), a 688-MW hydroelectric system in the Sierra Nevada Mountains west of Lake Tahoe, began in 1957. Today, the UARP supplies 16% of our energy needs with low-cost, carbon-free electricity. With a range of other clean energy resources in our portfolio, SMUD's energy supply is on average 50% carbon-free today.

It's in our DNA to lead the way in carbon reduction. We've consistently set renewable energy and carbon reduction goals that are ahead of and more aggressive than state mandates. We set these aggressive goals because it's the right thing to do.

Having ambitious goals helped SMUD become the first large California utility to have at least 20% of our energy come from renewable sources. We have a long list of notable firsts: The original green power pricing program for our customers, the first utility in California to make time-based rates standard for all customers and the first solar-powered electric vehicle charging station in the western United States. But we recognize these are not enough.

Globally, 2016 and 2020 were the hottest years on record and California has witnessed first-hand the devastating impacts of carbon on our climate, with devastating wildfires, rising temperatures and decreased snowpack. In 2018, SMUD set one of the most aggressive carbon reduction targets in the country with the goal of achieving net zero emissions by 2040, five years ahead of California's 2045 net zero goal. In July 2020, our Board of Directors declared a climate emergency and adopted a resolution calling for SMUD to take significant and consequential actions to become carbon neutral (net zero carbon) by 2030. The Board also directed SMUD staff to report by March 31, 2021 on clear, actionable and measurable strategies and plans to reach SMUD's climate emergency goals. Rapidly advancing clean energy technology and a collaborative and inclusive approach to carbon reduction has allowed SMUD to set the even more ambitious goal of zero carbon by 2030, with the 2030 Zero Carbon Plan being our strategy to achieve that goal.

Eliminating carbon emissions will deliver far-reaching benefits. It's the right thing to do for the environment, air quality, our children and grandchildren and for equity in communities that have traditionally been left out of decisions and discussions about carbon emissions. This ambitious goal puts the Sacramento Region on the map as an example to follow and a region where innovative, climate-friendly businesses want to be.

We have a track record of setting game changing goals and achieving them. Our 2030 Zero Carbon Plan details how we'll get to zero without compromising reliability or affordability. It comes with a commitment to keep rate increases within the rate of inflation. While nine years is

an aggressive timeline, we know the clean energy and clean technology sectors and customer preferences will change significantly between now and 2030, so flexibility is central to our Plan.

Going absolute zero carbon is a bold and ambitious goal -- one we believe we can and must achieve. We can't get there with today's technology and we can't get there alone. That's why innovation and partnership are key pillars of the Plan. Working in partnership with our customers and community, government agencies, community leaders and organizations, business leaders and the business community, legislators, regulators and others, we'll help align resources and programs for maximum impact in all communities. We know, for example, that widespread adoption of customer-owned distributed energy resources like electric vehicles and rooftop solar will be key to achieving zero carbon. Making these technologies accessible to all customers will be a central focus of our program development efforts over the coming years.

Our 2030 Zero Carbon Plan is our road map to eliminate carbon emissions from our electricity production by 2030 while maintaining a reliable and affordable service and partnering with our customers, communities and a wide-range of stakeholders on this journey.

Our commitment to our customers and community

As a community-owned, not-for-profit utility, our customers and community are at the heart of all we do. By pursuing zero carbon, we're helping create a cleaner and healthier region for all. Our goal of zero carbon by 2030 is anchored in our longstanding commitment to provide safe and reliable power with rates among the lowest in California. We won't compromise on this commitment.

Our customers, community and other partners are central to our vision and part of the solution to decarbonize our region. Their input and participation have helped us develop the 2030 Zero Carbon Plan. Ongoing communications and engagement with our customers and community will help ensure we continue to deeply understand their needs, which will be essential to enhance our programs to support zero carbon while meeting our customers' evolving preferences. Continuing to educate customers on the benefits of zero carbon and ways they can take action will also be critical to achieving our goal.

SMUD's zero carbon goal is best achieved by finding mutually beneficial solutions and we reaffirm our commitment to being inclusive, supporting regional innovation, clean tech jobs and attracting clean energy investments to the region through collaborative partnerships.

We have an opportunity to bring together a wide-range of stakeholders — businesses, elected officials, community leaders and organizations, think tanks, academia, regulators, start-ups, native tribes, venture capitalists and others to align resources for maximum impact. We'll partner with others to develop technology, healthy ecosystems, find innovative sources of funding and develop new business models. We will also need to work closely with regulators with respect to climate-friendly policies and regulations that encourage electrification in the building and transportation sectors, which are currently the largest emitters of carbon/greenhouse gases in California.

SMUD is committed to achieving our zero carbon goal in an inclusive way that leaves no communities behind. For decades, SMUD has supported low-income customers with innovative programs to make energy efficiency and other technologies accessible. In 2016, SMUD introduced additional energy saving pilots which expanded our reach and helped thousands of income qualified customers adopt carbon reduction measures in their homes and reduce their overall energy bill burden. Measures included replacing gas appliances with electric appliances, installing rooftop solar systems, insulation, heating and cooling systems, and lighting and/or other weatherization improvements. We'll continue to re-examine our programs and pilots to tailor them to supporting our goal and our customers' needs in all segments.

Our Sustainable Communities Initiative helps bring environmental equity and economic vitality to all communities in our service area, with special attention given to historically under-resources neighborhoods. We believe in the ability to make a greater collective community impact through partnerships. Through our Sustainable Communities Initiative, we collaborate with private industry, government agencies and nonprofits to invest in and implement programs that provide equitable access to indicators of sustainable community success, with a focus on social wellbeing, healthy environment, prosperous economy and mobility.

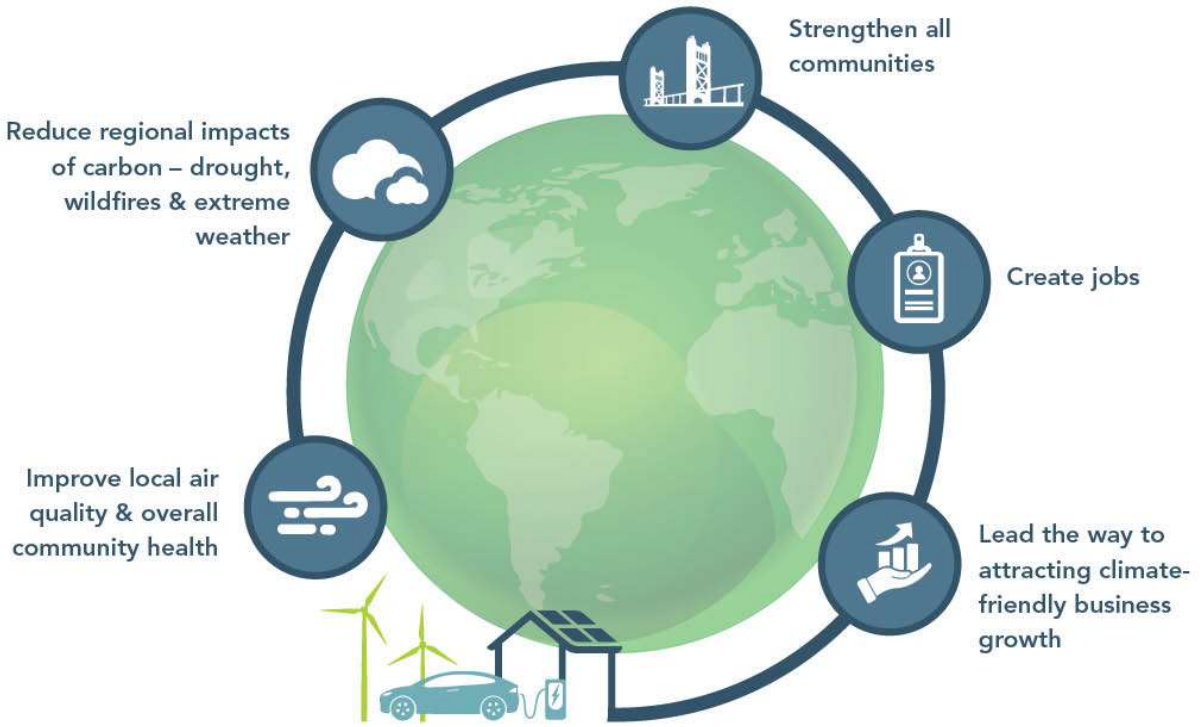
We're looking at other creative ways to support investment in underserved communities, including partnerships with financial institutions and other businesses and pursuing foundation and private investments to support decarbonization programs.

We'll continue working with our business customers to identify partnership opportunities to align resources, test technology, electrify buildings and transportation. Together, we'll develop tailored programs and pilots, while exploring co-development of new technologies and solutions. We plan to partner to seek funding for new initiatives that can help our region decarbonize faster and at lower cost.

Policy makers and regulators play an incredibly important role in shaping our zero carbon future. We plan to work collaboratively to promote cost-effective measures to reduce carbon emissions and support policy that encourages carbon reduction. We'll also work with government agencies to seek funding opportunities for new technologies and solutions that support SMUD's research and development efforts.

We have a history of partnering with our community and are excited to have broad support from our customers and community for our commitment to eliminating carbon from our power supply. We will build on what we're already doing – leading by example and engaging members of our community and industry – and together we can create and work toward a shared vision for the future. We'll continue to empower our communities to work with us to make sure Sacramento communities are livable, resilient and ready for a low-carbon future.

Community benefit



The road to zero: Four focus areas

As a community-owned, not-for-profit utility, our customers and community are at the heart of all we do. By pursuing zero carbon, we're helping create a cleaner and healthier region for all. Our goal of zero carbon by 2030 is anchored in our longstanding commitment to provide safe and reliable power with rates among the lowest in California. We won't compromise on this commitment.

Our customers, community and other partners are central to our vision and part of the solution to decarbonize our region. Their input and participation have helped us develop the 2030 Zero Carbon Plan. Ongoing communications and engagement with our customers and community will help ensure we continue to deeply understand their needs, which will be essential to enhance our programs to support zero carbon while meeting our customers' evolving preferences. Continuing to educate customers on the benefits of zero carbon and ways they can take action will also be critical to achieving our goal.

SMUD's zero carbon goal is best achieved by finding mutually beneficial solutions and we reaffirm our commitment to being inclusive, supporting regional innovation, clean tech jobs and attracting clean energy investments to the region through collaborative partnerships.

We have an opportunity to bring together a wide range of stakeholders — businesses, elected officials, community leaders and organizations, think tanks, academia, regulators, start-ups, native tribes, venture capitalists and others to align resources for maximum impact. We'll partner with others to develop technology, healthy ecosystems, find innovative sources of

funding and develop new business models. We will also need to work closely with regulators with respect to climate-friendly policies and regulations that encourage electrification in the building and transportation sectors, which are currently the largest emitters of carbon/greenhouse gases in California.

Our 2030 Zero Carbon Plan is a road map with the flexibility needed to adjust to changing technology and customer preferences to completely eliminate the use of fossil fuels in our electricity production by 2030. With the clean energy technology in our power supply today, we expect to be able to reduce our carbon emissions by 90%, without compromising reliability or our low rates. Eliminating the last 10% will be more challenging and will require SMUD to take bold actions and pioneer new game-changing technologies.

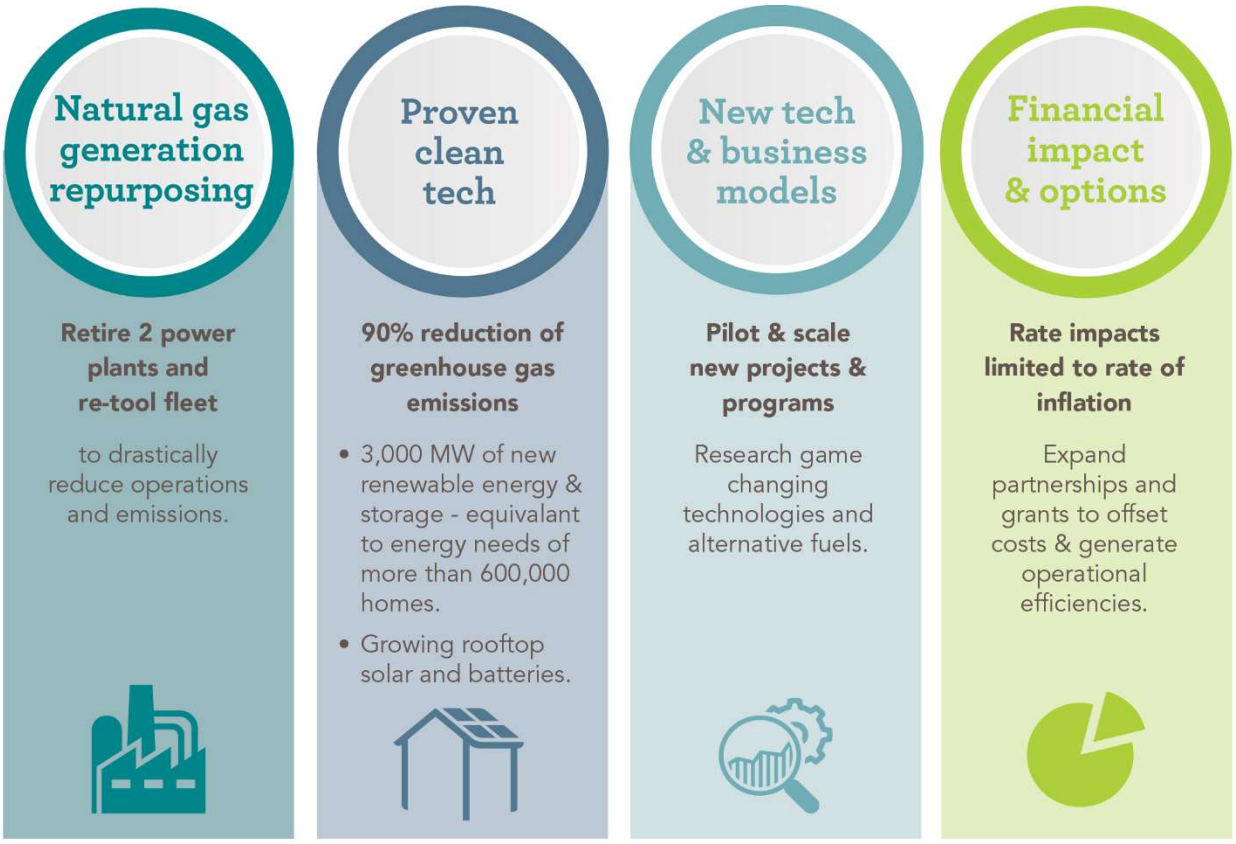
To achieve zero carbon, we're focused on four main areas:

- **Natural gas generation repurposing**. Eliminating greenhouse gas emissions from our power plants is essential to reach our goal of zero carbon. We're focused on reimagining our existing generation portfolio to eliminate greenhouse gas emissions through retirement, re-tooling and using renewable fuels.

- **Proven clean technologies,** which are carbon-free technologies available today, including solar, wind and geothermal energy and battery storage. We'll significantly expand our investments in these technologies and adjust our plan as we progress in the other three areas.

- **New technologies and business models**, which are technologies that are either currently unknown or are not ready for large-scale adoption due to price, reliability or other factors. We'll launch pilot projects and programs to test and prove new and emerging technologies and develop paths for prioritizing technology adoption and scaling.

- **Financial impact and options.** We're focused on making sure achieving our zero carbon goal is possible at a reasonable cost that minimizes rate increases for our customers. We'll do that by identifying savings and pursuing partnerships and grants that support the Plan.

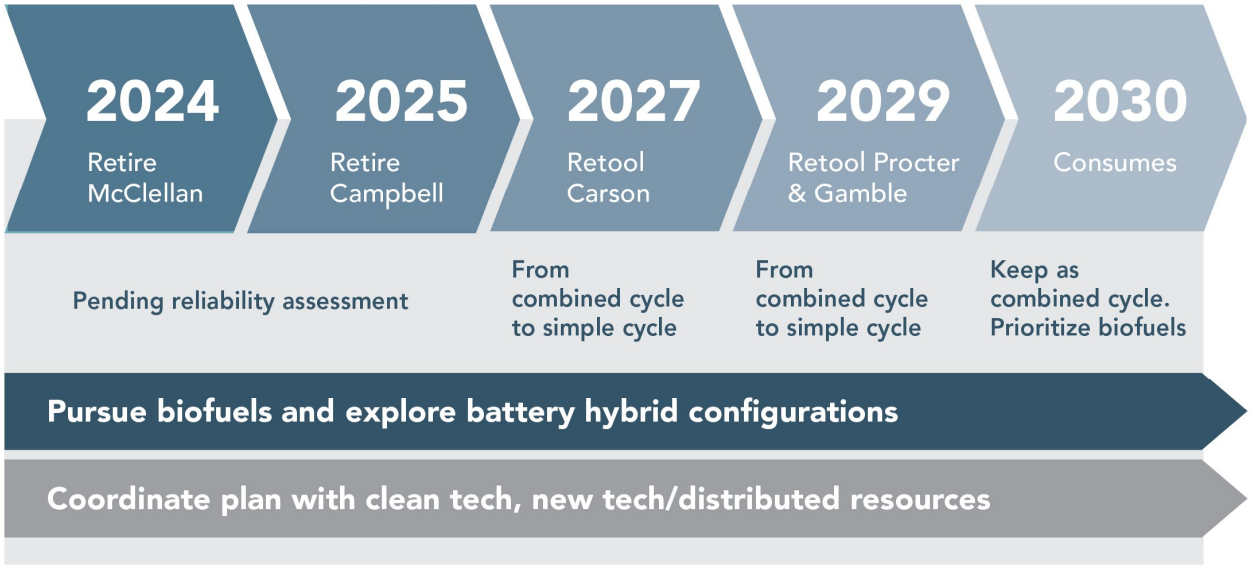


We're committed to eliminating carbon emissions in our power supply while recognizing flexibility is needed to adapt as new technology emerges, costs decline and our customers adopt more distributed energy resources and other technology. While pursuing each of the four areas will be important through 2030, activities may accelerate or decline in individual areas based on overall progress and advancements in specific areas.

Natural gas generation repurposing

Our gas power plants provide low-cost, reliable energy. While recent investments mean SMUD's Cosumnes Power Plant is the most efficient combined cycle gas plant in California, today our gas plants are our main source of greenhouse gas emissions, so retiring and/or refueling them is a significant part of how we'll reach zero emissions. We looked at a variety of options in developing our 2030 Zero Carbon Plan.

We believe our gas power plants can continue to play a vital role to support reliability without emitting greenhouse gases. By retooling two of our plants from constant operations to become more flexible peaking units, we can drastically reduce their use and carbon emissions while maintaining most of their capacity. We're targeting operating them on biofuels such as renewable gas from landfills, biodiesel or other renewable sources when they'll need to operate for reliability.



Our Campbell and McClellan gas plants are located in areas already affected by air pollution. Modifying or retiring these plants will bring air quality benefits to these historically under-resourced communities because they're located in areas of SMUD's territory with some of the highest environmental sensitivity scores. Based on our studies to date, we believe we can retire McClellan in 2024 and Campbell in 2025 and replace them with proven clean technologies. Final decisions about the retirement of these plants will be based on additional reliability studies and discussions and engagement with the community.

Our Plan, which includes retiring two power plant and retooling other, will reduce our emissions and improve air quality in Sacramento. Below is the summary of our plan to retire, retool and minimize the use of natural gas at our plants.

Power Plant	Generator Type	Unit	Capacity (MW)	Fuel Source
Sacramento Power Authority at Campbell Soup	**Retired***			
McClellan Gas Turbine	**Retired***			
Central Valley Financing Authority at Carson Ice	Combustion Turbine	1	50	Biofuels**
	Steam Turbine	2		**Retired**
	Combustion Turbine	3	50	Biofuels**
Sacramento Cogeneration Authority at Procter & Gamble	Combustion Turbine	1	50	Biofuels**
	Steam Turbine	2		**Retired**
	Combustion Turbine	3	50	Biofuels**
	Simple Cycle Peaking	4	50	Biofuels**
SMUD Financing Authority at the Cosumnes Power Plant	Steam Turbine	1	207	Waste Heat
	Combustion Turbine	2	207	Biofuels**
	Combustion Turbine	3	207	Biofuels**

**Final generator configurations are pending reliability assessment.*
***Final 2030 fuel mix is to be determined. Dependent on options available and may include one or more of the following: hydrogen, biogas, renewable natural gas, biofuels.*

Proven clean technologies

Proven clean technologies are the relatively mature zero emission technologies available in the market today and have demonstrated reliability and cost benefits. Along with reimagining our natural gas power plants, proven clean technologies are the foundation of this Plan and we expect they'll help reduce our carbon emissions by about 90% by 2030, far exceeding the regulatory and legislative mandates in place today.

Proven clean technologies include utility-scale wind, solar, batteries, hydroelectric power, biomass, geothermal, as well as customer-owned solar and battery storage. Our Zero Carbon Plan includes a significant increase in investments proven clean technology over the next nine years, by SMUD and our customers.

Utility-scale investments (2021-2030)

- **Local solar:** 1,100 to 1,500 MW
- **Regional Solar:** 100 MW
- **Local battery storage:** 700 to 1,100 MW
- **Wind** (various locations): 390 to 590 MW
- **Geothermal** (various locations): 100 to 220 MW

These utility-scale investment ranges are based on current and expected market conditions and costs for new technologies, recognizing market conditions can change quickly, impacting resource availability and costs. External market factors such as changes in

California and western U.S. electricity market rules also play an important role in resource adoption, as do legislative and regulatory changes. If emerging technologies develop faster than expected, we will adjust our proven clean technology strategy accordingly. Similarly, if costs for new technologies decline slower than expected or if promising research areas don't yield the expected results, we may need to scale up our investments in other areas.

Customer-owned adoption of solar and storage (2021-2030)

- **Customer rooftop solar:** 250 to 500 MW
- **Customer battery storage:** 50 to 250 MW

We recognize our customers' investment in rooftop solar and battery technologies depend to a large extent on costs as well as overall customer sentiment about zero-carbon technologies. Investment estimates are based on today's forecast of probable adoption rates and the ranges reflect the uncertainty of costs associated with these systems over the next decade.

To safeguard reliability, it's also important that SMUD maintains a diverse resource portfolio that reflects different generation technologies and geographic diversity. So, our Plan includes intermittent renewable energy such as wind and solar as well as energy storage and geothermal resources that support reliability.

New technologies and business models

Emerging technologies play a critical role in our Plan, specifically to eliminate the remaining 10% of carbon emissions. We'll look to emerging distributed energy resource options and large-scale new technology innovations. This includes focusing on new applications for customer-owned distributed energy resources by assessing the attractiveness, costs and reliability of emerging technologies and business models. After launching and evaluating pilot programs and projects we will evaluate, prioritize and scale the technologies and programs we expect will have the largest impact reducing carbon in our 2030 resource mix, especially in terms of short duration generation capacity. To that end, we're focused on four main areas of technology:

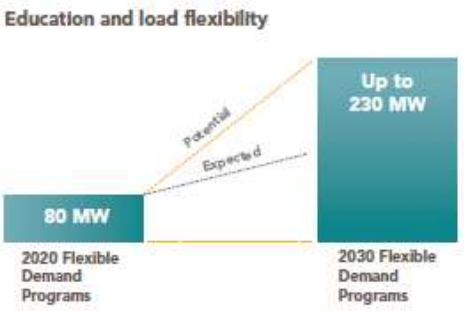
- Electrification.
- Education and demand flexibility.
- Virtual power plants (VPP) and vehicle-to-grid technology (V2G).
- New grid-scale technologies.

Taken together, we expect customer-owned resources and SMUD customer-focused programs will contribute between 360 and 1,300 MW of capacity to our grid by 2030, depending on the rate of customer adoption and the success of the programs and technologies we develop.

Electrification

Electrification of buildings and vehicles is a priority for SMUD today to support the decarbonization of these sectors, which are the largest carbon emitters in California. Our 2030 Zero Carbon Plan continues to prioritize electrification of transportation as well as new and existing buildings. In addition to piloting innovative electrification programs, we'll continue to engage under-resourced and low-income communities to achieve bill savings and ensure access to clean technologies. Examples of potential programs include:

- Electrifying multi-family homes, schools, commercial buildings, and under-resourced communities.
- New construction smart homes.
- Financing options.
- Turnkey EV charging solutions for residential and commercial properties.
- Incentives for used EVs.



Learnings from these pilot programs will help us identify the ones to scale. Pursuing external grants to help make these initiatives more affordable for all customers, we'll also advocate for regulatory changes and seek to collaborate regionally to accelerate the adoption of zero carbon technologies.

We're on an important journey with our customers and it's important to help ensure our customers understand the actions they can take to help support decarbonizing our region. Through pilot programs aimed at flexible energy use, we can help customers reduce their energy usage and bills at times when the stress on our grid is the highest. These types of universal customer programs reduce carbon emissions without requiring customers to spend money on advanced technologies. If successful, we'll scale our flexible demand programs as a lower cost alternative to large solutions such as utility-scale battery storage.

Customers will also have options to participate in programs that leverage the advanced and automation capabilities of their own devices, such as thermostats and electric vehicles, for deeper bill and carbon savings. We expect to develop about 165 MW of flexible load programs by 2030, but more could be possible as our programs continue to evolve to leverage advancing technology.

Virtual power plants (VPP) and vehicle-to-grid technology (V2G)

These programs seek to optimize the operation of our customers' equipment and distributed energy resources, balancing customer and grid needs to maximize benefits for both, while compensating customers for the energy they supply into SMUD's grid for use by other customers.

A virtual power plant consists of many small devices often owned by customers and located at their homes and businesses. When operated and managed together in a coordinated way, they can become an alternative to a conventional utility-scale power plant. VPPs can include electric vehicles, batteries, thermostats and electric water heaters. By aggregating their capacity and flexibility, a VPP can mimic a power plant and provide services that help reduce electric peak demand during hot summer days or cold winter nights, potentially reducing the need for SMUD to build or buy other resources freeing resources to more aggressively invest in renewable energy.

We will launch several VPP pilot programs between 2021 and 2024 to demonstrate and test their reliability, cost and value compared to alternative resources. This will inform selection of the best model for bringing VPPs to scale between 2025 and 2030. Our goal is to develop a flexible program where customers can bring a variety of devices that we use as one VPP to help reduce demand during key times of the year. Our approach will include working with third-party providers to jointly test VPP programs that can offer grid services such as resource adequacy and short-term energy.

Vehicle-to-grid technology is a key area of VPP innovation. Electric vehicle batteries can be connected to the grid to help stabilize the grid by either providing energy to the grid during periods of very high electric demand or by taking a portion of surplus renewable energy available on the electric grid to charge the grid-connected vehicle. We anticipate vehicle-to-grid advancements will offer some of the benefits of stationary battery storage without the added investment of a separate stationary battery.

New grid-scale technologies

While retiring and retooling our gas plants will drastically reduce emissions, the use of natural gas will not be completely eliminated unless we identify sufficient amounts of renewable fuels or develop alternative generation sources. Our initial studies indicate about half of our fuel needs after retooling can be met with renewable natural gas that we already have under contract. Additional fuel sources or technical advancements are necessary to close the remaining gap and fully eliminate our greenhouse gas emissions. We're looking at several options to address this:

- Biofuels and other clean fuels, including renewable natural gas, green hydrogen, biodiesel and ethanol.
- Long duration storage which could include technologies such as flow batteries, thermal storage and liquid air energy storage.
- Carbon capture and sequestration, including the Allam-Fetvedt cycle to assess the feasibility of this and similar technologies in the Sacramento region.
- Pumped storage hydro using our existing UARP dams and hydroelectric facilities.

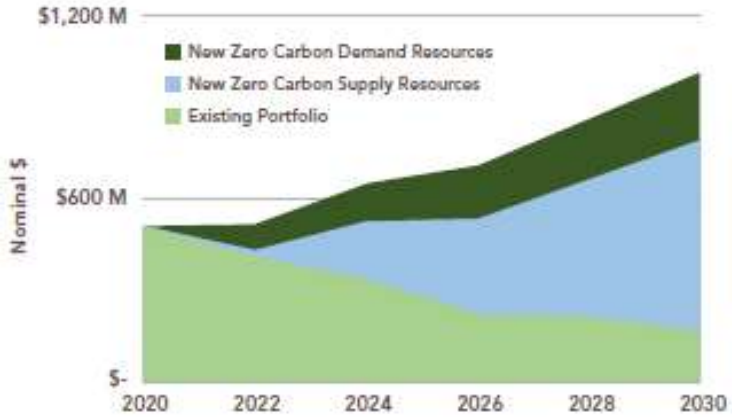
This research and the ability to secure sufficient volumes of biofuels will allow us to scale up the most promising technologies. We'll continue to evaluate and seek innovative options as new technologies emerge.

Financial impacts and options

SMUD's rates are significantly lower than those of neighboring utilities and are among the lowest in California. We believe eliminating carbon emissions from our power supply by 2030 is achievable with rate increases that don't exceed the rate of inflation, which is consistent with California utility rate increases over the past 25 years. While these low rate increases are achievable, they will be challenging to achieve.

We've identified the need for between $50 and $150 million in sustained and ongoing savings to help offset the costs of our Plan, which we'll deliver through operational savings and pursuing partnerships and grants. We expect to work closely with community organizations, industry partners, government agencies and regulators to jointly develop and finance innovative solutions and pave the way for cost reductions in new and emerging clean technologies.

Cost of SMUD's electricity supply 2020-2030, including Zero Carbon portfolio costs



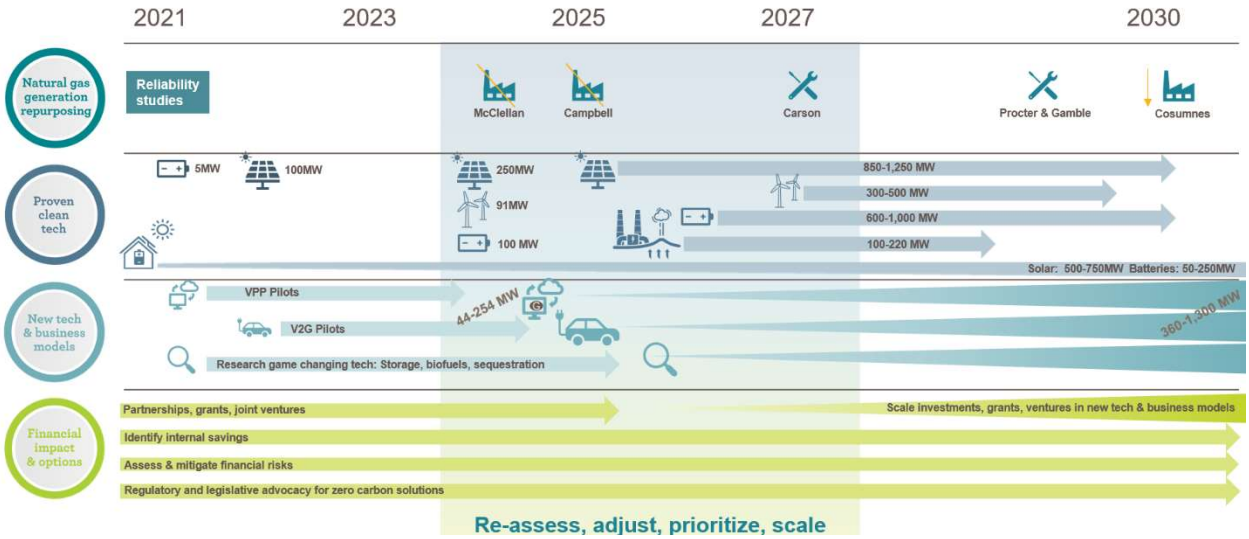
The estimated costs and rate impacts discussed in this section represent one possible outcome based on our current expectations for market developments and costs. There are many factors that could cause the costs for achieving our zero carbon goals to go higher or lower than our initial estimates presented here. For example, if costs for technologies such as solar and battery storage decline faster or more significantly than expected, we may be able to accelerate the pace of our carbon reduction efforts without sacrificing affordability. Conversely, if costs are higher than expected or if some technologies fail to deliver on their projected potential, the overall pace and choices of technologies may need to be adjusted. We expect to revisit the 2030 Zero Carbon Plan regularly to adjust as necessary to these changing factors.

2030 zero carbon action plan

Our initial analysis indicates SMUD can reach zero carbon by 2030, while recognizing that there are a number of unknowns and risks and we'll adjust our Plan as technology, customer adoption and other factors change. While the specifics of our long-term activities to support decarbonization will be adjusted based on what we learn through the early implementation of our Plan and the results of our research and pilot programs, we have a number of priorities for the first year of the Plan as summarized in the table below.

Year 1 Zero Carbon Plan implementation priorities
Implement plan for the Natural Gas Generator Repurposing Strategy, including • Perform detailed studies of reliability, economics and environmental impacts of retiring McClellan and Campbell. • Research new utility-scale technologies, fuels and options.
Implement plan for the Proven Clean Technology Strategy, including: • Conduct locational analysis, system impact study and economic valuation and solicit counterparty offers. • Study strategic new technology options complementing the Natural Gas Generator Repurposing Strategy. • Explore delivery options for out-of-area renewables. • Develop and issue competitive solicitation for new proven clean technology projects.
Implement plan for New Technology and Business Models Strategy, including: • Perform information technology system upgrades to enable DERs and VPPs. • Include DERs in operations, distribution and grid planning processes. • Launch new customer-partner pilot programs for VPP Involving thermostats, EVs, rooftop solar and batteries. • Launch pilots for behavioral demand response “Flex Alert”, EV managed charging and vehicle-to-grid demonstrations.
Evaluate the 2030 Zero Carbon Plan for NERC reliability standards, system adequacy requirements, operational reliability requirements, and new reliability services contributions.
Assess system adequacy and reliability impacts, including: • Evaluate operational reliability requirements to manage the variability of solar and wind generation. • Evaluate grid reliability services contribution from virtual power plants, distributed energy resources, demand response and load flexibility. • Perform detailed studies of sub-transmission system impacts from the re-tooling of the Carson plant.
Set internal goals for operational efficiencies needed to manage risks to rate impacts.
Organize grant capture team to proactively seek opportunities for funding partnerships and research with manufacturers, vendors, government agencies, utilities and research institutions.
Engage government, agencies and policy makers • Brief policymakers on the 2030 Zero Carbon Plan. • Advocate for and support electrification policies. • Support cities’ and county General Plans and Climate Action Plans. • Connect with federal agencies and policy makers on climate action and our 2030 Zero Carbon Plan.
Identify new workforce skills needed to support zero carbon technologies.
Develop and implement a comprehensive regional communications, marketing, outreach and educational effort.

High-level summary of the key elements and actions in our 2030 Zero Carbon Plan.



We're pleased to release our draft 2030 Zero Carbon Plan for public comment. We'll use this input from our customers, community and other stakeholders to finalize our Zero Carbon Plan. Please submit written comments to smud.org/ZeroCarbon. You can also sign up for regular updates at smud.org/BoardNotifications.

Introduction

In July 2020, Sacramento Municipal Utility District's (SMUD's) Board of Directors adopted a climate emergency declaration, prompting SMUD to develop a bold and ambitious plan for reaching zero carbon by 2030 while ensuring we continue to provide safe, reliable, affordable and inclusive power to our customers and community. This 2030 Zero Carbon Plan is a flexible road map to eliminate greenhouse gas emissions (GHG) from our power supply by 2030. It was developed following completion of several technical studies.

We have identified investments in local solar and large-scale batteries as well as a plan to repurpose and retire our natural gas power plants. We can achieve our goals most effectively through customer partnerships that embrace more distributed energy resources (DERs). Our studies found that new technologies and renewable fuels are needed to achieve our goals most cost-effectively.

This Plan was developed in collaboration with our stakeholders through several events and public meetings between December 2020 and March 2021. As we implement this flexible plan, we'll continue seeking inputs and ideas from our customers, community and other stakeholders.

This report is organized as follows:

- **SMUD's carbon reduction journey** is a retrospective look at the work SMUD has done so far to reduce our carbon footprint.
- **Building resilient customers and communities** is a snapshot of the work SMUD has undertaken to support under-resourced communities and low-income customers.
- **A history of planning for the future** is a brief summary of our previous long-term plan and aspects we're building upon in this 2030 Zero Carbon Plan.
- The **Energy system overview** provides a snapshot of our current energy delivery system, which is the foundation that we'll build our 2030 strategies upon.
- Then, we focus on the development of our 2030 Zero Carbon Plan. This includes an overview of our **2030 Zero Carbon Plan**, our **public consultation process** and describes the **plan structure**.
- Our plan is divided into four strategies – **natural gas generation repurposing**, **proven clean technologies**, **new technology and business models** and **finance** – that make up our flexible road map to eliminate GHGs from our power supply by 2030.
- Implementation of our plan will require close coordination with local, state and federal regulations. Our **government affairs** strategy provides a plan to ensure we're closely coordinated with many governing partners.
- Our report concludes with our **Action plan and risk mitigation strategy**.

About SMUD

SMUD is a community-owned, not-for-profit utility that generates, transmits and distributes electricity. SMUD began serving Sacramento in 1946 and is now the nation's 6th-largest community-owned electric utility, serving a population of over 1.5 million people and providing services to about 640,000 residential and commercial customers. Our service territory is nearly

900-square-miles and includes California's capital city, most of Sacramento County and small slices of Placer and Yolo counties.

Our vision is to deliver clean energy with zero carbon emissions while maintaining our commitment to reliable service, sustainable communities and affordable rates.

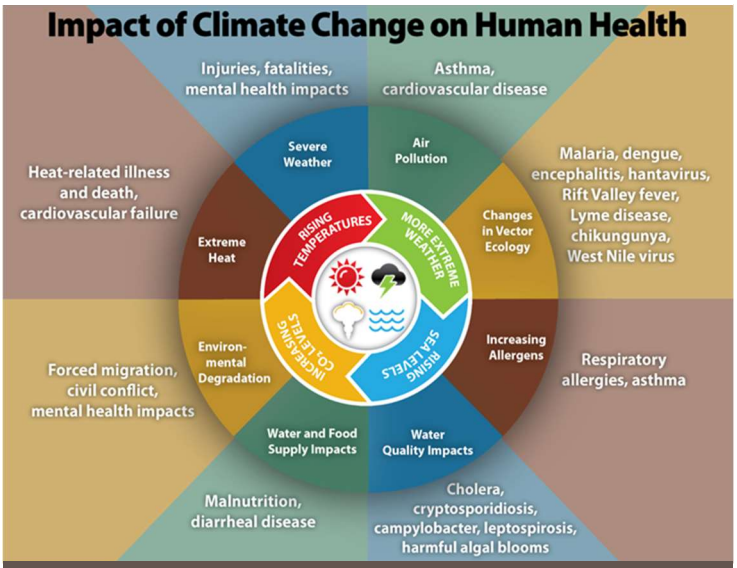
As a community-owned utility, SMUD is governed by a 7-member Board of Directors elected by voters to serve 4-year terms. Our Board of Directors determines policy direction and appoints our Chief Executive Officer & General Manager, who is responsible for SMUD's day-to-day operations.

Climate change

Temperatures around the world are rising and 2020 tied with 2016 as the hottest years on record. [1] Climate science has shown that fossil fuel combustion and land use changes disrupting carbon sinks[2] have greatly increased atmospheric concentrations of GHGs, resulting in climate change and a wide range of cascading impacts to ecosystems and economies around the world. The changing climate is already impacting SMUD's operations, employees, customers, communities and plans for the future.

Locally, the impacts of climate change include extreme heat, droughts, wildfires, flooding, species loss, rising sea levels and human displacement. Research suggests that the number of extreme heat days (days when the highs exceed 95°F) in the Sacramento Valley will increase and, by the end of the century, could include four months each year.[3] Rising temperatures are anticipated to impact the productivity of nearly 20% of our region's workforce that work in high climate risk industries, such as manufacturing, construction and agriculture. These industries may experience labor productivity decreases between 1% and 2.2% by the late century. [4]

Figure 1. Impact of climate change on human health



Source: Federal Centers for Disease Control & Prevention

[1] https://www.noaa.gov/news/2020-was-earth-s-2nd-hottest-year-just-behind-2016#:~:text=It's%20official%3A%202020%20ranks%20as,an%20analysis%20by%20NOAA%20scientists.
[2] Carbon sinks that occur in nature include plants, soil and the ocean, which naturally absorb atmospheric carbon.
[3] Risky Business Project. *From Boom to Bust? Climate Risk in the Golden State.* April 2015. Available online: https://riskybusiness.org/site/assets/uploads/2015/09/California-Report-WEB-3-30-15.pdf. Last access: 05 Jan. 2021.
[4] ibid

In the past, correlation in historical weather patterns, such as average temperatures or snowpack, could be used as reasonable predictors of customer electricity load and generation from SMUD's Upper American River Project (UARP) hydroelectric system. However, we're in a period of uncertainty where historical data is no longer a reliable indicator of the future. Prolonged droughts and lower-than-average snowpack results in less water available to generate hydroelectric power, which is one of the cleanest and most economical power sources we have. These challenges also present opportunities to accelerate our pursuit of sustainable, resilient and cost-effective solutions. SMUD is committed to evolving our operations and business practices to keep pace with these changes.

