Los Angeles Department of Water & Power

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DAVID H. WRIGHT
General Manager

August 29, 2017

Mr. John Mathias
Electric Generation System Specialist
Supply Analysis Office
Electricity Supply Analysis Division
California Energy Commission
1516 Ninth Street MS-20
Sacramento, CA 95814

Dear Mr. Mathias:

Subject: Los Angeles Department of Water and Power Assembly Bill 2514 - Energy Storage Procurement Target Reevaluation

Pursuant to the requirements of Section 2836(b)(4) of Assembly Bill (AB) 2514 (Skinner, Chapter 469, Statutes of 2010), the Los Angeles Department of Water and Power (LADWP) hereby submits this report to the California Energy Commission (CEC) regarding the reevaluation of its energy storage (ES) system procurement targets adopted by the Board of Water and Power Commissioners (Board).

Consistent with LADWP's recommendation, on August 15, 2017, the Board adopted resolution 018039 authorizing the revision of the LADWP ES procurement target for 2021 to 155 megawatts (MW). This revised total includes 128 MW, 25 MW, and 2 MW of combined capacity from transmission-connected, distribution-connected, and customer-connect ES systems respectively.

The enclosed document titled *Energy Storage Development Plan 2017 Update* discusses LADWP's target setting process, energy storage achievements, and current projects underway to meet the revised 2021 target.

Please contact Ms. Pjoy T. Chua at (213) 367-1750 or via e-mail at Pjoy.Chua@ladwp.com with any questions regarding LADWP's energy storage efforts.

Sincerely,

Louis C. Ting
Chief Compliance Officer and
Director of Power Planning and Development Division

MH:rq
Enclosure
c: Pjoy T. Chua

LA DWP Los Angeles Department of Water & Power

RESOLUTION NO. ________________

BOARD LETTER APPROVAL

REIKO A. KERR
Senior Assistant General Manager – Power System Engineering, Planning, and Technical Services

MARTIN L. ADAMS
Chief Operating Officer

DAVID H. WRIGHT
General Manager

DATE: July 25, 2017

SUBJECT: Los Angeles Department of Water and Power's Energy Storage Procurement Target Updates

SUMMARY

California Assembly Bill 2514 (AB 2514) requires that the Los Angeles Department of Water and Power (LADWP) set its own technologically viable and cost-effective Energy Storage (ES) procurement targets to be achieved by a first target date of December 31, 2016 and a second target date of December 31, 2021 and to report to the California Energy Commission (CEC) the adoption of these targets, if any, by October 1, 2014 and that LADWP reevaluates the ES procurement targets no less than once every three years.

City Council approval is not required.

RECOMMENDATION

It is recommended that the Board of Water and Power Commissioners (Board) adopt the attached Resolution authorizing the implementation of the updated LADWP ES targets for procurement now through 2021 as delineated in the charts below. It is also recommended that ES procurement targets be revised every three years to take into account changing Power System needs and ES cost effectiveness.

The 2017 IRP will take into consideration the recent market pricings for ES and compare the 2016 resource scenarios and make adjustments to LADWP's targets.

LADWP is expediting ES efforts due to Aliso Canyon gas storage issues with the accelerated Beacon ES project from the original 2020 completion date to 2018, and we anticipate the Board award date of August 15, 2017. LADWP in-house forces accelerated the ES plus solar project at Fire Station 28 located near the Aliso Canyon gas storage facility, and the scheduled in-service date is August 14, 2017. LADWP accelerated its ES training program and has installed two battery ES systems at its Truesdale training center. In addition, LADWP is in the process of procuring the John Ferraro Building (JFB) ES system, which has an expected in-service date of 2018 and will be part of LADWP's Distributed Energy Resources (DER) pilot.

