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SMUD AB 2514
2017 Storage Procurement Final Report

An evaluation of energy storage in the Sacramento Municipal Utility District's service territory to establish a procurement target in accordance with Assembly Bill 2514

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SMUD AB 2514
2017 Storage Procurement Report

Energy Storage Procurement Target Statement

In response to Assembly Bill (AB) 2514 the Sacramento Municipal Utility District (SMUD) Board of Directors has re-evaluated their September 4, 2014 decision not to establish an energy storage procurement target. On September 21, 2017, the SMUD Board of Directors adopted a target of 9 MW of energy storage to be procured by December 31, 2020 in the Sacramento Municipal Utility District service territory. SMUD expects to meet roughly 80% of the target with battery energy storage systems and 20% with thermal energy storage systems. All 9 MW are currently planned behind-the-meter with approximately 80% as residential and 20% as commercial and industrial installations.

This report describes the background and analysis conducted to establish the adopted procurement target, as well as the anticipated implementation strategy for achieving the target based on the best information currently available. The implementation of the energy storage target will be executed in the best interest of SMUD's customer-owners, pursuant to a cost-effective implementation plan. SMUD's implementation plan will be updated as new information becomes available and as early projects inform business and technical plans for implementation.

Introduction

Background

In 2010, the California Legislature passed into law AB 2514, which launched a program for procurement of "viable and cost-effective" energy storage by the State's electric utilities. AB 2514 required the California Public Utilities Commission (CPUC) to determine appropriate storage targets, if any, for the IOUs. The CPUC required the IOUs to procure various amounts of energy storage capacity during the first procurement period ending December 31, 2016. The law also required large POUs to determine appropriate targets for the first procurement period by October 1, 2014.

On September 4, 2014, the SMUD Board of Directors approved the staff recommendation not to adopt energy storage targets. This decision was based upon a significant body of research SMUD staff had conducted that found the storage technologies and applications available were not expected to be viable and cost-effective for SMUD and our customers by 2016. Additionally, a 400 MW/6,400 MWh pumped hydro storage project at Iowa Hill was under serious consideration and, if built, would have further rendered additional energy storage an unnecessary asset.

AB 2514, as amended, also requires the governing boards of POUs to reevaluate prior determinations of storage targets every three years. Thus, SMUD's Board of Directors has reviewed SMUD's 2014 decision and updated in the manner described in this report.

Since the Board's 2014 decision, SMUD staff has investigated various applications of energy storage technologies to advise the Board which, if any, have become viable and cost effective for our ratepayers. Prices of battery storage systems have declined significantly over the last three years, making this technology more affordable but not quite cost-effective at the present time. However, these cost reductions, along with significant state incentives through the Self Generation Incentive Program and the inclusion of energy storage in the federal investment tax credit, are creating an environment that is supportive of new business models leveraging storage technologies. SMUD expects various applications of battery technologies to become cost-effective without these incentives in the five to seven year time horizon.

Energy Storage Status at SMUD

After many years of study and careful evaluation, SMUD has decided not to proceed with the proposed Iowa Hill pumped storage project, due to cost, financial risk and changes in the electric utility business. An updated cost-benefit analysis has led SMUD to conclude that, over the long term, other energy-storage technologies may provide more economical options for reducing peak demand, meeting our renewable-energy goals and reducing carbon emissions.

Throughout the Iowa Hill evaluation process SMUD has continued to investigate and test new technologies to identify cost effective energy storage products that meet the best interests of SMUD's ratepayers and of the environment. As industry leaders in research and development (R&D) of energy innovations, SMUD strives to achieve our vision to empower our customers with solutions and options that increase energy efficiency, protect the environment, reduce global warming, maintain high system reliability, and reduce the cost of serving our region.

SMUD is dedicated to identifying best-fit solutions for customers that optimize individual customer choice and benefits across the customer base. SMUD's energy storage program includes research in thermal, mechanical and electrical energy storage systems. Through these efforts SMUD is working to facilitate the transition of emerging technologies into full market ready utility products that will reduce energy costs, manage peak demand and participate in the growing number of evolving energy markets. The energy storage program is integrated with key planning and implementation departments to ensure the storage strategy is closely aligned with each business unit's vision and strategy. The program coordinates with SMUD's Legal and Legislative groups to ensure alignment with State policies and mandates.