Climate emergency

In recognition of the severity of the global climate emergency, in July 2020, SMUD's Board of Directors adopted a Climate Emergency Declaration requiring SMUD to work toward our most ambitious carbon reduction goal — carbon neutrality in our electric power supply by 2030. Through the declaration, the Board acknowledged a climate emergency within its jurisdiction and signaled that:

- The planning process will be open, transparent and will be explored in a public process with the Board.
- SMUD will collaborate with local cities, counties, agencies, businesses and other organizations.
- SMUD affirms its commitment to environmental justice principles and leadership through our Sustainable Communities Initiative.
- SMUD has made a strong commitment to find additional opportunities to accelerate decarbonization.
- By March 31, 2021, the CEO & General Manager will report on clear, actionable and measurable strategies and plans to reach SMUD's climate emergency goals.

Our accelerated carbon reduction journey builds on previous efforts and our latest resource plan: the 2040 Clean Energy Plan, which was accepted by the California Energy Commission (CEC) in 2019. Rapidly advancing clean energy technology and a collaborative and inclusive approach to carbon reduction has allowed SMUD to set the even more ambitious goal of zero carbon by 2030, with this 2030 Zero Carbon Plan being our strategy to achieve that goal.

To achieve our 2030 zero carbon goal, we must address our reliability needs, for which new and emerging technologies such as energy storage, flexible load, carbon capture and storage and renewable gas technologies will be needed. We'll also need to increase investment in new clean energy supplies, new and emerging technology and pursue new business models and partnerships.

Global efforts to decarbonize energy supply

This Plan lays out an aggressive, flexible and inclusive clean energy pathway, with a goal of zero carbon that SMUD cannot and should not achieve alone. By working with other pioneering utilities, governments, businesses, agencies, community leaders and organizations, academia, start-ups and others, we will align resources to maximize carbon emission reductions with broad

and long-lasting impact. Our 2030 Zero Carbon Plan is part of a growing body of work that's necessary to combat this climate change emergency. As part of our climate emergency, our Board set a goal of achieving carbon neutrality by 2030.

Other, smaller utilities, such as City Light (Seattle) and the San Francisco Public Utilities Commission's Hetch Hetchy Power System (City and County of San Francisco) have already achieved carbon neutral operations. Both utilities have resource portfolios built around access to large swaths of hydroelectric power. At City Light, over 80% of delivered power is generated from hydroelectricity and Hetch Hetchy, 100% is from hydroelectricity.[5,6] Hetch Hetchy does have a small amount of non-hydro renewable generation, representing about 2% of the system (11 megawatt (MW) of solar, wind, and biogas). But, for utilities without access to significant hydro resources, like SMUD, achieving carbon neutrality will not be as straightforward. As shown in Table 1, SMUD's carbon reduction goals are among the most ambitious globally. More details are available in Appendix D: Global energy decarbonization efforts.

Table 1. Global carbon neutrality and net zero goals

Location	Target Year	GHG Reduction Goal
SMUD	2030	Carbon neutrality
Sacramento County	2030	Carbon neutrality
Puget Sound Energy	2030	Net zero GHG (carbon neutrality by 2045)
Lincoln Electric (Nebraska)	2040	Net zero GHG
Portland General Electric	2040	Net zero GHG
California	2045	Carbon neutrality
LADWP	2045	100% renewable electricity
Sweden	2045	Net zero GHG
Arizona Public Service Electric	2050	100% carbon free electricity
Madison Gas & Electric	2050	Net zero GHG
Ameren	2050	Net zero GHG
PSE&G	2050	Net zero GHG
Dominion	2050	Net zero GHG
Southern Company	2050	Net zero GHG
Orlando Utility Commission	2050	Net zero GHG, proposes carbon offsets for EVs
Alliant (Wisconsin)	2050	Net zero GHG, allows carbon offsets
Entergy	2050	Net zero GHG, allows carbon offsets
Duke Energy	2050	Net zero GHG, allows carbon offsets
DTE	2050	Net zero GHG, allows carbon offsets
Consumers Energy	2050	Net zero GHG, allows carbon offsets

[5] https://www.seattle.gov/city-light/energy-and-environment#:~:text=Over%2080%25%20of%20the%20power,Skagit%20and%20Pend%20Oreille%20Rivers.&text=*City%20Light%20does%20not%20have,in%20its%20power%20supply%20portfolio. Last Accessed: 24 March 2021

[6] https://sfwater.org/modules/showdocument.aspx?documentid=16653. Last Accessed: 24 March 2021

Engaging with our under-resourced communities

Climate change is a critical public health issue which disproportionately impacts our under-resourced communities. The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity, now and into the future. It includes 17 sustainable development goals, which are an urgent call for action by all countries in a global partnership. They recognize that ending poverty and other deprivations go hand-in-hand with strategies that improve health and education, reduce inequality and spur economic growth – all while tackling climate change and working to preserve our oceans and forests.[7] Similarly, the United Nations Declaration on the Rights of Indigenous Peoples recognizes that indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment. These global agreements have relevance to SMUD, our operations, our employees and our customers.

Closer to home, our under-resourced communities lack equitable access to many essential community components that we attribute with a high quality of life, including living wages and training opportunities, affordable housing, access to transportation and connectivity, health care access, nutrition, education opportunities, computer and internet access and a healthy environment. Our neighbors in these communities feel the physical impacts of climate change more acutely than wealthier communities while bearing little responsibility for the crisis, and history has shown that these communities often suffer unintended consequences when new social policies or strategies are introduced.

Involvement of all our communities is foundational to this plan and we recognize that, too often under-resourced communities are excluded from the process and conversation when goals and implementation plans are developed. SMUD recognizes the importance of partnering with all the communities we serve. We commit to reaching impacted communities as we work toward our goal of zero carbon.

If designed well and with citizens and communities in mind, climate action can avoid green gentrification and displacement and can help address some of the pre-existing social and economic inequalities in our region. Additionally, collaborative reexamination of indigenous practices that support healthy ecosystems can also help us build a more resilient region. The strategy for one city, one neighborhood, or even a single facility will not be a one-size fits all solution. We're committed to engaging all our community members so they may participate in building a plan that supports their community's vision for the future and may fully understand potential impacts of the plan.

[7] For a full list of the UN's sustainable development goals, see Appendix B.

SMUD's carbon reduction journey

For several decades, SMUD has been recognized nationally and internationally for our environmentally conscious and innovative renewable power and energy efficiency programs. Our commitment to zero emission and low GHG resources dates back decades, and in fact, began with the development of the UARP hydroelectric project in 1957. We continued clean energy leadership as we developed one of the first utility-scale solar photovoltaic power plants in 1984; our first solar-powered electric vehicle (EV) charging station in 1992 and our first community targeting net-zero energy in midtown Sacramento.[8]

SMUD strives to provide our customers with a sustainable power supply, which is defined as one that reduces SMUD's GHG emissions while assuring reliability of the system, minimizing environmental impacts on land, habitat, water quality, air quality and maintaining affordable rates relative to other California utilities. Our Board sets policy direction to for our sustainable power supply through Strategic Direction – 9 Resource Planning. The full text of SD-9 can be viewed here.

In the 1990s, we were already buying renewable energy from wind, geothermal and biomass sources. By 1997, we were offering our first voluntary green pricing program, Greenergy®, to our customers. And in 2001, we established our first renewables portfolio standard (RPS), with a combined energy supply goal for our RPS and Greenergy program of 12% by 2006 and 23% by 2011.[9] By 2008, we established a separate RPS goal of procuring 20% of our retail electricity sales from renewables by 2010. SMUD was the first large community-owned utility in California to achieve a 20% RPS goal, and has continued to grow our portfolio of non-emitting resources over the past decade, reaching 33% in 2020.

Our commitment to addressing climate change was brought to the forefront in 2003 when, as a precursor to setting GHG reduction targets, SMUD became the first utility to certify our emissions inventory (2002) under the newly formed California Climate Action Registry.[10] Soon after, we were one of the first utilities to support the passage of Assembly Bill 32, California's landmark climate change legislation. In 2008, we committed to reducing our emissions by 90% below our 1990 levels by 2050, exceeding the state target of 80% below 1990 levels by 2050. And in 2009, we received the first Climate Change Leadership Award from the Association of Climate Change Officers. We've continued to exceed our goals and expect to be nearly 15% below our 2020 GHG emissions goal.[11]

Historically, energy efficiency programs have significantly contributed to SMUD's carbon reduction efforts. Helping our customers use less electricity has effectively offset increasing demand, managed peak energy use and helped customers save on their utility bills. With growth

[8] For more information on our net-zero energy community in Midtown Sacramento, see https://www.youtube.com/watch?app=desktop&v=fW2YtZ1eDl8. Last Accessed: 24 March 2021.
[9] https://www.smud.org/-/media/Documents/Going-Green/PDFs/SMUD-RPS-Guidebook---FINAL-1.ashx. Last accessed: 14 December 2020.
[10] http://www.caclimateregistry.org/wp-content/plugins/carrot/carrot_reports/sacramento-municipal-utility-district-2002-ca.pdf last accessed 16 December 2020.
[11] Emissions values take some time to finalize. 2020 emissions values won't be finalized until Summer 2021.

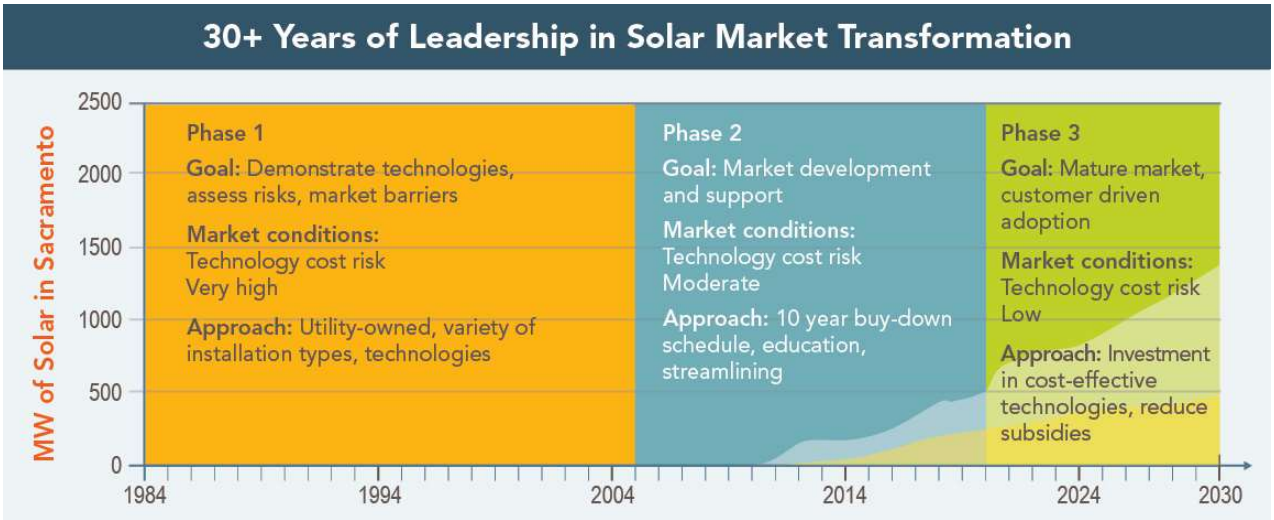
in renewable energy supplies and the imperative to reduce carbon emissions, our approach to energy efficiency has expanded and now integrates building electrification into our programs to help customers take advantage of clean, renewable electricity supplies. We've also developed innovative program offerings, allowing our customers a choice to voluntarily buy additional renewable energy.

By 2012, we reduced our normalized emissions by 30% below 1990 levels and by 2019, our normalized emissions were 45% below 1990 levels.[12] Accepted by the CEC in 2019, our 2040 Clean Energy Plan outlines a path to net-zero emissions by 2040. Read our 2018 Sustainability Report for more detailed information about our commitment to clean energy.

Pioneer in solar energy and market transformation

For over 30 years, SMUD has been promoted and encouraged the adoption of solar technologies, helping commercialize this important carbon-free resource. In the early 1980s we saw that solar photovoltaic systems (PV) – although very expensive at the time – had great potential for the future. With this understanding, we set out to overcome roadblocks to developing solar energy through a robust long-term market transformation strategy.

Figure 2. Leadership in the solar market transformation



By implementing these strategies, SMUD created a body of knowledge and experience that supported market development and growth, lowered costs and helped the solar market transition to the mature, profitable, large-scale global industry we have today.

[12] To assess our progress in achieving our GHG reduction targets, we "normalize" our emissions to ensure that beneficial weather or hydroelectric conditions do not understate or overstate our carbon reduction achievements. In 2019, these normalizations increased our reported normalized emissions by nearly 10%.

Bringing solar to our communities

In the early 1990s, SMUD was one of the first utilities to develop a rooftop solar program, installing hundreds of utility-owned solar systems on the roofs of customers' homes and businesses. Installations helped SMUD evaluate the technology and paved the way for a transition to a customer-owned program in the late 1990s. At this stage, SMUD made large purchases of modules and inverters, designed as solar system kits, and offered them at a discounted price to customers. We trained installers, which helped establish regional solar contractors who helped to scale the technology, giving a much-needed boost to the solar industry.

As part of our Solar Advantage Home program, launched in 2001, and our later SolarSmart Homes® program, we worked with local home builders to promote installation of solar coupled with efficient new homes exceeding building code requirements. By doing so, the program demonstrated how rooftop solar systems can be integrated into new home design and construction. Over the course of the program, 4,000 new SolarSmart Homes were built.

By 2007, we launched our part of California's Million Solar Roofs initiative. Through this ambitious program, we committed $125 million in incentives for the installation of solar at homes and businesses. The program was a success, reaching its goal of 130 MW, with solar on more than 15,000 homes and businesses in Sacramento, helping the market transition to a mature solar industry.

We've learned a lot from our 40-year experience with solar. Through the 1980s and 1990s, we found ways to reduce costs and improve performance. Our first utility-scale solar development was our Rancho Seco PV 1 plant in 1984, one of the first utility-scale PV plants in the world, which established Sacramento as an early leader in solar. By 2009, SMUD signed feed-in tariffs (FIT) with projects totaling 100 MW, powering on average over 20,000 homes per year. Earlier this year, we welcomed our newest solar project at Rancho Seco, a 160 MW solar PV project capable of powering over 36,000 homes per year.

Incorporating wind technology

Wind turbines are now one of the most economical energy generating technologies, and in most cases, are lower cost than fossil-fuel generators.[13] We also have access to a great wind resource region at our doorstep in Solano County. Our Solano Wind Farms produce enough electricity to power more than 63,000 homes per year.[14] We plan to expand these projects by replacing some older, less efficient turbines with larger and more efficient units. This expansion will reduce the footprint of our wind projects while increasing net output by over 70 MW, enough

[13] https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf
[14] Based on 750 kWh/month average household electricity use.

to power more than 21,000 homes per year. In 2019, we began purchasing energy under contract for 200 MW of wind energy from a wind-rich region in New Mexico.

Hydroelectric power

We own and operate a hydro project in the Upper American River called the UARP. The UARP contains multiple powerhouses along the same waterway, which means the same "fuel" is used over-and-over as water flows downstream from one powerhouse to the next. Operating and maintaining our hydro facilities requires a license from the Federal Energy Regulatory Commission (FERC), which issued SMUD a new 50-year license in July 2014. [15]

An additional 6% of our power generation is provided by hydro power purchase contracts, allowing us to meet an average of about 20% of our total power needs with carbon-free hydro generation. Today, including our hydroelectric resources and other carbon free resources, our energy mix is on average 50% carbon free.

Investments in other renewables

Although solar, hydro and wind comprise the largest share of our zero GHG emission portfolio, our procurement of biomass and geothermal power adds diversified value to our portfolio. These resources generally provide constant generation over time. Some of these resources may also be able to respond to fluctuations in load and provide other reliability services.

Biomass resources

Biomass is a local renewable resource and abundant in nature. Biomass resources include residues from forestry (like dead and dying trees, vegetation materials from the UARP), urban wood wastes, food waste, agricultural residues, dairy wastes and other organic wastes. These biomass resources can be converted to bioenergy via thermochemical and biochemical processes for power, heating, cooling, fuels, chemicals, renewable natural gas (RNG), biogas, hydrogen and other value-added products with zero net and negative carbon emissions.

Occurring abundantly in nature, biomass can be a problematic waste if unmanaged and should be disposed of in a sustainable and environmentally safe manner. Ideally, some biomass can and should be composted for soil amendments. However, compost demand cannot address the full amount of the waste problem. Another solution is converting the left-over waste to renewable biomass energy.

Although bioenergy (biomass-derived energy) generally requires combustion technologies, the alternative dispositions of biomass are usually more harmful to the environment or public safety than the impacts of energy production. Bioenergy can also be a critical strategy to reduce potent climate pollutants, such as short-lived climate pollutants (SLCPs). According to the California Air Resources Board (CARB), increasing bioenergy – especially biogas production and use – is

[15] FERC's new license order for the UARP can be found here: https://www.smud.org/-/media/Documents/In-Our-Community/Recreational-Areas/UARP/Hydro-License-Compliance/License-and-Amendments/FERC-Project-No-2101-Order-Issuing-New-License-07-23-2014.ashx. Last accessed: 11 December 2020.

critical to reduce SLCPs, which can be tens to thousands of times more damaging to the climate than carbon dioxide.[16]

The decomposition of biomass at landfills, wastewater treatment plants and dairies create methane (essentially natural gas) and other pollutants that can be greatly mitigated through collection of the gases. Biomass collected through forest thinning and wildfire mitigation projects are beneficial because they provide revenue for thinning projects and avoid pile burning or catastrophic wildfires.[17]

SMUD has a long history of purchasing biomass energy, including from large generators in Washington state and small local dairies. Currently, we procure energy from Sacramento's Kiefer Landfill as well as landfills in Yolo county and biogas from Sacramento's Regional Sanitation District.[18] We have also supported the development of five digesters at local dairies.

Geothermal

Geothermal energy takes advantage of temperature differences within the earth's crust, such as areas hot enough to produce steam from water. This steam can be used in steam turbines – one of the oldest methods for powering machines. This resource is valuable because geothermal energy is a constant power source, unlike intermittent wind and solar energy.

There are ideal locations for geothermal development throughout California, including the Imperial Valley and Sonoma County as well as sources in Nevada that are accessible via our existing transmission line. We have been buying geothermal energy since the early 1980s and currently receive 52 MW annually through contracts in California and Nevada. That's enough to power more than 38,000 homes per year.[19]

Giving our community tools to confront climate change

Undisputedly, California is a national leader in addressing climate change, and SMUD's goals are even more ambitious than those set forth by the state. Our commitment to improving the quality of life for our customers and community is evident through our progressive policies and outcome-driven actions. We've demonstrated success in providing low carbon energy solutions to our customers and implementing robust, community-focused programs aimed at conserving energy and accelerating the transition away from a fossil-fuel based economy toward an economy that supports sustainable resources and sustainable communities.

Community partnerships and programs

We have a robust portfolio of customer programs that reduce GHGs by using or producing energy more effectively through energy efficiency, electrification, renewables, energy storage and EVs. Programs like Greenergy, SolarShares®, Shade Trees and a variety of incentives

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[16] CARB. *Short-Lived Climate Pollutant Reduction Strategy*. March 2017. Available Online: https://ww2.arb.ca.gov/sites/default/files/2018-12/final_slcp_report%20Final%202017.pdf. Last accessed: 4 March 2021.
[17] https://www.placer.ca.gov/1810/Biomass. Last accessed 3 March 2021.
[18] https://www.regionalsan.com/biogas-recycling. Last accessed 23 February 2021.
[19] Based on 750 kWh/month average household electricity use.

support sustainable growth within our region by offering customers a choice of energy solutions that fit their unique needs.

Our workforce outreach programs help our community learn about and prepare for careers at SMUD. Programs include Career Ambassadors, paid high school and college internships and college scholarships. With an increased emphasis on zero carbon technologies, it's even more important that the workforce of the future is prepared for these new careers.

Finally, influencing the private sector to develop clean energy goals involves educating them about the impacts of climate change and highlighting opportunities to partner with SMUD in order to reach their goals. Through our Sustainable Communities program, we're facilitating collaborations by leveraging our entire partnership portfolio. Collective action is key to our success as climate change cannot be solved by any one stakeholder acting alone. Cross-sector collaboration is essential to holistically address systemic challenges, and partnerships are vital to incentivize businesses to take action to address this climate emergency.

Energy efficiency and electrification

SMUD has been offering programs to help our customers save energy for more than 50 years, delivering significant carbon reduction and billions of dollars of savings to SMUD and our customers. In the 1990's, we launched an initiative to fund and promote energy efficiency savings equivalent to the amount that could be produced by a 500 MW power plant annually, and we were recognized nationally for our energy efficiency leadership. In 2006, we adopted a goal of getting 1.5% of our annual retail sales forecast from energy efficiency programs and exceeded the resulting annual targets each year from 2009 through 2020. Recent efforts have helped our customers become more energy efficient. These programs include:

- **Express Energy Solutions:** Provides incentives to qualified contractors for high-efficiency equipment across a variety of end-uses: lighting; heating, ventilation, and air conditioning (HVAC); refrigeration and food-service equipment as well as supporting the conversion from gas to electric equipment.
- **Complete Energy Solutions:** Comprehensive energy audits of small- and medium-sized businesses with a customized report recommending energy improvements, estimated savings, estimated cost and payback. Then an administrator assists the customer in hiring a contractor to complete the project. The program also supports the conversion from gas to electric equipment.
- **Savings by Design:** Provides incentives to avoid natural gas consumption through electrification, along with incentives for classic energy efficiency measures. The program incentivizes efficient construction via two participation methods: A performance approach tailored to the customer's unique building or a simple prescriptive approach.
- **Residential new construction of all-electric homes:** Provides incentives to builders and their design teams for residential developments of all-electric homes and neighborhoods.
- **Advanced Home Solutions:** Encourages homeowners to improve their home's performance through insulation, sealing and conversion to all-electric, efficient equipment. Implemented as a contractor-driven program, customers are eligible to received incentives for HVAC, water heating and insulation improvements.
- **Appliance efficiency:** Our retail partnership program works with big box retailers to pay retailer incentives for all the energy efficiency items they sell in their stores.

- **Refrigerator/freezer recycling:** This program provides free pick-up and environmental recycling of old refrigerators and freezers.

In 2020, SMUD was the first utility in the country to adopt a carbon-metric for measuring in the impact of our efficiency programs, allowing us to define our success by the GHGs these programs reduce and embracing the use of energy during low GHG emission times. Our focus on electrification means we'll nearly triple the carbon savings impact of our energy efficiency programs by 2030, relative to an electricity efficiency-only framework.

Greenergy

Recognizing many of our customers wanted to power their homes with green energy, SMUD launched Greenergy in 1997. This first-of-its-kind program gave our residential customers the option of buying renewable energy to serve their home energy needs, up to 100% of their use, by adding a flat fee to their standard electricity bill. As one of the most successful utility green pricing programs, 13% of our customers participated in 2020.

SolarShares – a new model to expand access to solar energy

As we worked to develop a robust rooftop solar energy market in Sacramento, we recognized that some customers could not install solar on their homes, due to cost, home ownership, orientation of their home, tree shading or other factors. We also recognized that despite its high price, utility-scale solar was still far less expensive than rooftop solar. That's why in 2007, SMUD launched SolarShares. Initially, our SolarShares program was served by a 1 MW PV project located in Sacramento. Within 6 months, the program was fully subscribed, resulting in a waiting list for those customers who were interested in future opportunities to subscribe. In 2016, SMUD expanded SolarShares to commercial customers who were looking for new options to meet their sustainability goals. In 2019, our original residential SolarShares program closed to new participants.

Following our SolarShares program, in 2019, SMUD created a new community solar program that provides new home builders with an alternative option to meet California's mandate that new homes include solar. This program, Neighborhood SolarShares®, was approved by the CEC in 2020 as an alternative to rooftop solar systems in areas with dense trees or limited rooftop space.

Sacramento Shade Tree program

Beyond electricity, we've invested in carbon sequestration through our 30-year partnership with the Sacramento Tree Foundation. Not only do trees cool homes naturally and beautify our neighborhoods, they also produce oxygen and store carbon. Since 1990, the program has resulted in planting more than 600,000 trees, helping Sacramento maintain one of the leading urban tree canopies in the world. Our Sacramento Shade Tree program has evolved to address

climate change and the need for sustainable urban and community forests by expanding both the number and types of trees offered, including evergreen trees. Additionally, the program supports environmental equity by planting and stewarding trees in under-resourced communities.

Electric transportation incentive programs

SMUD has long been committed to the advancement of electric transportation and we currently offer incentives, expert advice and assistance to customers to help them transition to electric transportation. Our residential programs have been expanded to include online EV purchasing tools for our customers looking to purchase an EV. Customers also continue to receive an EV rate discount, which incentivizes them to charge their vehicles during off peak hours. Through the California Clean Fuel rewards program, we support customers in receiving up to $1,500 for the purchase or lease of a new Battery Electric or Plug-in-Hybrid vehicle.[20] Our commercial EV program offers workplace and multi-family customers incentives for EVs and charging equipment. Additionally, we are partnering with the CEC to offer incentives for the purchase and installation of fast charger infrastructure.

Customer engagement programs

We engage with our customers and community to inform them about our programs, rebates and incentives and other initiatives such as our 2030 Clean Energy Vision and 2030 Zero Carbon Plan, while encouraging their involvement and partnership. Our educational and awareness communications are critical to informing and including our customers in new programs and initiatives.

SMUD's Community Education and Technology Center provides energy efficiency and sustainability education, along with new energy technology evaluation, to areas students and our residential and commercial customers. Through workshops, events, videos and other channels, SMUD supports our commercial, residential and kindergarten through university students with the knowledge and ability to better control their energy expenses, be more sustainable in their energy consumption and get more value out of their energy use.

- **Residential and Commercial education**: We offer a range of seminars, webinars and other courses to educate commercial and residential customers on a variety of topics including EVs, energy efficiency, lighting, induction cooking, building standards and more.[21,22]
- **Outreach and awareness**: Annually, SMUD supports hundreds of low-income outreach and awareness presentations and education events with community partners. These events provide information about our low-income programs like our Energy Assistance Program Rate, our Medical Equipment Discount (MED) Rate and energy efficiency and electrification education.
- **Kindergarten through university education**: SMUD uses a variety tools to help train the next generation of energy leaders about sustainability and the environment. On a

[20] For more information on the Clean Fuel Rewards program, see: https://cleanfuelreward.com/
[21] Businesses can find our commercial education videos, interactive online courses and webinars on SMUD.org/Workshops.
[22] Available on SMUD.org/Learn

yearly basis, the Community Education and Technology Center offers regional science, technology, engineering and math competitions. [23]

Research and development pilots

A robust approach to research and development enables us to deliver innovative products, programs and services that provide solutions our customers care about. This allows us to test innovation in a controlled setting or with a modest number of customers, making refinements along the way as we expand the opportunity for the larger customer base. These efforts ensure that SMUD takes a measured approach at investigating viable alternatives to today's technology and business solutions in a low-risk setting. This is a core component preparing our organization for deeper decarbonization.

Our climate journey has benefited from the innovative solutions, products and services resulting from our investments in research and development projects. These projects integrate emerging technologies and new business models into our customer offerings in a way that benefits our customers and community. SMUD's research and development vision is rooted in achieving excellence and leadership in four foundational pillars.

Excellence in technology and services: Cultivate emerging technologies, advanced applications and innovative services to achieve operational excellence in delivery of products and services for our customers.

Safe and reliable grid integration: Enable safe and reliable integration, operation and visibility of DERs, grid-scale storage and large-scale renewables into the electric grid, and prepare for the migration to a distributed and transactive grid.

Leadership in sustainability: Further SMUD's environmental and sustainability leadership role in the energy industry by informing SMUD's strategy to reduce regional GHG emissions, advance sustainability technology and direct climate readiness planning.

Strength in economics and markets: Prepare for the delivery of customer products and services, enable customer participation in new energy business models and identify new approaches to SMUD's participation in energy markets to maintain financial strength.

Our research and development strategies focus our activities in areas that show the most promise for improving the delivery of our core business. This ensures our research strategies address existing goals defined by SMUD's Board of Directors as while keeping an eye on the horizon for energy industry uncertainties and technology advancements that could change the existing energy delivery paradigm. Maintaining strong research and advancement strategies that better meet customer needs has given SMUD a position of industry influence in progressive policy, advanced standards development, emerging business models and market transformation.

[23] More information can be found at SMUD.org/Education.

SMUD's commitment to research has demonstrated progress in areas once considered cutting edge that are now standard operations. We've strategically leveraged research to advance change in high-impact areas while simultaneously mitigating financial, operational and customer experience risks. For example, SMUD's Time-of-Day (TOD) rates were born out of the nation's most comprehensive time-of-use experimental research study exploring the impacts of default and opt-in time-based rates on customer engagement, peak load and customer bills.

SMUD is rethinking the systems and resources that we rely on for everything, from things like new sources of generation, building construction and how electricity-consuming devices in a building operate. We're looking at emerging technologies, alternative fuel sources and the evolution of grid operation and resource planning in a new way, creating opportunities for customers to be a partner in the grid of the future. Through our research and development, we strive to improve the efficiency of the grid and empower our customers to be active participants in an innovative, modern electric grid.

Our research and development group is home to seven technology innovation programs. The programs are highly interdependent and therefore most research efforts touch multiple programs. See our 2020 Innovation report to take a deeper look at recent projects. [24]

[24] SMUD's 2020 Innovation report can be found at https://www.smud.org/-/media/Documents/Corporate/About-Us/Energy-Research-and-Development/Innovations/Innovation-Brochure.ashx.

Building resilient customers and communities

Our customers and community are at the heart of all we do and we're recognized in our industry and by the customers as a leader in community involvement. As one of the region's largest and most influential employers, our goal is to enhance the quality of life for all our customers and improve vitality in all the communities we serve. Social, economic and environmental inequities exist in the in our region, impacting customers across our service territory. As a state, California ranks number one in power outages and rural and under-resourced communities are often at the margins of electrical grids.[25] Through strategic partnerships, focused investments, community engagement, diverse educational strategies and targeted programs that help our customers in greatest need, we'll ensure all our communities and customer households are partners with us in creating a clean energy future today, and for future generations to come.

Growing together, embracing a low-carbon future

"The nation is still in the early stages of urban environmentalism, a complex subject with intricate and important histories. The potential for unintended consequences for people, for place, and for policy is great. […] Citizens living in urban, poor, and people-of-color communities are currently threatened by gentrification, displacement and equity loss on a scale unprecedented since the Urban Renewal movement of the 1960s."[26] These communities are often the hardest hit in economic downturns and continue to be left behind in periods of economic boom. These same communities often suffer from significant environmental disparities including poor air quality and negative carbon emission impacts.

With federal policies and programs, municipalities, urban planners and developers are able to undertake "revitalization" projects. On the surface, these projects are beneficial, beautifying a sometimes-blighted area and improving the overall environmental conditions. But from the perspective of residents and small businesses, these efforts can be seen as non-inclusive and destroying what remains of the original community and neighborhood culture. In the absence of other policies (e.g., housing-based), rising property values that can accompany these "revitalization" projects can result in original residents being priced out of the market, displacing the very community the project was designed to help.[27] Often, this displacement is unintentional; the gentrification and displacement associated with federal reuse, redevelopment and revitalization programs may not be conscious or intentional, but local implementation of these programs often has that effect.[28]

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[25] League of California Cities. *Energy Resiliency and Independence for Rural Cities Webinar.* March 2020.
[26] National Environmental Justice Advisory Council. *Unintended Impacts of Redevelopment and Revitalization Efforts in Five Environmental Justice Communities.* August 2006. EPA. Available online: https://www.epa.gov/sites/production/files/2015-02/documents/redev-revital-recomm-9-27-06.pdf. Last accessed: 12 February 2021.
[27] Coppinger, Kaitlin, Douglass Lee, Sari Radin, and Catherine Taylor. *Economic Development and Highway Right-Sizing: White Paper.* November 2018. FHWA. Available Online: https://rosap.ntl.bts.gov/view/dot/38931.
[28] National Environmental Justice Advisory Council. *Unintended Impacts of Redevelopment and Revitalization Efforts in Five Environmental Justice Communities.* August 2006. EPA. Available online: https://www.epa.gov/sites/production/files/2015-02/documents/redev-revital-recomm-9-27-06.pdf. Last accessed: 12 February 2021.

A 2018 Brookings Institute Report − Charting a Course to the Sacramento Region's Future Economic Prosperity − found that between 2006 and 2016, the Sacramento metropolitan area ranked in the bottom-third of the 100 largest metro areas in composite rankings measuring improvements in growth, prosperity and inclusion, three critical elements of regional economies that work for everybody. These long-term trends reflect the downturn during the Great Recession and suggest it was deeper and more sustained in Sacramento than in other parts of the nation, particularly in our historically under-resourced areas.

In the five years after the Great Recession, we made some progress as a region; however, 34% of Sacramento's residents still live-in households that do not earn enough to cover their basic expenses. These struggling families are disproportionately made up of people without a high-school degree as well as 47% and 42% of our region's Black and Hispanic residents, respectively.[29] Moreover, households in under-resourced communities spend a significant share of their income on energy bills. Households that earn less than $50,000 annually, on average, for a family of four, spend around 16% of their income on energy costs. For families earning over $100,000, the energy-to-income share drops to 3.5%.[30]

SMUD is at the center of both the climate crisis and the search for solutions. We need to act quickly to protect and provide for all customers, especially those most impacted and least represented. SMUD is already leading the way. Our Sustainable Communities partnership and low-income customer strategies collectively meet the unique needs of our customers where they are by acknowledging the intersectionality between the need for a zero carbon future and the need for economic equity, with the goal of creating a high-quality of life for all of our customers. . We work collaboratively with community organizations to deliver concrete practices such as delivering electric car sharing programs to under-resourced communities and increase portions of zero or low carbon affordable housing.

Low-income programs, helping our neighbors

Simply stated, the objective of our low-income strategy is to help our customers most in need by providing them individualized solutions at the household-level that provide a feeling of control and a reduction to their energy burden. Our low-income strategy focuses on the distinct individual needs of our customer households by providing rate assistance and dwelling assistance programs for those customers in greatest need, as qualified based on income requirements (up to 200% of the Federal Poverty Level).

Although SMUD has been offering low-income weatherization for many years, our holistic low-income strategy launched in 2016, targeting households with high energy burdens to provide education and energy efficiency upgrades. These upgrades provide our customers greatest in need a feeling of control, reduces their energy burden and creates bill savings. We provided solar as part of an energy saver bundle in partnership Grid Alternatives where we targeted

[29] Parilla, Joseph, Sifan Liu, and Marek Gootman. *Charting a Course to the Sacramento Region's Future Economic Prosperity*. April 2018. Brookings Institute. https://www.brookings.edu/wp-content/uploads/2018/04/sacramentoregioneconomicprosperity_fullreport.pdf. Last accessed: 3 February 2021.
[30] https://www.politico.com/news/agenda/2021/02/01/you-want-environmental-justice-look-to-energy-efficiency-463839.

households as described by Senate Bill 535.[31] Additionally, our energy assistance program rate was changed in 2018 to provide those greatest in need the appropriate discount and dwelling solutions to address energy burden disparities.

We also offer low-income energy retrofits. These are complete energy retrofits for qualifying low-income households through four offerings: Weatherization, Energy Saver Deep Retrofit, Energy Saver House Bundle and Energy Saver Apartment Bundle. Through these programs, we've provided education and energy efficiency improvements to more than 24,000 low-income households since 2016, resulting in a reduction in energy burden and savings on customer bills. Since 2019 as part of our retrofits, we've replaced over 800 natural gas appliances with efficient electric appliances, saving on customers' bills, saving carbon and reducing air pollution from natural gas combustion. This effort is ongoing and will ensure our vulnerable populations are not left behind as we work toward our overall carbon reduction goals.

Looking to the future, our approach is three pronged:

1. **Increase** program offerings that align with participants' lifestyles to address energy usage and provide them greater feeling of control over their energy usage.
2. **Improve** sustainability and integrity of the low-income program by helping those most in need
3. **Strengthen** the safety net for Sacramento's under-resourced populations through strategic partnerships to positively impact customers in a more holistic manner.

Between 2020 and 2022, we have extensive plans to continue and increase our investment our low-income communities.

- We're proactively providing carbon reduction measures (via electrification) to ensure low-income customers aren't the last ones to adopt electrification.
- We're leveraging community partners like Habitat for Humanity to expand our reach, working to bring electrification, rooftop solar and the opportunity for EV home charging to all our customer households.
- We're refining our analytic approaches to ensure we're recruiting those most in need, and those with the highest energy burdens to prevent anyone from falling through the cracks.
- We're linking our efforts with local healthcare providers, improving access to carbon reduction measures that may impact medical-related outcomes and using our MED Rate to provide discounts to those that have a qualifying medical device.

We're always looking for creative ways to partner with our communities. One example is our partnership with Sacramento Housing & Redevelopment Agency to provide energy efficient refrigerators in their affordable housing complexes. Mutual Housing is another great example where we provided capital funding for energy efficiency upgrades before the affordable housing upgrades were completed. When planning for the Mutual Housing partnership, we solicited their

[31] SB 535 requires the state to direct at least 25% of state cap-and-trade revenues to go to projects that benefit disadvantaged communities. It provides a very specific definition of disadvantaged communities as the top 25% scoring areas from CalEnviroScreen along with other areas with high amounts of pollution and low populations. For more information on this definition, see CalEPA's report on Designation of Disadvantaged Communities.

feedback on a list of properties that they wanted to upgrade. We developed load shapes for each of the buildings and identified those that were most likely to benefit from the upgrades. Based on this information, we prioritized and selected complexes that could be upgraded and deliver more of an impact, leveraging SMUD and Mutual Housing funds. This capital allowed Mutual Housing to identify matching funds and justify some significant upgrades to 168 units' HVACs and 91 units with energy star refrigerators. After the upgrades were completed at one multi-family housing unit, the average energy usage fell by 39% during peak hours.

Sustainable communities, strengthening our neighborhoods, together

The Brookings report was the catalyst for SMUD's Sustainable Communities program, launched in 2018, and builds on the significant work we've done to support under-resources communities for decades. We're bringing attention to our historically under-resourced neighborhoods through our Sustainable Communities program, which aligns our partnerships, goals and investments around supporting healthy, vibrant and economically sustainable neighborhoods for all customers. In 2020, we launched an interactive Sustainable Communities Resource Priorities Map that identifies out which areas in our region need our help the most. The map helps analyze current data to indicate the local areas most likely to be underserved or in distress due to lack of community development, income, housing, employment opportunities, transportation and more. This information helps align our region's investments toward the goal of creating and supporting healthy, vibrant and economically sustainable neighborhoods.[32]

By partnering with policy makers, transit leaders, technology companies, health care providers and other community-based organizations, SMUD can maximize its impact and collaboration with community members to solve real problems for real people. We're leveraging our existing efforts, employees' skills and expertise and partnerships across the community to maximize our collective impact to help those most in need.

To promote workforce and equitable economic and community development, SMUD has invested in programs targeting economic development, community/environmental health and neighborhood outreach activities in vulnerable and under-resourced communities throughout the Sacramento region. To date, SMUD has invested over $5 million into this effort, leveraging partnerships to increase impact in these areas of need. We have several workforce development programs and work with a variety of partners to support the development of solar and renewable energy across the greater Sacramento region.

Our Sustainable Communities program works strategically to establish long-term partnerships with community-based organizations and businesses, working together on projects helping our

[32] Learn more at smud.org/SustainableCommunities.

under-resourced communities, with the goal of increasing inclusion and closing the disparity gap in the Sacramento region. These partnerships create trusted relationships and serve as a foundation for the community outreach, engagement, collaboration and education needed to build livable, diverse and resilient communities. We've invested more than $5 million in 130 local organizations to work on projects aligned with our Sustainable Communities program, many of which are advancing historically under-resourced populations closer toward our zero carbon future goal.

One such partnership is with Habitat for Humanity, Greater Sacramento, which we support through Sustainable Communities and our low-income programs. Together, we've brought solar and new energy solutions to hundreds of new and existing homes for low-income families, which will continue over the next few years. By adding EV plug-ins at most Habitat homes, SMUD is supporting the electric transportation revolution. Through these partnerships, we can help all our communities – from rural to suburban to urban – to be part of a zero carbon future.