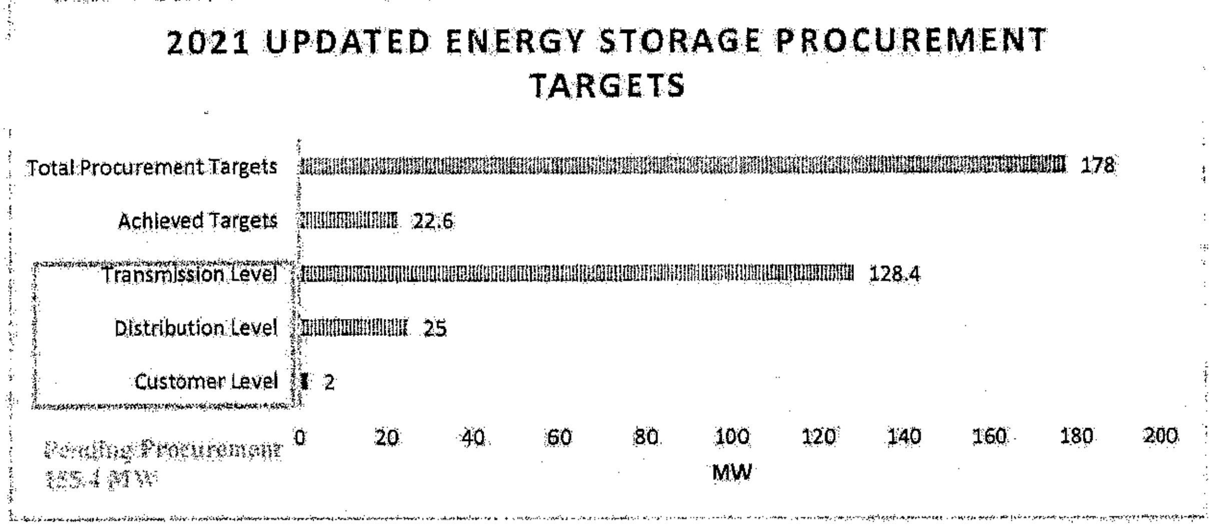

Figure 1 Updated Energy Storage Targets

	Existing			Update	
Connection Level	**Pre 2010 Existing ES**	**2016 Targets**	**2021 Targets**	**Achieved**	**2021 Targets**
Generation	1,275 MW	21 MW	60 MW	21 MW	128.4 MW
Transmission	-	-	50 MW	-	
Distribution	-	-	4 MW	-	25 MW
Customer	9.08 MW	3.08 MW	40.3 MW	1.6 MW	2 MW
Subtotal	1284.08 MW	24.08 MW	154.3 MW	22.6 MW	155.4 MW
Total	1,284.08 MW	178 MW		178 MW	

Table 1 Existing vs. Updated Energy Storage Targets

ALTERNATIVES CONSIDERED

Historically, it has been difficult to evaluate benefits that ES provides to the grid, not only due to high costs, but also because of the array of services it provides and the challenges posed in quantifying the value of these services, particularly the operational benefits such as ancillary services, and the overall improvement to power system reliability. The challenge of simulating energy storage in the grid, estimating its total value, and actually recovering those value streams continue to be a major barrier. However, ES could be beneficial to the grid, especially at times when short-term demand is high, by shaving or shifting peak load, and providing regulation services with increasing variable energy resource penetration.

As with the alternative generation technologies, cost will be the primary factor for determining which ES technologies are suitable for LADWP's grid. ES technologies that offer cost-effective applications are proposed for installation.

FINANCIAL INFORMATION

At this present time the actual cost that will be incurred by LADWP to achieve the 2021 ES targets is pending completion of feasibility studies including procurement costs that might be recommended based on findings from ongoing system studies (see Table 2). Once these feasibility and system studies are completed, LADWP will re-evaluate the established ES targets for procurement in 2021 and report back to the Board and CEC accordingly, pursuant to Section 2836(b)(4) of AB 2514.

