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Rachel MacDonald
Supply Analysis Office, Energy Assessments Division
California Energy Commission
1516 Ninth Street MS-20
Sacramento, CA 95814

December 23, 2020

Dear Ms. MacDonald:

Subject: Sacramento Municipal Utility District (SMUD) Energy Storage System Procurement Targets 2020 Compliance Report (Assembly Bill 2514 / Assembly Bill 2227)

Pursuant to the requirements of Assembly Bill (AB) 2514 (Skinner, Chapter 469, Statutes of 2010) and AB 2227 (Bradford, Chapter 606, Statutes of 2012), codified at Public Utilities Code sections 2835-2839 and section 9506 (collectively "AB 2514"),SMUD hereby submits the enclosed report to the California Energy Commission (CEC) regarding its energy storage system procurement targets and policies adopted by SMUD's Board of Directors.

AB 2514 requires evaluation of appropriate targets, if any, for electric utilities to procure viable and cost-effective energy storage systems. Each publicly owned electric utility (POU) governing board was required to determine appropriate energy storage procurement targets to be achieved by the utility for December 31, 2016, and December 31, 2020. AB 2514 further requires each POU to report to the CEC regarding its progress towards compliance with these energy storage procurement targets and policies by January 1, 2017 for the 2016 target and by January 1, 2021 for the 2020 target. The enclosed is SMUD's report to the CEC demonstrating compliance with energy storage system procurement targets and policies adopted by SMUD's Board of Directors to be achieved by December 31, 2020.

By Resolution No. 17-09-07 the SMUD Board adopted an energy storage system procurement target of 9 MW of behind-the-meter storage capacity to be procured no later than December 31, 2020. The enclosed Compliance Report discusses SMUD's energy storage system procurement target and policy achievements, and on-going energy storage system procurement efforts. As of December 8, SMUD had procured 8.94 MW of energy storage.

By Resolution No. 20-09-10 the SMUD Board approved on a going forward basis that energy storage forecasts be implemented through SMUD's Integrated Resource Plan process. A copy of the Resolution is also enclosed.

December 23, 2020
LEG 2020-0187

The enclosed report, in conjunction with reports previously submitted on October 28, 2014 and December 28, 2016 as supplemented on November 3, 2017, fulfills the compliance reporting requirements updated pursuant to AB 2514.

/s/

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cc: Corporate Files (LEG 2020-0187)

RESOLUTION NO. 20-09-10

WHEREAS, the State of California has declared that expanding the use of energy storage systems can reduce costs to ratepayers, reduce emissions from fossil fuel generation and enable and accelerate the implementation of more renewable generation and its integration in California's electrical system; and

WHEREAS, Assembly Bill 2514 (AB 2514) was enacted on September 20, 2010, requiring that, on or before March 1, 2012, the governing board of each local publicly owned electric utility, including SMUD, initiate a process to determine appropriate targets, if any, to procure viable and cost-effective energy storage systems to be achieved by December 31, 2016, and December 31, 2020, which the Board must re-evaluate not less than once every three years; and

WHEREAS, by Resolution 12-03-07, adopted on March 1, 2012, this Board initiated a proceeding under which staff would consider energy storage options through the Integrated Resource Planning (IRP) process; and

WHEREAS, by Resolution 14-09-02, adopted on September 4, 2014, this Board determined that all energy storage systems, except for pumped hydro storage, were not viable and cost-effective to develop by 2016, and thus did not adopt energy storage procurement targets; and

WHEREAS, by Resolution 17-09-07, adopted on September 21, 2017, this Board determined that despite a significant decline in energy storage prices, energy storage was not financially viable or cost-effective but was anticipated to become so in SMUD's service territory between 2023 and 2027, and thus adopted an energy storage

system procurement target of 9 MW to be procured no later than December 31, 2020; and

WHEREAS, recognizing that SMUD's current IRP as approved by the California Energy Commission (CEC) includes energy storage forecasts exceeding the current 9 MW target, ensuring that SMUD continues its environmental leadership, staff recommends that the ongoing evaluation of energy storage continue within the IRP rather than conducting a separate planning and approval process for set storage targets; **NOW, THEREFORE,**

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

That this Board hereby approves post-2020 energy storage forecasts and the evaluation of SMUD's energy storage determinations to be implemented through SMUD's Integrated Resource Plan (IRP) and that no separate targets will be adopted for AB 2514 beyond the required determination for December 31, 2020.