One of the most promising aspects of a zero carbon future is the new jobs and careers that will be generated by building electrification, advanced storage strategies, energy management and increased EV usage and infrastructure needs. Healthy communities rely on a strong workforce where residents have opportunities to thrive economically and our 2030 Zero Carbon Plan will help create jobs and ensure that all communities are included in this economic development strategy. SMUD's Sustainable Communities program has developed an inclusive Regional Workforce Development strategy that ensures that all communities have access to job training, internships and pathways to careers needed to power our zero carbon future. We're working with partners like the Greater Sacramento Urban League, La Familia and Asian Resource Inc., to understand the challenges communities face in pursuing zero carbon careers and remove such barriers with programs and organizations like the California Mobility Center training program, the Energy Careers Pathways Program with Baker Energy and Grid Alternatives and our online STEM careers curriculum.

Looking to the future, we'll identify new skills needed and partner with community organizations to develop upskill or entry level training programs to support new zero carbon technologies. We'll develop customized strategies to attract and retain residents from under-resourced communities to these stable, economically mobile careers.

Embracing zero carbon, together

The 2018 Brookings Institute Report, mentioned above, identified significant gaps in our community, prompting us to acknowledge that we have a duty to do more to intentionally address the disparities of the under-resourced communities we serve. By investing in under-resourced neighborhoods and working with community partners, SMUD is part of a larger regional mission to deliver energy, health, housing, transportation, education, workforce and economic development solutions to support sustainable communities.

As we implement our plan, we will be nimble and flexible while working to support customized solutions for all customers and communities. Our processes will be rooted in genuine engagement with a broad and diverse set of stakeholders, particularly those suffering from

inequality and the impacts of climate change. We will adopt policies actively designed with people, fairness and justice at the center of decision-making. Finally, we will work to ensure clear mechanisms exist – or can be put in place – for measuring, monitoring and evaluating the direct impacts of our 2030 Zero Carbon Plan.

We have a history of partnering with our community, but with our 2030 Zero Carbon Plan, it's time to build on what we we're already doing – leading by example and engaging members of our community–and together we can create and work toward a shared vision for the future. We don't want to just "bring others along" with us, rather we want to empower our communities to work with us and take the lead in developing place-based strategies –to make sure that Sacramento communities are livable, resilient and ready to embrace a low carbon future. This can only be achieved by recognizing that our communities are diverse, and we need to develop strategies that respect and build upon our local, unique qualities and listen to the input of our communities.

A history of planning for the future

SMUD's long history of affordable rates, reliable power and environmental leadership stems from innovation and our communities' desire to be cleaner and greener than the rest of California. When we plan for the future, SMUD must balance environmental considerations, customer rates and safety and reliability impacts. Like other utilities, we rely on an integrated resource planning (IRP) process to develop our long-term strategic environmental objectives to create resources and programs.

Charting our future

Our low-carbon future is not limited to electricity supply, it also includes decarbonizing homes, businesses and transportation. This will take a coordinated effort, including our local partners, to decarbonize the region. To achieve our ambitious goals, we must work on the leading edge as we conduct research, deploy new technologies and develop innovative programs to consistently reduce GHGs in Sacramento.

As we look ahead, we must consider the role that solar, wind and other renewables will play in decarbonizing our power grid. These resources provide opportunities and some risks. We embrace these opportunities and will develop new strategies to mitigate the risks and achieve our goals. Some possible strategies include, storing energy, developing renewable fuels and aggregating customer devices to mimic a power plant.

In preparation for new DERs, we're working to develop a Distributed Energy Resource Management System (DERMS) to enable us to aggregate distributed resources like solar and storage to provide grid services and enhance shared benefits of these resources with all customers.

We're rolling out several energy storage programs for residential customers aimed at maximizing shared value between system owners and the broader SMUD customer base. Programs like our Smart Energy Optimizer program that launched in 2019 offer up-front and ongoing incentives in exchange for access to a portion of a customer's battery to provide these grid services. Our commercial customers will see new shared investment programs like StorageShares that give participating commercial customers financial benefits similar to onsite storage, but the storage will be located in areas where our transmission and distribution systems are nearly at maximum capacity. This could displace investments we might otherwise need to make to increase grid capacity, and can provide additional value by participating in energy markets whenever transmission and distribution support is not needed.

We're expanding and further aligning our SolarShares and Greenergy programs to reduce carbon emissions in Sacramento in the most cost-effective way. These programs have the potential to scale quickly without financially impacting other SMUD customers. We're also developing programs to increase access to solar and renewable energy at a reasonable cost for all residential customers.

As we look to the future, we're considering the successor to our net energy metering (NEM) rate for customers with rooftop solar, which is now our largest annual customer program expense, exceeding the combined cost of our entire portfolio of energy efficiency programs. In 2020, we completed a Value of Solar and Solar + Storage Study as a precursor to proposing more equitable rates that balance our collective desire to reduce carbon with the imperative that we do so in the most cost-effective manner possible for all customers.

2040 Clean Energy Plan

In 2018, the Board adopted our latest IRP, also referred to as the 2040 Clean Energy Plan, which put SMUD on an aggressive path to decarbonizing the greater Sacramento region with the ultimate goal of achieving net-zero GHG emissions electricity by 2040. As part of this plan, our GHG emissions strategy embraced supply and demand-side solutions and accelerated GHG reduction targets, including net-zero by 2040.[33]

This 2030 Zero Carbon Plan builds on the strategies in our 2040 Clean Energy Plan, our commitment to community-wide decarbonization and continued investment in electrification, energy efficiency and DERs. The 2040 Clean Energy Plan was, and still is, an aggressive and diverse investment strategy to minimize local GHG emissions while keeping our system reliable and our rates affordable.

Electrification plan

Our 2040 Clean Energy Plan includes goals for electrifying buildings and transportation, and was one of the most ambitious and holistic carbon reduction pathways considered at the time. These goals called for electrifying approximately 80% of natural gas end uses and 70% of transportation end uses by 2040. For buildings, with these goals, SMUD would achieve carbon reductions by 2030 that were three times more than that of an equivalent plan focused only on energy efficiency.

Despite the many benefits of electrification – cleaner, cheaper, healthier, safer, better performing appliances – customer awareness remains relatively low. As we look to our 2030 Zero Carbon Plan, boosting awareness is critical to achieving both our IRP and zero carbon goals. To this end, SMUD will bolster communications about electrification to our customers through a comprehensive outreach and education program over the next several years that will last for decades. This includes introducing more online tools, expanding experiential "behind the wheel" events and launching more sophisticated direct, digital and broadcast marketing campaigns.

[33] https://www.smud.org/-/media/Documents/Corporate/Environmental-Leadership/Integrated-Resource-Plan.ashx

Energy system overview

SMUD delivers clean, reliable power to our customers thanks to our renewable energy portfolio, GHG-free hydro resources, efficient power plants and innovative customer-focused programs.

Our power is delivered via an integrated electric system that SMUD owns and operates, which includes generation, transmission and distribution facilities. We supply energy to our bulk power substations through a 230 kilovolt (kV) and 115 kV transmission system. This system transmits power from our generation plants and interconnects with Pacific Gas & Electric and the Western Area Power Administration (WAPA). Power is distributed throughout Sacramento and the entire SMUD territory with overhead and underground sub-transmission and distribution lines.

The following is a snapshot of our current energy delivery system, which is the starting point for our zero carbon journey. Understanding this system provides context to the challenges, complexities and opportunities in achieving a zero carbon future.

Participating in external markets: Imports and exports

Imports are the energy that we purchase from other entities to help serve our customer demand. Exports are the energy that we sell to other utilities or system operators. We get power from various sources within the SMUD territory and the rest is imported from elsewhere in California or the Western U.S. Currently, we have a scheduling import limit at a given time of over 1,300 MW with the California Independent System Operator (CAISO) and own and have access to over 500 MW of transmission rights from California-Oregon border on the California-Oregon Transmission Project. We receive additional transmission services from the WAPA, providing access to in-state hydro resources and additional energy from the California-Oregon border.

SMUD is one of several members of the Balancing Authority of Northern California (BANC). As the balancing authority, BANC is responsible for matching of generation to load and coordinating system operations with other balancing authorities. BANC is a partnership between public and government entities and is an alternative platform to other balancing authorities like the CAISO. BANC provides reliable grid operation consistent with standards developed and enforced by the FERC, the North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council.

Being part of BANC benefits our customers. For instance, during the summer of 2020, an extreme heat wave encompassed much of the West. This unprecedented heat storm resulted in larger than average energy use across the Western Interconnection, and power generally available to be imported into California was suddenly needed in other states. The result was an energy supply shortage that left many Californians subject to rolling blackouts. Our customers did not experience these outages. Through proactive contracting for energy supply and prudent risk management, SMUD was able to avoid rotating outages for our customers and even helped our neighboring utilities by providing them with some of our energy supply.

Our commitment to reliable service

Reliability is foundational to our business and a robust reliability framework that has guided our current system architecture. Reliability is the ability of the power system to provide the services our customers expect when they want and need them, even under difficult circumstances. Our Board sets reliability metrics to measure our success under Strategic Direction 4 – Reliability.[34]

For more than 70 years, SMUD's been delivering reliable energy to our customers, and we'll continue maintaining all aspects of reliability while transitioning to zero carbon emissions.

Reliable operation means we operate the elements of the power system within thermal, voltage and stability limits. Operating within these limits allows our system to continue to operate when an unexpected event occurs, such as a sudden unanticipated loss of a generator or transmission line. In short, if we were not operating reliably, equipment could be damaged, or system instability, uncontrolled separation or cascading failures could result in a system-wide blackout. Reliably operating our power system needs the following three critical components:

Resource adequacy

Resource adequacy is a condition in which we have acquired adequate resources to satisfy our forecasted energy needs reliably. SMUD uses the same metrics as most other California utilities, which are defined by the California Public Utilities Commission (CPUC) – that is, we maintain enough resource capacity to cover the monthly peak load forecast plus an extra 15% margin. This extra 15% resource capacity is referred to as Planning Reserve Margin (PRM). With the recent system challenges, the CPUC is evaluating possible increases the PRM.

System adequacy

For system adequacy, we ensure we're capable of serving our load under extreme weather conditions and identify our system's energy import limits. Our load serving capability describes the maximum load that our transmission system can serve reliably. Our import limit is the maximum simultaneous energy that we can import from external entities without exceeding any operating limits. Together, these studies make sure that we have sufficient transmission and distribution infrastructure to reliably deliver energy to our customers under even extreme circumstances.

Reliability adequacy

Reliability adequacy means that we have adequate grid reliability services to keep the electricity flowing. These services are sometimes referred to as ancillary services and include additional generation capacity and generator capabilities that we need to respond to sudden changes in system conditions and system disturbances, frequency response, generation and load balancing and voltage control.

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[34] https://www.smud.org/-/media/Documents/Corporate/About-Us/Directives/Strategic-Direction/SD-4.ashx Last accessed 2-9-2021.

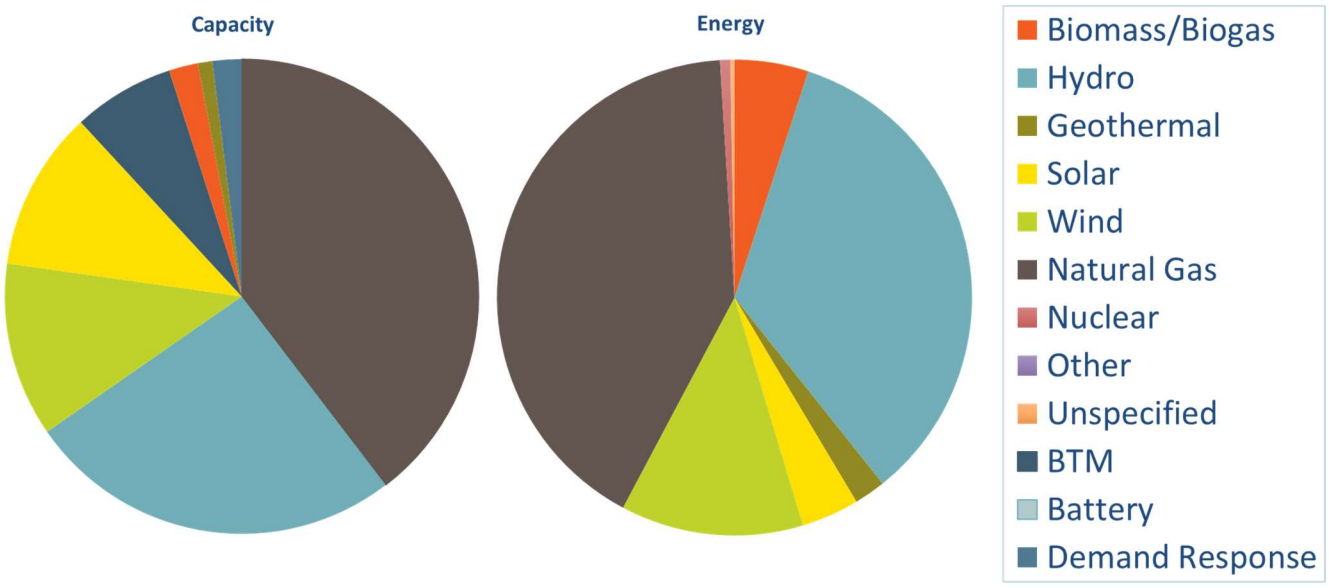
North America Electric Reliability Corporation (NERC) Reliability Standards

The Energy Policy Act, passed by U.S. Congress in 2005, authorized FERC to oversee the development and enforcement of the Reliability Standards with the purpose of improving reliability of the U.S. power system. In 2006, the NERC was approved by FERC to develop the Reliability Standards. In 2007, FERC approved the first 83 Reliability Standards developed by NERC and began to enforce them. To date, there are approximately 110 mandatory and enforceable NERC Reliability Standards.

Power supply

SMUD is a steward for our local community and economy. Unlike investor-owned utilities, we aren't driven by profits or investors. We're driven by our desire to offer our customers the most cost-effective energy with the lowest impact on our environment. This is evident in how we operate our thermal power plants and maximize zero emission procurement from hydro and renewables. For a full list of our current operating power plants, see Appendix A: Existing SMUD resources.

Figure 3. Capacity and energy of resources in the SMUD portfolio (current data)[35]



Thermal gas power plants

Today, gas power plants are an important part of the reliable foundation of SMUD's power supply. Our 1,103 MW of thermal generation are vital to maintaining our electric system reliability and to serving our growing system load. Integral to SMUD's long-range resource plan, Cosumnes Power Plant provides customers with a stable, cost-effective power supply. It can generate enough electricity to power more than 450,000 single-family homes per year. It's the

[35] Capacity is the maximum output an electrical generator can produce (i.e., MW), while energy is the amount of electricity a generator produces over a specific period of time (i.e., one hour – MWh).

most efficient combined cycle power plant in California[36] and, on average, 5% more efficient than similar power plants.[37] This also makes it one of the most inexpensive plants to operate, and the cleanest – less fuel burned per unit energy also means less GHGs emitted per unit energy. We maximize the economic operation of this power plant, which means that when solar energy is setting market prices, our Cosumnes Power Plant is operating at a minimum. When other less efficient resources are bidding into the market, we're displacing their emissions. Even with its notable efficiency, nearly two-thirds of our GHGs come from our Cosumnes Power Plant.

Our least economical resources are our peaking power plant units. We run them less often, which results in these units having a much smaller GHG footprint. As the name implies, our peaking units run in the few hours of the year when renewables, hydro, combined cycle and market power cannot meet our expected load without risking reliability. These plants generally run for a few hours at a time. Although these plants are often not running, being operational and grid connected allows them to provide needed ancillary services, resource adequacy and other energy and capacity reserves.[38]

Cogeneration is a part of SMUD's reliable power formula. The Carson, Procter and Campbell cogeneration plants add over 400 MW to our resource portfolio, brought one new manufacturing facility to the region and have reduced operating costs for the three-existing thermal "hosts." Natural gas-fired cogeneration plants produce electricity and steam. The electricity is fed into SMUD's power grid while steam is fed into a factory for manufacturing use, often replacing steam produced by a less-efficient boiler plant at the facility. The low-cost steam helps keep manufacturing expenses low, providing an incentive for firms to keep their plants in Sacramento, and air quality improves relative to non-cogeneration factory operation due to use of advanced air pollution abatement technologies.

Hydroelectric power

SMUD owns and operates over 688 MW of large and small hydroelectric resources as part of the UARP. The UARP consists of 11 reservoirs and nine powerhouses. In a normal water year, the UARP provides roughly 16% of our electricity – enough to power about 180,000 homes per year. The UARP is able to provide operational flexibility, system reliability and economical power. The value of the UARP also extends beyond the boundaries of SMUD's service territory by helping to maintain the integrity of the Northern California electric transmission system.

We also contract for additional hydro electricity from the U.S. government through a long-term contract with the WAPA for 336 MW of small and large hydro capacity. While this generation is not as flexible as our UARP, it does provide consistent GHG-free electricity.

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[36] Analysis of publicly available data from the CEC-1304 Power Plant Owner Reporting Database. https://ww2.energy.ca.gov/almanac/electricity_data/web_qfer/Heat_Rates_cms.php. Last accessed 23 March 2021.
[37] Nyberg, Michael. 2020. Thermal Efficiency of Natural Gas-Fired Generation in California: 2019 Update. California Energy Commission. Publication Number: CEC-200-2020-03. Average heat rate 7.3, CPP, 6.9.
[38] Capacity is the maximum output an electrical generator can produce (i.e., MW), while energy is the amount of electricity a generator produces over a specific period of time (i.e., MWh). Generators typically do not produce their full capacity 100% of the time.

Renewable resources

Our existing renewable energy portfolio includes projects we own as well as contracted resources. Currently, we have a good balance between baseload and intermittent renewables. By the end of 2021, we'll have 285 MW of local solar and 160 MW of regional solar in operation. SMUD owns and operates a significant amount of wind generation in Solano County near Rio Vista. Energy from these wind resources is delivered into the CAISO and occasionally wheeled to SMUD. For a detailed list of our renewable portfolio, see Appendix A: Existing SMUD resources.

Load forecast

Our energy delivery system relies on internally developed forecasts of future electricity sales and demand. We don't rely on external forecasts, such as the CEC's electric demand forecast. Internally, we have a better understanding of our customer base and long-term growth potential. Use of internal forecasts also allows us to maintain consistency across the various planning and operational departments at SMUD.

Our demand model is based on expected (or normal) weather conditions, also known as a 1-in-2 load forecast. It includes economic impacts to the region and changes in customer end uses because of building code and technology changes. The forecast includes system energy, system peak, customer accounts and energy sales for SMUD's service territory. In the long term, our forecasts include affects from our outreach and other customer programs, electrification of buildings and transportation, customer-owned DERs (such as solar and energy storage) and energy efficiency improvements, all of which will change our energy demand.

Table 2 and Table 3 provide the annual energy and peak load forecast used in this Plan.

Table 2: SMUD's 10-year planning demand forecast (GWh)[39]

Year	Electric Demand Forecast	Energy Efficiency	Electric Vehicles	Building Electrification	Rooftop Solar	Customer Battery	Managed Electricity Demand[40]
2021	11,123	-94	16	7	-479	0.2	10,573
2022	11,268	-159	34	18	-524	0.4	10,637
2023	11,309	-215	61	33	-568	0.7	10,621
2024	11,410	-274	96	53	-610	1.0	10,676
2025	11,417	-334	158	80	-649	1.4	10,673
2026	11,472	-391	243	118	-688	1.9	10,756
2027	11,538	-451	355	169	-725	2.4	10,888
2028	11,643	-514	500	232	-762	2.6	11,102
2029	11,700	-556	676	315	-795	2.9	11,343
2030	11,747	-608	883	405	-828	3.0	11,602

Table 3: SMUD's 10-year planning demand forecast of peak load (MW)[41]

Year	Peak Demand Forecast	Energy Efficiency	Electric Vehicles	Building Electrification	Rooftop Solar	Customer Battery	Managed Peak Demand[42]
2021	3,036	-15	0.9	0.4	-149	-0.7	2,873
2022	3,068	-22	1.9	0.9	-165	-1.4	2,882
2023	3,075	-30	3.6	1.6	-179	-2.3	2,869
2024	3,100	-44	5.8	2.6	-192	-3.4	2,869
2025	3,107	-54	11.0	4.0	-200	-4.5	2,863
2026	3,114	-62	18.0	6.0	-198	-5.9	2,872
2027	3,140	-71	26.5	8.6	-226	-7.6	2,870
2028	3,151	-69	37.4	11.9	-241	-8.4	2,882
2029	3,173	-75	50.6	16.2	-251	-9.1	2,905
2030	3,201	-98	66.0	21.0	-262	-9.3	2,919

[39] The average household in Sacramento uses 9-megawatt hour (MWh) per year. 1,000 MWh = 1 gigawatt hour (GWh).
[40] Managed electricity demand is the total of the electricity demand forecast and contributions from new energy efficiency, EVs, building electrification, rooftop solar and customer battery.
[41] The average peak household load in Sacramento is 4.8 kilowatt (kW). 1,000 kW = 1 megawatt (MW).
[42] Managed peak demand is the total of the peak demand forecast and contributions from new energy efficiency, EVs, building electrification, rooftop solar and customer battery.

Within Sacramento, our electricity demand is expected to grow slowly over the next 10 years. This is due to expected local economic conditions, energy efficiency requirements for new homes, business activity in the region, SMUD's energy efficiency programs and the installation of customer-sited solar power and battery storage. While the region is building new homes, they are much more energy efficient than older homes, plus due to the zero net energy requirement, they are required to have rooftop solar so the net impact to load is smaller than in the past. The expected increase in the market penetration of EVs and an increased focus on building electrification are expected to increase electricity demand and offset the impact of otherwise slow load growth.

Long-term climate change impacts are not directly factored into this long-term forecast, but a climate trend is included to reflect changes in high and low temperatures, which increases energy use in the summer and decreases demand in the winter. Additional or accelerated climate changes could further increase long-term demand for electricity and impact daily and seasonal demand patterns. Extreme heat and storm events, which are projected to become more frequent, add additional uncertainty.

Distributed energy resources (DER)

DERs are energy solutions where customers implement technology that change how they use energy. DERs can include, among many others, rooftop solar, energy efficiency improvements, demand response and batteries. Energy efficiency, load flexibility and electrification are essential for our long-term mission to use energy more effectively and reduce GHG emissions. The importance of these resources is reflected in our existing programs as well as plans to expand these programs. Our demand-side programs help our customers manage energy use or generate their own energy through incentives, rate design and communication. We're also working to increase the electrification of transportation and buildings in our service territory, which is essential to achieving air quality and GHG reduction objectives in our community.

Energy storage

In 2016, SMUD adopted a DER strategy that included recommendations on battery storage. As part of that strategy, SMUD evaluated the value of energy storage dispatch under different control schemes as well as expected customer adoption of energy storage to gain a better understanding of the implications of the technology on our system. This strategy also calls for developing behind-the-meter business models and corresponding rate plans that can enhance the shared value of distributed energy storage between customer participants, the rest of the grid and non-participating customers.

In September 2017, the SMUD Board adopted a target of 9 MW of energy storage procurement by December 31, 2020, which we achieved. This target was largely met by residential and commercial energy storage pilots and a utility scale battery procurement coupled with a commercial energy StorageShares program.

We expect solar adoption will continue to grow in our service territory because of continued cost declines and regulatory mandates, such as Title 24, which requires rooftop solar for new buildings permitted under the 2019 Title 24 building standards. We also expect an increasing portion of these solar installations to include battery storage as battery costs decline. Through 2020, our customers have installed a total of over 260 MW of behind-the-meter solar.

Long-term success of energy storage and grid modernization in SMUD's service territory will continue to rely on external factors such as battery cost reduction and technology innovation from 3rd party businesses, but SMUD also recognizes that to maximize the potential of energy storage, proactive engagement from the utility, in advance of financial viability, is needed. We also need more information and field testing to evaluate the impact of extreme heat conditions on battery performance in our region. With SMUD being a member of BANC, we have a greater level of independence with grid operations, which uniquely positions SMUD to develop programs, incentives and partnerships in our service territory that will enable access to a broader set of benefits. Access to these system level economic or reliability services will enable further 3rd party innovation, allow SMUD to collaborate with innovators to align grid needs with technology solutions and help us provide products that create value for our customers.[43]

EVs and load flexibility

EVs will likely be one of the most flexible resources of our electrification efforts. In addition to EVs, there is also a proliferation of smaller devices being adopted today, including batteries, smart thermostats, water heaters and home management systems. The number and types of these devices is growing independently of utility support and represents a significant load flexibility opportunity for SMUD to partner with customers to improve overall system utilization and minimize costs associated with new infrastructure.

Through passive rate instruments like SMUD's nighttime plug-in EV discount, customers have been shown to be effective at changing seasonal system-wide load shapes. These load shape modifications could also be achieved with actively managed charging technologies. However, these technologies have only been piloted and demonstrated at small scale to date, largely due to relatively low EV adoption and a lack of standardized hardware and software interfaces for integrating between grid management systems and the vehicle charger. In an attempt to bring some standardization to the market, aggregator business models are emerging to pool different vehicles and chargers for utility access, entering custom integration agreements with many 3rd party systems working towards a single interface for utility integration. The aggregation model may be inefficient for the long-term, but is a near-term necessity as standardized programs, business models and communications pathways are slowly being developed and advocated for by utilities.

Demand response

Our system is developed to operate under the most stringent and difficult operating conditions. In practice, this means we strive to meet our customers' needs during all hours of the year. There are times when paying or otherwise signaling our customers to reduce usage is less expensive than turning on an additional power plant. Demand response initiatives are one kind of load flexibility program at SMUD and are primarily used for contributing toward our capacity reserves and reserve margin needs.

> **Peak Corps Program** is a residential air conditioning load management program that provides a summertime resource for emergency situations if the need arises. Currently,

[43] For a more detailed discussion of SMUD's energy storage goals, please see https://www.energy.ca.gov/sites/default/files/2019-05/AB_2514_Oct_1_2017_Report_UPDATED_91517.pdf. Last accessed: 11 December 2020.

the program has the capacity to reduce demand by 59 MW. The technology supporting this program is reaching the end of its technical life and the program is expected to end before 2030. A new NextGeneration Air Conditioning Load Management program is being planned to replace Peak Corp with updated technology for a launch as early as 2023.

PowerDirect Program is an automated demand response program for commercial customers available for use between June and September from 2 to 6 p.m. It's an operational resource for reliability and economic purposes. The program is planned to grow over the next few years reaching 30 MW by 2027 and is expected to maintain that level going forward.

Individual commercial customer agreements are comprised of individual curtailment agreements with some of our largest industrial customers that allow us to curtail load for reliability or economic purposes with the potential for up to 6.5 MW within 10 minutes' notice. SMUD can call on these customers throughout the year.

Our 2015 Demand Response Potential Study looked out over a 10-year period and estimated the capacity expected to be available during the peak hour of system demand as ranging from 189 MW to 471 MW across four scenarios considered, with the base scenario predicting 368 MW. This equates to 11.3% of SMUD's peak load. The load reduction potential would come from three sources: programs, dispatchable pricing and non-dispatchable pricing. Variation in the peak capacity across the various scenarios can be attributed to differences in pricing enrollment policy, technology cost forecasts and the degree of marketing and incentive levels. This study was key contributor to our load flexibility strategy.

Table 4. Dispatchable load flexibility programs 2021-2030 (MW)

Year	Peak Corps	PowerDirect	Curtailment Agreements	New Planned[44]	Total
2021	58	15.2	6.5	0.0	79.7
2022	57	17.7	6.5	1.0	82.2
2023	56	20.2	6.5	11.1	93.8
2024	55	22.7	6.5	26.0	110.2
2025	54	25.5	6.5	41.7	127.4
2026	53	27.7	6.5	58.1	145.3
2027	52	30	6.5	75.9	164.4
2028	51	30	6.5	94.5	182.0
2029	50	30	6.5	115.5	202.0
2030	0	30	6.5	128.2	164.7

[44] In addition to expanding on these existing programs, our 2030 Zero Carbon Plan will also focus on new programs and strategies for flexible loads.

Over the next few years, we're planning to launch new load flexibility initiatives, which have been informed by the results of SMUD's Demand Response Potential Study. These new programs are planned to be flexible and available to respond with very short notice. This will be helpful when we're trying to balance supply and load due to increasing amounts of intermittent renewable generation on the system.

Enhanced electricity rates

SMUD encourages energy efficiency and conservation through time and temperature dependent rate structures. These rates provide signals to our customers when energy costs are at their highest, and generally coming from the most polluting sources. These rates include our residential and commercial TOD and temperature dependent rates.

The TOD rate structure encourages customers to conserve energy by rewarding them for reducing their usage during peak hours. To encourage residential EV adoption, our TOD rate offers a plug-in EV discount of $0.0150/kWh on all electricity used between the hours of midnight and 6 a.m.

We also have industrial customers on our Temperature Dependent Rate, equivalent to 15 MW of capacity. During the summer when outdoor air temperatures exceed 100°F for a certain period, we can notify customers and provide them the option of curtailment or continued service at a higher cost.

2030 Zero Carbon Plan approach and overview

SMUD's carbon reduction journey has entered a critical juncture as we look toward to the next decade and plan to achieve our aggressive goal of eliminating GHG emissions from our power supply by 2030. The remainder of this Plan provides the foundation for our next steps as we address the challenge laid before us, to:

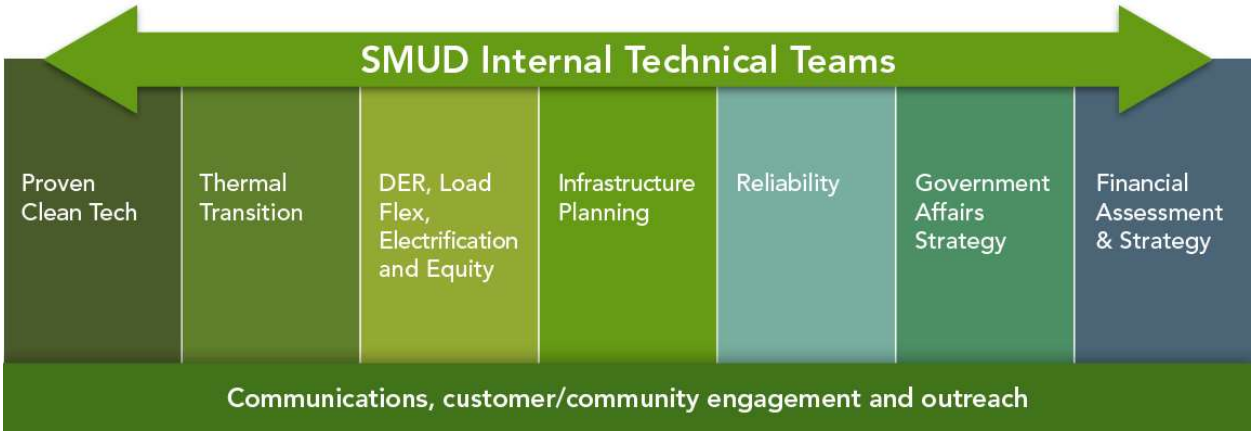
Reduce our stationary source carbon emissions to zero by 2030 while continuing to offer reliable electricity at affordable rates and maintaining our commitments to our community.

This Plan was developed in consultation with our community, experts in the utility industry and energy field and SMUD staff subject matter experts. To inform our Plan, we consulted with the engineering firms Black & Veatch, Energy + Environmental Economics (E3) and IEC Corporation. These firms conducted detailed analysis and studies on the status of proven clean technologies and the expected performance and costs of new and emerging clean technologies.

SMUD technical teams

Beginning in October 2020, eight technical teams of nearly 100 SMUD employees mobilized to investigate various methods to completely decarbonize our electricity supply. Developing a plan of this scope and magnitude is generally a process that is undertaken over years, not months. Our teams were formed quickly and worked collaboratively and creatively to develop a robust, fact-based plan to achieve zero carbon emissions by 2030. Each team had a specific focus, though constant coordination was required across all teams to develop a comprehensive and cohesive plan. Figure 4, below, shows the eight technical teams that contributed to developing the 2030 Zero Carbon Plan.

Figure 4. Technical teams contributing to 2030 Zero Carbon Plan development



Public consultation process

A key theme in the development of our 2030 Zero Carbon Plan is collaboration and public outreach. We know we cannot achieve ambitious climate goals alone and need to partner with our entire community to make sure we deliver solutions that are attractive, affordable and beneficial to our entire region, leaving no community behind.

While developing the 2030 Zero Carbon Plan, we engaged in extensive outreach to seek input from our customers, communities and other stakeholders. Our outreach process included four principal paths:

- **Three virtual presentations** to our customers and community organizations in December 2020.
- **An online survey** to collect feedback and views from our customers and community organizations on the development of the 2030 Zero Carbon Plan and their sentiments about their own climate investment plans and willingness to partner with SMUD.
- **Seven virtual stakeholder workshops** with selected groups and organizations. These workshops included participants from community organizations and nonprofits, environmental groups, the solar + storage industry and local business leaders.
- **Three industry expert panel discussions** to help our Board, SMUD staff and the public learn more about the latest technologies and ideas for decarbonizing our power supply.
- **Seven Board meetings** where members of the public had opportunities to learn about the progress of the 2030 Zero Carbon Plan and provide comments. All of SMUD's Board and Board Committee meetings are public and our customers and other members of the public will have ongoing opportunities to provide public comment on our 2030 Zero Carbon Plan and other topics.

The vast majority of people who attended our meetings expressed strong support for our 2030 Clean Energy Vision. While some expressed concerns over potential cost increases and emphasized the need for all communities and customers to be part of the solutions (including under-represented or under-resourced communities), most were enthusiastic and expressed interest in partnering with SMUD to support our goals.

In parallel with the meetings mentioned above, we developed a webpage, smud.org/ZeroCarbon, where interested participants could register for the meetings, learn more about our 2030 Zero Carbon Vision, sign up for future notifications, get answers to frequently asked questions and give SMUD input for the 2030 Zero Carbon Plan. The meeting recordings are posted on this webpage.

Figure 7. Community benefits of a zero carbon future

The interest from our customers and our communities has been outstanding. During our accelerated timeline of only about 3 months to develop the Plan, more than 500 participants provided their inputs and comments representing customers, businesses and community organizations in the region as well as national organizations. We have also received many comments and suggestions through our zero carbon webpage and our dedicated email ZeroCarbon@smud.org.

Customer and community presentations

In December 2020, we held two virtual meetings for residential customers and one meeting for community organizations. The objective was to introduce the 2030 Zero Carbon Plan and collect feedback. We sent email invitations to the meeting to a representative cross-section of our residential customers. We also invited every not-for-profit organization we are connected to in the Sacramento region, as well as subscribers to our listservs, and we announced the meetings via social media. This outreach resulted in 415 participants in the two residential customer meetings and 82 participants in the community meeting.

Online survey results and insights

Customers who participated in our customer and community meetings in December 2020 were also invited to provide their views and input through an online survey. A full summary of the survey results is posted on smud.org/ZeroCarbon. Table 5 provides a high-level summary of the survey results.

During the sessions, customers asked many questions about our energy resource mix, our investment plans and what the 2030 Zero Carbon Plan means for our communities. These questions, many of which were answered directly during the customer and community meetings, have been converted into a frequently asked questions (or FAQ) section that's available at smud.org/ZeroCarbon.

Table 5: Summary of online survey results

	The vast majority of residential and community group attendees feel that it's extremely or very important to improve air quality in the Sacramento area.
	The majority of residential and community group attendees indicated that they "loved" SMUD's Zero Carbon goal.
	The top 3 ways attendees felt SMUD should support the community were to provide: 1) Affordable electricity options 2) Reliable energy 3) Achieve zero carbon in a way that benefits all communities.
	60% of residential and 77% of community group attendees indicated that they are very willing to partner with SMUD by personally taking action to reduce Sacramento GHG.
	39% of residential customer attendees say they are very likely to purchase smart home technologies in the next 12 months. Almost one-fourth are very likely to purchase/lease EVs or rooftop solar, while slightly fewer (17%) are very likely to purchase/lease a battery.
	When asked how much they would be pay voluntarily, almost half of residential customer attendees claimed they are **willing to pay up to $10 more per month** to support the 2030 Zero Carbon plan. However, almost one-fourth were not willing to pay any more.
	Almost 6 of 10 residential customer attendees claimed they are very likely to respond to tips from SMUD to reduce their GHG emissions. 43% said they are very likely to participate in a Demand Response program and 30% to replace their gas appliances with electric.

Stakeholder meetings

We organized meetings to solicit input from a wide range of key stakeholders. Each group met twice – once at the beginning of our 2030 Zero Carbon Plan development process in mid-December 2020 and once at the end of February 2021 to learn about the results of our studies and key recommendations we intended to include in the Plan. Meetings were held targeting four stakeholder groups: solar + storage industry, environmental organizations, community organizations and business leaders.

Each meeting was scheduled for 90-120 minutes and included a brief presentation from SMUD followed by a discussion session with the participating stakeholder groups with the objective for SMUD to learn as much as possible about these groups' views on our 2030 Zero Carbon Plan. The meetings were facilitated by the Smart Electric Power Alliance (SEPA), a not-for profit organization focused on helping utilities and other energy companies decarbonize their energy supply chain and work with their communities and stakeholders to achieve those goals. As a result of these meetings, the following key themes emerged:

Support. Across all sessions and groups, strong support was expressed for SMUD's goals. All groups indicated interest in partnering with SMUD, ranging from offering to communicate our 2030 Clean Energy Vision to their respective communities to expressing interest in new customer incentives. Several stakeholders also emphasized the need to partner with technology

and solutions providers to find innovative solutions. Some stakeholders also expressed support for specific technologies, in particular support for rooftop solar, batteries and EVs.

Costs. Concerns over the costs for eliminating carbon emissions were raised by multiple stakeholders, particularly community organizations and business leaders. Community organizations also highlighted the importance of all communities getting access to clean energy options and that no communities are left behind in the process.

Outreach and education. All stakeholder groups expressed the need for education and outreach about how our 2030 Zero Carbon Plan will help address climate change. Several community organizations also offered to provide outreach on these efforts in their communities.

Repowering gas plants. Several, but not all groups, expressed support for repowering or re-purposing our gas plants to carbon free alternatives to avoid costs associated with prematurely retiring our gas-fired plants, which would result in stranded costs.

Stakeholders also provided general appreciation for the opportunity to be involved in the development of the 2030 Zero Carbon Plan and provided support for the preliminary draft that was presented at the second set of meetings in February 2021. While supportive, several stakeholder organizations and groups reiterated their continued emphasis on key issues, such as community involvement, the value of electrification, cost concerns and their willingness to partner with SMUD to help support our zero carbon goals.

Industry expert panels

With the support of SEPA, we convened leading experts from around the nation to help inform the SMUD Board and our staff of the latest technology developments, research, products and services that should be considered when aiming to be a zero carbon utility by 2030. We hosted a total of three industry expert panels over the course of three Board meetings that included 11 experts. These meetings were open to the public and some members of the public also provided comments during the process. Each panel meeting had a specific theme.

- **January 12, 2021: Vision, solutions and technology for a carbon free future.** In this panel, experts from Vibrant Clean Energy, Rocky Mountain Institute (RMI), Electric Power Research Institute and National Renewable Energy Lab provided an overview of the latest developments and research, including the future role of customer-located generation and storage and the potential of a closely coordinated and operated electric distribution grid to reduce the cost of renewable integration.
- **January 26, 2021: DERs and the edge of the grid.** Experts from Lawrence Berkeley National Lab, Sunrun, Olivine and Schneider Electric provided their views on the role of DERs in a zero carbon future. Panelists highlighted the potential for virtual power plants (VPPs) to supplement grid resources and reduce costs. The panel also emphasized the importance when power is used, suggesting that initiatives and technologies capable of changing when energy is used can contribute to a more stable and reliable grid. Panelists suggested that the aim is not perfection, but to test and improve technology to find solutions that work best for communities.
- **February 9, 2021: Grid scale solutions for a carbon free SMUD.** Experts from General Electric, Ameresco and Green Hydrogen Coalition focused on large-scale zero carbon supply options that could be available by 2030. The experts highlighted that

today, there are already many options for energy and alternative fuels. Hydrogen was identified as a fuel with the potential to provide long-duration storage options and support reliability in an otherwise mostly renewable energy powered grid, noting that we're still some time away from having a reliable supply of affordable hydrogen or other biofuels in volumes that are sufficient to fully replace SMUD's natural gas use.