Establishing a 2020 Energy Storage Procurement Target

SMUD's energy storage program has focused on storage as an emerging technology within the Research and Development department, with the exception of our large pumped hydro resources and a nominal amount of commercially deployed thermal energy storage projects. In preparation for the re-evaluation of SMUD's procurement targets, a cross-functional team conducted a four step evaluation addressing SMUD's ability to integrate energy storage into our standard business practices.

- Step 1: As-Is Assessment
    - Review existing body of primary research and determine technology readiness
    - Conduct storage benchmarking study of utility systems and 3rd party ESS providers
- Step 2: Systems Integration Strategy
    - Determine SMUD's visibility and control options for energy storage today
    - Review SMUD's advanced distribution management system roadmap and establish opportunities for storage integration
- Step 3: Economic Analysis
    - Analyze potential distribution planning deferral opportunities
    - Identify viable business models for future deployments
    - Assess ability to realize modeled economic benefits
- Step 4: Integrated Resource Planning Analysis
    - Determine reliability needs for storage
    - Assess economic benefit of incorporating storage into the IRP

This body of analysis indicated that the lack present-day economic drivers cannot be the sole driver of SMUD's energy storage future. While present-day cost-effectiveness is a critical consideration for SMUD, the long-term impacts of SMUD's storage strategy will help to realize California's zero net energy goals, soften the effects of large scale electric vehicle adoption, increase grid resiliency while concurrently increasing the penetration of renewables, and most importantly, it will help to ensure SMUD's preparedness for behind-the-meter customer uptake of energy storage in an evolving electric utility paradigm. Based on the analysis summarized in the following sections, SMUD has selected a target that balances the financial sensitivities of current storage economics with our desire for agility and longer-term market preparedness.

Step 1: As-Is Assessment

Existing Storage Installations

An overview of SMUD's energy storage research efforts can be found in our previous submittals[1] to the California Energy Commission. SMUD's established history of investing in energy storage research has provided valuable first-hand empirical data regarding the marked improvement in reliability and performance in energy storage systems and controls. Our field research projects have demonstrated promise in storage technology, but results also indicated system performance reliability, capacity availability and stable communication remain as obstacles.

With advancements in both battery system and controls technology, system integrators have demonstrated success in energy storage deployments nationally, including examples in SMUD territory in the past three years. Our commercial deployment of a 36 kW/72 kWh battery at Whole Foods has proven reliable and is performing to meet the customer's energy management expectations. We've also benefitted from a successful implementation of 34 residential systems at our 2500 R Street project, which demonstrated a smart community including battery storage, solar, demand response, time-variant pricing, and deep energy efficiency. Results from our recent primary research indicate that the storage industry has achieved technical readiness for many behind the meter applications, which will further stimulate market adoption.

Benchmarking Study

To better understand developments outside of SMUD's direct experience, SMUD commissioned a benchmarking study conducted by Black & Veatch to assist in our assessment of best practices from across the United States. The study scanned four different energy storage markets that represent a reasonable diversity of projects by some of the most active entities in the field: California, New York, Arizona, and Hawaii.

The report[2] draws the following conclusions when comparing SMUD to each of the four respective markets and assessing how each market's projects are relevant to SMUD.

- A ten year procurement goal between 50 and 100 MW would fall within the peer average when normalized for load..
- Current installations of energy storage in SMUD territory meet peer average when normalized for load.
- Most utilities are considering a diverse set of storage projects across their portfolios. SMUD's long-term energy storage strategy proposes similar goals.
- SMUD meets peer average for amounts of pilot projects installed.