Approved: September 17, 2020

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

SMUD AB 2514

2020 Storage Procurement Final Report

An evaluation of energy storage in the Sacramento Municipal Utility District's service territory to demonstrate compliance with procurement targets and policies adopted in accordance with Assembly Bill 2514

December 21, 2020

Powering forward. Together.

SMUD®

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1 Introduction

1.1 Background

In 2010, AB 2514 enacted statutes requiring IOUs to procure 1325 MW of energy storage by 2020 and POUs to individually determine appropriate cost-effective energy storage procurement targets, if any, for December 31, 2016 and December 31, 2020. In response to AB 2514, the SMUD Board of Directors determined a target of 0 MW by December 31, 2016 to be appropriate due to the lack of cost effectiveness of battery energy storage options, and in consideration of the Iowa Hill project, which had the potential of 400 MW/6,400 MWh storage resources available. On December 28, 2016, SMUD submitted a report to the California Energy Commission (CEC) demonstrating compliance with that target.

In 2017, the SMUD Board of Directors approved a 9 MW storage target to be achieved by December 31, 2020. The 9 MW target was reported to the CEC with guidelines that the implementation of this target would be executed in the best interest of SMUD's customer-owners, pursuant to a cost-effective implementation plan.

The 9 MW target determination was based on SMUD's investigation of various energy storage technologies. Prices of battery storage systems had declined between 2014 and 2017 making this technology more affordable, but not necessarily cost-effective. These cost reductions, along with significant state incentives through the Self Generation Incentive Program (SGIP), and the inclusion of energy storage in the federal investment tax credit, created an environment supportive of new business models leveraging storage technologies. SMUD is expecting various applications for battery technologies to become cost-effective without these incentives on a five-year time horizon.

1.2 2020 Storage Compliance

With the approval of the 2020 energy storage target and policies, SMUD launched pilot programs for residential, commercial, and industrial battery and thermal energy storage applications and procured its first utility-scale battery. In addition to pilot programs and utility-scale storage, SMUD pursued advanced research in energy storage, including demonstrations in commercial settings integrated with complimentary distributed energy resources. The 2018-2020 plan emphasized the work needed to prepare SMUD for strategic readiness as energy storage systems become more prevalent in the market.

As of December 8, 2020, SMUD has procured 8.94 MW toward its 9 MW determination. SMUD's objective was to procure energy storage in a cost-effective manner and in the best interest of SMUD's customers. With this objective in mind, SMUD made the strategic decision to proceed with the incentive levels designed to benefit both participants and non-participants rather than increasing incentives, which would have disproportionally favored participants. Table 1 shows SMUD energy storage procurement totals by application.

Initial uptake in SMUD's residential pilot programs has been positive. The commercial and industrial markets have seen increasing interest in energy storage, but uptake has been slower than originally planned, and SMUD expects this trend to continue through the next year due to COVID-19 and subsequent impact to the economy.

Pilot Programs & Demonstrations	Planned Target (MW)	Cumulative 2020 Procurement (MW)
Residential Battery Energy Storage Pilots	Up to 3 MW	2.82
Commercial & Industrial Energy Storage Pilots & Demonstration	Up to 1 MW	1.00
Residential New Construction Pilot	Up to 3 MW	0.06
Utility-Scale Battery (Hedge)	Up to 2 MW	4.40
Residential Controllable Heat Pump Water Heaters- Retrofit Pilot	Up to .5 MW	0.05
R&D Storage Projects	Up to .3 MW	0.61
Total:	**9 MW**	**8.94 MW**

Table 1: Energy storage procurement by market segment

2 Energy Storage Pilot Programs & Demonstrations

SMUD's portfolio of energy storage pilot programs is focused on aligning customer behind-the-meter-benefits with grid needs through research in the residential, commercial, and industrial sectors. As storage is not yet cost effective, the goal was to research energy storage solutions procured by early adopters to understand usage, technical capabilities, utility impact, and the market potential for various energy storage products. Findings from this research will allow SMUD to improve program design and develop new programs to position SMUD as the trusted advisor for our customers as storage adoption rates increase.

Since 2018, SMUD developed and implemented five battery storage pilot programs, designed a dispatchable thermal energy storage demonstration on SMUD's campus, and initiated a utility-scale battery installation. The energy storage pilots and demonstrations that were deployed during this compliance period are described below, all of which are currently active as of the date of this report. The descriptions reflect the pilots and demonstrations as they were designed and deployed during the compliance period.