SMUD Board and committee meetings

SMUD staff has provided updates to the Board and its committees at virtual meetings from December 2020 through March 2021. At these meetings, we presented the status of work performed and next steps. We also received guidance from the Board on their desired direction of our work as well as inputs from the public through public comments during the meetings. The views expressed in this forum have helped to shape the scope and the analysis of our work on this 2030 Zero Carbon Plan.

Innovation Leadership Team (ILT)

SMUD solicited innovative ideas from the public and our employees to help develop this Plan. Our ILT reviewed and prioritized ideas to into the Plan. The most promising opportunities were studied further. Information and analysis from our contractors and vendors, along with staff expertise were used to prioritize options for inclusion in the 2030 Zero Carbon Plan. Table 6 highlights key factors used to prioritize ideas. For a list of non-confidential submissions from the public, see Appendix C:

Table 6. Key factors for considering innovations

Category	Criteria
Benefits	Helps meet 2030 goal
	Fills portfolio need
	Flexible/Adaptable to changes
	Innovation prospects
	Opportunities for collaboration
Costs	Projected costs (capital, operations & maintenance, procurement)
	Certainty of cost projection
Risks	Public safety
	Siting, permitting, and environmental impact
	Political/regulatory
	Technology maturity, commercialization, scalability for deployment
	Dependency on other projects and investment climate

Carbon accounting

There are many valid methods for accounting for GHG emissions, however, they don't all measure the same thing, which makes comparison difficult. In framing our 2030 Zero Carbon Plan, it's important to recognize that a 100% renewable generation procurement target does not guarantee corresponding GHG emissions reductions.[45] At its most basic level, carbon accounting is challenging to reach consensus on the application of valid approaches. Complicating this is the fact that once electricity enters the grid, it's impossible to distinguish the source, making it difficult to estimate our emissions footprint if one generation source is indistinguishable from the next. Generally, accounting methods can be broadly grouped in terms of timescales, such as annual and hourly accounting. For this Plan, we used an hourly accounting framework.

Annual accounting methods are the basis for many GHG accounting frameworks and disclosure regulations in California.[46] In this approach, we count as ours all zero-emission energy we buy or generate, generally at a higher price or cost, and we consider the energy we sell to be from our GHG-emitting sources. This methodology is widely accepted because it appropriately attributes the extra cost of zero emission resources to the purchaser. It also acknowledges that power bought in the open market is indistinguishable from other electrons, therefore market power purchases are treated as carbon emitting resources unless the buyer can show otherwise.

The drawback of annual accounting is that, as we're seeing today, the value of renewable energy can exceed the market value. This can cause market inefficiencies and negative energy prices during high solar producing periods. One method to guarantee the most emissions reductions from renewable energy is to match power consumption with renewable generation on an hourly basis.[47] In practice, this means whenever we draw power from the grid, we need to be simultaneously injecting or buying an equal amount of renewable power. As more information becomes available and increasingly accurate, consumers can shift flexible consumption to portions of the day where grid power is cleanest, further reducing emissions. With a 100% renewable energy supply, customers can reduce the carbon footprint of the entire grid in addition to their own footprint.[48] A summary on these methods, as used by SMUD, is in Table 7.

For this Plan, we used an hourly accounting methodology. This accounting framework is more stringent than most mainstream utility and regulatory programs and, more importantly, it's also most closely aligned with our Board's direction and SMUD's 2030 Clean Energy Vision.

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[45] de Chalendar, Jacques and Sally M. Benson. *Why 100% Renewable Energy Is Not Enough.* June 2019. Joule 3, 1389-1393. Available Online: https://www.cell.com/action/showPdf?pii=S2542-4351%2819%2930214-4. Last accessed: 25 January 2021.

[46] Our 2040 Clean Energy Plan also layered on an additional accounting framework to measure programmatic successes for our energy efficiency and electrification strategy, and identified GHG reduction from electrification to include in our net-zero accounting.

[47] de Chalendar, Jacques and Sally M. Benson. Why 100% Renewable Energy Is Not Enough. June 2019. Joule 3, 1389-1393. Available Online: https://www.cell.com/action/showPdf?pii=S2542-4351%2819%2930214-4. Last accessed: 25 January 2021.

[48] Ibid.

Table 7. Accounting methodology

	Annual Accounting	Hourly Accounting
SMUD Thermal Sales – Credit for exports/sales	Emission Intensity (EI): 0.39t/MWh or linked to the average EI of operating thermals	
Undelivered Renewable Energy (Sold into the CAISO)	Energy displaces unspecified imports (on an energy basis) one-for-one, in terms of annual accounting. Renewable sales in excess of this value provide no additional GHG value.	Energy displaces unspecified imports (on an energy basis) one-for-one, in terms of hourly accounting. Renewable sales in excess of this value provide no additional GHG value.
Unspecified Imports	EI: 0.428t/MWh	EI: 0.428t/MWh
	Only applied to import in excess of renewables in the CAISO (under annual accounting)	Only applied to import in excess of renewables in the CAISO (under hourly accounting)
Specified purchases and imports	EI of the known resource. If unavailable, assume all are gas resources emitting 0.428 t/MWh. Renewable procurement should not be able to displace specified contracts.	

System modeling

The industry standard practice for planning studies is to develop and analyze several options that are capable of offering reliable electric service, subject to our policy, environmental, physical and economic limits. We conduct these studies using a series of computer simulations that model building new resources, operate the system over several years and test the system's ability to meet our needs in the most difficult circumstances. Although these models are powerful tools, they're time-consuming data-intensive processes. To assist our efforts, we hired E3 to support the modeling for this Plan.

This Plan relies upon two resource planning models developed by E3 and tailored towards analysis of electric systems at high penetrations of renewable generation to develop and analyze a range of scenarios to explore potential options for carbon reductions in the SMUD system portfolio:

- ***E3's Renewable Energy Capacity (RECAP) model*:** A loss-of-load-probability model that provides a detailed and statistically robust perspective on electric systems that rely on a combination of conventional, renewable, storage and demand-side resources.
- ***E3's Renewable Energy Solutions (RESOLVE) model***: A capacity expansion model that uses optimization techniques to identify a least-cost portfolio of resource investments to meet future reliability and clean energy objectives.

These two tools complement one another in their application, together providing a strong foundation to analyze and understand implications of long-term transitions towards low carbon and carbon free portfolios. These models are used together: first, the Plan uses RECAP to characterize potential contributions of different technologies toward system resource adequacy needs; this, in turn, serves as an input to RESOLVE, to ensure that the least-cost portfolio outcome meets reliability goals.

The following sections will address key questions and considerations for achieving zero carbon by 2030. Our goal in this report is to provide data and information to answer the following questions:

- What role can our thermal assets play in this Plan?
- How close can we come to meeting our goals using currently available proven clean technologies?
- What new and emerging technologies show promise for filling the remaining gap to zero carbon?
- What are possible scenarios for achieving these goals? How will these scenario results later inform our strategy discussion as elements of our plan become more concrete?

The 2030 Zero Carbon Plan

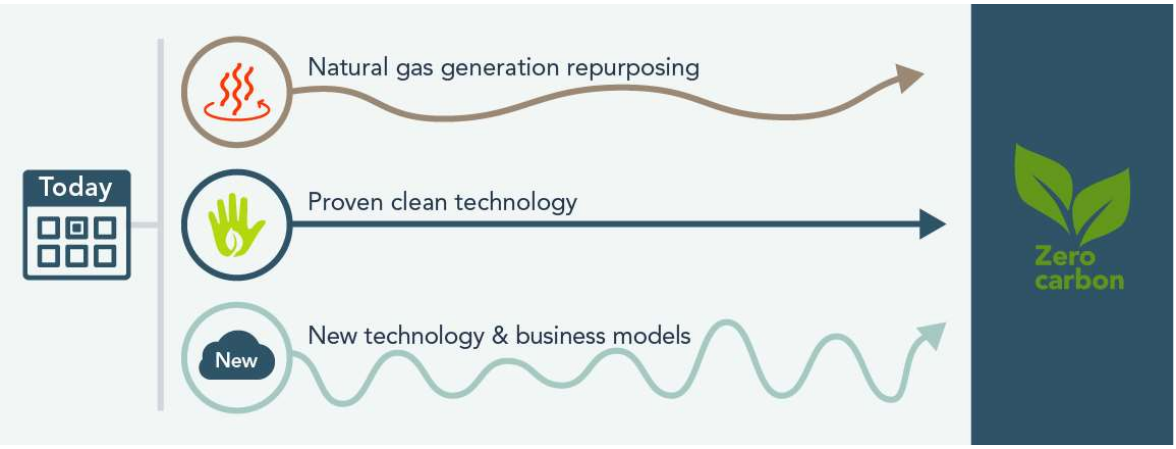
Achieving our goals requires eliminating fossil fuel GHG emissions, either by displacing natural gas use from our power plants or capturing our emissions before they reach the atmosphere. Informed by expert consultations, system modeling and supplemental studies, we've developed four strategies to guide our initial decisions on our journey toward eliminating carbon emissions from our power supply. Each group is comprised of options and decision points. Although there is not a single path to achieve our objective, this Plan has helped identify strategies that will help us along the way. We'll continually revisit our strategies and planned path along the way and course correct as needed. In the end, we'll have traveled our unique pathway to reach the end of our 2030 zero carbon journey.

SMUD's 2030 Zero Carbon Plan is a flexible pathway to eliminating carbon emissions from our power supply by 2030.

Developing our flexible pathway to zero carbon

Each strategy addresses distinct challenges. The decisions we make will take us one step closer to our goal but may also require that we reassess our next decision. Our flexible pathway to zero carbon is based on what we know today, and our pathway will evolve as new technologies are developed and we learn from our experiences. Some strategies, like proven clean technologies, are more straightforward, and we have a clear understanding of the risks and the costs. Other strategies are not as well understood and are more complex. As technology and business models evolve, we may reevaluate previous decisions and reconsider our decarbonization plan to align with new information. These strategies are interdependent, but each element of our plan will require a unique strategy complete with different resources, milestones and risks. In our flexible pathway, we'll need all three strategies to contribute, and understanding how each will ultimately contribute by 2030 will be refined over time.

Figure 5. Illustrative flexible plan



Natural gas generation repurposing: The future of our natural gas-fired thermal power plants is a critical component of our energy delivery system. These power plants are economic and reliable sources of both energy and non-energy services to the system. This strategy challenges us to consider what role these units could play in our zero carbon future. Elements considered include retirement or retooling of thermals, using alternative fuels such as renewable hydrogen, RNG, or renewable diesel or developing new technologies, such as carbon capture and long-duration storage.

Proven clean technologies: These are mature zero emission technologies available in the market today. Mature technologies, such as solar and wind, are economical resources with a known track record for performance. Coupled with storage and DERs (rooftop solar and customer-owned batteries), proven clean technologies are expected to form the foundation for our clean energy goals. This strategy also provides the replacement attributes needed to support our natural gas generation repurposing strategy. As part of this strategy, we considered technologies such as wind, solar, lithium-ion batteries, hydroelectric power, biomass and geothermal.

New technology and business models: There are exciting technology advancements that are currently evolving in the electricity market. Building on the alternative fuels studied as part of our natural gas generation repurposing strategy, we're also exploring how our customer relationship can evolve as we work to integrate additional distributed energy and demand response resources into our system. As we achieve greater success in this strategy, our strategies above would be less necessary, possibly allowing us to achieve our goals at lower costs.

Financial impacts and options: We're committed to achieving the 2030 Zero Carbon Plan while keeping rates affordable. While the plan represents significant new investments, there are several opportunities to manage the impact to customer bills. This strategy depends on regional, national and international partnerships to share the costs of common goals and fund the development and acceleration of new technologies. We'll continue to expand new revenue sources, such as Low Carbon Fuel Standard (LCFS) credits, U.S. EPA electric Renewable Identification Number and carbon credits. This strategy also focuses on leveraging use of our low-cost of capital, mechanisms such as green bonds and commodity prepays that may lower costs and improving efficiency in delivery of our core services. As technologies progress, we'll regularly review the financial impact and manage our finances to keep rate increases low and stable.

In the following sections, we'll explore the pathway options of our road map to decarbonization and discuss plausible implementation scenarios that will allow us to realize our 2030 Clean Energy Vision. Our previous studies have shown that renewables are an economical resource; however, all of our studies to date show that renewables, even with today's battery technologies, cannot get us to zero carbon reliably and affordably. To keep our commitments to our customers, we'll need to embrace the leading edge of technology, innovation, research and development, and deploy groundbreaking and sometimes counter-intuitive solutions.

Natural gas generation repurposing strategy

Natural gas generation repurposing

- Reimagine thermal fleet as peaking plants.
- Study the retirement of McClellan in 2024.
- Study the retirement Campbell in 2025.
- Retool Carson and Procter & Gamble from combined cycle operations to simple cycle peaking units.
- Eliminate carbon emissions and minimize operating hours.
- Research and scale alternatives to natural gas.

Our Plan starts with our thermal power plants, which currently depend on natural gas for generation. This section takes a detailed look at our thermal fleet and our commitments in this area. This includes our electricity delivery system, which for decades has been built and maintained around the continued operation of our natural gas power plants. In this analysis, we look to these resources not as an impediment to our 2030 goals, but as an opportunity. These thermal power plants represent existing assets that can be leveraged to achieve our goals at lower cost and greater reliability, while considering neighboring communities, particularly under-resourced areas.

To study how our existing thermal power plants can play a role in our carbon reduction journey, we scanned the industry for technologies and strategies that could decarbonize SMUD's natural gas-fired thermal fleet. For this analysis, we assessed the following topics.

- Technology options for their maturity and future potential.
- The cost and availability of alternative fuel sources.
- Location of thermal power plants to under-resourced communities.

Our goal of this analysis was to find tools that can be used to:

- Protect grid reliability during the transition to zero carbon.
- Provide a baseline reference point for comparison of replacement options.
- Minimize the adverse impacts on under-resourced and sensitive communities.

As we studied this strategy, we considered our under-resourced communities, health impacts and reliability of our system. We looked at three broad options for our thermal plants, including retirement, retooling or a hybrid approach.

Thermal power plants and our communities

When considering the future of our natural gas power plants, we must understand how these plants operate and acknowledge that these resources provide more than energy to our system. These plants are also fixtures in our communities, for better or worse, and we must consider and include our neighbors in these decisions, to fully weigh the impacts of retiring or changing the operations of these power plants.

SMUD owns and operates five power plants within Sacramento. Our power plants are fueled by using natural gas and two locations are also supplemented by RNG. Excluding McClellan, our power plants are designed as either combined cycled or cogeneration power plants. These systems allow each power plant to capture the waste heat from the combustion turbine in energy efficient ways. In general, our thermal power plants operate like this:

- A gas turbine burns fuel and air is compressed and mixed with gas that is heated to a very high temperature. The hot gas mixture exhausts through the gas turbine blades, making them spin, rotating a generator and producing electricity.
- In combined cycle and cogeneration plants, a heat recovery system captures the gas turbine exhaust waste heat that would otherwise escape through the exhaust stack and instead creates steam.
    - In a combined cycle power plant, the steam is delivered to a steam turbine that makes additional electricity. As shown in the table below, a steam turbine can generate about 50% more electricity from the turbine's captured waste heat.
    - In a cogeneration power plant, the steam is delivered to a neighboring facility for use in their production. Our steam deliveries are regulated via formal "Steam Sales Agreements" with our steam customers.

Historically, we've operated our power plants as baseload plants, designed to be online for long periods of time, operating at a consistent level, with little downtime for annual maintenance and repairs. As larger amounts of low-cost solar power have become available, we now find ourselves "cycling" the power plants from high load to minimum load and in some cases even shutting units down for extended periods. Although combine cycle power plants are very efficient when running, the internal mechanics and thermodynamics of the system restrict how quickly and how often the plant can start up and shut down. In many cases, if we expect to need the plant the next day, it's more efficient and economical to keep it running. These engineering and economic factors drive operations at the Cosumnes and Campbell power plants.

We've also operated cogeneration power plants that use the exhaust heat to produce steam for industrial customers. In particular, our steam host obligations are one of many factors we must consider as we operate the Procter & Gamble and Carson power plants. Similar to combined cycle plants, these steam turbines take time to warm up and cannot be shut down quickly. We must also consider our obligations to our steam customers when considering daily operations.

Table 8 provides an overview or the current configurations of our thermal power plants.

Table 8. SMUD thermal power plant overview today

Power Plant	Generator Type	Unit	Capacity Rating (MW)	Fuel Source
Sacramento Power Authority (SPA) at Campbell Soup	Combustion Turbine	1	116	Natural Gas
	Steam Turbine	2	62	Waste Heat
McClellan Gas Turbine	Combustion Turbine	1	72	Natural Gas
Central Valley Financing Authority (CVFA) at Carson Ice	Combustion Turbine	1	48	Natural Gas and Biogas
	Steam Turbine	2	20.6	Waste Heat
	Combustion Turbine	3	42.5	Natural Gas and Biogas
Sacramento Cogeneration Authority (SCA) at Procter & Gamble	Combustion Turbine	1	52.4	Natural Gas
	Steam Turbine	2	42.5	Waste Heat
	Combustion Turbine	3	48.3	Natural Gas
	Simple Cycle Peaking	4	50	Natural Gas
SMUD Financing Authority at the Cosumnes Power Plant (CPP)	Steam Turbine	1	207	Waste Heat
	Combustion Turbine	2	207	Natural Gas and Biogas
	Combustion Turbine	3	207	Natural Gas and Biogas

Reliability considerations

As noted earlier, reliability services are needed to maintain a reliable grid. Some of these services can be provided by proven clean technologies, like batteries or hydro, but during expected compounded weather events such as multiple days of adverse conditions like low-wind, cloudy days, heavy fog, heavy smoke and long periods of drought, our operational experience has shown that renewables struggle to meet our immediate needs consistently and reliably. As part of developing this Plan and during the next steps to implement it, we'll keep reliability at the forefront of our decision-making. The following operational characteristics are currently provided by our thermals and must also be provided in our 2030 Zero Carbon Plan.

- **Fast and flexible dispatchability:** Dispatched by Automatic Generation Control every 4-seconds over a wide output range.
- **Sustained operating reserves:** Operating reserves are required to be fully deployable in 10 minutes and can sustain for 60 minutes.
- **Quick frequency response following a disturbance:** Respond to system frequency deviation within 10 seconds and sustained for at least a few minutes.
- **Dynamic voltage control:** Dynamically adjust reactive power[49] based on system voltage swings.

[49] Reactive power isn't used for mechanical work and is relationship between the phases of AC current and voltage. The more out-of-phase current and voltage are the less efficiently power is being transmitted.

- **Inertia:** Physical resistance to frequency changes in the first few seconds following a system disturbance before generator frequency response kicks in. This resistance to change (typically from large rotating generators) gives automated control devices needed time to respond.
- **System oscillation damping:** Stabilize generator oscillation quickly within 10- to 20-seconds by providing additional damping through generator control.
- **Black-start capability:** Capability of a generator to start up without support from external power sources, which is needed in the event of a system blackout to energize other equipment and restore the system.

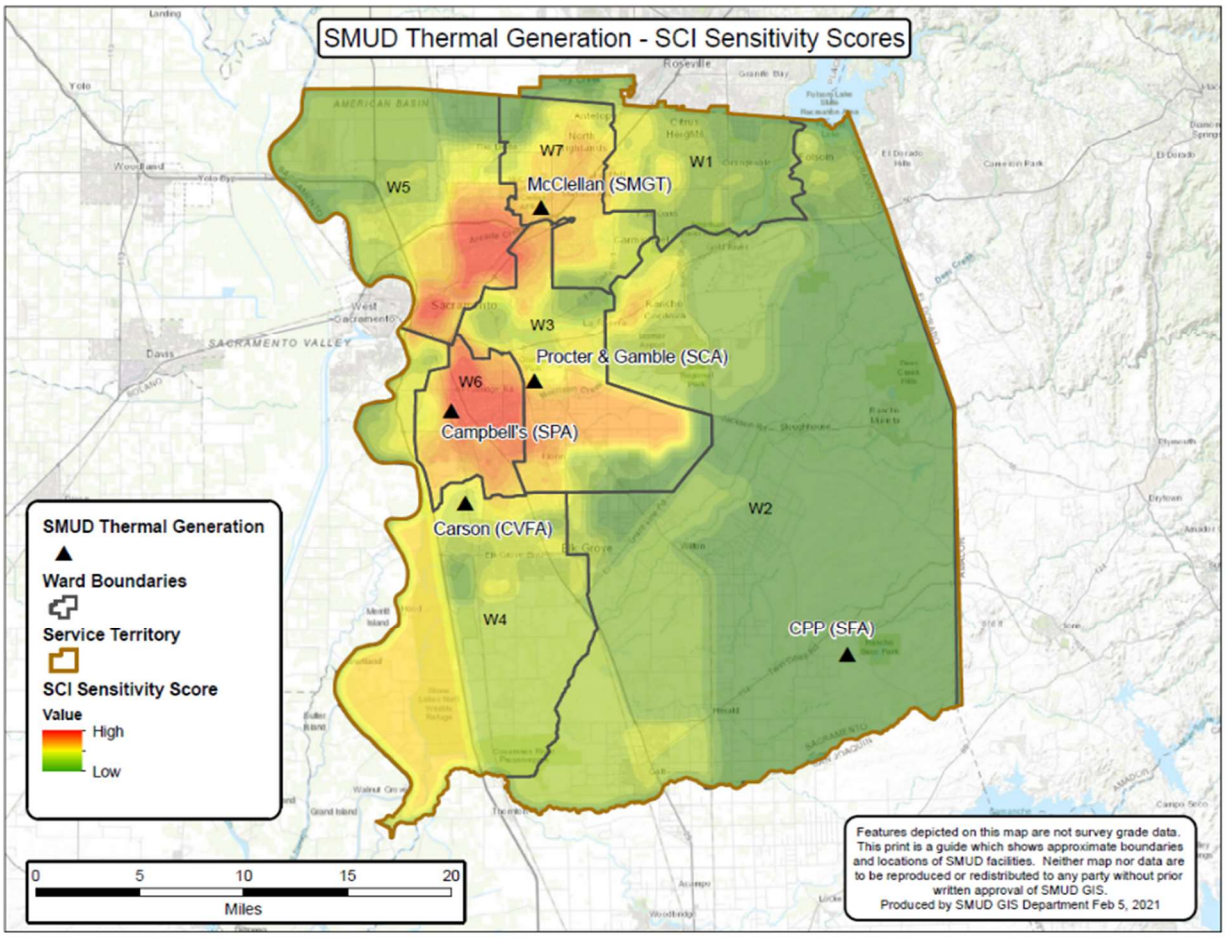
Thermal power plants have been integrated into our grid for decades and our electrical system has been built around them. As we change how these plants operate, we need to analyze all aspects of our system, including our ability to import power. While this Plan provides a high-level look at import and load serving capabilities, additional studies are required to examine each resource option and their capabilities and shortfalls. In terms of reliability, our preliminary analysis suggest that retirement of a power plant may be possible if initial steps can be taken to add generation and dispatchable capacity where needed before retiring a thermal unit. These considerations are plant- and solution-specific and must be evaluated at each location.

One particular challenge exists at our Carson (CVFA) power plant. This facility directly serves a portion of our 69kV sub-transmission system that is expected to see significant load growth over the next five years and beyond. Without this generator, the sub-transmission system will no longer be adequate to serve existing and forecasted demands in the area. Detailed studies need to be performed to fully assess the impacts of CVFA's retirement on the adequacy and reliability of the local sub-transmission system. These detailed studies will include an assessment of mitigation options such as infrastructure upgrades, utility-scale renewable generation, DERs, demand response or a combination of these options. It's important to note that the combined solutions must provide the same services this power plant currently offers.

Under-resourced communities

Our Campbell plant (SPA) and the McClellan Gas Turbine thermal power plants are located in areas with a sensitivity score of high or moderately high on our Sustainable Communities Priority Map. In terms of our community, modifying or retiring McClellan and Campbell would have the greatest impact on our under-resourced communities relative to our other thermal plants because they're located in areas of SMUD territory with some of the highest sustainable communities' sensitivity scores, see Figure 6. Decisions about the future of these plants will include discussions and engagement with the community.

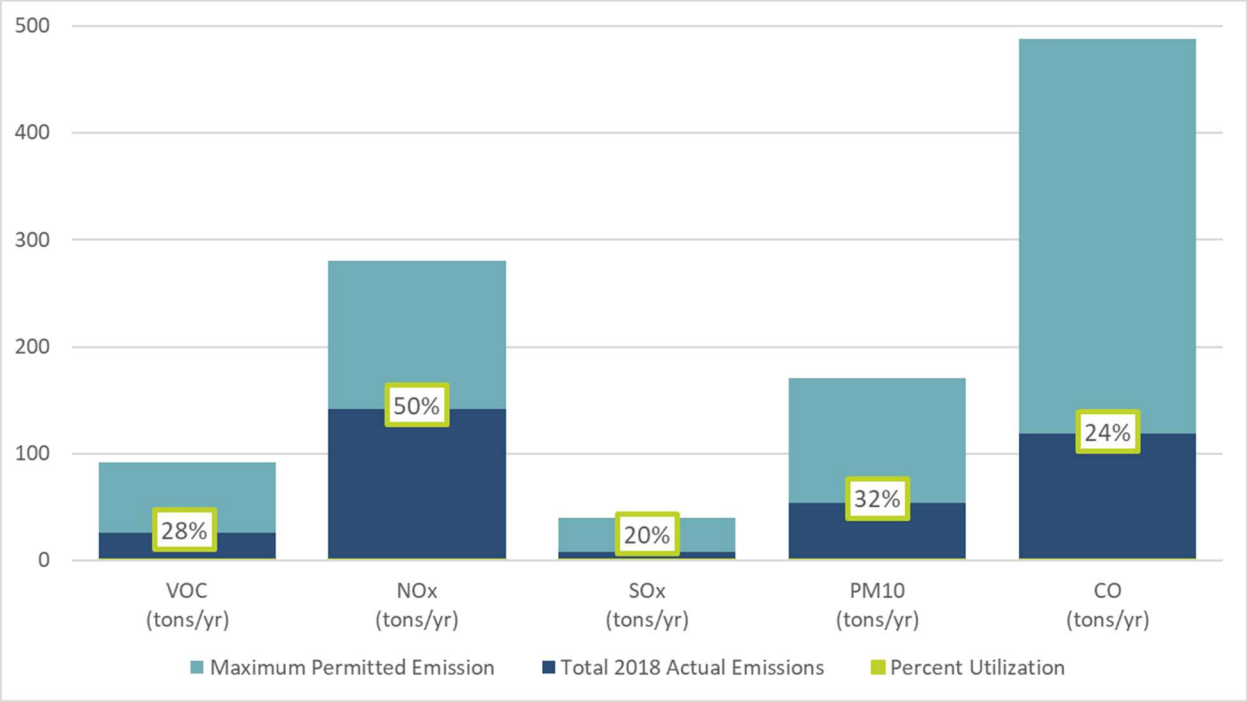
Figure 6. Thermal power plant locations



Air quality considerations

Currently, we operate our thermal power plants far below their permit limits and will continue to look for opportunities to reduce our emissions. Our utilization rates are shown in the boxes below in Figure 7, a comparison of the power plants' maximum permitted emissions and their actual 2018 emissions as regulated by the Sacramento Metropolitan Air Quality Management District (SMAQMD) and the U.S. EPA. Studies show that criteria pollutant emissions, such as Nitrogen Oxide (NOx), from fuel combustion in buildings and light-duty passenger vehicles present higher health risk concerns in Sacramento than SMUD's power plants. Electrifying homes and buildings will result in significantly improved regional air quality.

Figure 7. Comparison of maximum permitted emissions and 2018 actual emissions



The best way to determine the impact of air pollutant emissions on nearby communities is to perform a refined health risk assessment of each thermal power plant. Health risk assessments calculate the potential health risk to individuals over time using various real-life data, such as the height of the power plant's stack, temperature of the pollution release and proximity of neighborhoods, schools, hospitals and other work sites. Impacts on health risk can be looked at in terms of the potential to increase one's cancer risk[50].

In 2018, SMUD submitted to SMAQMD separate health risk assessments for the Carson Ice, Proctor & Gamble and Campbell cogeneration power plants. The assessments were based on individual facility 2016 operating data. We found the cancer and non-cancer risks associated with each power plant are below the thresholds indicating any significant health impacts to our neighboring communities. This includes the South Sacramento/Florin Community, which is actively working with SMAQMD to implement a Community Air Monitoring Plan under Assembly Bill 617 (Community Air Protection Program).

In 2018, SMUD submitted a separate health risk assessment for the Cosumnes Power Plant. While the plant's cancer risk is above the 1.0 threshold limit, the risk level is determined based on the plant's maximum *permitted* emissions rather than *actual* emissions, and is mitigated because the power plant is in a sparsely populated area with no sensitive receptors, such as K-12 schools or hospitals.

[50] Cancer Risk is the theoretical probability of contracting cancer when continually exposed for a lifetime (70 years) to a given concentration of a substance. The risk is presented as the number of chances in a million of contracting cancer.

For comparison, the SMAQMD lists several types of facilities with cancer risks well above our assessed risks. These other facilities include a dry cleaner, two chrome plating shops and over 200 diesel-fired internal combustion engines. Although not updated by the Air District since 2004, it's expected that a majority of retail gas stations will continue to have cancer risks above the one in a million-cancer risk threshold.

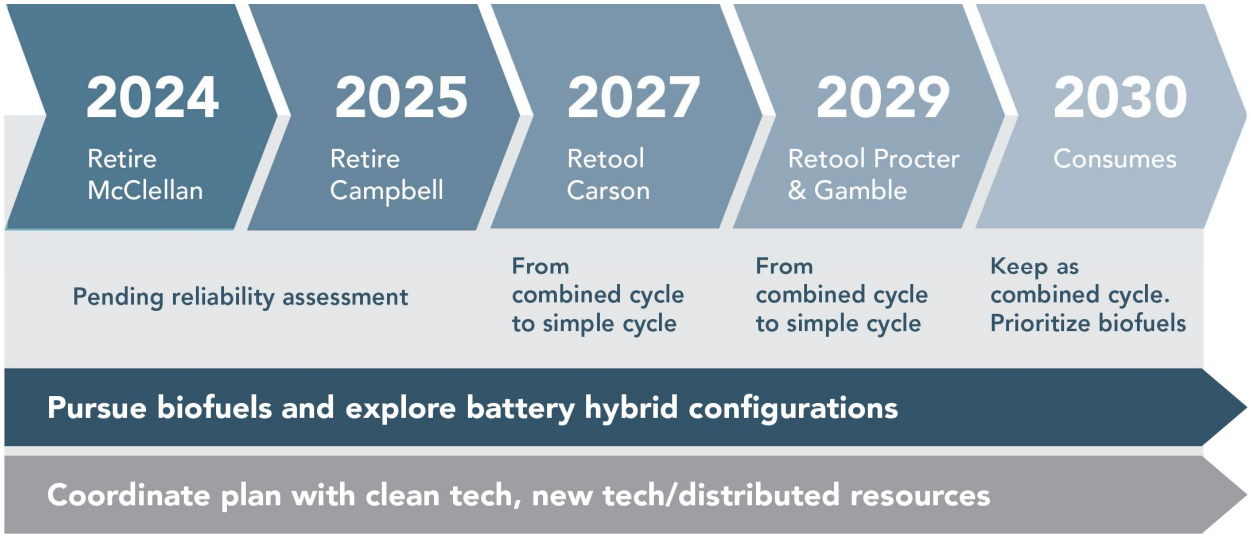
Thermal transition options considered

To inform our Plan, we consulted with IEC Corporation to identify the latest technologies available for our thermal power plants and Black & Veatch to provide the status of new resources and alternative fuels. Listed below, our study focuses on three broad options for decarbonizing our thermal power plants by 2030.

1. **Thermal power plant retirement:** Under this scenario, by 2030 we'll retire our thermal fleet and completely eliminate our reliance on fossil-fuel derived energy and reliability services from neighboring markets, including all energy purchased and sold.
2. **Refueling with zero carbon fuels:** As part of this scenario, we'll evaluate the technology landscape and feasibility of replacing all fossil fuel used at our thermal power plants with renewable or carbon-free fuels by 2030.
3. **Reimaging our thermal fleet:** We'll continue to leverage the reliability and cost-effectiveness of our thermal fleet and reimagine operations under fuel and emissions constraints. The thermal power plants would become flexible peaking units, providing short runs with lower capacity factors and ancillary services thereby eliminating their cogeneration status and greatly reducing their GHG footprints to absolute minimums.

Each of these options were considered under similar assumptions, included any steam sales obligations with our neighboring manufacturing facilities, and the schedule shown below in Figure 8. As we make and implement decisions, this Plan will be revised and expanded to account for on-the-ground conditions and advancements in technology and infrastructure.

Figure 8. Thermal retooling schedule



Evaluation of thermal power plant retirement

We also studied retiring our thermal units and relying solely on proven clean technologies to provide reliability services and energy for our customers. What's challenging under this option is replacing reliability services with non-carbon emitting resources in all hours throughout the year. The results of our analysis were similar to our previous studies: Retiring our thermal power plants and relying completely on proven clean technologies is possible, but it's an expensive option that may not be reliable under every weather scenario.

Beyond building for annual energy needs, our updated analysis of this option found the need to build over 3,000 MW of 4-hour duration batteries coupled with 5,000 MW of additional local solar generation (total resource build calls for 8,000 MW of solar).[51] These additional 8,000 MW of resources, beyond our base resource build in this scenario, are needed to minimize risks that could result in local blackouts similar to the outages faced by California customers during the heat storm of 2020. Again, these resources are needed to achieve only minimum reliability standards in 2030. If this option is considered further, we'll need to do an intra-hour analysis to identify additional firming resources such as batteries to address intra-hour variability, where momentary cloud cover can reduce the output of a solar field by over 50% in a matter of seconds.

This scenario also requires over 3,200 MW of resources to be built and operated outside our service territory. This means, an increased reliance on energy imports. There are significant economic risks to developing energy within a neighboring balancing authority such as CAISO. In particular, within California, solar is already dominating the market and flooding solar generating hours with low-cost energy. This is currently causing the market price for energy to be negative, meaning we must pay someone to take the energy if we cannot deliver it to our customers. This flood of generation is also starting to fill up available transmission lines, meaning there are times when we may not be able to access the generation we need. Our most economic decision during these instances could be to curtail our utility-operated solar and wind generators, essentially paying our generators to stop generating. In the study of this option, solar and wind were curtailed 7.5%. Batteries and other storage technologies mitigate this issue, somewhat. Lastly, additional analyses will also be needed to assess the impacts to our transmission and distribution system under this continuous high-import scenario.

Long-duration energy storage

To help overcome reliability challenges associated with high penetrations of renewables and make thermal retirement more viable, long-duration energy storage (LDES) is one potential opportunity worth continued exploration. While still an emerging market, long-duration storage such as flow batteries and thermal storage may one day be available to help us overcome multi-day weather events impacting renewable generation, as identified in our 2040 Clean Energy Plan and our studies to support this Plan.

[51] Longer duration, 8-hour, batteries could be used to meet this need, but for consistency, this measure uses equivalent 4-hour batteries.

Although many consider batteries with a duration longer than 4-hours as “long-duration,” we use the following classifications to differentiate our LDES needs.

- Short-duration: 4-hours or less
- Intra-day duration: 5 to 12-hours
- Inter-day duration:13 to less than 48 hours
- Multi-day duration: 48 hours to 168 hours (1 week)
- Long-term or seasonal energy storage: beyond 168 hours (For example, technologies that can store energy for use in a later “season” such as from summer to winter.)

In this Plan’s technology selection and evaluation, we explored “multi-day duration.” However, existing and proven technologies do not meet the 48-hour minimum.

- Compressed Air Energy Storage has a proven duration of 3-24 hours.
- Flow batteries have a proven duration of 2-12 hours.
- Lithium-ion batteries have a proven duration of 0.5-8 hours.
- Molten salt thermal storage has a proven duration of 6-7 hours.
- Pumped hydro storage has a proven duration of 6-24 hours.

Black & Veatch concluded that, while short-duration energy storage is a well-established equipment supply area, multi-day LDES is not. The largest gap for these technologies is the successful integration and sub-sequence control of the minimally required demonstration prototype that’s capable of being scaled up. At this time, the development of these technologies is not assured and there are questions about their performance in extreme weather conditions. Therefore, they were not included as a specified element in our plan. With additional research, development and commercialization, these emerging technologies may be feasible for inclusion in our resource portfolio by 2030. We must also allow for flexibility in the implementation of our plan to allow for breakthroughs in these and other viable technologies before 2030.

Evaluation of refueling with zero-carbon fuels

We also considered augmenting, or fully replacing, fuels with renewable fuels. There is a wide-range of fuel options and levels available. Given the nature of this Plan, we did not attempt to model every permutation of the resources. We did however, set some benchmarks for additional analyses based on our evaluation of the most promising fuel sources. We considered the viability, availability and cost of the options and the technical feasibility of using each fuel at our power plants, including the need to switch out generation equipment.

Renewable hydrogen

Hydrogen is one of the most abundant elements in the universe and can be found in the fuels we use as well as our air and water, making it an attractive resource option. Hydrogen can be used as a fuel source either through direct combustion or non-combustion technologies. For the Plan, we considered using renewable hydrogen at our existing power plants or building new facilities. Our evaluation included an assessment of the hydrogen in natural gas blending limits at each site as well as the technical performance, cost considerations and the market availability of renewable hydrogen. We did not consider options to blend hydrogen with fossil natural gas as these are carbon *reduction* strategies and would not *eliminate* our GHG emissions.

Hydrogen use

With IEC Corporation, we began by analyzing the current technology configurations and turbines at our existing power plants. Unfortunately, the turbines available today cannot burn 100% hydrogen. We also explored using hydrogen as a fuel supplement, where hydrogen is co-fired with natural gas or RNG. Some of our turbine models can currently use a fuel blend of up to 50% hydrogen.

We're proactively reaching out to others in the industry to assess their efforts in advancing hydrogen technology and seeking opportunities to potentially partner on hydrogen demonstration projects. Some of the turbine manufacturers, such as General Electric, Siemens and others are studying the future potential of direct hydrogen combustion within their turbines. We'll stay active in this space to ensure that any technology developments that make this option feasible by 2030 are considered and will updates our plan as needed.

Market availability, storage and transport

The most promising process for renewable hydrogen is electrolysis, which is the process of splitting water into hydrogen and oxygen using electricity. Most hydrogen today is produced by a steam methane reforming process using fossil natural gas. RNG may also be used, but the costs and technical challenges will be compounded with that fuel option.

Electrolysis produces a zero carbon fuel when the electricity used for the process is renewable or zero carbon. Excess solar may be the ideal candidate for hydrogen production, resulting in hydrogen stored for later use.

Currently, the hydrogen fuel market is highly dependent on a small number of distribution facilities. In 2019, a Northern California plant was down for several months, reducing the available supply by nearly half for the San Francisco Bay and Sacramento regions.[52] This challenge may also be an opportunity to explore partnerships or joint ventures for local development of a hydrogen infrastructure. Currently, large-scale renewable hydrogen production is not available in our region. As such, the fuel would need to be either shipped via trucks or freight trains. The amount of hydrogen required would also require semi-constant deliveries of the fuel to each affected power plant.

Since hydrogen is the lightest element, it can be challenging to store large quantities because of the need for higher pressures or lower temperatures than natural gas. Intermediate storage of hydrogen could also become a blight on neighboring communities. Cosumnes, as a remote site, could host a possible pilot hydrogen production facility and storage tanks. Some storage options for hydrogen are described below.

> **Compressed hydrogen storage** is the most common method used by industrial hydrogen consumers. Depending on the amount of hydrogen being stored, pressures can range from 2,000 to 10,000 psia (pounds per square inch absolute) with the high end of this range more suitable for small cylinders used in transportation rather than large bulk tanks.

[52] California Energy Commission staff. 2020. Final 2019 Integrated Energy Policy Report. California Energy Commission. Publication Number: CEC-100-2019-001-CMF. Page 99.

Hydrogen liquefaction may be a feasible option, depending on the amount of hydrogen storage needed. Storing hydrogen in this fashion requires energy, more complicated auxiliary equipment, and extremely cold temperatures (i.e. -423°F) need to be maintained. The storage volumes for liquefied hydrogen would be much smaller than that for compressed storage and depending on the scale of storage required, therefore liquefaction can still be more economical than compressed hydrogen storage, particularly at large scales. An additional consideration with the liquefaction equipment is the thermal cycling and ramp time. Cycling from ambient to the extremely low temperature thermally stresses the equipment.

Geophysical hydrogen storage takes advantage of existing geological formations such as salt caverns, rock caverns, and depleted gas fields. These formations are an opportunity to store large volumes of hydrogen. Conceptually, hydrogen is compressed and stored in an existing geological formation and then withdrawn for later use. The details of this concept are extremely site specific and would require extensive geological study to locate an appropriate site.