[1] "SMUD AB 2514 Storage Procurement Report" (August 29, 2014) and "Energy Storage Compliance Report of the Sacramento Municipal Utility District (December 28, 2016)
[2] "SMUD Energy Storage Benchmark Assessment", Black and Veatch (June 20, 2017)

- Like SMUD, many utilities are still determining interconnection and integration plans for energy storage projects, especially behind-the-meter.
- SMUD does not have the same key drivers as peer utilities, resulting in fewer installations compared to other utilities with a greater number of drivers.
- Of the regions outside of California that were studied, Hawaii has the closest environment to California relative to drivers and conditions; however, unique conditions related to the islanded grids in Hawaii provide stronger economic drivers.

The benchmark study indicated that SMUD is on par with peer utilities when normalized for load, but a more interesting observation is the significant focus in California on utility-scale storage systems with less emphasis on behind-the meter storage systems.

In light of this finding, we identified a clear opportunity to take an innovative step forward by focusing on behind-the-meter storage solutions. The behind-the-meter market is rich in shared value potential that we see as currently under-addressed yet a viable, long-term business relationship across a range of storage technologies: batteries, controllable heat pump water heaters, and commercial thermal energy storage systems.

Energy Storage Drivers Impacting Goals

On October 21, 2013, the CPUC issued Decision D.13-10-040 requiring PG&E, SCE, and SDG&E, to install a combined total of 1,325 MW (~3-3.5% of peak load) of electricity storage projects by 2024 across each of the transmission, distribution and customer grid domains. In 2014, Los Angeles Department of Water and Power (LADWP) adopted a self-directed total target of 179 MW, approximately 2.9% of peak load. The investor owned utilities and LADWP targets are heavily weighted toward utility scale storage installations with 16%-24% planned behind the meter.

As detailed later in Table 3 of this report, the proposed 2026 SMUD procurement target of 75 MW is equivalent to approximately 2.4% of SMUD's peak load and is very similar in range to the other California utilities' targets when adjusted for peak. Staff carefully considered SMUD's circumstances in comparison to our peers when establishing the recommended target. While we recognize the long term value of energy storage for SMUD customers, the near term value proposition is less compelling for SMUD customers than it is for our California peers.

- With SMUD's large hydroelectric power source, we have adequate flexibility to manage current and expected intermittent resources on our system.
- Southern California utilities are faced with significant capacity challenges as a result of the Aliso Canyon gas leak and the retirement of the San Onofre Nuclear Generating Station. The Sacramento region does not face comparable capacity challenges.

- Rate structures and underlying load profiles that drive costs vary significantly by utility. SMUD's rates don't lend themselves to reasonable payback periods with today's energy storage prices for customers seeking rate arbitrage and demand management.
- Net Energy Metering rate design is currently underway for California IOUs with the proposed peak periods making a considerable shift from the previous NEM rates. If approved, the value of solar for IOU customers will be significantly impacted creating an opportune segment for battery storage adoption.

Despite the lack of immediate drivers for energy storage in SMUD territory, we recognize the value in investing in planning and development for the future energy grid and evolving customer expectations. As such we sought to select a target that seeks to achieve balance between strategic readiness and financial investment. While SMUD is keeping in line with the storage procurement trajectory of our California peers, a significant distinction of SMUD's target is the notable emphasis in development of behind-the-meter customer programs with 68% of the target focused on customer installations. We believe this approach will prepare SMUD to be agile when the storage market gains momentum and enable us to provide our customers with storage solutions that have been tested and vetted prior to scaling.

Step 2: Systems Integration Strategy

Interconnection

The interconnection of energy storage involves consideration of storage as both generation and load. When operated in parallel with the distribution system, battery energy storage systems are treated as an inverter-based generator similar to solar photovoltaic. Both battery energy storage and load shifting storage, such as thermal energy storage, also have the capability of behaving as a load. Typically behind the meter energy storage installations are not large enough that they have a significant impact as a load on the distribution system.

SMUD customers and their contractors are able to conveniently apply for interconnection with SMUD using the SMUD PowerClerk 2 website. Solar interconnection applications typically have just a one week turnaround. Storage interconnection applications currently take longer, although this time is expected to reduce as contractors become more familiar with the technology and interconnection processes, resulting in a streamlined process similar to solar. Interconnection review is performed for the hardware configuration provided in the application.