2.1 Residential Pilot Programs

2.1.1 Commitment to Operate (CTO)

The CTO pilot program incentivizes customers to use their battery systems to shift renewable generation, when paired with solar, from midday to the evening on-peak period to avoid more costly energy consumption. CTO participants operate 51% of their battery capacity to meet electrical needs during peak periods leaving 49% battery capacity available for back-up power needs. Customers who install battery storage and agree to operate the system according to program guidelines are eligible to receive a one-time $300 incentive for systems sized between 1-10 kW or a $600 incentive for systems sized 10.1 kW and above. Customers and installers utilize SMUD's interconnection portal and configure their battery system to provide savings on their monthly electricity bill. The CTO pilot program, which

started in July 2018, has achieved 380 enrollments, which represents an 85% enrollment rate of all eligible installed systems in SMUD's service territory[1].

2.1.2 Smart Energy Optimizer (SEO)

The SEO pilot program enhances the value of residential battery systems for customers and the electrical grid by shifting battery operation as dispatched by SMUD. For up to 120 days of the year, SMUD sends a signal to the battery systems to discharge the batteries during the periods of highest grid need. In exchange, participating customers receive additional incentives beyond what is offered in CTO. On the remaining 245 days of the year, customers still receive anticipated bill savings from the battery by shifting renewable energy to the on-peak period as in the CTO program. Customers receive a one-time incentive based on system size and current CTO enrollment status. Additionally, SEO participants receive a monthly on-bill credit for participation. Customers who upgrade from CTO to SEO receive a smaller upfront incentive to ensure that when combined with the initial CTO incentive their total upfront incentives are equal based on system size. These incentives are summarized in Table 2.

Battery Size	One-Time Incentive		Monthly Bill Credit
	Current CTO Participant	Non-CTO Participant	
1-10 kW	$200	$500	$10 per month
10.1+ kW	$400	$1,000	$20 per month

Table 2: Smart Energy Optimizer Incentive Levels

Only customers who installed SolarEdge StorEdge battery systems (SolarEdge inverter) are eligible to participate in the initial launch of the SEO program because of compatibility with the pilot visibility and control requirements. The SEO pilot program, which rolled out in December 2019, has achieved 18 enrollments, which represents a 24% enrollment rate[1].

2.1.3 PowerMinder – Residential Thermal Energy Storage

PowerMinder operates much like SEO in many ways. On up to 120 days of the year, SMUD sends a signal to residential controllable heat pump water heaters (CHPWH) to pre-heat based on a pre-determined, SMUD-controlled schedule. On the remaining 245 days of the year, devices are optimized to SMUD's Time-of-Day rate. Customers must have installed a thermostatic mixing valve with their CHPWH to qualify for the pilot program. Customers receive a one-time enrollment incentive of $150 and an ongoing monthly incentive of $2 for participation in events. There are currently 97 customers enrolled in the program.

2.2 Commercial and Industrial Pilot Programs

2.2.1 Commercial and Industrial Commitment to Operate Pilot Program

This pilot program provides a one-time incentive up to $5,000 for eligible commercial customers to operate their battery system in a way that reduces electricity costs for the customer and contributes to lower cost operation of the grid. Participants in the commercial CTO program agree to prioritize discharge of up to 51% of their battery during the on-peak period and recharge using either renewable energy or grid energy during off peak periods. To date one commercial customer has enrolled in CTO,

[1] Enrollments as of December 8, 2020

pairing their battery with an electric vehicle charging depot. The local commercial storage market is expected to grow in 2021 due to SMUD's commercial rate restructure, approved by the SMUD Board of Directors in 2018, which will be implemented over the next 7 years.

2.2.2 Energy StorageShares

SMUD's innovative Energy StorageShares program allows commercial customers to maximize the benefit from their investment in energy storage while also increasing the overall benefits energy storage can provide to the electrical grid. In this first-of-a-kind program, eligible commercial customers are given the option to make an up-front investment into the StorageShares program instead of installing a battery behind-the-meter at their business. In exchange for the investment into the program, participants receive shares which provide 1 kW of demand charge reduction savings per share that is provided as a monthly credit on the customer's bill for a 10-year term. The demand savings from a share represents the savings an on-site battery would have provided for demand charge reduction. SMUD bundled the investments from the program participants with our own capital and procured a battery in a location that will increase overall grid benefits. The program provides guaranteed savings to the customer without impacting their business operations, maintenance obligations or requiring physical space at their business for a battery system while also deploying energy storage to optimal locations on the grid. Share prices in 2020 range from $475 to $520 per share depending on a customer's rate class.