Pipeline hydrogen storage may also be feasible as pipelines are the most cost-efficient way to transport large quantities of hydrogen over long distances. There are currently approximately 1,600 miles of hydrogen pipelines installed in the U.S., primarily in the Gulf Coast region, which are predominantly operated by major industrial gas companies. Hydrogen pipelines are considered mature technologies and can typically cost up to 10% more than a traditional natural gas transmission pipeline. Hydrogen will tend to permeate through metal over time, resulting in gas loss and pipeline embrittlement.

Potential role in SMUD's future portfolio

We found that while hydrogen production and storage is technically feasible using commercially available technology, renewable hydrogen has many challenges and definitive use before 2030 cannot be assured. The Black & Veatch study also found that blending 50% renewable hydrogen with 50% natural gas would yield only a 20% reduction in GHG emissions. This is due to the combustion characteristics of hydrogen where molecules are too small and flame speed is too high to properly consume all fuel within the turbine. Similarly, NOx emissions from our turbines would also increase requiring additional emission controls and mitigation.

While this strategy is valid to reduce our carbon emissions, it will not get us to zero by 2030 on its own. We believe that this is an option to keep in consideration for possible use with RNG. For our 2030 Zero Carbon Plan, renewable hydrogen should be considered an emerging fuel, with the potential option of utilizing one of our thermal power plants as a demonstration site. In the long-term, our Cosumnes Power Plant may be a reasonable site to consider fully replacing with hydrogen production coupled with a combustion power plant.

RNG: Biogas and biomethane options

Of particular interest, RNG can be used as direct replacement for the fossil natural gas we currently use. Although RNG is relatively common, the production of these fuels is generally much more expensive and less accessible than fossil fuels. There are regional sources of biogas and it can also be sourced from landfills and municipal wastewater treatment plants,

which can be refined into RNG. As part of our studies, we evaluated the current production levels and the resource potential for future local production.

RNG is a term used to describe biogas that has been conditioned and purified to become pipeline quality to replace fossil natural gas. RNG can be produced via biochemical means like anaerobic digestion of dairy wastes, food wastes, wastewater, landfill wastes and other organic wastes. RNG can also be produced thermochemically via gasification (partial combustion) and methanation processes. Natural gas in the interstate pipeline system is generally 85% to 95% methane, the predominant energy carrying molecule in natural gas. Raw biogas typically has a methane content between 45% and 65% and must go through a series of refining steps to replace natural gas. Refinement includes removing moisture, carbon dioxide and trace-level contaminants and other impurities. Once purified, the gas can be injected into a natural gas pipeline or used as a substitute for fossil natural gas.[53] We currently have a long-term contract to buy RNG.

Black & Veatch found that the most accessible local sources of biogas resources are from landfills and wastewater treatment plants in the broader Sacramento region. Their assessment found that while the local supply is too limited to replace the *full* fuel use of our power plants, we identified opportunities to develop an additional supply of local biogas that could be used at our power plants. Further study is needed to quantify the gas potential available, assess the viability and develop these resources.

RNG: Emerging solid-fuel biomass conversion opportunities

The conversion of woody biomass to biogas via thermochemical conversion technologies is an emerging energy conversion pathway to produce RNG. We expect that biogas production could act as an energy supply and a viable disposal option of wood waste from forest thinning or wildfire mitigation projects, like in our UARP transmission corridor. Although the economic viability and total resource availability of this option is currently uncertain and complex due to inherent nature of catastrophic wildfires, the availability and pricing of woody biomass from wildfire thinning activities could improve over the next 10 years. With new wildfire management initiatives in California, Black & Veatch expects the amount of wood fuel available in the broader Sacramento region, when compared to the supply of sustainable forest-based wood estimates in prior studies, to increase significantly. This biomass is anticipated to be partly used by existing biomass power plants competing for this resource. There are three biomass power plants in the Sacramento region that are strong candidates for use of this “high hazard zone” woody biomass to meet contract opportunities.

Renewable diesel

We studied the technological specification of our existing power plants and found that most of our turbines are already capable of firing “#2 Fuel Oil,” which is essentially diesel fuel. Following air quality permitting and licensing approvals, our power plants would then need minor physical modifications to allow them to burn renewable diesel.

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[53] For more background information on sources for RNG, see: An Overview of Renewable Natural Gas from Biogas. U.S. EPA, July 2020. EPA 456-R-20-001. https://www.epa.gov/sites/production/files/2020-07/documents/lmop_rng_document.pdf. Last accessed 2-9-2021.

Renewable diesel is fuel that is made from plant oils and animal fats. Renewable diesel is currently being developed commercially for some truck transport applications. IEC Corporation and SMUD staff have reached out to several renewable diesel producers to gauge the feasibility of this approach. We were not able to identify sufficient supply at an affordable cost for power generation. This option will continue to be evaluated in the future as the production technologies mature and additional supply is available in the market.

Reimagining the operations of our thermal fleet option

Our analyses repeatedly show that the most expensive hours to deliver energy are during our peak hours and during low solar and wind production periods. These periods are generally constrained to a few hundred hours a year. Additionally, high-level analyses indicate that most large electricity systems can support up to 80% to 90% proven clean technologies if existing gas resources are left online.[54] Within this option, we consider reimagining operations at our thermal power plants such that we do not emit GHGs.

Carbon capture and sequestration

One option for eliminating carbon reduction at our thermal power plants is to capture the carbon before it's released into the atmosphere. The main post-combustion carbon dioxide separation techniques and technologies considered include amine-based chemical absorption, solid sorbents and membranes. Although solid sorbents and membrane technologies hold great potential and are promising for the future, the team found that post-combustion capture technique based on chemical absorption using amine-based absorbents is the most proven technology and commercially available at this time to effectively remove carbon dioxide from flue gas emissions.

Black & Veatch found that carbon capture technology could be integrated into our system. However, there are challenges including cost, implementation and viable storage options. The carbon capture technology alone will require a substantial capital commitment of over $800 million for our Cosumnes Power Plant. However, the technology could reduce our carbon dioxide emissions by over 90%, and coupling it with renewable fuels, could help us realize carbon free operation. Although capturing our thermal GHG emissions is technically possible, we must consider this option holistically. This option will require locating permanent geological storage and a commitment to long-term debt that ties us to natural gas.

We're currently evaluating NET Power's power plant design, which have no stacks. Instead, they use the Allam-Fetvedt Cycle.[55] These plants burn fossil fuel with oxygen instead of air to generate electricity without emitting any carbon dioxide or NOx, the main atmospheric and health contaminant emitted from gas plants. This is a new, high-pressure, oxy-fuel, supercritical carbon dioxide cycle that generates low-cost electricity from fossil fuels while producing near-zero air emissions. All carbon dioxide that is generated by the cycle is produced as a high-pressure, pipeline-ready by-product for use in industrial processes, or that can be sequestered

[54] California Energy Commission. *SB 100 Joint Agency Report: Charting a path to a 100% Clean Energy Future.* March 2021. Available online: https://efiling.energy.ca.gov/EFiling/GetFile.aspx?tn=237167&DocumentContentId=70349. Last accessed: 16 March 2021.
[55] https://netpower.com/technology/. Last accessed 23 March 2021.

underground in tight geologic formations. The challenge of determining how to dispose of the carbon is unsolved.

The technologies we studied do capture carbon dioxide, but for this technology to be zero carbon, we must find approaches to sequester the carbon such as long-term geological storage where carbon is stored in permanent geologic formations, for instance, a deep saline reservoir. There is a growing body of research regarding sequestration in the greater Sacramento area. Industry research has found that there is space in California to store carbon dioxide underground safely and permanently.[56] Thinking about SMUD assets, one study from Lawrence Livermore National Laboratory found a potential carbon dioxide sink just over 16 miles away from our Cosumnes Power Plant. This sink is near a saline aquifer in the Sacramento Basin, one of California's larger marine basis with potential sequestration opportunities.[57] As our 2030 Zero Carbon Plan continues to evolve, we'll seek opportunities to partner with industry to further explore carbon capture and sequestration potential in the greater Sacramento area.

Retooling and RNG

As we studied the options, interestingly and somewhat counter intuitively, it became obvious that the very things that made most of our power plants so efficient was limiting their ability to integrate into our zero carbon future. Due to start up and shut down restrictions and steam host obligations, many of our plants are held online even during the most expensive hours to deliver energy or during high-solar and wind production periods. With that in mind, we reimagined our thermal fleet operations to be as flexible as possible, generating power when needed for shorter durations and thus significantly reducing GHG emissions. This option was shown to be the most viable way forward and was studied in depth.

As previously discussed, the heat recovery systems make these plants efficient and valuable resources, but these systems can also be damaged if cycled too quickly. Disconnecting our power plants from their heat recovery systems will make them less efficient, but it'll also make them incredibly flexible, able to be turned on and off quickly and able to sit idle for long-periods of time. In this configuration, batteries can also be added to the peaking plants making the gas turbine appear to be online without burning any fuel. Understanding that solar and wind energy resources need flexible power plants that respond in seconds, it seems to follow that making these plants more flexible would allow for greater adoption of proven clean technologies. One tool to achieve this is to retool our thermals to make them as flexible as possible.

When we look through our past studies, we find that the periods we most need our thermals are usually constrained to a few hundred hours a year. This may make it possible to leverage our existing RNG contracts to fuel our gas plants. We currently have a long-term agreement in place for RNG at a maximum limit of 12,800 dekatherms (dth) per day. This gas is currently nominated/delivered to the Cosumnes Power Plant for RPS credit. Foregoing RPS credit, we can renominate this gas to any of our power plants. In this case, we're using RNG that is produced to pipeline specifications and delivered via intrastate pipeline and is a drop-in replacement that all our existing power plants can use without modification. The next challenge

[56] https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2020/July/1-Dr-George-Peridas--Achieving-Carbon-Neutrality-in-California.ashx
[57] https://www.westcarb.org/pdfs/geologic_co2_sequestration%20_potential_hq.pdf

is that RNG, including our current agreements, is injected into the pipeline as soon as it is produced. For this option to work, we need to store the gas until it's needed.

We currently have contracts with two natural gas storage fields capable of storing 2 million dth of natural gas. These contracts are set to expire within the next couple of years. Our daily burn averages approximately 110,000 dth per day. Between both storage contracts, we're able to withdraw up to a maximum of 40,000 dth per day. Our storage arrangements allow us to balance supply and demand during operational challenges as well as help mitigate financial risks from periods of extreme price fluctuation. A large part of our storage capacity is set aside to support running our plants during event where natural gas becomes scarce. This, and other storage options, may be useful as we consider relying less on natural gas.

Operationally this would mean managing our thermal units like our hydroelectric system. We manage our hydro system to ensure that we meet minimum flow requirements for fish and recreation. Additionally, we must manage our water releases to ensure we have adequate water for generation during the late summer and early fall, before reservoirs are refilled. In essence, we manage a limited fuel source for maximum benefit to our system. For our RNG, we'd need to adopt a similar strategy where we store our gas in offsite storage fields and only use this gas when we need it.

As briefly mentioned above, General Electric has developed a battery designed to augment the operations of their engines and intended to reduce the need to turn on the power plant during short duration peak energy needs. These batteries would increase the flexibility and operability of our power plants, reduce our need for spinning reserves, and most importantly, reduce the need for RNG.

Our thermal transition plan

Following the studies, we prepared the following strategy to transition our natural gas generators to flexible renewable peaking plants. We've drawn on many different studies and data for this Plan and note that other options may prove more viable in the future. As we move to implementation, we'll need to remain flexible and open to new ideas and strategies. The following recommended natural gas generation repurposing strategy, coupled with the proven clean technologies and new technologies and business models strategies, will help us achieve our 2030 Zero Carbon Plan.

Preliminary analysis shows that McClellan and Campbell plants could be retired in 2024 and 2025, respectively. Prior to committing to retirement, we'll perform a detailed reliability assessment in 2021. Carson Ice and Procter & Gamble will be converted to simple cycle peaking plants in 2027 and 2029, respectively, and considering steam host obligations and staggering the time between retooling efforts. Cosumnes, while the most efficient and largest of the thermal plants, is not as nimble. Currently, we plan to keep Cosumnes as a combined cycle plant and locate additional sources of RNG to buy and store. Our reimagined power plants in 2030 are shown in Table 9.

Table 9. SMUD thermal power plant overview in 2030

Power Plant	Generator Type	Unit	Capacity (MW)	Fuel Source
Sacramento Power Authority at Campbell Soup	**Retired***			
McClellan Gas Turbine	**Retired***			
Central Valley Financing Authority at Carson Ice	Combustion Turbine	1	50	Biofuels and TBD**
	Steam Turbine	2	**Retired**	
	Combustion Turbine	3	50	Biofuels and TBD**
Sacramento Cogeneration Authority at Procter & Gamble	Combustion Turbine	1	50	Biofuels and TBD**
	Steam Turbine	2	**Retired**	
	Combustion Turbine	3	50	Biofuels and TBD**
	Simple Cycle Peaking	4	50	Biofuels and TBD**
SMUD Financing Authority at the Cosumnes Power Plant	Steam Turbine	1	207	Waste Heat
	Combustion Turbine	2	207	Biofuels and TBD**
	Combustion Turbine	3	207	Biofuels and TBD**

**Pending reliability assessment.*
***Final 2030 fuel mix is to be determined. Dependent on options available and may include one or more of the following: hydrogen, biogas, RNG, biofuels.*

Planning for a possible retirement

Ultimately, we may choose to refuel some plants, retire others, or retool them all. As we transition toward our zero carbon goal, we'll carefully evaluate all possible options and will retire units only when we can do so reliably. Before making any decisions, thorough analysis and thoughtful planning will be needed with robust testing and additional studies completed. We may also consider cases where the solution or replacement generator is operated in parallel until we have confidence that the replacement system is reliable. When we commit to retire a power plant, we may opt to have the plant remain in place unused until the replacement generator demonstrates reliability over several years before deciding to fully decommission the plant.

Researching grid-scale solutions

As part of our analysis, we identified several tools that we can use as part of our 2030 Zero Carbon Plan. These include retirement, refueling and reimagining as well as new technologies such as alternative biofuels, long duration storage, renewable hydrogen and carbon capture. As we implement this plan, we may find that the tool we employ for one thermal asset may not be the right tool for another. We'll focus on place-based strategies and work with our communities where these assets are located to design solutions that ensures Sacramento communities are livable, resilient, and ready to embrace a low carbon future.

While retiring and retooling our gas plants will drastically reduce emissions, the use of natural gas will not be completely eliminated unless we identify sufficient amounts of renewable fuels or develop alternative generation sources. Initial studies indicate about half of our fuel needs after retooling can be met with RNG that we already have under contract. Additional fuel sources or

technical advancements are necessary to close the remaining gap and fully eliminate the use of natural gas. We're looking at several options to address this:

- Biofuels and other clean fuels, including RNG, green hydrogen, biodiesel and ethanol.
- Long duration storage which could include technologies such as flow batteries, thermal storage and liquid air energy storage.
- Carbon capture and storage, including the Allam-Fetvedt cycle to assess the feasibility of this and similar technologies in the Sacramento region.
- Pumped storage hydro using our existing UARP dams and hydroelectric facilities.

This research and the ability to secure sufficient volumes of biofuels will allow us to scale up the most promising technologies. We'll continue to evaluate and seek innovative options as new technologies emerge.

As we approach 2030, it'll be important that we remain nimble and ready to integrate these new technology models as they become available ready over the next decade.

Proven clean technologies strategy

Proven clean technologies

- This strategy, when implemented with the natural gas generation repurposing strategy, will reduce our emissions by at least 90% of 2020 levels by 2030.
  - We'll exceed the State 60% RPS target by 30%.
- Continue aggressive customer DER programs.
  - Demand response and flexible load
  - Rooftop solar
  - Customer batteries
  - Transportation electrification
  - Building electrification
  - Energy efficiency
- Develop a robust portfolio of local and regional utility-scale renewables and batteries to complement our thermal retooling plan.
  - Local utility-scale solar 1,100 to 1,500 MW
  - Local 4-hour batteries 700 to 1,100 MW
  - Regional wind 300 to 500 MW
  - Regional geothermal 100 to 200 MW
  - Regional solar 100 MW

As our next strategy, we explored the landscape of proven clean technologies. These are additional zero carbon emission resources that can be developed by 2030 using proven, commercially available technologies. Our 2030 Zero Carbon Plan will rely heavily on proven clean technologies, such as solar and wind.

As we continue to rely more on resources whose output are dependent on weather conditions, there will be increases in variability and uncertainty related to available supply. This will require us to carry more reserves or backup resources to maintain the same level of reliability.

This challenge exists when we have either too much or not enough supply. For example, we must account for how much our solar and wind generation could vary from forecasts within the hour, and ensure that we're carrying enough supply that has the flexibility to increase to meet shortfalls and decrease in order to accommodate excess generation at any given time.

Although these challenges cannot be solved with today's available technology, some of the things that can help alleviate them include:

1) **Diversification of resources**: To avoid over-reliance on any one fuel source, it'll be important to build our portfolio of resources from different technologies. Together, resources from various technologies and geographic locations can complement each other and mitigate some of the weather, timing and over/under-supply risks. To accomplish this, we must continue to research and explore the different resource types and be thoughtful about how we formulate our supply portfolio.
2) **Evolution of energy markets**: Depending on how energy markets continue to evolve, they may be an important to helping us meet carbon reduction goals. Grid

regionalization could accelerate expansion of planning and operations over a larger footprint, which would enhance the grid's ability to efficiently match supply and demand and reduce curtailment of renewable energy. Some of these benefits can be seen in market re-designs such as the Energy Imbalance Market and potentially in initiatives like Enhanced Day Ahead Market. It'll be important for us to monitor these changes and act to influence them accordingly.

3) **Demand side management**: Historically, supply has been responsible for chasing demand and it is our responsibility at SMUD to ensure that this balance is maintained continuously. As the cost to maintain the same level of reliability increases as the proportion of variable and intermittent resources rise, it may make more sense for customers to have a more proactive choice in how this balance is maintained and how costs are allocated. This means understanding customer preferences and staying engaged with our customers will be critical.

The resource build expands SMUD's current resource portfolio and achieves all current environmental commitments and internal directions. The following resources were considered as additions to our portfolio by 2030.

- **Short-term reliability resources**: Short-term market contracts for capacity are generally from gas generators. However, by 2030, batteries may be a market option.
- **Energy storage:** Short duration (4 hours or less) energy storage batteries and pumped hydro.
- **Non-local renewable resources**: Renewable resources outside of SMUD's territory (solar, onshore wind, offshore wind, biogas/biomass and geothermal).
- **Local renewable resources**: Renewable resources inside of SMUD's territory, limited by resource availability (solar and biogas/biomass).

Our proven clean technology scenarios were layered onto the thermal transition options, exploring the limitations of the technologies over the full range of available technologies. Below is a more technical discussion of our findings and includes detailed information on our proven clean technology strategy, information on why we considered prospective technologies, as well as specific information on the technology considered as part of our 2030 portfolio and some potential locations.

Capabilities of today's proven clean technologies

Achieving our ambitious carbon reduction goals without sacrificing reliability and affordability will be challenging. We need to understand how far these technologies can get us. In this section, we highlight the status of mature zero emission technologies available today and comparatively analyze how far these technologies have come since our 2040 Clean Energy Plan.

Our natural gas generators have characteristics that provide valuable energy and reliability services to our power grid. For many of our customers, our natural gas plants are synonymous with energy delivery, but our gas plants do more to keep the lights on than deliver electricity. They're also dispatchable by power system operators and associated real-time control systems to provide grid reliability services. Our gas resource, coupled with our robust hydroelectric system, is why we've been able to deliver energy to our customers at some of the lowest rates in the state with a strong reliability record.

Transitioning to zero carbon emission does not change the need for a reliable grid (see the section on Our commitment to reliable service). As we reimagine our energy system, we must also consider how to replace non-energy products provided by the gas plants such as, capacity, voltage support and reactive power. While there is a wide variety of clean resources, solar and wind are the most economic and abundant resources in California today. However, these resources are highly dependent on the weather. On most days, we can be reasonably confident they'll produce at least some energy, but sometimes thick fog, cloud cover, too little or too much wind or smoke and ash from wildfires unexpectedly reduce energy production. Additionally, generation from these resources do not *precisely* match the timing and shaping of our customer's demand for electricity.

Knowing that there are times when we cannot count on solar and wind like we do our traditional generation resources creates uncertainty. This uncertainty and the underlying intermittency make it difficult to balance our energy supply with demand. The strategies to address these limitations are limited by available technologies. Proven technologies currently require that we build more resources than we need, make sure there is sufficient supply, use energy storage to shift the energy to other times or some combination there between.

Thinking about the average household, most of their electricity use is in the morning when we are getting ready for work and kids ready for school, and in the early evening when we've finished work, are cooking dinner and heating or cooling the house. But in the early morning hours and evening, the sun is low on the horizon or completely set. Also, there are many occasions when the wind isn't blowing during these times. Currently, we fill these "gaps" when solar and wind aren't available with traditional generation resources (such as our gas plants or hydroelectric resources), but as we move toward zero carbon, we'll need to have other options.

Resources included as proven clean technology

The following are the known proven clean technologies. Not all of these technologies are currently accessible due to limitations on development, cost and geographic considerations. With each section, we discuss the technology and the ability of these resources for our plan. The resource potential, or the amount of developable resource, was estimated using SMUD's internal expertise and consultation with Black & Veatch and E3.

Black & Veatch performed a variety of resource assessments, primarily focused on specific geographical areas. E3's analyses were informed by the 2019-2020 CPUC IRP process, and more specifically, the adopted Reference System Plan. Assumptions for the first available year of candidate renewables resource types in the 2019-2020 IRP cycle reflect feasible timelines for bringing resources online based on the current interconnection queue and typical development timelines.

The CPUC IRP assumptions on the technical potential of candidate renewable resources were based on data developed by Black & Veatch for the CPUC's RPS Calculator v.6.3.[58] The Black

[58] Black & Veatch, *RPS Calculator V6.3 Data Updates*. Available at: http://www.cpuc.ca.gov/uploadedFiles/CPUC_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electric_Power_Procurement_and_Generation/LTPP/RPSCalc_CostPotentialUpdate_2016.pdf. Note that although the data was developed with the intention of incorporating it into a new version of the RPS Calculator, no version 6.3 was

& Veatch study includes an assessment of potentially viable sites and resource potential within those sites to determine an overall technical potential for each renewable technology. The Black & Veatch study uses geospatial analysis to identify potential sites for renewable development in California and throughout the Western Interconnection. Table 10 summarizes the potentials by region, which in some cases may change depending on new transmission, resource preference, or our assumed willingness to pay more for new resources.

Table 10. Summary of proven clean technology resource potential ranges (MW)

Resource	Location	Potential (MW)
Hydro	N/A	0
Biomass	Sacramento and surrounding	270-900
Solar PV	Sacramento	1,500-3,764
	Southern CA	22,800
	Northern CA	1,900
Onshore Wind	Sacramento	0
	California	468
	Out-of-state	1,054-1,554
Off-shore Wind	California	1,600
Geothermal	California	41-92
	Out-of-state	183
Storage – Battery	Sacramento	Not limited
	California	

Hydro

SMUD's existing hydro resources will be an integral part of the zero carbon plan as carbon free and flexible assets that are capable of mitigating some intermittency from solar and wind. Although hydro will continue to be a vital part of our system, we did not include new resource potential in this Plan. In our experience, new hydro resources, including pumped hydro, are not likely to be built in California due to the cost, permitting challenges and environmental concerns. We also see a broader trend to reduce the number of existing dams. However, we'll continue to study options to increase efficiencies and the capabilities of our hydro resources as well as procure new small hydro projects as appropriate.

Solar photovoltaics

Solar energy has the largest potential for resource development in California and into the southwest U.S. Solar is the lowest cost proven clean technology available and has potential for local development. Advances in battery technologies make co-locating solar with battery storage a cost-effective option for most projects.

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developed. This is because the IRP system plan development process replaced the function previously served by the RPS Calculator.

Through years of development efforts and feasibility studies, we've identified local areas best suited for solar development considering available land, environmental impacts, transmission access and system reliability. Within Sacramento, we estimate nearly 1,500 MW of utility scale solar could be developed with little or no major system upgrades and environmental impacts. Up to 3,764 MW of solar development may be developed locally, at higher cost. More studies are needed to assess the precision of this added cost, including land-use concerns, transmission and electricity system studies.

We also considered the procurement of solar energy resources from other balancing authority areas, including the CAISO. Given the large resource potential available in Southern California, additional out-of-state resources were not considered in this study. E3 assumed we could access to 5% of the CA statewide development potential for solar, yielding access to 22,800 MW of solar in Southern California and 1,900 MW of solar in Northern California, not including SMUD's service territory.

Rooftop solar was also considered as a proven clean technology. Capital costs to build or install these resources exceed three times the price of utility solar. Additionally, SMUD's energy purchase costs for rooftop solar are much greater that the power purchase price of utility-scale solar. In many cases, utility-scale solar can take advantage of scaling for labor and material costs, resulting in a unit cost of nearly $1 per watt (direct current). However, in most residential applications, this cost can exceed $3 per watt (direct current).[59] In addition, utility-scale projects can be oriented to maximize production, whereas rooftop systems are generally limited to the orientation of the house and roof. For example, a 50 MW utility scale PV project could power 15,000 homes, whereas the equivalent rooftop system would only power about 9,500 homes.

Onshore wind

Wind was once the commercially dominant renewable resource in California. However, wind development in California has slowed to a trickle as many prime wind resource areas have already been developed, have new transmission needs or, increasingly, state or local prohibitions are restricting new development. There are no viable locations for wind development within SMUD's service territory.

Solano wind resource area

Typically, during the summer, our Solano area wind resources produce generation that is complementary to our solar generation. As the sun is setting in July, most evenings the Delta Breeze comes through the region, increasing wind generation. As such, our Solano wind resources are especially valuable to SMUD. These resources have the potential to be fully delivered to our service territory and studies on repowering showed the new larger turbines have a complementary shape to our solar resources. Even though delivery of Solano wind resources to SMUD's territory has not been fully studied as part of this analysis, this potential will be a great option for our zero carbon future.

Black & Veatch reviewed the potential of fully repowering all turbines within Solano County, California. Solano County has been heavily developed with wind for several years. Many turbines are of sufficient age to be worth repowering given advances in technology. Black &

[59] https://eta-publications.lbl.gov/sites/default/files/tracking_the_sun_2019_report.pdf

Veatch reviewed existing wind project locations across the county. Sites already developed were assumed to be available for repower. They concluded that repowering and replacing older operating projects in the region could increase energy production in the region with fewer turbines.

California wind resource potential

E3 assumed we could access nearly 10% of the remaining wind resource potential throughout California, in addition to the wind potential identified in Solano, as estimated for the latest CPUC IRP modeling effort. This results in the potential for an additional 468 MW of wind, located within the CAISO.

Out-of-state wind potential

There is vast untapped wind potential in Wyoming and New Mexico. However, much of this potential remains undeveloped due to a lack of existing transmission. E3 assumed we could gain access for up to 1,000 MW of wind in those regions, provided we would be willing to develop new transmission.

Additionally, there is still undeveloped wind potential in Oregon, southern Washington and parts of Idaho. E3 assumed we could access 5% of the remaining potential, as identified in the latest CPUC IRP proceeding. This results in the potential for 554 MW of wind resources.

Offshore wind

The wind potential off the Pacific coast is an untapped and valuable resource. The depth of the sea floor makes developing these resources challenging, which would necessitate floating applications. Many of these areas lack adequate transmission. Despite these challenges, offshore wind is expected to be a viable future resource. Black & Veatch studied offshore wind development off of Humboldt Bay and identified the potential for 1,600 MW of developable wind with the earliest operational year estimated to be 2030. Black & Veatch studied two options, one with new transmission to deliver power to SMUD (a higher cost option) and the other relying on CAISO transmission to access the power.

Geothermal

Geothermal is a baseload resource operating at an 80% to 90% capacity factor. 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. E3 estimated that we could have access to 10% of California's potential as calculated for the CPUC IRP, or 364 MW. Known locations with geothermal potential include Salton Sea, areas of Nevada and the Wilbur Hot Springs area. The geothermal resources in our 2030 Zero Carbon Plan include existing and new projects located in Northern and Southern California and Nevada. Black & Veatch's assessment indicated there is up to 50 MW of developable locations in Northern California, at higher cost than the resources identified by E3.

Biomass, RNG and biogas

Biomass resources within Sacramento County and the other 15 surrounding counties could generate 270 MW to 900 MW, with the high end of this range costing more because it will cost more to collect and deliver that biomass to a power plant. Black & Veatch identified several

challenges limiting the long-term viability of biomass resources. These include lack of long-term feedstock supply contracts for woody biomass resources, opposition from environmental groups regarding existing biomass power plants and competition and pricing of biomass supplies in the Sacramento region. Despite some of these issues and challenges, significant progress has been made in evaluating and documenting carbon intensity issues and benefits for a variety of high-moisture waste biomass feedstocks, particularly in the case of animal manure such as dairy manure.

Research and development activities focused on lowering the cost of biogas upgrading equipment, biomass gasification and synthesis gas cleaning/methanation equipment are needed to make RNG costs competitive with fossil-based natural gas. These focus areas may provide some opportunities for SMUD to obtain research funding.

RNG derived from landfills and wastewater treatment plants appears to be economically feasible for use at our thermal power plants. Black & Veatch estimated that the resource potential for this gas is about 270 MW. However, future study will be needed to identify these locations and assess the viability of collecting the gas.

Energy storage

Today's proven energy storage technologies can address many of our short-term balancing needs. These technologies help store energy for later use improving the flexibility and resiliency of our grid. Excess solar power produced on a particularly sunny day could be stored for use later in the evening when the sun isn't shining. Alternatively, energy storage can help less flexible baseload resources respond to changes in demand, by quickly injecting or extracting energy to match supply to demand.

The current limitations of lithium-ion based battery storage include lower duration, initial cost, lack of tax incentives, battery degradation and state of charge limitations. Many of these limitations such as cost, or lack of tax incentives could change in the near future. These limitations may be offset by avoidance of fuels cost exposure, simple maintenance and operations costs from fewer mechanical parts and the ability to arbitrage negative prices in the energy market or reduce curtailment of renewable generation.

For this Plan, we assumed that our potential for current battery storage is effectively unlimited.

Proven clean technologies complement thermal transition

The most economical proven clean technologies are solar and wind, which are variable and weather-dependent. Generally, on their own, these technologies can provide only limited grid reliability services. Repeatedly, our past studies show that reliance on only current proven clean technologies would be very expensive and would not pass basic reliability tests.

Our studies showed the same results. Aside from the cost, there could be physical impacts and blight on our local communities from the development of thousands of MW of local batteries plus thousands of additional MW of solar PV. That's the 8,000+ MW mentioned as part of our earlier Evaluation of thermal power plant retirement section. A 100% proven clean technology option is untenable with today's technologies. That said, our analyses also repeatedly showed that

renewable development costs continue to decline, and in fact, solar PV has declined by more than 30% since we last studied these resource costs as part of our 2040 Clean Energy Plan.

The takeaway is, we need to find a complementary balance of proven clean technologies with the other resource strategies.

With significant reliance upon variable energy resources (VERs), strategies for both periods of abundant and insufficient energy supply will continue to be evaluated and mitigated to ensure sufficient operational flexibility. Part of this analysis will include further enhancements of forecasting technology for VERs as well as the control systems to manage the variability of their power output.

One of our zero carbon solutions will be energy storage. However, while today's storage technology is capable of addressing some of the short-term energy or variability needs, we'll need other solutions to ensure we can maintain reliability. Hydro resources will continue providing support, while being mindful of water supply, as well as environmental and licensing requirements. Continued exploration into the options of LDES will help us identify ways to maintain reliability and reach zero carbon emissions.

Initial reliability assessment

We ensure the long-term ability to serve our customers under all conditions by following federal, state and NERC requirements for reliability and operations. For planning purposes, we plan to have the resource capability to meet load plus a 15% PRM. We conducted a series of studies to evaluate our ability to serve load with only proven clean technologies.

Currently, we rely on 1,380 MW of thermal generation (some imported) to serve load and ensure sufficient capacity reserves are available at all times. We evaluated the impact of removing all thermal generation during the summer peak. Our initial assessment indicated that without SMUD's internal thermal generation, our capability to serve load would be reduced by approximately 1,000 MW (equivalent to peak energy needs of 200,000 homes). In addition, our capability to import power could also be reduced by approximately 200 MW (or 10,000 homes). We also found an opportunity where adding 1,000 MW of proven clean technology at the location of our thermals could increase our load serving and import capability to the current levels, allowing us to continue meeting system demands and ensure reliability and adequacy for our customers. It's important to note that this 1,000 MW must be capable of delivering during summer peak to maintain the load serving capability and import capability required to meet the summer peak demand in year 2030.

Our flexible proven clean technology study informs our plan

Proven clean technologies will be instrumental to achieving our zero carbon goal, especially because energy from solar and wind have become relatively inexpensive. We can easily imagine a world where we can buy enough energy from renewables to meet our load. The challenge is, too much of this energy will come when we do not need it, and conversely, not

enough when we do. The tools identified in this scenario analysis will help up address this challenge.

Energy storage looks like it will be the economic choice to shift this generation around so that, on average, we'll have enough energy. We can also build our portfolio with a variety of proven clean tech resources to take advantage of diversity benefits. For example, solar and wind are complementary with wind ramping up in the early evening as solar drops off. The scenario presented here is one of many plausible ways to achieve our objectives. We'll need to explore the reliability of the resources proposed in this Plan within the context of our plans and objectives for our thermal generators.

Under this study scenario, the portfolio build, in terms of nameplate capacity rating (the maximum instantaneous generation rating) is expected to represent nearly 6,400 MW.

Table 11. Proven clean technology resource selection (nameplate capacity MW by 2030)

Resource	Type	Location	Capacity (MW)
Solar PV	Customer	Sacramento	250-500
	Utility	Sacramento	1,100-1,500
	Utility	CAISO	100
On-Shore Wind	Utility	Solano	90
	Utility	CAISO and PNW	300-500
Off-Shore Wind	Utility	CAISO	-
Biomass/biogas	Utility	Sacramento	-
Geothermal	Utility	CAISO/NV	100-220
Battery Storage 4-hour or less	Customer	Sacramento	50-250
	Utility	Sacramento	700-1,100

Scenario modeling results

Our studies found that thermal retooling has a dramatic positive impact on reliability and costs when compared to similar high-renewable energy scenarios. Without the retooled resources, we were only able to develop a resource portfolio that, on average, serve our retail sales with 80% carbon-free resources and reduce our GHG emissions 25% lower than our SD-9 goal (and adopted IRP) by 2030. When the retooling scenario is included, our zero carbon generation (including RPS-eligible renewables, hydro generation and thermal generation from RNG) is approximately 105% of our retail energy sales. RPS-eligible renewables is 90% of our retail sales, 30% more than the current state mandate is 60% in 2030.

This scenario requires a portfolio that generates more energy than we use, mostly excess solar that can be sold to neighboring utilities or curtailed. Our thermal generation has been reduced to only the hours vitally needed for reliability. Although we're currently assuming that the market will be able to absorb or purchase most of this generation from us, our modeling indicates that by 2030, over 15% of the solar PV generation we need to purchase must be curtailed due to the

lack of available buyers when the solar is generating. If batteries or alternative storage costs decline faster than expected, additional batteries may mitigate the need for curtailment.

To maintain reliability, our existing RNG contracts must be supplemented by other fuels. Assuming we continue using natural gas for this, our carbon footprint under this scenario is reduced by 90% from today's level. In terms of generation, natural gas comprises under 6% of the total generation we procure. In fact, we are expecting to curtail more solar power than is generated by natural gas in 2030. This does not mean that we can use the solar energy with today's proven clean technologies to displace our gas use. However, this does indicate that there are opportunities for new technologies, such as long-duration storage or renewable hydrogen production, that could absorb our excess solar energy and store it until we need it later in the year.

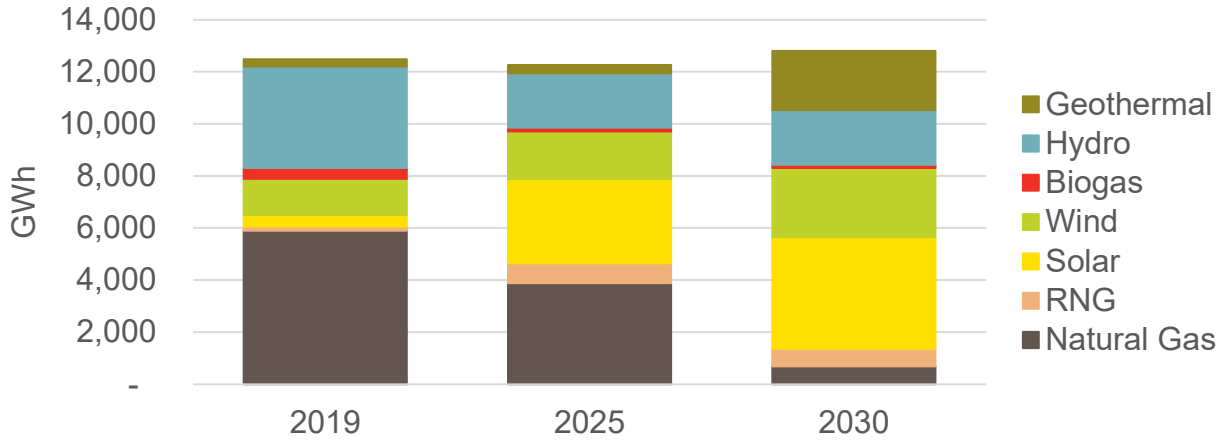
Our reliance on natural gas, compared to 2019, is reduced by nearly 90%. This is the result of retooling of our gas plants, limiting fuel use, and procuring proven clean technologies. In terms of capacity factor (a percentage measure how much a power plant is used), the thermal retooling scenario reduces the average capacity factor from 60% in 2019 to 21% in 2030. Of the 21% capacity factor, 8% is from RNG.

The resource mix that makes up our annual energy use is highly dependent on fluctuations in hydro availability. In 2019, our hydro resources performed above average and we were also able to procure additional zero carbon resources under short-term agreements from the Pacific Northwest. For our 2030 Zero Carbon Plan, we assumed hydro would generate according to average conditions and that we would not have long-term access to short-term agreements from the Pacific Northwest. Future analysis is needed to determine the resource mix needed under low hydro conditions and the impact to renewable curtailment during high hydro years. Additional zero carbon fuels will need to be procured and stored for use during low-hydro years to avoid the need to procure GHG emitting market power.

Figure 9 summarizes the annual generation from the modeling scenario compared to the latest generation data available, 2019. This generation mix includes generation used for retail sales, transmission and distribution losses, and sales to external utilities. This detail is consistent with our hourly carbon accounting methodology, which essentially requires that we eliminate all carbon emissions from our generation mix, whether sold into the market or used locally.

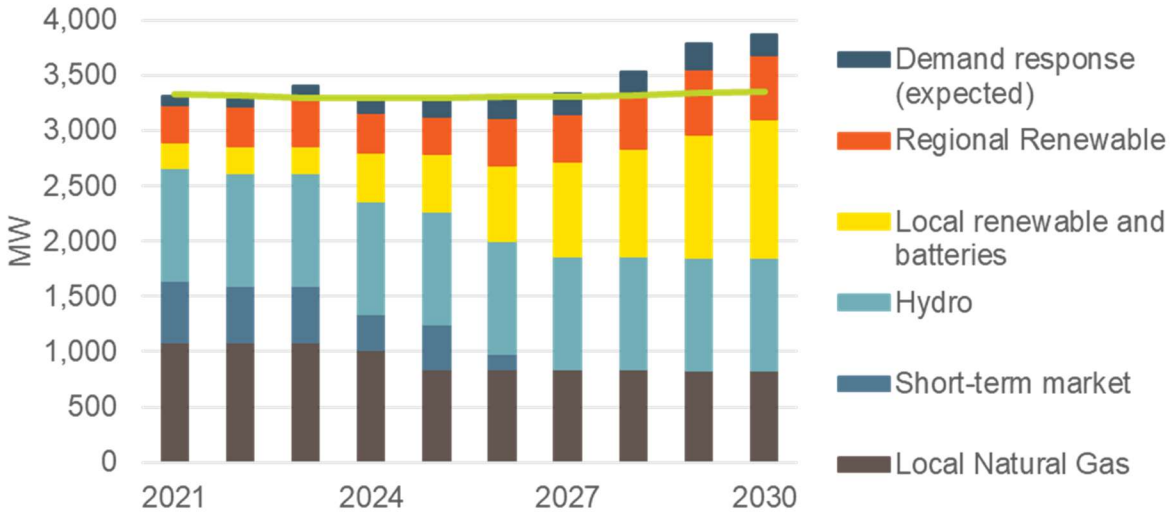
Additionally, this option preserves our power plants in the scenario where our solar is minimum, wind is low and we are in a drought. Even under these conditions, we have an obligation to meet customer electricity needs. If the weather persists, batteries will quickly get depleted and our dams will quickly empty.