CONNECTION LEVEL	PROJECT	STORAGE TYPE	ESTIMATED COST	CAPACITY
TRANSMISSSION	138kV System and above	Battery ES	$236,039,000	128.4 MW
DISTRIBUTION	34.5 kV Circuit	ES	$50,000,000	25 MW
CUSTOMER	Customer Side	ES	$7,200,000	2 MW
		TOTAL =	**$293,239,000**	**155.4 MW**

Table 2 Estimated ES installed cost for 2021 ES procurement targets

BACKGROUND

Legislative Context

On January 1, 2011, AB 2514 became law. Under this bill, local publicly owned electric utilities such as LADWP were required to initiate a process by March 1, 2012, to determine appropriate targets, if any, for LADWP to procure viable and cost-effective ES by certain dates. AB 2514 further requires that if determined viable and cost-effective, this Board shall adopt ES procurement targets by October 1, 2014 directing

LADWP to procure economically viable ES to be achieved by a first target date of December 21, 2016 and a second target date of December 31, 2021.

On February 7, 2012, the Board adopted Resolution No. 012-168 initiating a process directing LADWP to determine appropriate targets, if any, for LADWP to procure viable and cost-effective ES by December 31, 2016 and December 31, 2021.

On September 2, 2014, the Board adopted Resolution No. 015-033 establishing LADWP ES targets for procurement from 2014 through 2021 for a total of 178 MW.

ES Target Setting Framework

Setting ES targets require a systematic, sequential process. In general, the process of setting ES targets has been very comprehensive, beginning with an assessment of LADWP grid needs and costs, and balancing those costs with benefits from ES application. The process is informed by sound data and analysis, involving a wide range of LADWP staff, including Power System Planning and Development, Power Supply Operations and Engineering Divisions, and LADWP's Board before deciding the levels and types of ES procurement targets.

The basic steps for ES target setting are:

1. Identify system needs
2. Identify ES applications, technologies, and perform system studies
3. Evaluate costs
4. Consider external factors such as ES price projections, energy density, and environmental processes.

ES target setting is intended to assist LADWP in identifying the likely outcomes of a set of investments. This process will aid in determining how to allocate resources that will yield the best outcomes for LADWP ratepayers for a given level of expenditure.

ENVIRONMENTAL DETERMINATION

In accordance with the California Environmental Quality Act (CEQA), it has been determined that establishing ES procurement targets is exempt pursuant to the General Exemption described in CEQA Section 15061(b)(3). General Exemptions apply in situations where it can be seen with certainty that there is no possibility that the activity in question may have a significant effect on the environment. Any action or activity that is planned as a result of or to meet said targets will undergo its own, independent CEQA review.