Commercial customers interested in Energy StorageShares are bound by the following criterium:

a. Customers must actively be considering the adoption of energy storage for demand charge reduction.
b. Customer share acquisition is limited to no more than 50% of the customer's peak demand within the most recent 12 months (example: a customer with a maximum demand in the last 12 months of 500kW was eligible for no more than 250 shares).
c. Customers participating in Energy StorageShares cannot install on-site energy storage to obtain further demand charge reduction. This provision is required to ensure that the customer does not double-dip' on demand charge reduction savings.

StorageShares enrollments were not included in the cumulative energy storage procurement total reported; however, the utility-scale Hedge Battery installation that serves as the primary asset for the StorageShares program was included in the procurement total.

2.2.3 Hedge Battery

SMUD's first utility-scale battery system was procured in 2020 and will be installed and commissioned in 2021. The 4.4 MW/8.8 MWh utility-scale battery will be located adjacent to SMUD's Power Academy at the solar array near the Hedge substation.

This battery will provide 4,400 shares for the Energy StorageShares program. The battery, using the MESA-ESS open standard, is expected to be used for distribution infrastructure deferral, energy market participation, and workforce development in support of SMUD's Sustainable Communities initiative. SMUD has contracted with Mitsubishi Electric Power Products, Inc. (MEPPI) to engineer, procure, and construct the battery energy storage system, as well as provide SMUD with five years of monitoring and maintenance. Construction is planned for May 2021 and the system is scheduled to be operational in September 2021.

2.2.4 Thermal Energy Storage (TES) Demonstration

SMUD upgraded the existing control system at the SMUD Central Plant on the Headquarters campus to demonstrate the potential grid benefits and load shifting capability of the TES system. This demonstration is testing the ability to automatically adjust the TES charging schedule to reduce operation costs while still serving the campus cooling load. Testing will continue through June 2021 and will evaluate the ability to optimize TES charging by automating dynamic scheduling. By installing additional functionality to the existing energy management system, charging times are optimized to wholesale prices, rather than retail rates. This research will help SMUD to develop future TES programs for our commercial and industrial customers.

2.3 On-Going Energy Storage Research and Development

On July 16, 2020, the SMUD Board of Directors adopted a climate emergency declaration that commits to working toward an ambitious goal of delivering carbon neutral electricity by 2030. The declaration recognizes the immediate risks to our community and demands bold action to achieve results. As a result, SMUD expects battery storage to play an important role as SMUD develops the plan to reach this ambitious goal.

To support these plans, significant on-going research and development will continue to advance energy storage for SMUD and our customers. SMUD realizes the need to explore potential benefits of energy storage in the near- and long-term future. To meet this need, SMUD is exploring potential projects which include:

- Expansion of SMUD's behind-the-meter battery and thermal storage program offerings
- Integration of storage with a broad set of Distributed Energy Resources (DERs) through SMUD's Distributed Energy Resources Management System (DERMS) for operational implementation of utility use cases. The DERMS will provide Grid Operations, Distribution Operations, and Energy Trading access to dispatch controllable DERs.
- Investigation of long duration storage solutions as part of SMUD's resource mix
- Exploration of utility-scale battery storage as part of future utility-scale solar developments
- Storage-related white glove services SMUD can provide for residential and commercial customers
- Exploration of microgrids and other solutions that increase resiliency
- Developing energy storage fire and safety prevention standards

3 Strategic Readiness

Battery energy storage remains a nascent industry, however adoption rates for both behind-the-meter and front-of-the-meter systems continue to steadily rise. Despite the current economic barriers that exist today, there is a clear growing interest and desire for energy storage. SMUD expects that the adoption of battery energy storage will accelerate considerably in the coming years and significant technology proliferation will occur once the investment becomes fully cost effective.

The addition of significant amounts of energy storage has the potential to create meaningful grid benefits while also providing savings to individual customers. For SMUD to enable these co-benefits it is important that SMUD is well positioned to provide a seamless customer experience for interconnection and program participation for energy storage. Building the foundation for that customer engagement

and technology integration with grid planning and operating systems cannot wait until after technology proliferation occurs.

In 2017-2020, SMUD focused on this strategic readiness by investing in several energy storage pilot programs, updating the interconnection system to fully integrate energy storage and advancing control systems intended to dispatch aggregated fleets of energy storage systems. Looking forward, this phase of strategic readiness will give way to business integration and eventually transition into full cost-effective operation. The long-term vision is to fully operationalize energy storage so that it is considered side-by-side with any other grid investments.