Figure 9. Annual generation scenario results compared to actual 2019



The RESOLVE model selected 620 MW of 4-hour duration batteries, for a total of 724 MW of operating batteries in 2030. These batteries, with our flexible thermal and hydro system, will meet most reliability concerns longer than one hour in duration. Figure 10 shows the resource adequacy of the build compared to the PRM. However, intermittent resources, like solar and wind, can vary greatly over a few minutes (or even seconds), something which this model does not solve for.

Figure 10. Resource adequacy and PRM



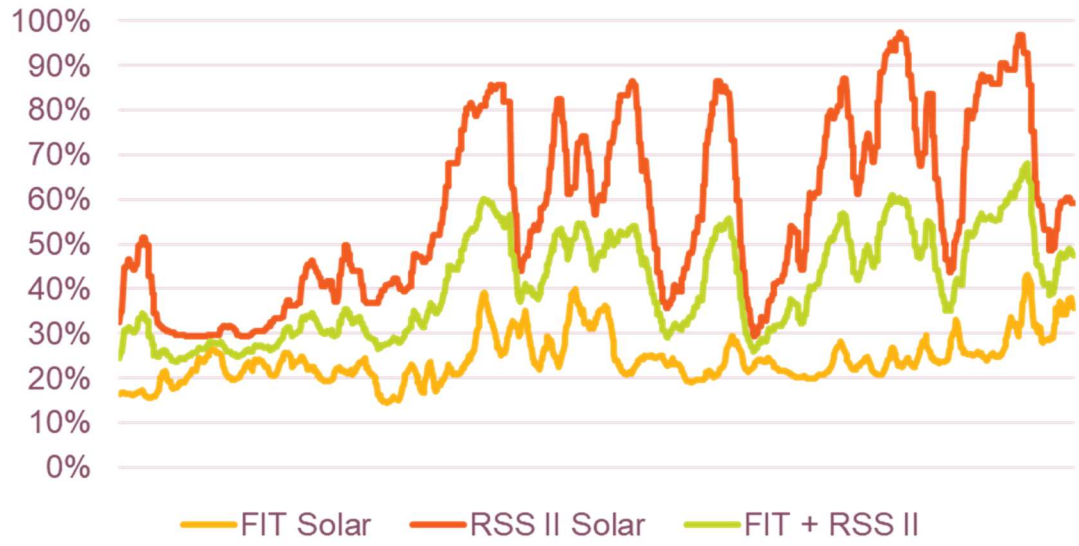
Intra-hour variability

Earlier this year, we began operating our new 160 MW solar power plant at Rancho Seco. This project gave us an opportunity to observe real-time fluctuations on a cloudy day for a large local solar project. Figure 11 shows actual output over a one hour period for our Rancho Seco 2 (RS2) solar project (red line). During this hour, RS2 experienced numerous significant output fluctuations over several minutes with the maximum fluctuation of more than 55%. Each time

this occurs, other power plants must either generate more or less to accommodate these changes. As we build more solar within our service territory, we expect to see this occur more and at a greater magnitude.

To mitigate some of these intra-hour variations, we can ensure that there is enough geographic diversity, meaning projects are not located in close proximity. This allows for a time delay as clouds pass over each array. To demonstrate this, we also plotted our FIT projects, which is comprised of several smaller PV systems with some geographic diversity (yellow line). These projects, FIT with RS2, plotted together (green line), represents a possible scenario for solar in 2030, where there is good geographic diversity among most plants, but we have a couple of large projects grouped together. Under this scenario, we still expect to see regular intra-hour variability of 30% to 40% of the total rated capacity.

Figure 11. RS2 and FIT projects output over one hour[60]



Within our natural gas generation repurposing strategy, we identified the location of 400 MW of 1-hour battery storage. The intent is to further reduce the reliance on thermals for sub-hourly needs, such as the solar variation we expect on cloudy days. This, with the resource build identified by RESOLVE, results in a battery capacity of 1,124 MW by 2040. This capacity is on the low-end of what we expect to need to cover intra-hour variability. We'll need a more detailed analysis of the impacts of solar PV deployment on the larger system and the benefits of geographic diversity.

Takeaway for evolving our Plan

Our transition away from natural gas generation with proven clean technologies is the foundation of our 2030 Zero Carbon Plan. These two strategies alone can eliminate 90% of our GHG emissions, possibly more with the development of new technologies. The final 10% will be

[60] Data represent actual metered output in February 2021 between 10:00-11:00 am

challenging to eliminate and will require leveraging partnerships and collaboration with local government, industry and academia as we explore new technologies and business models. These two strategies cannot meet the 2030 Clean Energy Vision on their own. Combined with advanced DER programs and successes in emerging technologies and business models, SMUD has charted a plausible and flexible pathway to being 100% carbon free.

Takeaway: Our 2030 carbon goal is achievable with flexible strategies and innovations in DERs, fuels and technology.

New technology and business models strategy

New technology and business models

- Identify and scale cost-effective DER solutions.
- Develop tools, programs and partnerships that align customer benefits with grid needs.
- Accelerate DER reliability and grid integration to establish operational confidence in advance of major thermal plant transitions.
- Enable DERs to become a standard grid service solution.
- Develop a customer-partner strategy for Virtual Power Plants (VPP).
- Continue providing support to our low-income customer-households and explore additional programs as our DER and electrification efforts evolve.

In the preceding sections, we shared a flexible strategy for a reimagined and highly flexible thermal fleet allowing for maximum integration of proven clean technologies, based on extensive studies. Using these strategies, we found that today's technologies can reduce about 90% of our carbon emissions while maintaining our commitment to providing reliable service to our customers. Also identified in these strategies are new utility-scale technologies and opportunities to reduce carbon further, addressing the remaining 10% of emissions. We've also found that additional DERs will play a critical role in reducing the remaining carbon emissions, provide capacity, help integrate renewables, lowering implementation costs and engaging our customers as partners in achieving zero carbon for the benefit of our entire region.

In the past DERs has mainly focused on rooftop solar and heating and cooling technologies, but as technology advances, this classification group now includes EVs, water heaters, solar panels with smart inverters, batteries and more. Customers are making significant investments in these technologies to enhance their lifestyles, reduce monthly expenses and reduce their carbon footprint. The opportunity for SMUD, our customers and Sacramento is to align the investments in technology and DERs with grid needs so the benefits of DERs can scale beyond the individual to have a community-level impact.

To help meet our aggressive carbon goals we'll need to embrace new technology options by 2030 in concert with the reimagined thermal fleet and robust proven clean technology buildout. To be successful, this will require large-scale customer adoption of DERs, high customer program engagement and advancement in the visibility and reliability of these technologies as a flexible resource. We simply can't do it alone and will need to establish partnerships to accelerate success. We'll focus on collaboration with local government, industry, academia and others to explore and pilot new technology and business models.

Finally, in considering the implementation of any new technology or business model, we must consider the impact on our communities, including the cost of service, environmental impacts and new clean energy job opportunities. We want our communities and customers to be first in line to realize the local job creation and clean energy benefits from our 2030 Zero Carbon Plan, which is why developing community partnerships is so important to our implementation.

Customer-partner plan and other opportunities with DERs

DERs have benefits beyond generating power or reducing load. They can also empower our customers to take charge of their energy use and join us as partners on our carbon reduction journey. New DERs and technologies give us the opportunity to work directly with customers to maximize the benefits of these devices on SMUD's system.

This strategy is our customer-partner plan, which brings SMUD and our customers together as active participants to study and learn from new technology and proactively reduce carbon.

Customer investment in DERs can create considerable opportunities to support the electrical grid, but most often helping our grid services is not the primary reason customers get DER-related devices. For example, smart thermostat settings can be managed by SMUD to control when energy is consumed from the grid, but customer comfort may be impacted. EV charging can be curtailed by SMUD to minimize grid impacts from coincident EV charging within a community, but the time required to charge the vehicle to full is increased. Accessing the potential of DERs requires balancing customer comfort and choice with economic benefit and reliable performance.

The new technology and business model strategy envisions a suite of solutions that engage with customers at a level they are comfortable with.

- **Electrification and energy efficiency**
  - Ongoing efforts, aligned with the 2018 IRP, to accelerate electrification and energy efficiency. Engagement with all customers to provide a seamless transition into an all-electric future.

Behavioral demand desponse
- Education and behavior based opportunities that empower customers to be informed energy consumers.

Bring your own device (BYOD) VPP
- Solutions that encourage customers to utilize the load flexibility of household devices to provide grid services through aggregation.

Contracted capacity VPP
- Suite of DER program offerings that deliver wholesale and location based system services such as energy, RA and ancillary services with powerplant-equivalent reliability.

Electrification and energy efficiency

One of the foundational elements of our 2030 Zero Carbon Plan is our continued focus on and investments in electrification. Recognizing the paramount importance of equity, we will also continue to prioritize under-resourced communities to help reduce the energy bill burdens of our low-income customers and ensure they aren't left shouldering the legacy costs of stranded fossil fuel infrastructure.

New all-electric program offerings that address lack of funds and other issues faced by renters will be critical to achieving our goal of helping low-income customers and under-resourced communities early. We'll expand our partnerships with local agencies and community-based organizations to raise awareness, bring in new sources of funds and accelerate adoption. In addition to bill savings, these electrification programs bring immediate public health benefits by reducing the significant indoor and outdoor air pollution from gas appliances that lack any emissions controls.

When considering electrification of transportation, scaling the charging infrastructure to meet fleet, workplace and multi-unit residential needs presents significant challenges. Large upfront investment is required for charging equipment and it'll take time for them to be used on a regular basis to get a return on investment. Additionally, transportation electrification may require costly upgrades to utility infrastructure.

To address these challenges, the Plan calls for ramping up our program investments in these spaces as well as engaging our business customers with streamlined solutions to overcome barriers, accelerate adoption and unlock access to electric transportation benefits. We'll similarly expand solutions for residential customers to make the switch to EVs simple and easy. We'll further collaborate with our regional partners to coordinate and align efforts for maximum impact. This Plan also includes workforce development to ensure equity in community benefit from the transition to electric transportation.

As more customers electrify their homes, buildings and vehicles, they'll add to Sacramento's overall electricity needs. Because much of this electrification will happen as technologies are advancing, we'll work to ensure flexible load while at the same time, minimize negative impacts by developing DER load flexibility programs. Investments in electrification will also provide a strong foundation for enabling integration of new renewable resources and displacing the need for additional utility-scale storage to accomplish this.

Behavioral demand response

Customer and technology contributions supporting grid decarbonization are not limited to "smart devices" or cutting-edge technology. Significant benefits can come from educating customers on ways to use energy that supports higher levels of renewable generation integration. SMUD's recent transition to TOD rates for residential customers is an important step in this direction. The TOD rate provides daily guidance to customers about when electricity usage is more and less expensive. Customers can adapt their consumption patterns in ways that change the load profile of the community and helps reduce overall grid costs.

On an individual basis, behavioral demand response has a minimal impact. However, this approach is widely accessible and can allow all customers to participate regardless of technology or circumstance.

Small contributions like delaying a load of laundry or turning on a ceiling fan instead of turning down a thermostat can really add up at the community level. When the community is acting in a coordinated way and everyone is doing what they can, the small contributions of individuals have the ability to fundamentally support the grid.

Virtual power plants

DERs provide an opportunity to enhance the capabilities of the existing distribution system, which can enable more cost-effective electrification of transport and buildings. As we explore new business models involving customer DERs, we'll assess their reliability and potential for cost-effective integration. We'll also consider our ability to scale these solutions in place of planned utility-scale proven clean technology investments, such as utility-scale solar and storage.

To build confidence in DERs as equivalent options to utility-scale resources, we'll need to test the operational capabilities and ensure the solutions are cost-competitive with other zero carbon alternatives. This will require proving our ability to layer dispatch to solve distribution capacity constraints simultaneously with economic optimization and reliability constraints from the bulk electric system.

Bring your own device VPP

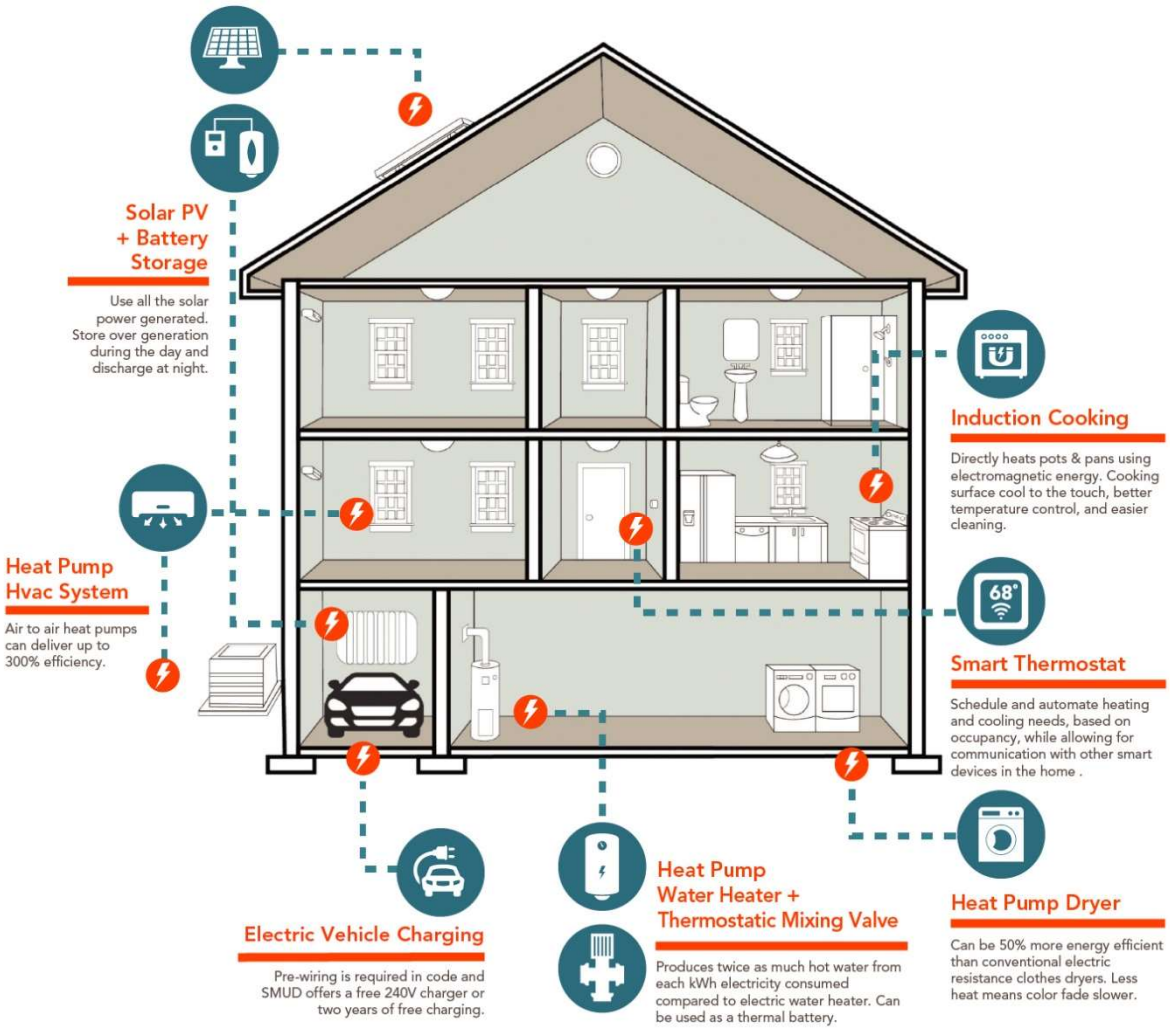
Early demand response programs depended on direct electricity load control of a customer's device, where one-way communication from the utility to the device was used to shed load. These programs were typically focused on air conditioning, but technology limitations meant it was difficult to understand the impact on individual customers. As a result, many customers experienced significant discomfort and would rightfully complain or request removal of a device when activated to support a grid reliability need on a hot day.

Since those early demand response programs, DER technology has evolved to cover a broader range of technologies capable of shifting load rather than simply curtailing it. These programs introduced two-way communication and the ability to manage events in aggregation.

More recently, utilities have started implementing "bring your own device" (BYOD) business models, which leverage the fact that customers are installing smart thermostats, water heaters and EV chargers that can be aggregated to provide energy management services to help meet grid needs.

In Sacramento, more than 85,000 smart thermostats have been installed to date, representing a significant existing potential resource. Thermostat-based programs allow standardized setbacks (e.g., 3 degrees setback from preferred setpoint), which ensures no customers are subjected to unexpected or significant discomfort. Aggregation is not limited to single types of technologies and DERs capable of participating in a BYOD VPP can now be found throughout the house.

Figure 12. Electrification and VPPs



One of the opportunities for this type of aggregation is the ability to leverage the customer's existing wi-fi connection to engage many of these devices. While dependence on this communication path can introduce connectivity risks, the overall cost is far lower than a dedicated cellular connection. This is one of the aspects of the reliability of this type of aggregation that needs to be proven out. A related challenge that we'll need to work on with partners is the fact that many lower income customers may lack both the technology and the basic internet access to be able to participate. Expanding access to both will be important from an equity standpoint.

The BYOD platform will use standardized communication and control interfaces to enable a broad range of technologies to participate. BYOD capacity will be used to provide load-shaping and other grid services as a complementary component to the reimagined thermal fleet.

Solar + storage based VPP

There is significant growth in solar in our service territory and we expect this growth to continue through 2030, much of which we anticipate being paired with storage. Thus, this VPP will look to accelerate the cost-effective deployment of storage with solar and maximize the shared benefits of this technology to both the purchasing customer and to the community.

Not all DERs will be able to provide grid services at a level comparable to a traditional power plant. Thermostats are reliant on temperature, EVs move from location-to-location and energy storage can only provide a finite amount of energy before needing to recharge. However, higher levels of operational confidence will create higher levels of grid benefits. The solar + storage contracted capacity VPP focuses on engaging with leading technologies to provide the most reliable grid services possible from DERs.

Initially, the focus of this VPP will be on solar + storage since these devices are highly reliable and their primary application is energy services. In the future, the intent is to expand into a broader set of technologies including EVs and potential home or building energy management systems.

The platform will contract with aggregators for the dispatch rights to fleets of behind the meter solar + storage systems. DER capacity contracts will be intended to mirror the structure of traditional power plant contracts in addition to consider the unique attributes of DERs. The utilization of the resources may target local grid constraints, providing seasonal capacity, absorbing excess renewable generation or any other grid services needed to support reaching zero carbon while providing reliable energy. Demonstrating success with these approaches could lead to the displacement of hundreds of MWs of future utility-scale solar + storage investments and help lower the cost of shifting away from our existing thermal plant operations.

DER progression plan

Including highly reliable load flexibility programs in our resource portfolio is key to the success of this strategy. These programs must perform similarly to a generator with performance characteristics that are known and can be planned against. This is even more critical if these programs participate in the electricity market. Realizing more value from DERs will allow the incremental value to be shared with customers through low rates and direct payments to customers for their participation. While inclusion of DERs in SMUD’s grid operations can lead to immediate operations and maintenance (O&M) benefits, there may also be times when DER services are valued higher in energy markets such as CAISO.

Figure 13. DER progression plan

For DERs to provide the envisioned benefits, they need to transition from their current promising state to a level of high operational confidence. The goal is for DERs to be fully integrated and optimized as part of normal grid operations. The 2030 Zero Carbon Plan is investigating several technology opportunities to deliver these grid benefits. A key element of the plan is evaluating the programs, determining which elements are effective and scaling those up, while stepping back from components that are not cost effective.

The overall contribution of DERs is dependent upon the types of devices enrolled and the level of collaboration between SMUD and our customers. The result is a range of potential capacity that could be enrolled into load flexibility programs. The expected trajectory will be within that range. The capacity will increase to levels that ensure we establish operational confidence by 2024. As we transition beyond operational confidence, we expect DERs to be evaluated based on cost effectiveness and performance.

Table 12. DER development trajectory

Electrification & decarbonization	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Building electrification	Implementation & pilots			Scale up & expand						
Transportation electrification	Implementation & pilots			Scale up & expand						
Cumulative equivalent all-electric homes (thousands)	54	57	60	65	71	81	93	119	131	154
Cumulative electric vehicles (thousands)	23	29	39	51	70	94	127	170	224	288

DER technology	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Energy education & behavioral DR	Implementation & pilots			Consolidation of offerings	Behavioral DR operation					
BYOD VPP	Implementation & pilots			Scale up & expand	BYOD VPP operation					
Contracted capacity VPP	Implementation & pilots			Scale up & expand	Contracted Capacity VPP operation					
Zero Carbon Base Case Capacity (MW)	7	15	27	44	64	95	141	201	275	364
Expected Trajectory (MW)	8	26	51	80	To Be Determined Based on Cost Effectiveness.					
High DER Potential Capacity (MW)	22	74	164	254	384	529	724	919	1,114	1,325

Key DER initiatives

Rates & programs

As a community-owned-utility, SMUD's journey to a zero carbon future is a partnership with our customers and community. Utility investments in proven clean technologies and customer investments in DERs are mutually beneficial. Although proven clean technologies directly reduce carbon footprint, new customer technologies play a complementary role in the 2030 Clean Energy Vision through rate and program offerings. The following recent or new initiatives in partnership with customers are proposed as part of the 2030 Zero Carbon Plan:

Energy efficiency & electrification

As part of this Plan, SMUD is further increasing its commitment to energy efficiency and electrification programs. By leveraging a carbon metric to measure outcomes, we're realigning our portfolio to maximize its climate benefit. Some of the new program models will introduce midstream marketing/incentives and turnkey "service" offerings so that customers can adopt or transition to new technologies with a lower level of effort. Examples include a revamp of SMUD's Express Energy Solutions and Complete Energy Solutions for building technologies, a turnkey EV charging infrastructure buildout service for commercial customers for fleet and employee workplace charging and a turnkey water heater replacement program that will provide a 1-to-2-day turnaround on a heat pump water heater to replace an existing gas water heater that has failed.

Behavioral demand response - "Flex Alert" pilot

We'll pursue a behavioral demand response pilot project to evaluate load reduction opportunity using customer messaging. Participation will not be prescriptive of devices or require device automation. This is expected to be a one- to two-year project starting in 2021.

BYOD load flexibility - Smart Energy Optimizer and PowerMinder

These projects are currently active. SolarEdge batteries are eligible for enrollment in Smart Energy Optimizer and GE and Rheem controllable heat pump water heaters are eligible for enrollment into PowerMinder. In both offerings, the aggregator optimizes device response to minimize utility supply-side energy and capacity costs. Customers are billed off their existing TOD rate while the device automation courtesy of the aggregators is only responsive on event days. The program terms and conditions allow for 120 events per year. Customers receive an upfront incentive and ongoing bill credit for sharing use with the utility on event days. More than a year of data is currently available from these pilots with the evaluation in progress for Smart Energy Optimizer and soon to begin for PowerMinder. Both programs address a portion of the research needs for the BYOD VPP program model/platform.

BYOD load flexibility & Contracted Capacity VPP- multi-DERs pilot

This pilot focuses on comparing different rate and program groupings. More specifically it'll evaluate a critical peak pricing rate, dynamic pricing rate and an incentive-based aggregator-managed load shifting program (VPP). This project will encompass three DERs types – smart thermostats, EVs and residential battery storage in a BYOD fashion. A Request for Proposals is planned for 2021 targeting a system-wide scale that is relevant to economic operation of SMUD's electrical system (10s of MW). In addition to exploring rate and program models, data

will be collected to build confidence on the firmness of load reduction response. This project will address research needs from both the BYOD VPP program model/platform and the Contracted Capacity VPP program model/platform.

Contracted Capacity VPP – Solar + Storage VPP

Programs for solar and battery storage systems will have to be designed with consideration of the successor rate to replace our NEM rate, which is expected to be an element in the upcoming rate process in 2021. Another VPP pilot is proposed, staggered after the multi-DERs pilot with more focused attention on the successor rate. This project will focus exclusively on the research needs of the Contracted Capacity VPP program model/platform with the intent of accelerating the benefits from behind the meter solar + storage.

Managed EV charging

One of the primary interests in utility management of EV charging is to reduce the need for service transformer upgrades due to coincident EV charging when many people are charging at the same time. Service transformer protection allows SMUD to accommodate a greater number of EVs at a lower cost. For customers to enroll in such a program and continue participation, they need assurance that their EV range confidence is not impacted. This assurance may be via a guarantee of a full charge or some minimum rate of charge is provided to the vehicle. Such a program needs to be piloted to evaluate mutual benefit and scalability. Research projects should span both the BYOD VPP and contracted capacity VPP program models/platforms.

Smart inverters

Under SMUD's Rule and Regulation 21[61] (also referred to as Rule 21), new solar interconnections are required to use smart inverters. One of the benefits to smart inverters is access to real time solar generation data which uncovers hidden behind-the-meter loads which is important for grid operations for switching and understanding contingency needs. Smart inverters also offer other functionality such as generation curtailment, reactive power and autonomous modes of operation. Further pathway analysis and modeling for the 2030 Zero Carbon Plan may uncover other priority use cases for smart inverters. Smart inverter utilization and program models are recommended for evaluation and eventual piloting.

Vehicle-to-grid

Vehicle-to-grid (V2G) involves EV batteries capable of discharging energy to the grid. This can act as a low-cost alternative to stationary battery storage. It's estimated that at scale this technology could provide over 250 MW/400 MWh of energy storage. There are two industry barriers to this technology: 1) Warrantied support today is limited to electric school buses only and 2) Vehicles and chargers are lacking hardware interoperability and compliance with utility interconnection standards.

Customer experience is a greater challenge for V2G. Customers will need assurance that utility draw/battery depletion does not impact vehicle use and range confidence. Beyond rate or incentive-based bill savings, in the future V2G could provide backup during outages, which would be an added benefit to customers. Instead of a pilot, smaller scale demonstrations are

[61] https://www.smud.org/en/Business-Solutions-and-Rebates/Interconnection-Information.

proposed. Partnering with industry leaders in demonstrations will help accelerate technology development and create pull for utility interconnection standards and EV supply equipment (EVSE) interoperability to displace stationary storage investments.

Research projects should span both the BYOD VPP and Contracted Capacity VPP program models/platforms. School districts that benefit from CEC and CARB grants are aggressively converting their bus fleet to electric and already require some V2G compatibility. The incremental cost to operationalize V2G with these school districts presents a relatively small barrier compared to other segments.

Equitable access

Bill savings from energy efficiency, building electrification and transportation electrification can benefit low-income customers and under-resourced communities that face socioeconomic challenges or are disproportionately burdened by pollution. The barriers for this segment being able to access energy efficiency, building electrification and transportation electrification are complex and individually unique. The barriers are often a combination of up-front technology cost, lack of information, lack of time or interest to invest in switching technology or a multiple party building change approval process such as tenant-property manager-owner. Variations to programs will need to be available to address this spectrum of challenges for this customer segment. Financing programs could play an important role in this portfolio of program offerings.

IT back office for customer-facing functionality

For load flexibility programs to scale, they must be convenient for customer participation. This means customer-facing functions such as program enrollment, device registration, event messaging, event opt out selection and performance-based incentives/billing all need to be automated. In small scale pilots, many of these functions are manually processed. A road map for automating functionality with determination of what will be supplied by IT partners versus SMUD back office systems needs to be established.

Grid operations

For the full value of load flexibility to be realized, it must be integrated with SMUD's operational procedures and tools. SMUD's implementation of our DERMS will be a significant step toward embedded DERs as part of normal grid operations. The DERMS will unleash economic value from aggregated DERs by displacing a portion of generator operation (namely utility battery storage) and energy market purchases and avoiding a portion of operational resources being reserved for transmission and distribution services or reliability.

Financial strategy and options

Financial strategy

- Explore opportunities for savings and cost reductions.
- Pursue grants, innovative financing and other funding opportunities.
- Cultivate new partnerships and collaborations.
- Connect with clean technology investors.

To maintain rate stability and access to credit markets, SMUD manages its finances to meet or exceed several target financial metrics. Some of the externally reported metrics include:

- **Days cash**: A measure of how much cash we have on hand to pay for ongoing expenses.
- **Fixed Charge Coverage Ratio**: A measure of how much cash comes in each year, compared to the principal and interest payments on debt.
- **Net Income**: SMUD's revenues less expenses.

Building the infrastructure, modifying current assets and acquiring the necessary resources to get to zero carbon will require a significant investment. It'll be important to continue meeting or exceeding our financial metric targets to ensure we have access to the capital needed to implement our 2030 Zero Carbon Plan, and protect against larger rate increases in the future.

Our financial strategy is based on taking action across many areas to help ensure that the goals of our 2030 Zero Carbon Plan can be achieved while keeping annual rate increases at or below the rate of inflation. This will require a mix of strategies, which are the focus of this section.

Proposed portfolio rate impact

The proposed resource portfolio represents a significant investment over what was planned before our commitment to zero carbon by 2030. Relative to our 2040 Clean Energy Plan, annual commodity costs are expected to increase from about $60M dollars in 2023 to more than $450M in 2030.

In the short term, these increases are driven by additional wind and solar contracts and resource development. Longer term, increases are driven by large deployments of batteries and geothermal. In addition to these commodity costs, we're planning to make significant investments in DERs and in electrification for under-resourced communities. These investments will help achieve needed changes to patterns of energy usage, while ensuring costs are born equitably among all our customers.

When evaluating these costs, keep in mind the forecast includes expected cost levels for proven technologies which are uncertain and may ultimately be higher or lower than shown here. However, there are steps we can take to reduce costs below these expected levels, such as:

- Working with staff and vendors to minimize cost increases for recurring programs and services.

- Identifying opportunities to streamline processes and reduce costs.
- Creating innovative rate structures to partner with customers on distributed energy investments and incentivize use of technology that supports adoption of renewables.
- Capturing grant funding to offset costs for innovative zero carbon R&D projects, demonstration of new technology and integration of existing technologies.
- Identifying partnerships with energy suppliers, technology companies, governments and academic institutions to create new business models that share the costs equitably and lead to a healthy marketplace.
- Identifying alternative financing mechanisms that provide for partnership funding, grants and/or lower debt service and commodity costs.

Additionally, new technologies are expected to continue improving, and as they're adopted, price and performance will become more certain. Many may achieve significant cost improvements relative to current planned assets, and therefore lower the cost of the portfolio. However, the scale and timing of these improvements are unknown, and therefore are not currently modeled.

Financial strategy

Our financial modeling results are preliminary and subject to change with fluctuations in commodity markets, changes in the economic landscape and advances in technology. As we progress towards our zero carbon goal, we'll continue to seek out opportunities to accelerate benefits by reducing commodity and borrowing costs, increasing operational efficiencies and optimizing partnership and grant funding strategies. Some strategies we may employ are:

- **Identifying priority projects, programs and technologies**: Prioritizing projects and programs across the enterprise, optimization of individual projects and monitoring technologies and costs to control spending.
- **Optimizing and seeking out partnership and investment opportunities**: Seeking Public Private Partnerships for acquiring or divesting of assets. Additionally, we can use our low cost of capital to finance projects that meet our risk profile at cheaper rates than may be included in modeled costs.
- **Identifying additional funding sources**: Seeking partnerships for grants and co-funding, as well as developing business models that leverage LCFS credits, U.S. Environmental Protection Agency (EPA) electric Renewable Identification Number and carbon credits.
- **Employing alternative financing structures and opportunities**: By employing alternative financing structures, such as renewable prepays, we could potentially lower commodity costs. Additionally, if cost effective and available, we could use direct subsidy bonds such as Clean Renewable Energy Bonds and Qualified Energy Construction Bonds. We could also implement a grant capture policy and process to influence awarding agency budgets and align with SMUD projects. All funding opportunities available to SMUD for both zero carbon and non-zero carbon grants should be explored to create as much of a positive impact on SMUD's budget as possible.
- **Managing financial metrics**: Metrics can be adjusted to manage fluctuations in costs, and to smooth out rate impacts over time.

Partnerships

Getting to zero carbon is a task that's larger than any single organization can achieve alone. As such, we're exploring ways to partner with the community at large to pool resources and mitigate risks as we explore new technologies and pursue large-scale projects. Community partners could include businesses, governments, academic institutions, financial/corporate institutions, native tribes, non-profit and philanthropic organizations, other utilities and investors. Each stakeholder brings new resources and perspectives to the challenge facing us, but together we're stronger and more capable of ushering in a zero carbon world.

We'll continue to explore opportunities to partner with others. These partnerships will likely be technology-specific. Some opportunities we're exploring include:

- **Partnering with other energy providers**: These partnerships could help facilitate construction of large-scale proven clean technology projects while achieve cost savings from economies of scale, as well as achieving regional decarbonization goals.
- **Partnering with manufacturers**: These partnerships could result in cutting-edge demonstration projects for technologies such as hydrogen fueled generators, biomass, biogas and biodiesel.
- **Enhancing investment in under-resourced communities**: By leveraging relationships with financial institutions and other businesses, we can work to enhance investment in under-resourced communities. Moreover, we can explore foundation and private investment funding to identify mission-related investments that support our goal of ensuring that no community is left behind in our 2030 Zero Carbon Plan. Examples of these possible funding sources include the Bill & Melinda Gates Foundation, William and Flora Hewlett Foundation and the MacArthur Foundation.

A key element of our partnership strategy is taking a more proactive stance towards identifying and developing potential partnerships. The "One Sacramento" initiative is a key example of this shift, bringing together local governments, academia, regional organizations, industry, under-resourced communities, healthcare organizations and investors. In the past, some of these groups have missed out on potential benefits and valuable partnership opportunities may have been overlooked. By creating a forum to discuss our shared goals, we can expand the array of potential partnerships, streamline planning processes and maximize the regional impact of expected new funding from stimulus and recovery packages and possible Green New Deal funding.

One Sacramento regional partnership

As we decarbonize, we must comb the market for strategic partners that are focused on solving the same problems. Collaboration with government, environmental agencies and private organizations will expand ideas, tackle common barriers to accelerate timelines and co-invest in solutions to lower total decarbonization costs in a coordinated and efficient way. Our grid and customer base can be a platform for innovation, where key partners can gain access to end users and a network of industry and regional collaborators.

SMUD is in the unique position to be a powerful convenor in our region to align resources to maximize our decarbonization efforts. Specifically, we will lead the formation of a "One

Sacramento" regional initiative. This initiative will mobilize a coalition of customers, researchers, civic leaders and private sector partners to advance healthy, affordable and sustainable building, mobility and community solutions and to propose and implement demonstrations of what can be implemented in the Greater Sacramento region's under-resourced communities, serving as a model for the rest of California and across the U.S.

SMUD maintains a unique leadership position in electrification for buildings and mobility, which are supported by our Sustainable Communities program, 2040 Energy Plan, recent climate emergency declaration and involvement with the California Mobility Center. We'll work to prepare the greater Sacramento region to definitively respond to the expected Biden Administration Green New Deal stimulus funding, climate adaption-focused Federal Emergency Management Agency (FEMA) funding opportunities and other opportunities likely to encompass environmental justice, infrastructure to support decarbonization and resiliency and equitable deployment of clean tech to our customers. This intersection of community vision, funding, political will and evolving policies will likely bolster our ability to attract private investment from industry stakeholders.

Our "One Sacramento" initiative will work to attract funding and resources to equitably and affordably decarbonize the current environment and mobility services, and improve community health and resiliency in the Greater Sacramento region. The goal is to achieve zero carbon by 2030 while simultaneously advancing social equity and economic prosperity for the region.

Regional partnerships supporting economic mobility

We also plan to expand partnership pilots to support the goals of our low-income and community engagement and Sustainable Communities programs. In expanding partnership pilots, we plan to:

- Leverage Sustainable Communities investments to identify opportunities to reach communities that are not already represented in the partnership portfolio and/or have limited representation.
- Incentivize current community partners to assist SMUD in achieving our 2030 Zero Carbon Plan through outreach, education, job training, etc.
- Implement additional training programs similar to Energy Careers Pathways that bring needed zero carbon job skills to under-resourced communities.

We're also looking to establish additional partnerships to leverage federal funds to invest in under-resourced communities. With these funds, we intend to ensure that under-resourced communities will have access to the new technologies that will reduce GHG emissions without increasing their energy costs. We'll also continue to work to incentivize companies to bring new companies to bring resources (e.g., new energy efficient businesses and technologies) to under-resourced communities. We're learning about models that other communities are using that can be implemented in Sacramento to bring new energy technologies to under-resourced communities, adding new job opportunities and economic development opportunities for these communities.

We'll leverage our involvement in the California Mobility Center as a conduit to potential innovation partners to accelerate managed charging and V2G technologies. It can also provide

a model that could be replicated to attract and build collaboration with stakeholders in the load flexibility and VPP domains.

SMUD must invest in training and hiring to ensure that strategic alignments are formed with well-vetted strategic partners and that ongoing exchange of mutual value is negotiated tactically in order to track and realize benefits for SMUD, our partners and our customers.

Grant funding

We analyzed current and past grant opportunities to develop a forecast of grants that SMUD has a good chance of getting over the next five years. This analysis only includes grants that support the 2030 Zero Carbon Plan and primarily awarded by the Department of Energy (DOE) and CEC because those agencies would be the source for the majority of zero carbon grants. Based on our analysis, awarding agencies will provide the opportunity to capture more than $150 million in grant funding over the next five years.

SMUD has extensive experience applying for and receiving grant funding that make innovative projects and customer programs possible. The recently completed Slab Creek Powerhouse grant started with the Power Generation team responding to a DOE request for information (RFI) and subsequent discussions with DOE on the need for this and the Iowa Hill Pumped Storage projects. Our most recent example is the awarding of $750,000 from California's Department of Resources Recycling and Recovery grant for the North City Landfill where the Environmental Services team engaged with the state to allocate funding in alignment with one of our SMUD projects by educating them on our project needs and timeline. SMUD’s Research and Development department has a Grant Acquisition Management team to respond to RFI’s, engage with awarding agencies, vet opportunity announcements and respond to funding announcements with grant applications and proposals for emerging technology funding opportunities.

In a similar climate of grant funding to support presidential administration goals, the 2009 American Reinvestment and Recovery Act (ARRA) provided several significant grants for SMUD from 2010-2015. SMUD was awarded over $150 million in federal funding for the SmartSacramento® project, the Home Performance Program through the California State Energy Program, Low Income Weatherization, Community Renewable Energy Deployment, Anatolia energy storage and the General Motors and Chrysler fleet grants. These projects were considered shovel ready and immediately generated jobs in the community. These projects moved SMUD toward zero carbon and have laid the foundation and given us the experience needed for our grant work as part of the 2030 Zero Carbon Plan.

SMUD has the potential to capture grants for the 2030 Zero Carbon Plan in two ways. First, the new Biden Administration has indicated that a new recovery act will be developed soon. Second, the DOE and CEC has a history of awarding grants for development, demonstration and research and development projects similar to those discussed in the partnership section of this plan. Research into grant awards shows the history of DOE grant funding to be stable and consistent across both the Obama and Trump Administrations. This trend is expected to continue under the Biden Administration.

To capture a similar level of grant awards with a new recovery act, we'll be ready to apply with shovel ready projects that align with the administration, DOE and CEC goals. Projects identified in the 2030 Zero Carbon Plan appear to align with these goals. Our successful capture of ARRA grants was related to SMUD's great reputation that enabled us to unite our community behind our ARRA projects such as SmartSacramento®. We've worked hard to maintain our positive reputation with the local community by educating and including local organizations in the ARRA projects. Our has built a reputation of successful implementation and grant management by placing the right amount of policy and procedures with the right controls. This ensured that the many audits we received resulted in positive reports to the awarding agencies and no give back of grant funds.

Approach

In anticipation of our zero carbon grant needs, we have implemented new approaches to improve the efficiency of our internal grant identification and application process. This includes taking proactive steps to build relationships with new partners, such as establishing regional forums on shared goals, as well as internally structuring our processes and teams to have streamlined and coordinated approaches to managing grant opportunities. This will allow us to be prepared with quick, yet comprehensive, responses as new funding is announced. Because grant funding opportunities typically require a 30-to-45 day response, we must be ready with shovel ready projects defined, sub-recipients or other partners identified and vetted, and teams with the capability and capacity to build a winning proposal.