UTILITY ES ACHIEVEMENTS

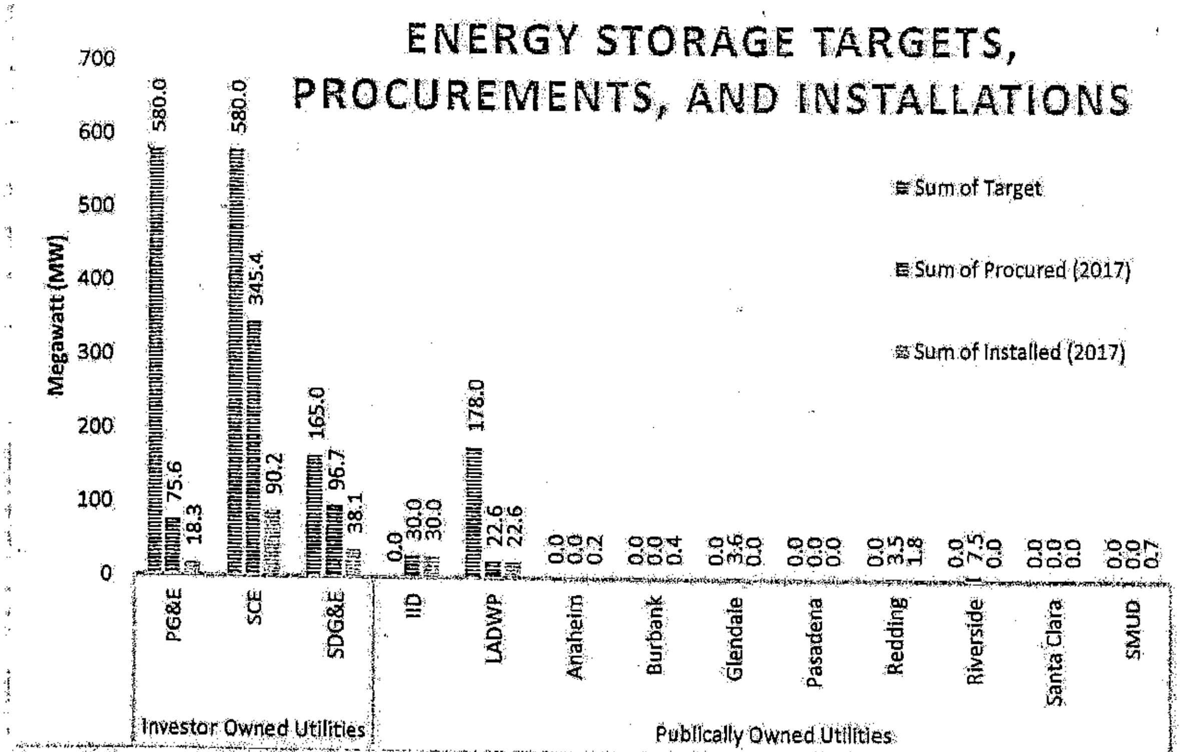

Figure 2: Source–California Energy Commission, California Public Utilities Commission, Department of Energy

The relatively higher ES achievements by the Investor Owned Utilities (IOU) can be attributed to the California Public Utilities Commission (CPUC) procurement mandates, which have pre-approved procurement schedules. Procurement is the contractual agreement of purchase and does not indicate installed capacity. In compliance with AB 2514, Publicly Owned Utilities (POU) are setting their own ES targets based on cost-effectiveness and feasibility. Procured and installed capacities per utility can be found in Figure 2[1]. Procurement capacity information is obtained from California Energy Commission (CEC) and CPUC for POU and IOU respectively. Department of Energy ES database provides a reference for the installed ES capacity at both IOU and POU.

CITY ATTORNEY

The Office of the City Attorney reviewed and approved the Resolution as to form and legality.

ATTACHMENTS

- LADWP Energy Storage Development Plan 2017 Update
- Resolution

[1] Procurement estimates are based on 2017 CEC and CPUC reportings by the utilities. Installed capacities are estimated using the DOE ES database dated 2017 https://www.energystorageexchange.org/

Louis Ting

Resolution No. 018039

WHEREAS, State Assembly Bill 2514 (AB 2514) became law on January 1, 2011, requiring the governing board of a local publicly owned electric utility, such as the Los Angeles Department of Water and Power (LADWP), to initiate a process by March 1, 2012, to determine appropriate targets, if any, for LADWP to procure viable and cost-effective energy storage systems by certain dates; and

WHEREAS, on February 7, 2012, in compliance with AB 2514 and pursuant to Board Resolution No. 012 168, the Board of Water and Power Commissioners (Board) initiated a process directing LADWP to determine appropriate targets, if any, for LADWP to procure viable and cost-effective energy storage systems by December 31, 2016, and December 31, 2021 pursuant to AB 2514; and

WHEREAS, AB 2514 further provides that if determined to be appropriate, the Board shall adopt procurement targets by October 1, 2014, for LADWP to procure viable and cost-effective energy storage systems to be achieved by a first target date of December 31, 2016, and a second target date of December 31, 2021; and

WHEREAS, on September 2, 2014, the Board adopted Resolution No. 015 033 establishing LADWP energy storage targets for procurement from 2014 through 2021 for a total of 178 Megawatts (MWs) based on an analytical framework from which its energy storage system procurement targets for 2016 and 2021 would be deduced, which includes system and feasibility studies aimed at investigating economically viable energy storage systems in all levels of LADWP's power system including generation, transmission, distribution, and behind the meter; and

WHEREAS, pursuant to AB 2514, the Board shall reevaluate the determinations made regarding energy storage system procurement targets not less than once every three years; and

WHEREAS, LADWP currently finds that, based on the assessment of LADWP grid needs and costs, LADWP will maintain its established energy storage procurement targets totaling 178 MWs which include (1) 22.6 MWs of recently achieved energy storage targets, (2) transmission-connected energy storage systems with a combined capacity of 128.4 MWs, (3) distribution-connected energy storage systems with a combined capacity of 25 MWs, and (4) customer-connected energy systems with a combined capacity of 2 MWs; and

WHEREAS, LADWP shall report to the California Energy Commission (CEC) regarding any energy storage system procurement targets and policies that may be adopted by this Board, and any modifications made to those targets as a result of the Board's reevaluations.