Grid Modernization for Storage Integration

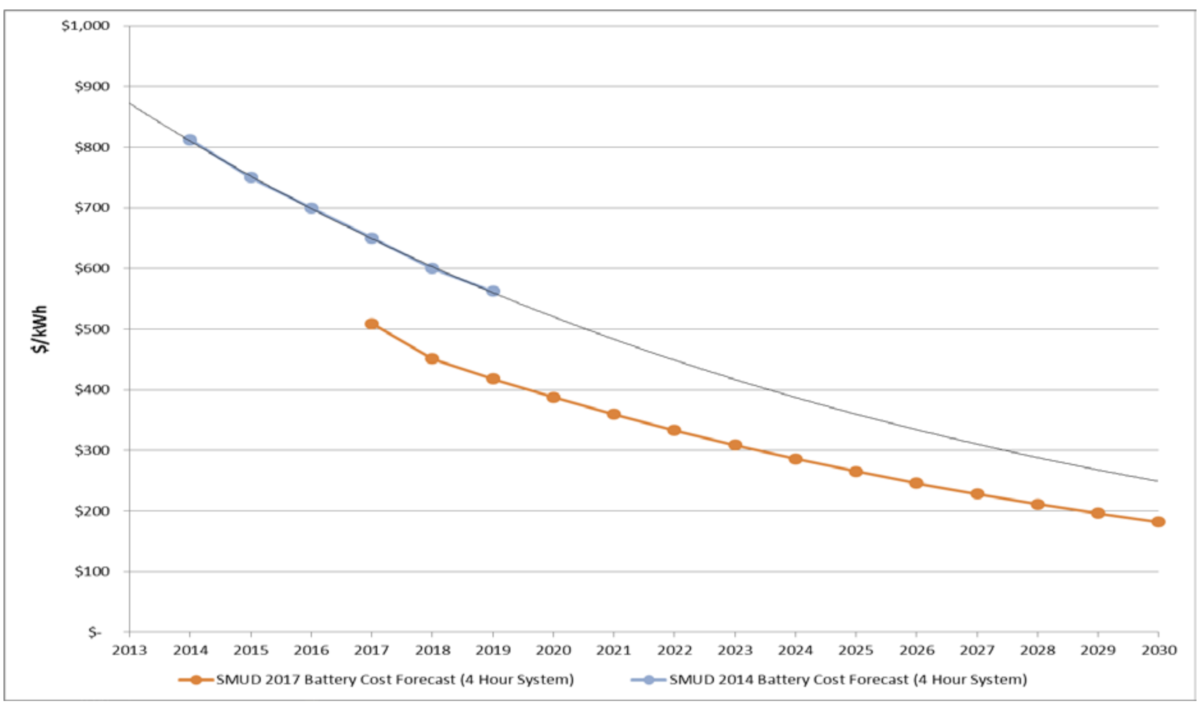
In 2016, SMUD demonstrated using our Demand Response Management System (DRMS) to dispatch control signals to residential batteries. We are currently in the process of procuring an Advanced Distribution Management System (ADMS) with a future Distributed Energy Resource Management System (DERMS) on the distribution automation roadmap. These systems are anticipated to expand the use cases and ability to identify opportunities for distribution-level value of storage and coordinate the location-specific control of distributed energy storage systems.

Step 3: Cost Effectiveness

Battery Storage Cost Effectiveness

Based on rapid acceleration of battery system cost reduction, increased ability of energy storage and other DERs to provide aggregated services and upward pressure on utility rates SMUD anticipates that energy storage will become financially viable in our territory between 2023 and 2027. Comparing the expected battery storage cost in 2017 to the model used in 2014 we have seen a 24% reduction in price from the previous model. Battery prices today were not expected to be available until 2020 or beyond.