Building on this momentum, we can capture grant funding by implementing a grant capture team focused on our 2030 Zero Carbon Plan goals. This team will leverage our current capture process to do three things:

1. Leverage industry partnerships to help define and align agency funding with SMUD projects.
2. Leverage our Government Affairs team and external partners to advocate for zero carbon grant funding.

Government affairs strategy

SMUD's 2030 Zero Carbon Plan will require close coordination across multiple agencies at all levels of government to enable near-term transformation. Governments are serious about addressing climate change, and their investment in SMUD's success will inform policies and pathways for other utilities to follow.

Key objectives

Already, certain policy goals emerge as critical to the success of the 2030 Zero Carbon Plan. As specific projects and technical needs emerge, SMUD's advocacy team will be prepared to advance policies that support those changes and investments.

Partner with Governments on innovation

As the nation's leader in emissions reduction, SMUD will become the partner of choice for government investment in innovative research and commercialization of utility applications for emissions reductions, including public-private partnerships, grants and specific projects.

SMUD is well-positioned to partner with federal and state governments to receive funding for existing and planned carbon reduction projects, with an eye toward achieving shared goals. Many of the projects we'll pursue are likely to be transformative projects that have a public policy nexus, such as electrification of cars and buildings, reduced energy consumption through energy efficiency and demand response and developing additional zero emission generation resources and energy storage.

Accelerate beneficial transportation and building electrification

Building and transportation electrification projects have the ability to promote environmental equity, health and safety benefits for our customers as well as improve load factor in a cost-effective manner to ensure continued affordability. Central to this approach is achieving policy changes that encourage the electrification of buildings and transportation, which will also contribute to further emissions reductions in those sectors.

In 2018, Governor Brown signed an executive order calling for the state of California to be carbon neutral by 2045. Also that fall, the mayors of Sacramento and West Sacramento adopted a joint-city carbon zero goal by 2045. Both of these goals will require electrification of most if not all end uses in buildings and much of on-road transport. To achieve these levels of electrification, gas appliances will need to be phased out in retrofit applications by 2030, and for new construction, the state energy code will have to require all-electric buildings by 2026. On the transport side, phasing out the sale of gasoline or diesel vehicles will need to be done by 2035. These types of policies will require many years of education and promotion of the technologies and their benefits to reach acceptance, both amongst the public and policymakers.

Improve technology standards and permitting processes for infrastructure

Robust efficiency standards must play a role in ensuring the power SMUD generates is not going to waste. After years of inaction on standards at the federal level, new requirements are likely to be proposed under the new administration. SMUD will support strong standards and engage on requirements that impact grid-enabled devices.

As SMUD identifies and begins construction on key projects required to affect the transition to zero carbon, policy support for deployment of renewable generation, storage technology and transmission infrastructure will also be crucial. This may come in the form of streamlined permitting processes, monetizing credit for early action in broader emissions reductions regimes or reducing unintended barriers to deployment.

Strategies

SMUD's objectives are ambitious, so our approach must be determined and focused. The decade of transformation has already begun, and SMUD is vaulting to the forefront of change by building strong relationships with elected officials and decision-makers who will help us succeed.

Educate policymakers

Our first order of business is to tell our key government stakeholders and external partnerships about our goal and strategy for achieving it, which is already underway. In addition to introducing our 2030 Zero Carbon Plan to policymakers in 2021, we'll inform coalition partners, trade associations, environmental advocates and the public about our plans to achieve zero carbon by 2030.

We'll develop an outreach plan for direct, regular and consistent interaction with decision-makers and influencers, utilizing grass-roots mobilization to engage a strong base of supporters and organizational allies to encourage change. Through this Plan, we'll promote our work to key federal agencies that can deliver funding for demonstration and deployment projects aimed at deep decarbonization.

Working across departments, we'll develop and disseminate consistent company-wide talking points and issue papers, provide training on critical issues and execute a strategic campaign to raise awareness of the 2030 Zero Carbon Plan and associated policy initiatives.

Promote beneficial regulation

We'll be highly visible as a champion of policy efforts to reduce carbon emissions, including drawing upon and sponsoring studies, offering technical support and feedback for policy development and partnering with government agencies on physical projects. We'll endorse and support policy proposals that facilitate utility actions to reduce emissions, including government research and development programs in emerging technologies like power-to-gas technology, hydrogen and methane, long-duration batteries and compressed air storage.

We'll identify, evaluate and maintain a list of beneficial programs, projects, rulemakings and legislation that enhances and/or facilitates the clean energy transition, with the highest support for those efforts that specifically facilitate our efforts. we'll work to raise awareness of, and

support for, these initiatives through briefings, social media, correspondence and other activities.

We'll also work with policymakers to provide constructive feedback on legislation and regulations, leveraging our technical expertise and engineering capabilities. We'll work individually and through coalitions and associations to shape climate and clean energy efforts, including financial support for and participation in organizations dedicated to clean energy transformation.

Actively work toward reforming outdated policy barriers

We'll proactively identify barriers to the clean energy transition that may be embedded in existing law, and work for their reform. We'll call for pragmatic changes to existing policies that inhibit a speedy transition to clean energy, such as permitting processes and requirements that do not appropriately balance the urgency of climate change against other objectives.

We'll continue to cultivate policy support for necessary reform of existing law when it becomes evident that such policy is an impediment to the 2030 Zero Carbon Plan.

In addition, we'll seek to reframe narratives from our industry and others that discourage ambitious goals or entrench the status quo. SMUD will be an advocate within advocacy groups, and counter opposition or indifference within those organizations. We'll be a voice for what's possible and will challenge assertions that policies should protect existing industries at the expense of emissions reductions.

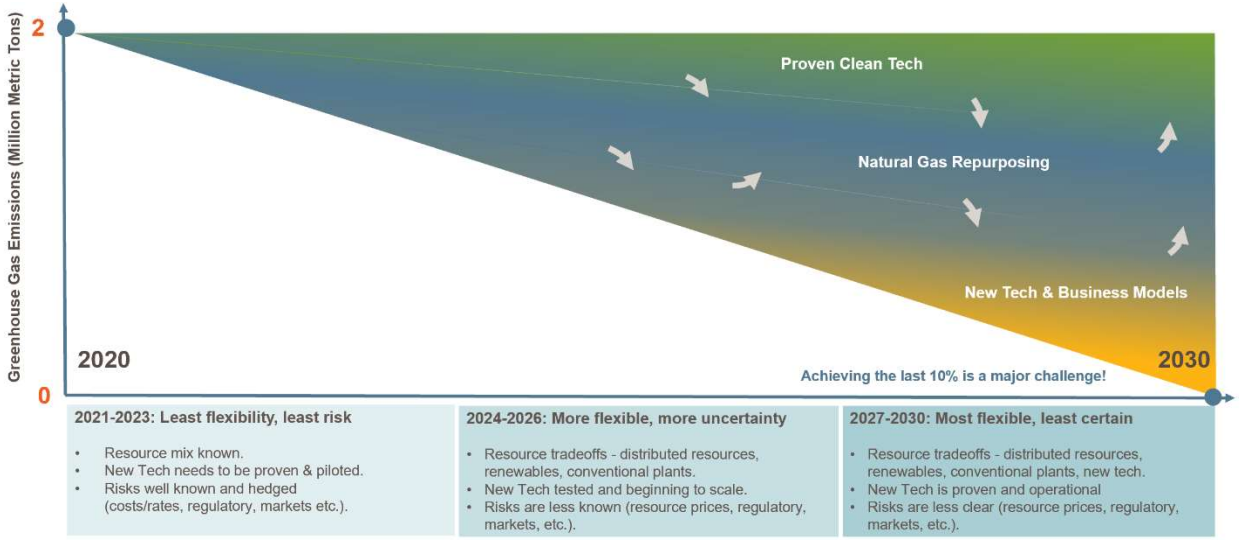
Conclusion

One of the defining features of our 2030 Zero Carbon Plan is that we're seeking to reduce emissions associated with all our electricity generation, not just our retail sales emissions. This exceeds the scope and timing of California's 2045 zero emissions goal as well as virtually all United States utility targets. Our all-encompassing goal will require removing natural gas from our portfolio, which most utilities identify as needed for reliability.

Our strategies support our core values, including maintaining reliability and affordable rates. We'll work with all our communities to ensure that Plan benefits sensitive groups and our under-resourced communities and that it's affordable for all. We'll use a thoughtful, data-based approach to study the reliability of these options before proceeding.

We've identified a broad and flexible road map to get us to zero carbon by 2030. This Plan will, and must, remain flexible to be successful. As we implement one element, we'll need to reassess the system, technology landscape and customer preferences. Clean energy technologies are evolving quickly, and we must ensure we're providing our community with the right solutions over the next decade and beyond.

Figure 14. Illustrative flexible pathway to zero carbon



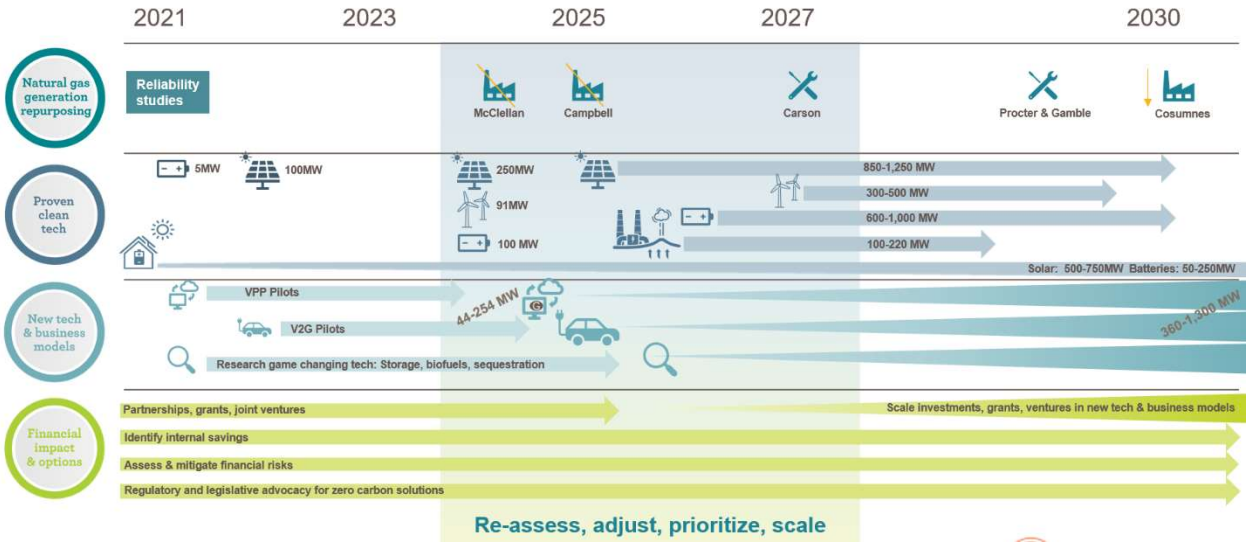
Flexible pathway to decarbonization

What we have discussed in previous sections is not a rigid plan of action, but rather an exploration of scenarios that have and will continue to inform our strategy discussion as elements of our plan become more concrete. As part of our strategy discussion, we modeled a variety of scenarios, each employing different tools available to SMUD as we continue our journey toward zero carbon. As we continue down this journey, we must approach each decision point decisively and educated with the best available information. Through the

implementation of this plan, we'll define our pathway and create a comprehensive resource portfolio that, by 2030, will allow us to reach zero carbon.

There is no single portfolio that will help us achieve zero carbon and it will not be a one-time optimization task. Instead, it will be up to us to create a resource mix that balances a variety of sometimes evolving objectives – cost, reliability needs and land-use, among others. We'll revisit these tools often as our priorities evolve and new technologies or business models become commercially available. Figure 15 is illustrative and suggests several possible ways that SMUD could balance the various tools we have at our disposal to reach zero carbon by 2030.

Figure 15. Possible ways to reach zero carbon by 2030



One view of our road map to 2030

While the future is far from certain, we know our power supply in 2030 will be significantly different than it is today. More options will be available, and while we don't know exactly which ones will be in place in 2030 and to what extent, this Plan is the foundation that will get us to zero carbon, with the flexibility to adjust as circumstances change.

The Plan assumes our generating capacity will increase. Under today's technology assumptions, our portfolio, in terms of nameplate capacity rating (the maximum instantaneous generation rating), is expected to grow from around 3,500 MW today (including short-term market capacity) to nearly 6,400 MW in 2030.

Figure 16 shows the capacity break out compared with today. Figure 17 shows one potential breakout of where our renewable resources could be located (local and remote).

Figure 16. 2030 Zero Carbon Plan

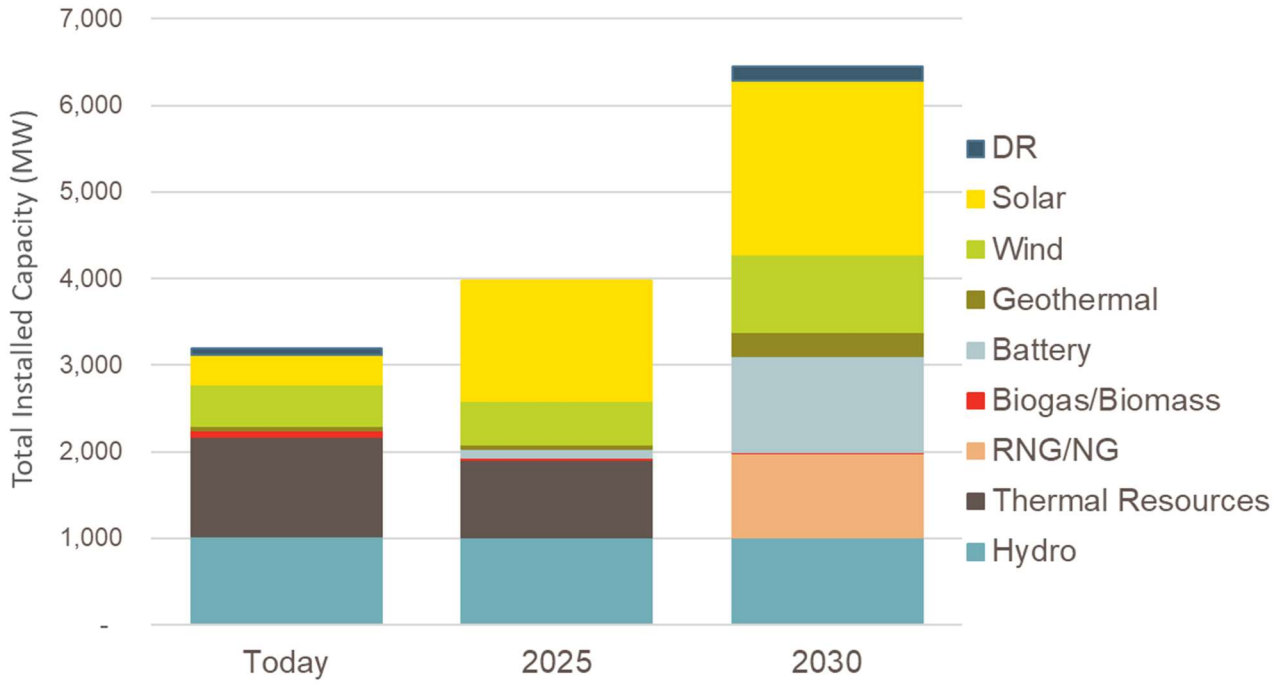
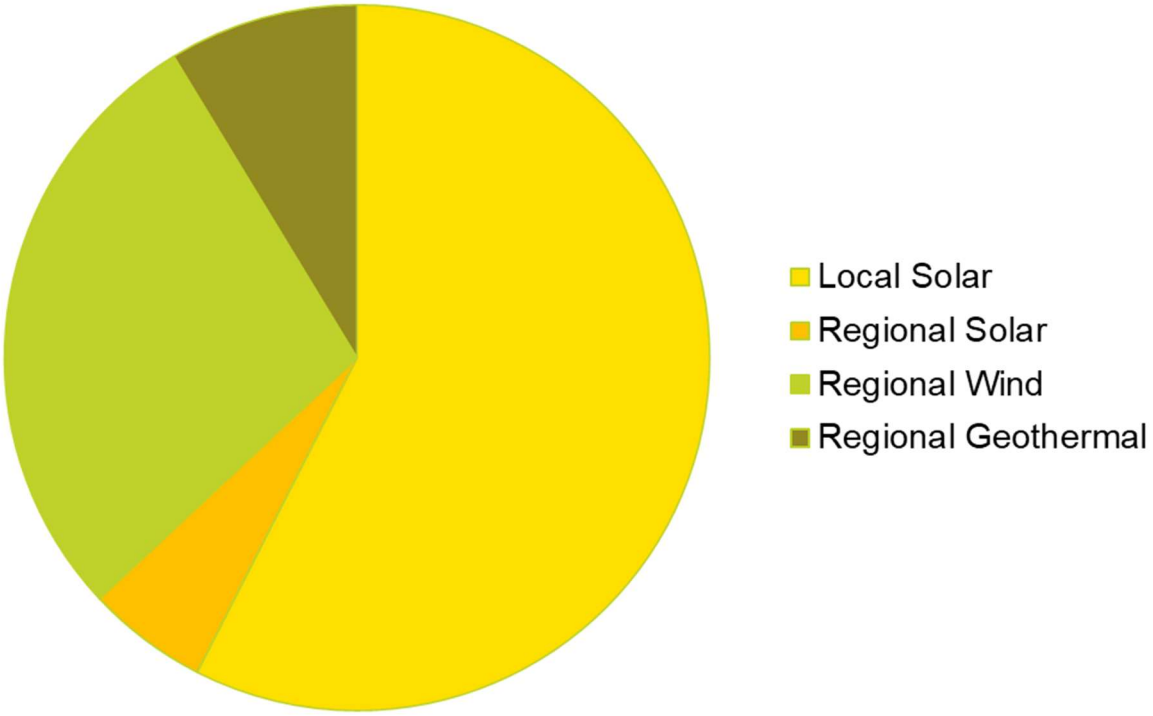


Figure 17. Where might our new renewables be located?

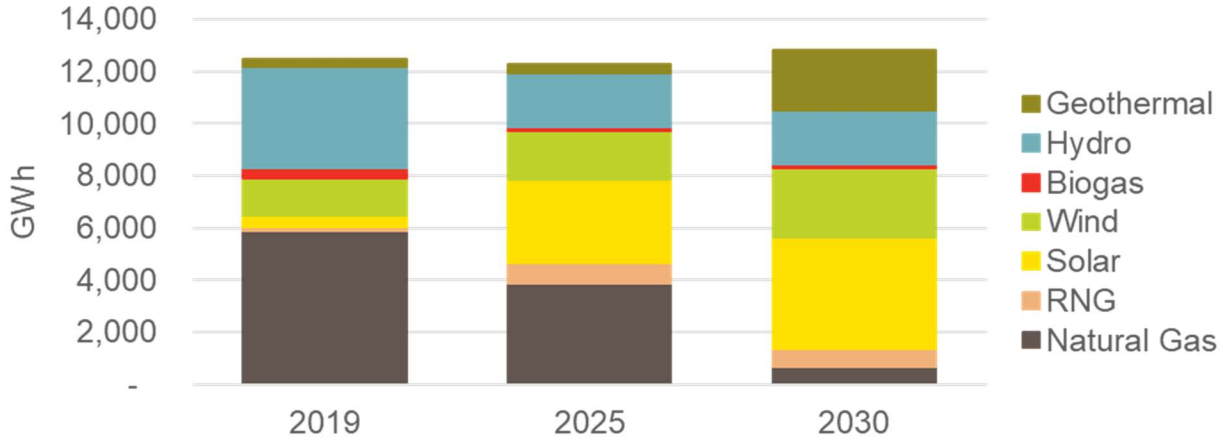


In terms of generation, natural gas comprises under 6% of the total generation. In fact, we expect to curtail more solar power (over 15%) than is generated by natural gas in 2030 in this model. While this does not mean that with today's proven clean technologies we can use the solar energy to displace our thermal assets. It does suggest that there are opportunities for new technologies, such as long-duration storage or renewable hydrogen production, that could absorb our excess solar energy and store it until we need it later in the year.

As compared to 2019, our reliance on natural gas is reduced by nearly 90%. This is mostly due to the retooling of our gas plants to operate as peakers. When used as such under the thermal retooling scenario, the average capacity factor drops from 60% in 2019 to 21% in 2030. Of the 21% capacity factor, 8% is from RNG.

The resource mix that makes up our annual energy use is highly dependent on fluctuations in hydro availability. In 2019, our hydro resource performed above average and we were also able to procure additional zero carbon resources under short-term agreements from the Pacific Northwest. For our 2030 Zero Carbon Plan, we assumed that hydro would generate under average conditions and that we would not have long-term access to short-term agreements from the Pacific Northwest. See Figure 18 for the annual generation break down by technology. Future analysis is needed to determine the resource mix needed under low-hydro conditions and the impact to renewable curtailment during high hydro years.

Figure 18. Annual generation for 2019 and 2030



Customer-partnerships: The road to VPP

Adoption and flexibility of DERs are gaining momentum and show promise as a valuable resource in our 2030 Zero Carbon Plan. Advancements in technology and declining costs are laying the foundation for promising business models that will provide customers with an opportunity to participating in resource programs and share in the benefits. Our building and vehicle electrification efforts are foundational elements to community-wide carbon reductions. Additionally, rooftop solar continues to decline in cost and batteries are reaching market parity with other capacity resources, creating an attractive financial proposition for customers interested in these types of investments. Taken together, we see great potential for technology aggregation to create a VPP.

The capabilities of such a configuration remains to be tested and refined to optimize overall performance and customer experience. We expect that aggregated DERs will have potential and capability to mimic the operations of up to 490 peak MW of the equivalent thermal power plant. The actual resource potential is uncertain until we develop the infrastructure, increase customer adoption of smart technologies and transition local vehicle sales to EVs.

Action plan and risk mitigation strategy

Based on extensive studies, we concluded there is a feasible pathway to achieve zero carbon by 2030, however, there are a number of unknowns and risks that we must be prepared to mitigate. We addressed many of these in the preceding sections, such as development risk, technology uncertainty and cost controls. Other challenges are likely to arise during implementation. Our flexible pathway allows for may mitigation efforts and complementary actions that we can undertake to achieve our goal on time.

Our plan of measurable actions is divided into near-term and mid-term. Long-term actions will be developed as we complete the near-term actions and update the plan in our mid-term review.

Below are our short- and medium-term action plans, subject to change based on new information, economics and technology readiness. These are the areas we'll focus on through March 2024, with ongoing updates to this Plan based on progress and factors that have changed since this Plan was created.

2030 Zero Carbon Action Plan

Near term action items, to be completed by March 31, 2022
Implement plan for the Natural Gas Generator Repurposing Strategy, including • Feasibility study of the reliability, economics and environmental impacts, focusing on solutions for McClellan and Campbell. • Community outreach, communication and engagement inclusive of all segments. • Study of new complementary utility-scale technologies, fuels and options.
Implement plan for the Proven Clean Technology Strategy, including: • Schedule and options for developing and deploying new resources. • Conduct locational analysis, system impact study and economic valuation and solicit counterparty offers. • Study strategic new technology options complementing the Natural Gas Generator Repurposing Strategy. • Explore delivery options for out-of-area renewables. • Develop and issue competitive solicitation for new proven clean technology projects.
Implement plan for New Technology and Business Models Strategy, including: • Perform information technology system upgrades to enable DERs and VPPs. • Include DERs in operations, distribution and grid planning processes. • Launch new customer-partner pilot programs for VPP Involving thermostats, EVs, rooftop solar and batteries. • Launch pilots for behavioral demand response "Flex Alert", EV managed charging and V2G demonstrations. • Quantify co-benefits in healthcare, mass transit, construction, internet service providers, etc.

Near term action items, to be completed by March 31, 2022
Evaluate the 2030 Zero Carbon Plan for NERC Reliability Standards, system adequacy requirements, operational reliability requirements, and new reliability services contributions. • Transmission system studies are completed, and a mitigation strategy is proposed for any identified violations. • Operational recommendations for mitigating intra-hour variability. • Data on expected grid reliability contribution based on New Technology and Business Strategy modeling.
Perform reliability assessments • Evaluate operational reliability requirements to manage the variability of solar and wind generation. • Evaluate grid reliability services contribution from VPPs, DERs, demand response and load flexibility. • Perform detailed studies of sub-transmission system impacts from the re-tooling of the Carson Ice generation plant.
Set internal goals for operational efficiencies needed to manage risks to rate impacts.
Organize grant capture team to proactively seek opportunities for funding partnerships and research with manufacturers, vendors, government agencies, utilities and research institutions.
Engage government, agencies and policy makers • Brief policymakers on the 2030 Zero Carbon Plan. • Advocate for and support electrification policies • Support cities' and county General Plans and Climate Action Plans • Connect with federal agencies and policy makers on climate action and our 2030 Zero Carbon Plan
Identify new workforce skills needed to support zero carbon technologies. Determine if these are net new jobs or upskilling of existing workforce. Careers can span zero emission vehicles, building electrification, etc.
Develop and implement a comprehensive regional communications, marketing, outreach and educational effort.

Medium term action items, to be completed by March 31, 2024
Update and implement Natural Gas Generator Repurposing Strategy, including • Finalize solution for McClellan and Campbell replacement. • Conduct comprehensive reliability analysis and retooling (or retirement) plan for each thermal generator location and update retooling plan annually as necessary. • Update our research and development plan for new large-scale technologies. Seek expertise and opportunities to partner, research and fund projects.
Update and implement the Proven Clean Technology Strategy, including: • Identify and develop the next set of renewable resources and storage needs locally and regionally with plausible delivery options. • Identify and solicit additional clean tech resources. • Update feasibility study of the reliability, economics and environmental impacts, focusing on solutions for retooling Carson and Proctor & Gamble.

Medium term action items, to be completed by March 31, 2024
Update and implement plan for New Technology and Business Models Strategy, including: • Accomplish planned system upgrade. • Accomplish future rates development • Continue to refine new programs and pilots and nurture partnership & grant opportunities. Collaborate with utility peers to support common interfaces to technology and program innovation.
Continue to study and monitor the impact of the plan on both distribution and transmission system. Perform transmission reliability studies to comply with the NERC reliability standards, load serving capability and import capability studies.
Continue to evaluate VER impact on operational practices and system conditions.
Set 2022 budget and 2022/23 rate increases with initial plan limits. Determine optimal borrowing strategy to meet plan and make necessary adjustments as part of the biennial Rate Case process.
Focus project outreach on residents within the recommended radius of each thermal plant based on key findings from scope study and partner feedback Identify community partners to develop training programs (upskill or entry-level) to support new zero carbon technologies. Develop strategies to attract (marketing, career pathways etc.) under-resourced communities to these stable, economically mobile careers.
State-level Actions: • Maximize CARB Cap-and-Trade allowances. • Protect LCFS revenue. • Support agency implementation of Governor's Executive Order on EV-only sales. • Protect against legislation that creates barriers to implementing our 2030 Zero Carbon Plan, such as costly mandates and funding of non-zero carbon transportation fuels. • Advocate for legislation that aligns with zero carbon priorities, including transportation, building electrification and zero emission technology funding and research.
Regional and local activities: • RMI SMAQMD NOx standards campaign. • City of Sacramento Electrification Ordinance adoption and support. • City of Sacramento Climate Action Workplan. • Building electrification and EV permit data and streamlining. • City of Sacramento EV Blueprint Phase II Implementation.

Risks and mitigation strategy

As was the case with our 2040 Clean Energy Plan adopted by the Board in 2018, any long-term market outlook carries significant uncertainty and there are many factors that could cause us to re-evaluate and adjust our plans by 2030. For example, a downturn in the economy may slow load growth as well as customers' willingness to invest in new technologies or programs intended to help meet our goals. Similarly, if costs for battery storage, solar PV or other emerging technologies decline faster than currently expected, there may be cause for SMUD to accelerate investments in these technologies or add them to the solutions to meet the 2030 goals.

Key risks

We have identified the following risks and developed a high-level risk mitigation strategy to that will allow for us to adapt as challenges occur.

Technology

Even proven clean technologies may experience negative impacts to performance due to factors such as the impacts from climate change on weather or other long-term changes beyond 2030 in load or customer behavior. Given this, knowing which technology will prevail in cost and performance is impossible.

Many utilities are wary of defining an inflexible strategy too soon and limiting their options. They don't want to presume the best technology before absolutely necessary. SMUD's carbon reduction goal is the most ambitious goal of any large utility in the U.S., so these considerations are of even greater importance for us. Some utilities are choosing to defer decision-making, while others approach their goals through investments in research and development but given each utility's small size relative to the market, it's difficult to have a meaningful impact. However, paralyzing indecision is also untenable and costly.

Our strategy for overcoming these hurdles is to embrace flexible planning that regularly assesses risks and opportunities, new technology advancements and applications of new business models that advance SMUD toward zero carbon.

Climate change

In recent years climate scientists have emphasized the interrelated nature of cascading and compound events, such as years of drought followed by extreme precipitation leading to excessive vegetation, wildfire and then mud slides resulting from new storms. As climate changes progress, California's already variable climate is expected to experience even greater extremes in the years to come. SMUD's infrastructure, our outdoor employees and our customers are vulnerable to these conditions, which will likely demand system hardening and other changes to adapt to shifts in electrical demand and working conditions.

As SMUD prepares to make significant additional investments in our zero carbon pathway, we must also consider how a host of new technologies and approaches to supplying electricity could be enhanced or constrained by the projected changes in the climate, both within our region and throughout the western United States. As such, each proposed investment in new technology or service delivery included in the 2030 Zero Carbon Plan must undergo customized evaluation or stress testing with consideration of the climate projections that could impact the end user and the operational conditions, performance and the life of the asset or measure.

Additional, solution-specific and location-specific climate research will be conducted as the plan is further developed. This research must encompass not only conditions anticipated in Sacramento County but in all the regions where we may source electricity, critical equipment and supplies. And we can act on new findings related to regional urban heat island[62] and

[62] https://climatereadiness.info/uhi-project/.

actually reduce ambient temperatures by investing in cool roofs, cool pavements and walls and urban greening in targeted areas.

Facilitating the awareness and incorporation of projected climate changes into SMUD's research, planning, design, operations and emergency response efforts is essential to prolong the life of our non-emitting resources, avoid additional stranded investments, increase the likelihood of new technology performance to expectations and to minimize unnecessary cost to our customers. It'll demand broader engagement throughout SMUD's management and the organization than has been the case in the past, to better connect operational knowledge with information about likely future conditions that will continue to shift over time. Implementation of the California Public Utility Commission's recent decisions[63] related to climate adaptation, which specify cross-functional and executive involvement in addition to specific data and planning criteria, will be an important step in this direction. This is also an area of great potential for collaboration throughout the region to build or evolve social and physical infrastructure that can address immediate needs and help us prepare for the future.

Regulatory

California's 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. Currently, numerous laws have been introduced to further require decarbonization of electricity. While we support these laws in general, we'll need to watch closely as new limitations are imposed and our options are restricted.

For us to reach our 2030 goal, we will continue to target programs and infrastructure supporting electric transportation and buildings. We must also be working on the leading edge of research, experimenting and deploying new technologies and customer programs. Although we anticipate regulatory changes to support electrification, this will take time to implement.

Development and land-use concerns

Our 2030 Zero Carbon Plan relies heavily on proven clean technologies to decarbonize our energy system. Currently, the most economical resources are wind and solar. These systems have large geographic footprints that require thoughtful development strategies, including alternative technologies, like rooftop solar and bioenergy. However, the local potential for other technologies is highly limited in the Sacramento region.

Economics

Solar and wind costs have steadily decreased in recent years to historic lows. These resource costs are susceptible to land value, incentive expiration (investment tax credit/production tax credit), 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.

[63] https://www.cpuc.ca.gov/climatechangeadaptation/.

Economic downturns, pandemics or factors that slow growth in regional jobs and population could change relative costs of goods and services that could warrant adjustments of our plan. Additionally, higher than forecasted market prices could create upward pressure on costs and rate projections and dampen the adoption of transportation and building electrification.

Infrastructure planning

We completed preliminary studies assessing the impact that removing all of our thermal generation during summer peak would have on the load serving capability and import capability for our transmission grid. The study results indicate that without SMUD's internal thermal generation, our capability to serve load would be reduced by approximately 1,000 MW (equivalent to 200,000 homes in the middle of summer). In addition, our capability to import power would also be reduced by approximately 200 MW (or 10,000 homes). The studies also indicate that 1,000 MW of renewable generation would need to be added to SMUD's transmission system at ***specific locations*** to return our load serving capability and import capability to the current levels.

When the 2030 Zero Carbon Plan is refined, additional studies will be performed to ensure the adequacy and reliability of SMUD's transmission and distribution systems.

Reliability

As our portfolio includes more solar resources, we'll need to account for the intra-hour variability and carry additional flexible resources. Solar resource output can widely swing due to local cloud cover and smoke, reducing output by over 60% in minutes. We must continue assessing this and developing our operating reserves structure to evaluate any needed changes.

Risk mitigation

This plan defines four flexible strategies to achieve our 2030 Zero Carbon Plan. We have chosen flexible approaches because a significant amount of work and additional analysis is needed to ensure we continue to provide safe, reliable and affordable power to our customers while advancing toward our ultimate goal of zero carbon.

There are methods for developing dynamic road maps to ensure achievement of the optimal strategy in the long run given changing circumstances. One such planning regime that avoids indecision is an adaptive road map utilizing a least-regrets decision analysis framework. These strategies allow us to use the information we know today to make the best possible decision, while considering all known unknowns, allowing for course correction and maintaining cost and reliability constraints.

To further address uncertainty and risks associated with changing regulatory framework, we have proposed a robust government affairs strategy. As part of this, we will work with regulators and policy makers to encourage flexible policies to support carbon reductions.

Flexible and adaptive strategies

Adaptive planning uses decision-tree analyses where each branch represents one possible version of the future and each decision node denotes where there are forks along the tree. This

method can provide insight into the sequencing of actions over time, potential lock-ins and path dependencies.

An adaptive plan can be thought of as a series of possible actions optimized to achieve some objective under the given scenario conditions, where there are several scenario conditions (e.g. future technology cost uncertainty) and therefore several pathways. Each possible strategy along the plan can be linked, to a certain extent, to capture strategy interdependencies and allow for changing contributions by each strategy as needed. Initially, any strategic path can be chosen, but as one moves down a selected path, moving to another path, or adapting to changing conditions outside of the particular scenario conditions optimized for, becomes more difficult.

This challenge is known as lock-in or path dependency. Typically, the more actions taken along a particular strategy, the more difficult it will become to adapt to future changes. Central to adaptive plans are tipping points, which are the conditions under which a pathway no longer meets the clearly specified objectives which trigger an evaluation and path transition. The key point of tipping points is to avoid costly ramifications from lock-in on a non-optimal path.

Least-regrets decision analysis is a method which could be used in tandem with an adaptive road map to determine decisions at each node or fork that minimize regret-costs. This method analyzes each decision along an optimal path (e.g., plant retirement or resource investments in our 2030 Zero Carbon Plan) under a set of different future trajectories to test the robustness of each decision to changing conditions. The analysis is used immediately prior to a decision being made, or in the case of a new initiative, on the first set of initial decisions required.

The first step is to determine no-regrets decisions, which are decisions made in every possible version of the future analyzed (e.g., solar investments are made in every scenario for SMUD's carbon neutrality analysis). These are decisions which can be made immediately if need be and represent little to no risk. The next step is to determine the set of initial decisions beyond the no regrets decisions and choose the option with the least-regrets costs. To calculate regrets costs, each decision, in turn, is "made" in the model and the model is run to determine possible cost impacts of this decision given uncertain futures. The decision that minimizes cost across various versions of the future is the least-regrets decision.

Board reporting schedule and check-ins

To ensure our Plan is taking advantage of technology advancements and addressing changes in market conditions, we'll conduct biannual IRP updates, which will incorporate changes needed to meet our 2030 zero carbon goal. In addition to biannual IRP updates, the Board will be updated on progress through our annual Strategic Direction reporting.

Glossary

Ancillary services: Services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the transmission system in accordance with good utility practice. The Ancillary Services include system balancing and control, frequency response, regulating reserve, contingency reserve, energy imbalance and voltage control.

Balancing Authority Area: The generation, transmission and loads within the boundaries of a balancing authority. The balancing authority is responsible for maintaining load-resource balance within this area.

Black-start capability: Capability of a generator to start up without support from external power sources, which is needed in the event of a system blackout to energize other equipment and restore the system.

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

California-Oregon Transmission Project: Transmission project connecting the Balancing Area of Northern California with the California-Oregon border trading hub.

Capacity: the maximum output an electrical generator can produce (i.e., MW)

Carbon accounting: the processes used to quantify the amount of carbon dioxide an entity (such as an organization or a country) emits.

Carbon sink: a reservoir able to accumulate and store carbon dioxide for an indefinite period of time; it absorbs more carbon than it releases

Days cash: A measure of how much cash we have on hand to pay for ongoing expenses.

Distributed energy resources: energy solutions where customers implement technology that change how they use energy. They can include, among many others, rooftop solar, energy efficiency improvements, demand response and batteries.

Energy: the amount of electricity a generator produces over a specific period of time (i.e., one hour – MWh).

Fixed charge coverage ratio: A measure of how much cash comes in each year, compared to the principal and interest payments on debt.

Frequency response reserve: The amount of the reserve that is online and can automatically respond to system frequency change.

Inertia: Physical resistance to frequency changes in the first few seconds following a system disturbance before generator frequency response kicks in. This resistance to change (typically from large rotating generators) gives automated control devices needed time to respond.

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 income: SMUD's revenues less expenses.

Operating reserves: The total capacity above the load demand required to provide regulation and to cover the load forecasting errors, planned and unplanned equipment outages and system emergencies. It includes regulating reserve, contingency reserve, frequency response reserve and other reserves that a utility decides to preserve for unexpected situations.

Planning reserve margin (PRM): Additional reserve margin for long-term planning equal to 15% of SMUD’s load.

Reliability adequacy: we have adequate grid reliability services to keep the electricity flowing. These services are sometimes referred to as ancillary services and include additional generation capacity and generator capabilities that we need to respond to sudden changes in system conditions and system disturbances, frequency response, generation and load balancing and voltage control.

Reliability: the ability of the power system to provide the services our customers expect when they want and need them, even under difficult circumstances.

Renewables Portfolio Standard (RPS): a regulatory mandate designed to increase production of energy from renewable energy sources. In California, it sets renewable energy procurement requirements for load-serving entities.

Resource adequacy: a condition in which we have acquired adequate resources to satisfy our forecasted energy needs reliably.

Short-lived climate pollutants: potent climate pollutants that have relatively short atmospheric lifetimes (relative to carbon dioxide). These pollutants include methane, hydrofluorocarbons, and anthropogenic black carbon.

Sustainable community: a community with a healthy environment, a prosperous economy, and equitable access to the multiple essential community components necessary to ensure a high quality of life including livable wage employment and training opportunities, affordable housing options, transportation and connectivity, health care access, nutrition, education opportunities, and digital access.

System adequacy: we’re capable of serving our load under extreme weather conditions and identify our system’s energy import limits.

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

Under-resourced community: these communities lack equitable access to the multiple essential community components necessary to ensure a high quality of life, including but not limited to livable wage employment and training opportunities, affordable housing options, transportation and connectivity, health care access, nutrition, education opportunities, digital access and a healthy environment.

Variable energy resource (VER): a generation resource where the output is not perfectly controllable by a transmission operator and is dependent upon a fuel resource that cannot be stored/stockpiled, and availability is uncertain. Examples include solar and wind.