NOW, THEREFORE, BE IT RESOLVED that the Board of Water and Power Commissioners of the City of Los Angeles hereby adopts the procurement target of 155.4 MWs of energy storage systems for December 31, 2021, pursuant to AB 2514.

BE IT FURTHER RESOLVED that LADWP shall report to the CEC regarding these adopted energy storage system procurements targets and report any modifications made to those targets as a result of reevaluation.

BE IT FURTHER RESOLVED that LADWP shall report back to this Board prior to September 2, 2020, for the Board to reevaluate the determinations made regarding the energy storage system procurement targets and shall report to the CEC any modifications made to those targets as a result of the Board's reevaluations.

I HEREBY CERTIFY that the foregoing is a full, true, and correct copy of a resolution adopted by the Board of Water and Power Commissioners of the City of Los Angeles at its meeting held on AUG 15 2017

Barbara E. Moschos

Secretary

APPROVED AS TO FORM AND LEGALITY
MICHAEL N. FEUER, CITY ATTORNEY

JUL 11 2017

BY
VAUGHN MINASSIAN
DEPUTY CITY ATTORNEY

NOW, THEREFORE, BE IT RESOLVED that the Board of Water and Power Commissioners of the City of Los Angeles hereby adopts the procurement target of 155.4 MWs of energy storage systems for December 31, 2021, pursuant to AB 2514.