Figure 1: Comparison vs. Battery Storage Forecast in 2014 and 2017



The overall cost effectiveness of energy storage is mainly driven by the decreasing costs of batteries, but also relies on the development of new revenue streams for distributed resources, increased value of load shaping, acceleration in PV adoption, rising EV adoption rates and the need to support aging infrastructure. Cost effectiveness of batteries and other storage technology is highly dependent upon being able to access multiple revenue streams by stacking a variety of services such as resource adequacy, wholesale energy arbitrage, retail demand charge reduction and retail back-up power. A majority of the services, transmission congestion relief, distribution deferral, frequency regulation and voltage support, considered by our peers when developing these stacked revenue models are not available in the SMUD service territory today. These services may not be available because the values of the available markets are too low to produce meaningful revenue, specific locational criteria are not met for infrastructure savings, processes do not exist to engage energy storage in the market or the market simply does not exist. Because not all services are viable revenue generators for SMUD, we cannot realize a maximum return on the potential value stack today.

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, in advance of financial viability, from the utility is needed. We are uniquely positioned to develop programs, incentives and partnerships in our service territory that will enable access to a broader set of stacked values. Access to these values will enable further 3rd party innovation, allow SMUD to collaborate with innovators to align grid needs with technology solutions and to provide products that create value for our customers. Delaying this effort, or pursuing too aggressively, creates a risk that the need for storage products and the ability to offer those products are not adequately aligned. Pilots and one time projects are important, but not sufficient to successfully deploy energy storage. For sustainable deployment of cost effective energy storage systems SMUD needs to incorporate the utilization of energy storage into regular businesses processes. Long term viability requires that energy storage move away from being a fringe product and become part of the standard operating procedures.

Thermal Energy Storage Cost Effectiveness

In addition to consideration of battery storage cost-effectiveness, we examined the cost-effectiveness of various Thermal Energy Storage (TES) technologies. On the commercial side, TES has been a technology that has been around for a long time and is relatively mature. It is also considered cost-effective relative to battery storage, but is limited as to where it can be deployed, typically due to space constraints as well as load factors for cooling and heating due to Sacramento's mild climate.

New since 2014 has been the entrance of residential TES in the form of dispatchable water heaters. In California, heat pump water heaters, which promise significant efficiency savings and carbon savings are being looked to to provide load shifting capability. The marginal cost for accessing this storage is very low as it only requires the addition of a communications module and a mixing valve. At the same time each unit is a pretty small storage contribution, on the order of 2kWh of storage and 500W of load dispatchability per unit. Despite this cost-effectiveness, significant market barriers exist to fuel-substitution from the predominant natural gas based water heating to electric water heating which limit the ability to scale this technology. A focus in residential new construction, which can offset natural gas infrastructure cost, could be a key opportunity to overcome market barriers with this technology.

Step 4: Integrated Resource Planning

As part of its 2017 integrated resource planning (IRP) process, SMUD's IRP committee studied the economics and need for transmission-level battery storage. From an economics perspective, the study looked at energy arbitrage value, ancillary service value, and capacity value of transmission-level battery storage. The study showed that forecasted value streams are insufficient in meeting current debt-service estimates of a large scale transmission level battery storage project. However, SMUD is aware of the declining battery storage cost curve which may show this resource as economically feasible in the next decade. From a needs or system balancing perspective, SMUD's current hydroelectric and thermal fleet has shown to be extremely flexible and is able to manage current and expected intermittent resources on its system for many years forward. SMUD will reassess the economics and need for transmission-level battery storage in future IRP updates.

In 2016, SMUD adopted a Distributed Energy Resources Strategy that included some recommendations on battery storage. Feeding into that strategy, SMUD looked at 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. We found that adoption which merely provides arbitrage against our rate structure provides a small fraction of the potential shared value from these investments. Part of this strategy 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 and the rest of the grid and non-participating customers. Evaluating these business models and rates is a key priority as we look toward cost-effectiveness of this technology over the next 5-7 years. By optimizing customer compensation to allow total value stacking of benefits for both the grid and the customer this will help to ease upward pressure on rates and distribute the benefits across the bulk and distribution system while still providing customers with the primary benefits of rate arbitrage and reliability. Consistent with these drivers and taking into consideration the IRP conclusion that transmission-level storage is not an immediate priority, the focus of our next 3 years of storage deployment will be in behind-the-meter applications to ensure we learn how to design and execute customer storage offerings that deliver maximum shared value to all of our customers.