3.1 Interconnection Process

SMUD's existing interconnection process for distributed generation was updated to integrate commercial and residential battery storage program offerings. Existing Electric Service Requirements (ESRs) were also amended to support interconnection for storage systems. The refreshed interconnection application enables a dynamic interaction for installers, utilizing new software features and configurations to automate program options based on technology and other eligibility factors. Installers can directly enroll customers into battery storage programs and incentives at the time of interconnection application submittal. This enables installers to actively engage with customers about SMUD incentives before sales contracts are executed, offer instant rebates, and partner with SMUD to deliver exceptional customer experiences. SMUD was able to capture more program enrollments by partnering with installers at the time of interconnection application submittal than it would have otherwise.

4 Visibility and Control of Batteries

4.1 Price Communication – Initial Approach for Behind-the-Meter DER

The SEO pilot program was designed to test utility visibility and control of residential batteries. The goal was to understand how customers use their batteries, and for SMUD to dispatch the batteries to balance customer and utility utilization. With approximately 1/3 of the residential batteries in the SMUD service area having SolarEdge StorEdge inverters, SMUD partnered with SolarEdge to modify their monitoring platform to provide visibility and control for the SEO participants.

The program was designed to be able to dispatch the program participants' batteries up to 120 days of the year. For pilot purposes, a simple mechanism for battery dispatch was chosen. Day-ahead pricing was used as a dispatch signal, however it was used only as an indicator of market pricing to inform battery operation. SolarEdge was left to make energy cost arbitrage decisions for battery charge and discharge on event days. For simplicity, customers were billed at their standard Time-of-Day rate and were compensated with the recurring bill credits in exchange for allowing SolarEdge to optimize battery operation to day-ahead supply side energy costs.

Day-ahead energy costs were estimated using data from the CAISO markets as a proxy[2]. Event days were communicated to SolarEdge by SMUD based on day-ahead arbitrage opportunity; that is the difference in energy cost between the most expensive and least expensive hours. Although several popular open communication standards support pricing such as IEEE 2030.5, OpenADR, and CTA 2045, the costs of compliance and certification to those standards can be prohibitively high. As a result, SMUD developed the Simple Price API to communicate price signals and event calls as a common language that all aggregators can understand.

4.2 DERMS – Supporting Broad Use Cases for All DER

In 2018, SMUD awarded a contract for an Advanced Distribution Management System (ADMS) and Distributed Energy Resource Management System (DERMS) to Open Systems International (OSI). The implementation timeline, as planned, is for the ADMS to be online in 2021 and the DERMS to be online in 2022. The DERMS will coordinate small DER using aggregator(s) or directly with the device in the case of large SCADA-connected DER. Once available, SMUD will use DERMS to dispatch and enable visibility of the residential behind-the-meter batteries in the SEO program and water heaters in the PowerMinder program through 3rd party aggregators. The utility-scale battery, located near the Hedge substation, will be dispatched directly by SMUD. The DERMS will utilize open protocols such as OpenADR 2.0b, CSIP implementation of IEEE 2030.5, and DNP3 using the MESA-ESS information model. This development effort is currently in progress. The DERMS will enable broader and more sophisticated grid and economic use cases with storage systems.

4.3 Grid Planning and Load Forecasting

Adoption of energy storage is beginning to ramp up and significant adoption is expected in the coming years. The total amount of behind-the-meter energy storage installed today is not yet sufficient to have a meaningful impact on grid operations. Although the capacity of storage installed is relatively low,

[2] The day ahead energy costs were derived from the connected California ISO NP15 nodal price plus a volumetric fixed cost adder. This dispatch process was optimized based on supply side energy costs and as a result other utility benefits such as peak reduction to reduce resource adequacy obligations and carbon avoidance were dependent on correlation with day-ahead energy costs. This simplified approach avoids the complexity of having to be embedded with process flows and tools used by Energy Trading and Grid Operations with the intention for such investments to be guided by this pilot. Despite its simplicity, this model still allows for evaluation of the effectiveness of utility dispatch and comparison of customer vs. utility benefit.

SMUD has continued to push the consideration and evaluation of storage into standard planning processes. The inclusion of storage into processes such as grid planning, integrated resource planning and annual load forecasting allows energy storage to be considered side-by-side with traditional grid solutions. By assessing energy storage as part of normal business operations, we can ensure that as storage becomes cost competitive with other resources it will be incorporated as appropriate within SMUD's total resource mix.