Acronyms

ARRA – American Reinvestment and Recovery Act
BANC – Balancing Authority of Northern California
BYOD – bring your own device
CAISO – California Independent System Operator
CARB – California Air Resources Board
CEC – California Energy Commission
CO – carbon monoxide
CPUC – California Public Utilities Commission
CVFA – Central Valley Financing Authority
DERMS – Distributed Energy Resource Management System
DERs – distributed energy resources
DOE – Department of Energy
dth – dekatherms
E3 – Energy + Environmental Economics
EI – emission intensity
EPA – U.S. Environmental Protection Agency
EV – electric vehicles
EVSE – electric vehicle supply equipment
FEMA – Federal Emergency Management Agency
FERC – Federal Energy Regulatory Commission
FIT – feed-in-tariffs
GHG – greenhouse gas emissions
GWh – gigawatt hours
HVAC – heating, ventilation, and air conditioning
ILT – Innovation Leadership Team
IRP – Integrated Resource Plan
kV – kilovolt
kW – kilowatt
LCFS – Low Carbon Fuel Standard
LDES – long-duration energy storage
MED – Medical Equipment Discount Rate
MW – megawatt
MWh – megawatt hours
NEM – net energy metering

NERC – North American Electric Reliability Corporation
NOx – Nitrogen Oxide
O&M – operations and maintenance
PM10 – particulate matter smaller than 10 micrometers in diameter
PRM – Planning Reserve Margin
PV – photovoltaic systems
RECAP – E3's Renewable Energy Capacity model
RESOLVE – E3's Renewable Energy Solutions model
RFI – request for information
RMI – Rocky Mountain Institute
RNG – renewable natural gas
RPS – renewables portfolio standard
RS2 – Rancho Seco 2 solar project
SEPA – Smart Electric Power Alliance
SLCPs – short-lived climate pollutants
SMAQMD – Sacramento Metropolitan Air Quality Management District
SMUD – Sacramento Municipal Utility District
SOx – sulfur dioxide
SPA – Sacramento Power Authority
TBD – to be decided
TOD – time-of-day
UARP – Upper American River Project
V2G – vehicle-to-grid
VER – variable energy resource
VOC – volatile organic compounds
VPP – virtual power plant
WAPA – Western Area Power Administrator

Appendix A: Existing SMUD resources

Table 13. Description of SMUD resource capacity as expected available in July 2021[64]

Resource	Resource Type	Fuel	Nameplate Capacity (MW)	Summer Capacity (MW)
Campbell	Combined Cycle	Natural Gas	178	170
Carson	Combined Cycle, Cogen	Biogas & Natural Gas	111	103
Cosumnes	Combined Cycle	Biogas & Natural Gas	621	576
McClellan	Gas Turbine	Natural Gas	72	72
Proctor & Gamble	Combined Cycle, Cogen	Natural Gas	193	166
UARP	Hydroelectric	Water	688	675
Southfork PH	Hydroelectric	Water	2.7	1
Chili Bar	Hydroelectric	Water	8	8
Camp Far West	Hydroelectric	Water	9	3
WAPA Hydro	Hydroelectric	Water	331	328
New Hope	Dairy digester	Biomass	0.45	0.4
Kiefer Landfill	Landfill gas	Biomass	14	12
Santa Cruz Landfill	Landfill gas	Biomass	1.6	1.3
Simpson Biomass	Biogas/Biomass	Biomass	55	42
Van Steyn Dairy	Dairy digester	Biomass	0.2	0.1
Van Warmerdam Dairy	Dairy digester	Biomass	0.6	0.5
Yolo	Landfill gas	Biomass	2.7	2.4
Cal Energy	Geothermal	Geothermal	30	25.5
Patua	Geothermal/PV	Geothermal/Sun	22	11.8
Feed-In Tariff Projects	Solar PV	Sun	98	57
Rancho Seco PV	Solar PV	Sun	11	5.4
Rancho Seco II	Solar PV	Sun	160	72.4
Recurrent PV	Solar PV	Sun	60	34
Wildflower	Solar PV	Sun	13	4.7
Grady	Wind	Wind	200	31.5
High Winds	Wind	Wind	50	14.4
Solano	Wind	Wind	230	52.7

[64] Nameplate rating is the maximum simultaneous rated capacity output of the project. Summer capacity is the rated availability during the summer for thermal and hydro resources and the statistical probable output of wind and solar. Summer capacity values are representative of our resource adequacy plans for July 2021.

Appendix B: UN Sustainable Development Goals[65]

The United Nations has identified 17 sustainable development goals to transform our world on three levels: Global leaders should pursue strong leadership, more resources and smarter solutions. At the local level, they should lay the foundation for needed transitions in policies, budgets, institutions and regulatory frameworks. As for people, everyone needs to take action to generate momentum and push for necessary transformations.

The 17 sustainable development goals are:
GOAL 1: No Poverty: Economic growth must be inclusive to provide sustainable jobs and promote equality.
GOAL 2: Zero Hunger: The food and agriculture sector offer key solutions for development and is central for hunger and poverty eradication.
GOAL 3: Good Health and Well-being: Ensuring healthy lives and promoting the well-being for all at all ages is essential to sustainable development.
GOAL 4: Quality Education: Obtaining a quality education is the foundation to improving people's lives and sustainable development.
GOAL 5: Gender Equality: Gender equality is not only a fundamental human right, but a necessary foundation for a peaceful, prosperous and sustainable world
GOAL 6: Clean Water and Sanitation: Clean, accessible water for all is an essential part of the world we want to live in.
GOAL 7: Affordable and Clean Energy: Energy is central to nearly every major challenge and opportunity.
GOAL 8: Decent Work and Economic Growth: Sustainable economic growth will require societies to create the conditions that allow people to have quality jobs.
GOAL 9: Industry, Innovation and Infrastructure: Investments in infrastructure are crucial to achieving sustainable development.
GOAL 10: Reduced Inequality: To reduce inequalities, policies should be universal in principle, paying attention to the needs of disadvantaged and marginalized populations.
GOAL 11: Sustainable Cities and Communities: There needs to be a future in which cities provide opportunities for all, with access to basic services, energy, housing, transportation and more.
GOAL 12: Responsible Consumption and Production: Responsible Production and Consumption
GOAL 13: Climate Action: Climate change is a global challenge that affects everyone, everywhere.
GOAL 14: Life Below Water: Careful management of this essential global resource is a key feature of a sustainable future.
GOAL 15: Life on Land: Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss.
GOAL 16: Peace, Justice, and Strong Institutions: Access to justice for all, and building effective, accountable institutions at all levels.
GOAL 17: Partnerships to achieve the Goal: Revitalize the global partnership for sustainable development.

[65] Adopted from https://sdgs.un.org/goals

Appendix C: Innovation

As part of the process to develop our 2030 Zero Carbon Plan, SMUD asked the public, stakeholders and its staff to submit innovative ideas to help achieve our goal of zero carbon by 2030. The table below includes a list of all the ideas that were submitted and accepted after evaluation by our ILT. This list includes ideas that are incorporated into this Plan plus others that will be explored after adoption of the Plan because additional analysis and studies are needed or insufficient time to properly assess the idea before the Plan is released in March 2021.

Table 14. Ideas submitted to and considered by the ILT

Title	Idea Description
Utility-scale photovoltaic generation maximization	Maximize in-service territory utility-scale photovoltaic generation (GWh) with high density reliable solar energy coupled with battery energy storage system.
Creating small and medium business (SMB) zero carbon advocates	Many SMB customers are not willing to make the initial investment in energy efficiency and/or zero carbon technologies that have perceived long payback periods. By performing journey mapping and looking at the end-to-end value chain, we can identify opportunities that can turn SMB customers into zero carbon advocates.
"Strategically located and right sized" battery storage	Strategically placed battery storage systems on our grid can help us achieve carbon reduction goals gradually ahead of 2030. This technology is already being used by the market as evidenced by the amount of solar + storage and stand-alone storage that are being developed in the CAISO interconnection queue. Many of the technologies that will help us reach absolute zero do not exist yet or are too expensive and unproven at this point. This approach allows us to realize some of these benefits without overcommitting and putting our customers at risk of rate increases.
Hydrogen fuel cells for long-term storage[66] [67]	Create hydrogen gas through electrolysis and store in tanks when energy is cheap or when there is excess from PV. Use the hydrogen with a fuel cell to dispatch that energy when needed. This has a very long-term storage potential since the hydrogen can be stored indefinitely without degradation.

[66] *Optimizing Renewable Energy Storage With Hydrogen Fuel* Cells, BALLARD (Dec. 17, 2020), https://blog.ballard.com/renewable-energy-storage?utm_campaign=Automatic%20Blog%20Email&utm_medium=email&_hsmi=103925816&_hsenc=p2ANqtz-9oqrcEKYF9CyBTuDyIhldVtQni_MYcOI6i_O_T5qL0LGZZrc2ZHDPvaVODLrOAEoNSAsqqK4_G1qmre654BgcCuKi5XA&utm_content=103925816&utm_source=hs_email.

[67] *To batteries and beyond: With seasonal storage potential, hydrogen offers 'a different ballgame entirely'*, UTILITY DIVE (Oct. 12, 2020), https://www.utilitydive.com/news/to-batteries-and-beyond-with-seasonal-storage-potential-hydrogen-offers/584959/.

Title	Idea Description
Incentives to vendors and community partners[68] [69]	Provide incentives to SMUD vendors and community partners to join in the zero carbon effort similar to what Walmart is doing with its supply chain. This suggestion would expand on the Walmart idea to include our Community Based Organization partners.
Reform grid architecture to support aggressive zero carbon goal[70]	This idea expands on previous ideas already mentioned. SMUD could focus priorities and resources towards creating a new foundation for the distribution grid to better utilize and integrate DERs; solar, batteries, microgrids, EVs, combined heat and power, RNG, hydrogen, fuel cells, etc. The grid management system would ensure the distribution grid is balanced and fully maximized before importing or exporting power to/from the transmission grid. The bottom-up approach would also involve the community and incentivize the customer to support more DERs to reach the new zero carbon goal.
Government relationship and lobby for favorable energy policies	Actively lobbying state and federal government on energy policies that are favorable to electric utilities. Forming coalitions with other utilities to shape policies and legislations regarding DERs.
Profit-sharing with VPP aggregators[71]	It is expected that VPP will become a major supply side resource in the future grid. Given the distributed nature and potential market risk of VPPs, the operations will likely be handled by third-party aggregators. In order to balance the risk and profitability, SMUD should carefully design contracts and evaluate different profit-sharing schemes with these aggregators.
Liquid air energy storage - Highview power[72]	Liquid air energy storage is a long-duration storage technology that stores renewable energy in the form of liquid air (-196degC) and then expand that air through a turbine to re-generate electricity. The technology is very scalable (4 hours to 4 weeks).
Malta electro-thermal energy storage system[73]	Long-duration energy storage that leverages a heat pump with a chilled liquid cold reservoir and a molten salt heat reservoir. Process is reversed through a heat engine. Process sometimes referred to as a Carnot battery.

[68] *See* https://corporate.walmart.com/newsroom/2019/05/08/walmart-on-track-to-reduce-1-billion-metric-tons-of-emissions-from-global-supply-chains-by-2030 . Last accessed 22 March 2021.
[69] *The challenge of climate change*, McKinsey & Company (Dec. 11, 2020), https://www.mckinsey.com/business-functions/sustainability/our-insights/the-challenge-of-climate-change#.
[70] Lorenzo Kristov, *The Bottom-Up (R)Evolution of the Electric Power System*, IEEE Power & Energy Magazine (March 20, 2019), https://cleanpowerexchange.org/wp-content/uploads/2019/05/IEEE-PE-1903-Kristov.pdf.
[71] *See* Leslie Nemo, *New York approves utility revenue sharing for battery storage systems*, Utility Dive (Jan. 29, 2021), https://www.utilitydive.com/news/new-york-approves-utility-revenue-sharing-for-battery-storage-systems/594207/?utm_source=Sailthru&utm_medium=email&utm_campaign=Issue:%202021-02-02%20Utility%20Dive%20Storage%20%5Bissue:32234%5D&utm_term=Utility%20Dive:%20Storage.
[72] *Technology*, Highview Power, https://highviewpower.com/technology/. Last accessed 22 March 2021.
[73] *Our Solution*, Malta Inc., https://www.maltainc.com/our-solution. Last accessed 22 March 2021.

Title	Idea Description
EV managed charging (V1G)	Manage charging times or throttle the rate of charging. Managed EV charging can reduce the scale of impact and need to upgrade service transformers and eventually (with higher EV adoption) upstream distribution infrastructure such as feeders and substations which will reduce the cost exposure to broad EV adoption. Managed EV charging also can help with the consumption of excess renewable generation supply (i.e. day time solar overgeneration via workplace or at-home charging) that reduces the need to curtail renewable generation, export to the market at a discounted price or make additional investments in energy storage resources.
EV Vehicle-to-grid (V2G) and/or Vehicle-to-home	Vehicle sends electricity back to grid/home. Manage charging times or throttle the rate of charging including potential reverse power flow (discharge of the vehicle battery). V2G from a functional standpoint is a superset of V1G. V2G-enabled EVs can mimic stationary battery storage. As a result, each V2G-enabled EV offers a greater amount load flexibility than a V1G-enabled EV.
DER aggregation / Virtual Power Plant	Including use of supply side renewables. Focus on larger scale - battery and rooftops directly controlled by DERMS. VPP technology is a longer-term solution further down the road. Confirm difference between this and load flexibility.
Load flexibility	Thermostat/Water Heater. Set and forget type systems on customer side.
Carbon capture and sequestration (CCS)	Run carbon from our thermal plants through chemical process to remove carbon dioxide to pure gas/liquid form and transport and store in underground geologic formations (such as spent gas fields). Currently viable technology, but there is no place to store or off-taker for this product in Sacramento. It would be expensive to pipe somewhere else.
Power-to-gas technology (Electrolysis + hydrogen)	Long-term solution that is the hot topic across the industry. Complexities around storage, transport, infrastructure permitting and safety. Very expensive, like 10x to 16x the cost of natural gas today. One hundred percent hydrogen turbines do not exist today, but turbines that can burn up to 30-40% hydrogen exist today (mixed with natural gas).
Long-duration storage	Could be multiple technologies (pumped hydro, flow batteries, etc.)
Drop-in carbon free fuels at existing gas plants	Drop-in carbon free fuels at existing gas plants (biogas, biomethane, or biodiesel). Fuels that can be burned in our existing gas plants with little to no capital expense on the generation set. This is a near- to mid-term solution with complexity in how to transport the carbon free fuels without emitting additional carbon during transportation. Options can be expensive.

Title	Idea Description
2030 Zero Carbon Hack-a-Thon[74]	In partnership with universities (Sacramento State, UC Davis, community colleges) and/or Code for Sacramento and Women Who Code meet up groups, host a single or multi-day opportunity for the best and brightest students in our region to come together and develop technology/software solution as an idea-generating event resulting in project ideas localized to our community. Provide a purpose-driven program that could result in valuable ideas and potential innovation.
Heliogen[75]	Modular Concentrating Solar Power. New innovations in tracking technology substantially reduce commissioning and O&M costs while increasing performance. Eighty-five percent solar-only CF using molten salt storage. Formed out of Idealab with key contributions from SolarReserve and eSolar. Two projects under development, 5 MW each. Current full-scale modular size is a 5 MW plant and can add multiple to tens of multiples together. Either build locally to tap into world-class summertime DNI in Sacramento or build in Mojave and wheel power.
Bioeconomy Development Opportunity Zone (low-risk feedstock conversion)[7677]	Establish bioeconomy facilities in Opportunity Zones which will bring high-value careers to under-resourced communities. There are no bioeconomy facilities in OZs currently so these communities are not easily able to take advantage of related careers. Focus would be on low-risk feedstock (*e.g.* The Wonderful Company). Research shows great potential.
Long term "Collab-etition" with storage and traditional infrastructure manufacturers to enable a zero carbon grid[78]	The baseline assumption for this idea is that in order to reach our zero carbon goal, we will need large-scale adoption of electrification measures such as EVs & EVSE, DERS, and a customer base that has been enabled to be responsive to SMUD's ADR+ signals. To provide a grid that is capable of easily interconnecting and interacting with these technologies while maintaining high reliability scores, investments in infrastructure improvements may be necessary. Investing in energy storage is an alternative to infrastructure improvements due to capacity restraints. The primary scope of this idea is to transform SMUD's grid to be ready for the 2030 zero carbon goal and to do so with an open relationship with one storage and one "traditional" infrastructure manufacturer at the planning table and jobsites.

[74] This idea is similar to Western Washington University's Institute for Energy Studies annual Carbon Hackathon. See the following for more information. https://energy.wwu.edu/carbon-hackathon. Last accessed 22 March 2021.
[75] *See How it Works*, HELIOGEN, https://heliogen.com/. Last accessed 22 March 2021.
[76] *See* https://bdozone.org/. Last accessed 22 March 2021.
[77] Jordan Soloman, *BD Zones and BDO Zones: Driving Bio-Based Investment in Opportunity Zones*, ENVTL. AND ENERGY STUDY INST.,https://www.eesi.org/files/073020_Ecostrat_Driving_Bio-Based_Investment.pdf. Last accessed 22 March 2021.
[78] Similar to the idea published by Kristen Coyne, 4 January 2016. https://nationalmaglab.org/news-events/feature-stories/collaborate. Last accessed 24 March 2021.

Title	Idea Description
Rail energy storage[7980]	Develop a portion of private land near UARP facilities with a rail-based gravity energy storage scheme. An electrically-powered railroad would be built between a high elevation point and a low elevation point on land out of the way from public access. Rail cars of heavy weight would run unattended on this line, connected into a train. Rail cars would be equipped with motor-generator units. This rail line would be sited adjacent to and existing UARP transmission line. During times of excess generation, the train would receive energy and run uphill, consuming energy from the grid. When load is needed, the train would run downhill, contributing energy to the grid. An example site is the region between Big Hill and Union Valley Reservoir.
Biomass power at the Sierra Pacific Industries (SPI) facility in Camino[81]	Seems like the technology is improving to make these facilities more efficient and we have this massive supply of materials just outside our service territory, in the mountains surrounding Sacramento. Many of these projects may not pencil out due to cost of transporting the materials to the facility but there are other benefits of having these facilities, namely reducing the build-up up of fuels from non-merchantable wood byproducts. We have a potential location in Camino at the old SPI mill site and this could be a joint venture with them, as they own a lot of land in the area and are regularly harvesting.
Liquid metal long-Term duration storage battery – Ambri[82]	Co-founded by MIT materials chemistry professor Donald Sadoway in 2010 and part-funded to get off the ground by Bill Gates, Ambri has designed a battery that uses a liquid calcium alloy anode, molten salt electrolyte and a cathode made of solid particles of antimony. The company claims this enables a low number of steps in the cell assembly process while the materials are low-cost. Ambri also integrates the batteries into a containerized energy storage system solution of 1 MWh and up to 250 kW.
Collaboration or co-development opportunity with Sacramento-based startup, Infinium[83]	Potential collaboration or co-development opportunity with Sacramento-based startup, Infinium. About Infinium: The company is commercializing a process that uses renewable electricity to release hydrogen from water and mix the hydrogen with waste carbon dioxide to make synthetic gas.

[79] Advanced Rail Energy Storage, LLC. UTILITY SCALE ELECTRIC ENERGY STORAGE SYSTEM, Patent No.: US 8.593,012 B2.
[80] *GravityLine*, ARES, https://aresnorthamerica.com/gravityline/.
[81] *See* https://www.spi-ind.com/. Last accessed 22 March 2021.
[82] *Technology*, AMBRI INC., https://ambri.com/technology/. Last accessed 22 March 2021.
[83] *Technology*, INFINIUM, https://infiniumco.com/technology/ Last accessed 22 March 2021.

Title	Idea Description
Utility solar in high country areas	Consider installing utility-scale solar in our UARP service area. There are lots of open area, burn scar acreage from the Kings fire and other fires that have been cleared and could be potential sites. Solar panels operate more efficiently at higher elevations where it is cooler and the air quality is better. Transmission lines are in the vicinity to import power into SMUD's power grid. Roads are available for site access too.
Thermal energy grid storage	MIT[84] is working on a very high temperature long-duration storage technology that leverages Graphite Thermal Storage Units to store electricity in the form of a liquid tin working fluid. The energy is extracted using a multi-junction PV power block. The liquid tin is transferred to the power block using a patented liquid tin pump. The liquid tin is heated to >2000degF using excess renewables, and converted back to electricity using the multi-junction PV power block, which can be inserted and removed from a cavity containing the molten tin to modulate power production. The tin, when heated to these temperatures, emits a bright white light that is used to capture the stored energy. The technology makes use of common very low cost materials, aside from the small amount of multi-junction PV cells, which are readily available, making it very scalable and low-cost.
Rancho Seco industrial area use	Use the Rancho Seco site to implement and test chosen ideas and technologies. Facility siting will need to be addressed, and a site that was home to a nuclear power plant should be able to house battery banks, H2 storage and many other possible technologies. Its proximity to solar and our Cosumnes Power Plant also make Rancho Seco a favorable location.
Each change matters	Make all high capacity solar energy/battery storage auto dispatchable using EMS to better manage energy in the grid. SMUD needs to have rooftop solar control capability. Install/lease more solar plants all over the SMUD region. Thermal plant/hydro plant controller needs to be tuned further to overcome solar variation. Control EV charging as needed. Need more battery storage to overcome duck curve and smooth control of grid. Not only SMUD needs carbon FREE energy, but that needs to be manageable like any other existing generating plant.

[84] *Atomistic Simulation & Energy Research Group: Thermal Energy Grid Storage (TEGS) Concept*, MASS. INST. OF TECH., https://ase.mit.edu/projects/thermal-energy-grid-storage-tegs/. Last accessed 23 March 2021.

Title	Idea Description
Allam-Fetvedt Cycle[85] for up front carbon capture	Net Power is operating a new type of natural gas plant in LaPorte, Texas that uses the Allam-Fetvedt Cycle. The process involves burning fossil fuel with oxygen instead of air to generate electricity without emitting any carbon dioxide. Not using air also avoids generating NOx, the main atmospheric and health contaminant emitted from gas plants. This is a new, high-pressure, oxy-fuel, supercritical carbon dioxide cycle that generates low-cost electricity from fossil fuels while producing near-zero air emissions. All carbon dioxide that is generated by the cycle is produced as a high-pressure, pipeline-ready by-product for use in industrial processes, or that can be sequestered underground in tight geologic formations where it will not get out to the atmosphere for millions of years. The Allam Cycle also means the power plant is a lot smaller and can be sited in more areas than older plants can.
Concentrating Solar Power with Thermal Energy Storage. [86]	Concentrating energy storage can shift bulk generation like pumped hydro, but with lower energy losses. These technologies are complementary to battery storage however are longer duration than current battery storage installations. Dispatchable CSP enables greater penetration of inverter-based generation.

[85] *The Allam-Fetvedt Cycle*, NET POWER, https://netpower.com/technology/. Last accessed 23 March 2021.
[86] Dr. Fred Morse, President of Morse Associates, Inc,

Appendix D: Global energy decarbonization efforts

In setting a goal of reaching zero carbon by 2030, SMUD is laying out an aggressive clean energy pathway. Here's an overview of carbon reduction goals in other jurisdictions.

- **Sweden** is on an ambitious GHG reduction trajectory with a long-term climate goal that by 2045 Sweden will have net zero GHG emitted into the atmosphere and should thereafter achieve negative emissions. This translates to 2045 emissions being at least 85% lower than emissions in 1990. Sweden has already implemented several major climate measures such as the Klimatklivet initiative (the Climate Leap), the reduction obligation, a bonus-malus-system for new light vehicles, urban environment agreements and the industrial green investment aid program Industriklivet (the Industrial Leap). Moreover, within Sweden there is robust cooperation for the Fossil Free Sweden initiative across the business community, municipalities, regions, research institutions and civil society organizations. So far, 22 sectors (including some large emitting sectors like steel, mining and minerals and the automotive sector) have produced and submitted road maps for fossil-free competitiveness.[87]
- **Australia** has set a goal of reducing economy-wide GHG emissions between 26% and 28% below 2005 levels by 2030. [88] It plans to leverage $18 billion in government funds and an additional $50 billion in private investments to drive down the cost of deploying new and emerging technologies aiming for economic competitiveness with existing business models. Priority technologies are clean hydrogen, energy storage, low carbon materials (steel and aluminum), carbon capture and storage and soil carbon.
- The **European Union** (EU) has set a binding target for net domestic reduction of at least 55% by 2030 relative to 1990 levels.[89] Within the EU, fossil fuels are the largest source of GHG emissions and reforming the energy sector will play a central role in transitioning to a climate-neutral economy. It will also craft policies to improve energy efficiency such as strengthening the role of Eco-design standards and improve EU consumer access to energy efficient products. It'll also explore opportunities to review and revisit renewable energy sustainability criteria and the EU certification system for all renewable and low carbon fuels. Finally, the EU will tackle vehicle emissions by strengthening carbon dioxide standards for cars and vans, and reflecting on the phase-out target date for internal combustion engines.
- The **United Kingdom** has set an economy-wide target to reduce GHG emissions by at least 68% relative to 1990 levels by 2030.[90] The U.K.'s Climate Change Committee has recommended a comprehensive path including encouraging healthier diets with reduced consumption of beef, lamb and dairy products; extensive electrification measures; expanded use of renewable and other low carbon power generation and development of

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[87] https://unfccc.int/sites/default/files/resource/LTS1_Sweden.pdf.
[88] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Australia%20First/Australia%20NDC%20recommunication%20FINAL.PDF.
[89] https://ec.europa.eu/commission/presscorner/api/files/attachment/866232/EU%20Climate%20Target%20Plan%202030%20Key%20contributors%20and%20policy%20Tools.pdf.pdf.
[90] https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20Kingdom%20of%20Great%20Britain%20and%20Northern%20Ireland%20First/UK%20Nationally%20Determined%20Contribution.pdf.

a hydrogen economy. Notably, its transportation sector recommendations move beyond passenger vehicles and heavy-goods vehicles to include marine vessels.[91]

- **Mexico** has set its GHG reduction goal at 50% of national GHGs by 2050 below its 2000 emissions level. For its energy transition, Mexico has established policies to direct action in five important areas: the clean energy transition, energy efficiency and sustainable consumption, sustainable cities, reduction of SLCPs and sustainable agriculture and protection of natural carbon sinks. It has also identified strategies for critical crosscutting issues including the need for market-based instruments to price carbon, increased innovation, more research and development of new technologies and the need to build a climate culture with mechanisms for social and private sector participation.[92]
- **Canada** has set a mid-century strategy consistent with net emissions falling by 80% by 2050, relative to 2005 levels. To do this, Canada has noted it will require substantial effort on the part of all Canadians and that there will need to be a fundamental restructuring of multiple sectors of the economy. Cost-effective abatement opportunities will be explored for virtually every GHG source and activity. Specific to the energy sector, Canada will pursue opportunities for enhanced energy efficiency and conservation, to find cleaner ways to produce and store electricity and to switch towards non-emitting electricity or other low-GHG alternatives.[93]

In the U.S., efforts to decarbonize energy supply are largely decentralized. Most of the gains within the U.S. are attributable to state-level action and the economics of solar and wind as well as the shale boom driving new development away from coal. Large U.S. corporations are also playing a role. For example, Microsoft has committed to be carbon negative by 2050. And, in its first sustainability report, it forecasts a 6% reduction in carbon emissions during the 2020 fiscal year. Moreover, Microsoft reinforced its commitment to sustainability by announcing that progress on sustainability goals will be included as a factor in executive pay. More recently, market forces have prompted General Motors to announce it would seek to be carbon neutral by 2040, which the company hopes to achieve, in part, by aiming to make all of its light-duty vehicles (cars, pickup trucks and SUVs) electric by 2035.

Cities and municipalities are also pledging to reduce their climate impacts.

- The **City of Sacramento** has adopted a climate emergency declaration that commits the city to carbon neutrality by 2045. The Mayors' Commission on Climate Change further identifies recommended actions to achieve net zero carbon emission by 2045. The City is in the process of updating its climate action plan to reduce community-wide emissions to 40% below 1990 by 2030 and is embarking on an electrification ordinance for new construction, with all-electric construction required for low-rise in 2023 and for buildings over three-stories in 2026.
- The **County of Sacramento** has adopted a climate emergency declaration that commits the county to carbon neutrality by 2030 and is in the process of developing a community-wide climate action plan to reduce emissions.

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[91] https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf.
[92] https://unfccc.int/files/focus/long-term_strategies/application/pdf/mexico_mcs_final_cop22nov16_red.pdf.
[93] https://unfccc.int/sites/default/files/resource/Canada's%20Mid-Century%20Long-Term%20Low-GHG%20Strategy.pdf.

- The **City of Palo Alto** has a plan to reduce its emissions by 80% by 2030. The road map for achieving carbon neutrality includes strategies such as advancing smart grids, incorporating a zero waste and a circular economy, partnering with the community and maximizing use of carbon sequestration and storage in the natural environment.
- The **City of Richmond** has a climate action plan built upon community input and cross-sector collaboration, which prioritizes actions and outcomes of greatest community benefit − initiatives to improve equitable services and overall quality of life. Past initiatives included a 'green' job training program and employment opportunities for local youth, more miles of bikeways and a 10.5 MW solar facility. Looking to the future, focus areas include energy-efficient buildings and facilities, increased use and generation of renewable energy and improved sustainability of transportation and land use.
- The **City of San Diego** has committed to 100% clean energy by 2035 and has set additional targets for transportation (50% of urban commutes via transit, walking and biking), tree coverage (35% coverage throughout the city) and waste reduction (zero waste by 2040). To achieve this, the City will work to educate consumers on energy and water efficiency; improve local public health and increase local control, reducing dependencies on imported water and energy. The City has also placed job creation at the forefront indicating a commitment to setting incentive-based policies to help create green jobs, such as those manufacturing and installing solar panels.

U.S. utilities are setting carbon reduction goals too, with many placing themselves on a trajectory toward carbon neutrality or 100% carbon free electricity. Below, we've summarized what a few utilities are doing, but this list is not exhaustive. See **Error! Reference source not found.** for additional high-level information on GHG reduction goals some additional utilities and other locations around the world have set.

- **Los Angeles Department of Water and Power (LADWP)** will supply 55% renewable energy by 2025, 80% by 2036 and 100% by 2045.[94] One way it will do this is with its Intermountain Power Project, which is a two-unit 840 MW combined cycle natural gas plant that will replace a 1,800 MW coal facility.
- **Xcel Energy** has set a target of reducing GHG emissions by 80% below 2005 levels company-wide by 2030, which it'll achieve through continued fleet transition, operational changes and by employing renewable, carbon free generation and energy storage technologies.[95]
- Virginia-based **Dominion Energy** had a plan to reach net zero carbon by 2050. However, that timeline has been accelerated by Virginia's Clean Economy Act, which requires Dominion Virginia to supply at least 30% of its electricity from renewables by 2030 and by 2045, they must shut down their carbon-emitting plants.[96] It's 2020 IRP indicates that efforts will focus on renewables, including a goal of 5.1 GW of offshore wind over the next 15 years, and eliminates previous plans to build new natural gas fired power plants.[97]

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[94] https://plan.lamayor.org/targets/targets_plan.html#:~:text=By%202050%2C%20L.A.%20will%20have,our%20progress%20in%20this%20fight.
[95] https://www.xcelenergy.com/staticfiles/xe/PDF/Xcel%20Energy%20Carbon%20Report%20-%20Feb%202019.pdf
[96] https://www.greentechmedia.com/articles/read/the-5-biggest-u.s-utilities-committing-to-zero-carbon-emissions-by-mid-century.
[97] Ibid.

- In January 2020, Arizona-based utility **Arizona Public Service Electric** set a goal to provide 100% clean, carbon free electricity by 2050. It plans to achieve this by working toward a 2030 resource mix that's65% clean energy with 45% of the generation portfolio coming from renewable energy. It's also accelerated the timeline to transition away from coal, ending all coal-fired generation by 2031 − seven years ahead of previous projections.
- **Portland General Electric** aims to achieve company-wide net zero GHG emissions by 2040. It plans on reducing emissions in its own operations by ending operations at coal plants and adding more renewables like wind, solar and battery storage.[98] It also plans to reduce emissions in the energy choices provided to its customers, continuing to create new, innovative programs that offer choices for customers looking for clean, green energy options.
- As the first carbon-neutral utility in the nation, over 80% of the power delivered by **City Light (Seattle)** is generated from carbon-free hydroelectricity.[99] It does not have coal or natural gas resources in its power supply portfolio, but it does make market purchases for balancing purposes. Emissions associated with those purchases are offset by the utility's GHG neutrality policy.
- The **Hetch Hetchy Power (City and County of San Francisco)** is comprised entirely of proven clean technology resources—385 MW of hydroelectric generation capacity and 11 MW of renewables (solar, wind and biogas). It powers all of the City's municipal facilities, residents and businesses in the San Francisco Shipyard, Treasure Island as well as other retail customers—nearly 20% of the City's electricity needs.

[98] https://portlandgeneral.com/about/energy-future/climate-goals.
[99] https://www.seattle.gov/city-light/energy-and-environment

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CLARIFICATIONS TO THE 2030 ZERO CARBON PLAN

1. Study and prioritize retirement of McClellan in 2024 and Campbell in 2025
As highlighted on pages 78-79 in the 2030 Zero Carbon Plan, our preliminary analyses suggest that McClellan could be retired in 2024 and Campbell in 2025. We wish to clarify that we intend to conduct detailed reliability studies in 2021 to confirm the feasibility of retiring McClellan in 2024 and prioritize this retirement. Similarly, for Campbell, we will conduct detailed reliability studies in 2021 or 2022 to confirm feasibility of its retirement in 2025 as an additional priority and then subsequently prepare detailed plans for the decommissioning of these plants and replacement of their capacity using suitable carbon free resources.

2. Eliminate the use of fossil fuels as soon as possible but no later than 2030.
It is SMUD's intent to retire all our thermal gas fired power plants as soon as possible or repurpose these plants to utilize a clean fuel such as green hydrogen. Some of our generators may be able to burn 100 percent hydrogen with limited modifications once hydrogen becomes available at scale and a reasonable cost. Therefore, re-tooling and reinvesting in critical components of our plants may be more cost effective than full retirement and subsequent investment in brand-new clean energy technologies. Further detailed reliability studies will determine whether we will retool or retire the plants to ensure reliable and cost-effective operation of the system. If we were to retool the plants, there may be a period of time where a transition fuel such as biodiesel, biogas, or ethanol could be used until another zero carbon fuel like green hydrogen is cost effective and feasible for use with our generators. We will conduct life cycle emissions analyses of the potential clean fuels prior to committing to their use. In any case, our plan is to focus on renewables and storage to eliminate the need to run the plants for energy. This means that these re-tooled units will be used only during times when they are necessary to support reliability and keep the lights on. This will reduce their use by about 90% compared to today. For those limited hours each year when these plants are still needed, we plan to use renewable fuels such as renewable natural gas and biodiesel as transitional fuels until clean fuels such as green hydrogen become more available and more affordable.

In addition to exploring the use of clean fuels, we intend to conduct research into other new technologies that could ultimately allow us to retire some or all of our thermal fleet. We plan to study options for long duration storage, vehicle to grid technology and the use of virtual power plants. Each of these technologies has the potential to help SMUD reduce the need and use of our thermal assets. We intend to maximize the use of these types of resources once we prove they are a safe and cost-effective way to maintain reliability of the system

3. Study the potential retirement of Carson, Procter&Gamble and Cosumnes prior to executing re-tooling strategy
Prior to making any decision on whether to re-tool or retire the remaining plants, SMUD will conduct detailed reliability and economic analysis to determine all feasible, reliable

and cost-effective resources available that could reduce or eliminate the need for the plants. All feasible, reliable and cost-effective options will be pursued to both reduce our greenhouse footprint and limit our need for fossil fuel based generation resources.

4. The 2030 Zero Carbon Plan is flexible and will consider a variety of technologies

SMUD will continue to research or expand several additional zero carbon technologies beyond those specifically listed in the Plan. Among the resources to be considered are concentrating solar power, large scale thermal storage, microgrids and fuel cells. As stated in the 2030 Zero Carbon Plan, we believe flexibility is important. The Plan will be adjusted as we research or determine how these and other technologies may play a role in helping us reach zero carbon emissions without compromising reliability or affordability. In addition, as we progress with implementation the exact timing, size, location and types of resource additions we will leverage post 2025 will become more defined.

5. Maximize the value of SMUD's existing hydro facilities in the Upper American River Project (UARP).

We wish to clarify that in implementing the 2030 Zero Carbon plan, we will

- seek to optimize the operations of our hydro system to facilitate the integration of renewable resources within our service territory for both grid-scale and behind-the-meter resources
- examine opportunities to pursue additional pumped storage or similar options within the existing physical boundaries of the UARP system

6. Behind-the-meter resources and virtual net metering

SMUD has a long history of supporting rooftop solar and other distributed resources. We see rooftop solar, behind-the-meter battery storage and other distributed energy resources as important resources in our 2030 Zero Carbon Plan. As highlighted in the Plan, we expect rooftop solar resources to grow from about 240MW today to as much as 500-750MW by 2030 and behind-the-meter batteries to reach 50-250 MW by 2030. The Plan calls for piloting, proving and scaling new technologies and business models that utilize customer assets to create virtual power plants, vehicle-to-grid applications and other flexible demand resources. As these programs are developed, they will be designed to offer benefits for the customer as well as for the grid.

The tariffs at which SMUD will buy and sell power to customers with rooftop solar and storage, play an important role in customers' decisions to invest in these technologies. However, tariff design and compensation levels for these resources are handled through our normal rate setting process that includes extensive stakeholder and public outreach. In addition, SMUD intends to offer a virtual net energy metering (or VNEM) program for income-qualified customers in the next rate setting process.

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RESOLUTION NO. _____

WHEREAS, by Resolution No. 20-07-05, adopted on July 16, 2020, this Board declared a Climate Emergency, which, among other things, directed the Chief Executive Officer and General Manager (CEO & GM) to report on clear, actionable and measurable strategies and plans to reach SMUD's climate emergency goals of carbon neutrality by 2030 no later than March 31, 2021; and

WHEREAS, staff presented at the December 1, 2020, Strategic Development Committee SMUD's plan for preparing an actionable **Zero Carbon Plan** for the Board to consider by March 31, 2021; and

WHEREAS, SMUD developed a webpage, smud.org/ZeroCarbon, where interested participants could learn more about the 2030 Zero Carbon vision, sign up for notifications for Board and Board Committee meetings, review meeting recordings, and access frequently asked questions (FAQs); and

WHEREAS SMUD began extensive communication and outreach to customers, stakeholders and community members to get input into the development of the **Zero Carbon Plan**; and

WHEREAS, on December 8 and 9, 2020, SMUD held two virtual meetings for residential customers, with a total of 415 participants, and one meeting for community organizations, with a total of 82 participants, where the **2030 Zero Carbon Plan** was introduced and feedback collected; and

WHEREAS, on December 14, 15, and 16, 2020, SMUD held four virtual stakeholder meetings with 104 participants moderated by the Smart Electric Power Alliance (SEPA) for representatives from the following groups:

- ***Solar + Storage***.
- ***Environmental Organizations***.
- ***Community Organizations***.
- ***Business Leaders.***

WHEREAS, SMUD hosted an industry experts panel discussion on Visions, Solutions & Technologies for a Zero Carbon Future at the publicly noticed January 12, 2021, Strategic Development Committee meeting; and

WHEREAS, SMUD hosted an industry experts panel discussion on Distributed Energy Resources (DERs) and the Edge of the Grid at the publicly noticed January 26, 2021, Strategic Development Committee meeting; and

WHEREAS, SMUD hosted an industry experts panel discussion on Grid Scale Solutions for a Zero Carbon Future at the publicly noticed February 9, 2021, Strategic Development Committee meeting; and

WHEREAS, staff provided an informational update on the public consultation and engagement process in developing the **2030 Zero Carbon Plan** at the publicly noticed February 16, 2021, Finance and Audit Committee meeting; and

WHEREAS, on February 23, 24, and 25, 2021, SMUD held three virtual stakeholder workshops with 73 participants for representatives from the following groups to obtain feedback and input:

- ***Environmental Organizations (including Solar + Storage)***
- ***Community Organizations***
- ***Business Leaders and Key Accounts***.

WHEREAS, staff presented the draft **2030 Zero Carbon Plan** for review and feedback by Board members and public comment at the publicly noticed March 9, 2021, Strategic Development Committee; and

WHEREAS, staff released the executive summary and draft **2030 Zero Carbon Plan** on March 26, 2021, for public comment through April 16, 2021, and presented a summary of the 2030 Zero Carbon Plan at the March 31, 2021, Special SMUD Board of Directors meeting; and

WHEREAS, SMUD received and reviewed 48 public comments and nine additional comments, recommendations and questions received after release of the executive summary and draft **2030 Zero Carbon Plan** on March 26, 2021, through smud.org/ZeroCarbon and through ZeroCarbon@smud.org; and

WHEREAS, staff addressed the public comments and clarified the **2030 Zero Carbon Plan** at the April 28, 2021, Special Board of Directors meeting, as reflected in **Attachment ____**; and

WHEREAS, the **2030 Zero Carbon Plan** establishes a goal to completely eliminate carbon emissions from SMUD's power supply by 2030 without compromising affordability or reliability, and in a manner that promotes environmental justice and equity; and

WHEREAS, collaborative partnerships with SMUD's customers and community, government agencies, community leaders and organizations, businesses, policy makers, and others to leverage opportunities to achieve rapid transformative reductions in regional GHG emissions form the cornerstone of SMUD's **2030 Zero Carbon Plan**; **NOW, THEREFORE,**

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

Section 1. This Board accepts the SMUD **2030 Zero Carbon Plan** in substantially similar form as set forth in **Attachment ___** with the clarifications included on **Attachment ___**.

3