Targets and Implementation

Storage Procurement Target Breakdown

Table 1: Battery Energy Storage (MW)

Point of Interconnection	2020	2023	2026	Total
Transmission	0	0	0	0
Distribution	0	0	24	24
Customer: Residential	5	5	6	16
Customer: C&I	2	3	5	10
Subtotal	7	8	31	50

Table 2: Thermal Energy Storage (MW)

Point of Interconnection	2020	2023	2026	Total
Transmission	0	0	0	0
Distribution	0	0	0	0
Residential Customer	2	6	7	15
C&I Customer	0	5	5	10
Subtotal	2	11	12	25

Table 3: Total Storage Target (MW)

Point of Interconnection	2020	2023	2026	Total
Transmission	0	0	0	0
Distribution	0	0	24	24
Customer: Residential	7	11	13	31
Customer: C&I	2	8	10	20
Subtotal	9	19	47	75

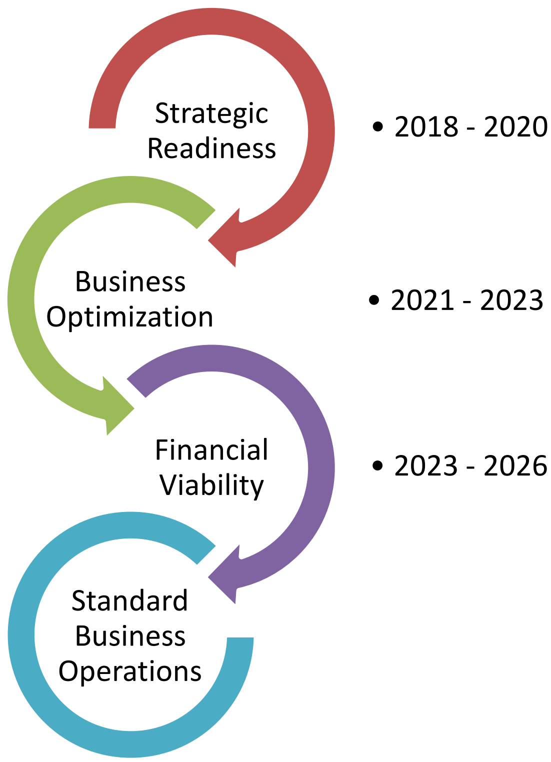
Deployment Strategy

Since the IRP analysis determined that SMUD does not have a need for transmission level energy storage, the value of energy storage in SMUD's service territory is instead best accessed by leveraging the distributed potential of batteries and TES systems in behind-the-meter (BTM) applications where the full value stack can be realized. The BTM market today is dominated by systems providing demand charge reduction, backup power and retail energy arbitrage. Many energy service providers are developing aggregation platforms and have the intent of accessing wholesale markets such as resource adequacy, frequency regulation, wholesale arbitrage and local infrastructure support. The hurdle faced by these aggregators and by utilities attempting to leverage DERs as grid assets is that the markets, control strategies and customer programs do not yet exist to create a meaningful balance between the existing BTM value streams and the potential gird service values. Without stacking revenues from both of these categories energy storage systems are unable to fully access their potential value. As well, public investment in enabling storage will have limited benefit where we are not able to access this full set of values.

Deployment of Thermal Energy Storage will be focused on large new construction applications for commercial and for residential will be focused primarily on residential new construction. Both of these are somewhat dependent on market conditions for construction, which are favorable at the moment, but the advantage of focusing on these segments is that they face the least market barriers to adoption.

SMUD's deployment strategy is focused on the development of programs and strategies that will enable energy storage assets, in addition to other DERs, to provide optimal value to both the grid and the customer. The deployment strategy is broken down into four phases. The first three phases are each three years long and emphasize different aspects of business operation to prepare for the long term utilization of energy storage as a grid asset.