5 Market Conditions

Energy storage offers two primary values to customers: back-up power in the event of a grid outage and economic optimization. Residential and commercial customers can benefit from energy arbitrage and some commercial customers also benefit from demand charge reduction. Behind-the-meter batteries also have the potential to create grid benefits including peak reduction and wholesale price optimization. In the future we anticipate there may be many additional benefits that behind-the-meter batteries will be able to provide. These benefits will be enabled to advanced control capability provided by a utility operated DERMS and partnerships with customers. For the utility, energy storage is different than many other customer-owned DERs since one of the primary applications of a battery is financial optimization. There is not a conflict with an alternate operating mode such as maintaining a comfortable in-home temperature or desired level of hot water. Capacity from a battery system can be more reliably available because it is less impacted by customer preference.

The future benefits available to behind-the-meter energy storage will improve the overall economics for customers buying those systems, but given the current cost of energy storage these investments are not yet cost effective.

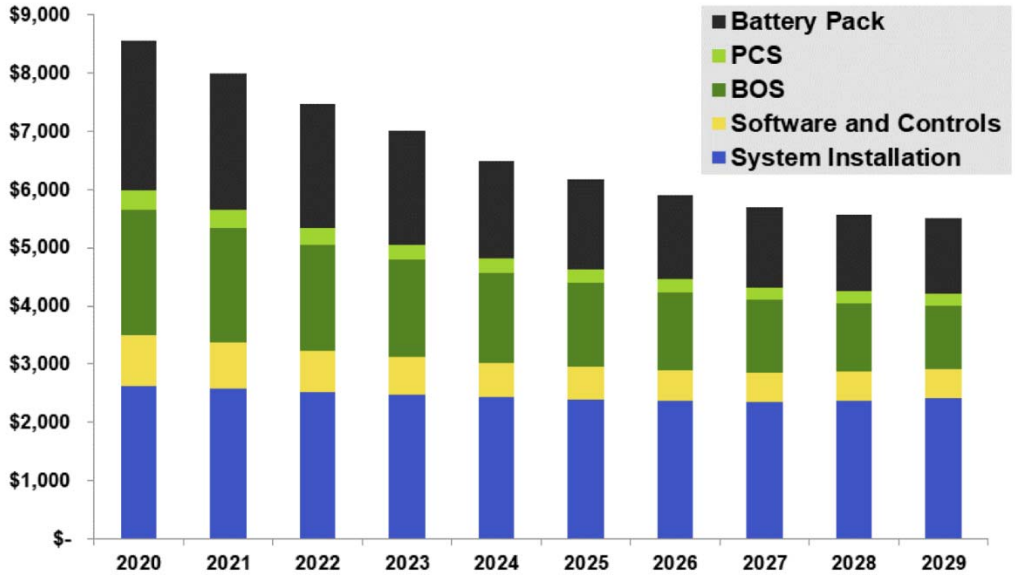

Chart 1: Residential Li-Ion Battery System Pricing, 5 kW/12 kWh System, US, Base Case: 2020-2029

Legend: PCS- Power Conversion System (Inverter), BOS- Balance of System

According to price forecasts from Guidehouse Insights, as shown above in Chart 1[3], the cost of a 5kW residential energy storage system was between $8,000 and $9,000 in 2020. SMUD's Time-of-Day rates in 2020 would have provided an approximate benefit of $225 of customer savings. The current benefits from storage are insufficient to repay the cost of the battery before the battery system reaches end of life. To achieve cost effectiveness storage prices will need to continue to decline and access to additional revenue streams through utility partnerships will be needed.

6 Conclusion

SMUD's development of these pilot programs and supporting processes allowed SMUD to focus on strategic readiness and integration of energy storage with SMUD's normal business practices to ensure preparedness to scale up battery storage when the time is right. Once cost parity is reached with competing resources and SMUD begins experiencing significant growth in the interconnection of energy storage on SMUD's grid, the focus will shift from strategic readiness to cost effective adoption of storage.

Given the Board of Directors climate emergency declaration and SMUD's goal to decarbonize the energy supply, battery storage is expected to play a critical role as SMUD develops the plan to reach this ambitious goal. Processes and pilot programs initiated by SMUD to reach the 9MW target by the end of 2020 established the foundation for energy storage to be considered as part of SMUD's larger decarbonization efforts.

[3] This chart is reprinted from Research Report Market Data: Energy Storage Pricing Trends, published Q2 2020, with the permission of Guidehouse Insights. Its use is intended only for the purpose of this report and should not be used or reproduced for any other purpose.