Figure 2: SMUD Energy Storage Deployment Phasing



The fourth phase is not time bounded. Phase Four represents the complete transition of energy storage into the standard business flow within SMUD. In this fourth stage energy storage becomes fully operationalized and will be utilized throughout SMUD any time that energy storage provides the best benefit to the customer and grid.

Figure 3: SMUD's 2026 Energy Storage Procurement Roadmap

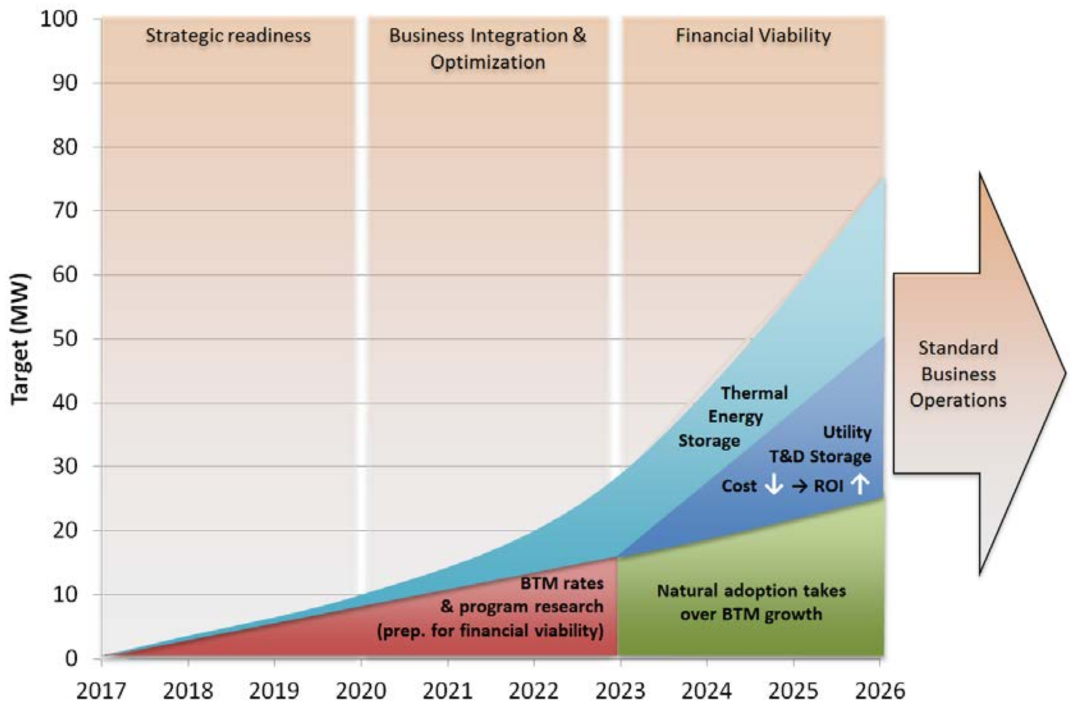


Figure 3 provides an overview of SMUD's 2026 storage procurement plan and its alignment to our deployment strategy.

Summary

As a community owned municipal utility, our primary purpose is to serve our customers reliable, safe, and environmentally friendly electricity at an affordable price. We take pride in our position as a forward-thinking utility but must balance investment in for innovation with pragmatic, lasting strategies that best suit our community. We take our role as financial stewards for our customers seriously, and must balance fiscal responsibility with environmental sustainability and the enablement of customer choice in energy solutions.

Our 2020 energy storage procurement target and 10-year energy storage strategy intend to best position SMUD to optimize our storage investment by seeking the highest value critical learning opportunities while positioning ourselves to be agile and nimble as the storage market continues to gain momentum. Our procurement plan coupled with our on-going storage research and development program provides SMUD with critical business learning, comprehensive systems integration, and the development of internal enterprise-wide expertise in storage technology, applications, and customer expectations to allow SMUD to scale our storage program to meet customer and grid needs as they develop and change over time.