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____
Secretary

APPROVED AS TO FORM AND LEGALITY
MICHAEL N. FEUER, CITY ATTORNEY

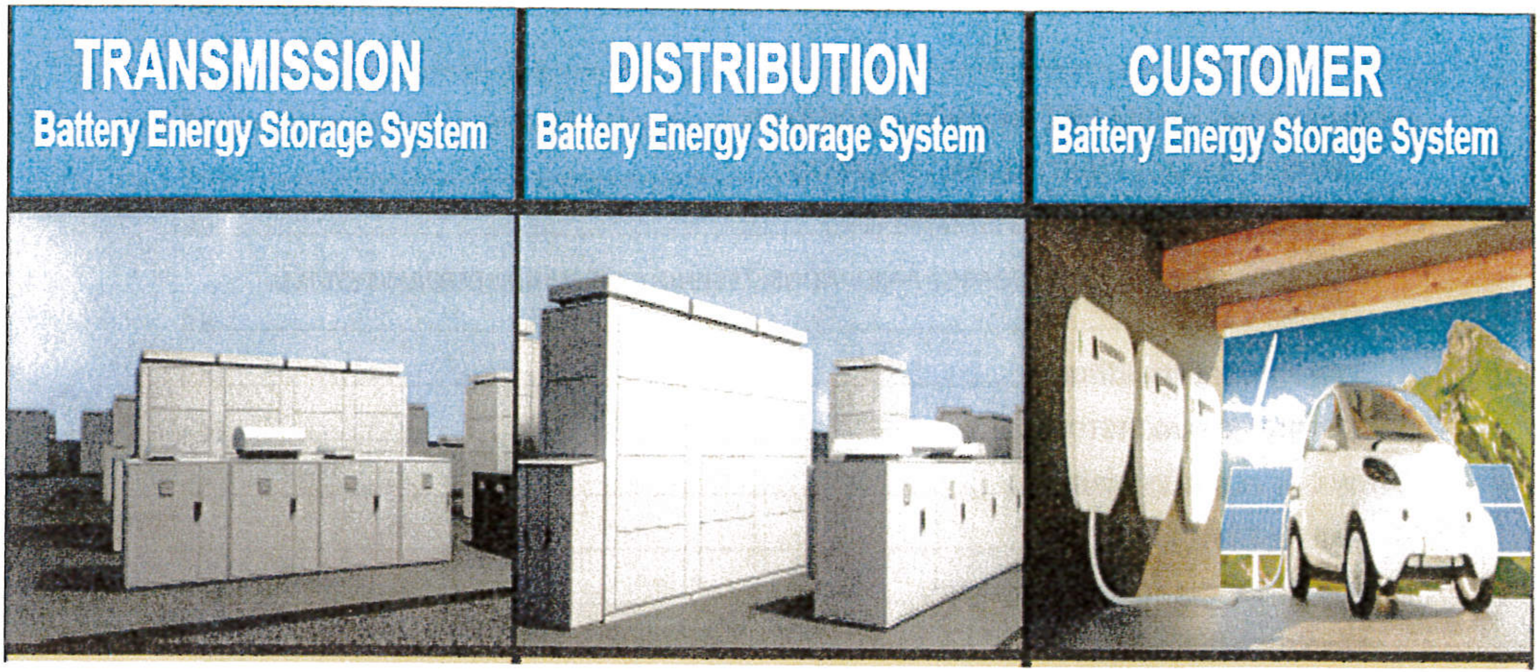
JUL 11 2017

BY________________
VAUGHN MINASSIAN
DEPUTY CITY ATTORNEY

Los Angeles Department of Water and Power

Energy Storage Development Plan

2017 Update



Power System Planning and Development

2021 Energy Storage Targets for State Assembly Bill 2514

August 2017

Contents

INTRODUCTION

This report recommends revised energy storage targets for Los Angeles Department of Water and Power (LADWP) consistent with Assembly Bill 2514 (AB 2514).

OVERVIEW

The Los Angeles Department of Water and Power (LADWP) is a vertically integrated municipal utility that owns and operates generation, transmission, and distribution resources. As such, energy storage has the potential to participate in these three functions of the electric grid. Understanding the value offered by energy storage requires research and analyses and coordination among the three functions of power system. LADWP's Power Planning and Development Division reviewed, analyzed, and revised energy storage targets for the Board of Water and Power Commissioners (Board) review. These efforts have led to analyses to identify cost-effective applications of energy storage and suitable locations in the power system.

The Utility needs to incorporate energy storage in current system planning, valuation, operations, procurement, system interconnection, and rate design. LADWP is reviewing and assessing its existing procedures and practices to inform the development of energy storage specifications and targets.

This report re-evaluates LADWP's energy storage targets, a process that includes:

- Review of power system needs
- Technical and economic feasibility
- Review of existing targets
- New targets recommendation
- Approval of modified targets

This document provides information and best practice to inform the LADWP target setting process. This report on energy storage re-evaluation presents an overview of the diversity of energy storage applications and targets in the key functions of power system and deployment. The report draws lessons from the experience to date with energy storage studies from a design perspective. It highlights the critical importance of definitions and specific design features suited for different energy storage applications. The overall aim of this report is to lay out a comprehensive framework that can inform the Board as they embark on the task of revising LADWP's energy storage targets.

SETTING NEW TARGETS

NEW TARGET SETTING FRAMEWORK

In accordance with AB 2514, LADWP evaluated existing and future Energy Storage (ES) targets for the entire power system, including transmission, distribution, and customer points of interconnection. The analysis determined the ES procurement targets in megawatts (MW) based on the processes described in this report.

LADWP's updated energy storage targets are as follows—see Table 1 and Figure 1 below.

Table 1 Existing vs. Updated Energy Storage Targets

	Existing			Update	
Connection Level	**Pre 2010 Existing ES**	**2016 Targets**	**2021 Targets**	**Achieved**	**2021 Targets**
Generation	1,275 MW	21 MW	60 MW	21 MW	128.4 MW
Transmission	-	-	50 MW	-	
Distribution	-	-	4 MW	-	25 MW
Customer	9.08 MW	3.08 MW	40.3 MW	1.6 MW	2 MW
Subtotal	1284.08 MW	24.08 MW	154.3 MW	22.6 MW	155.4 MW
Total	1,284.08 MW	178 MW		178 MW	

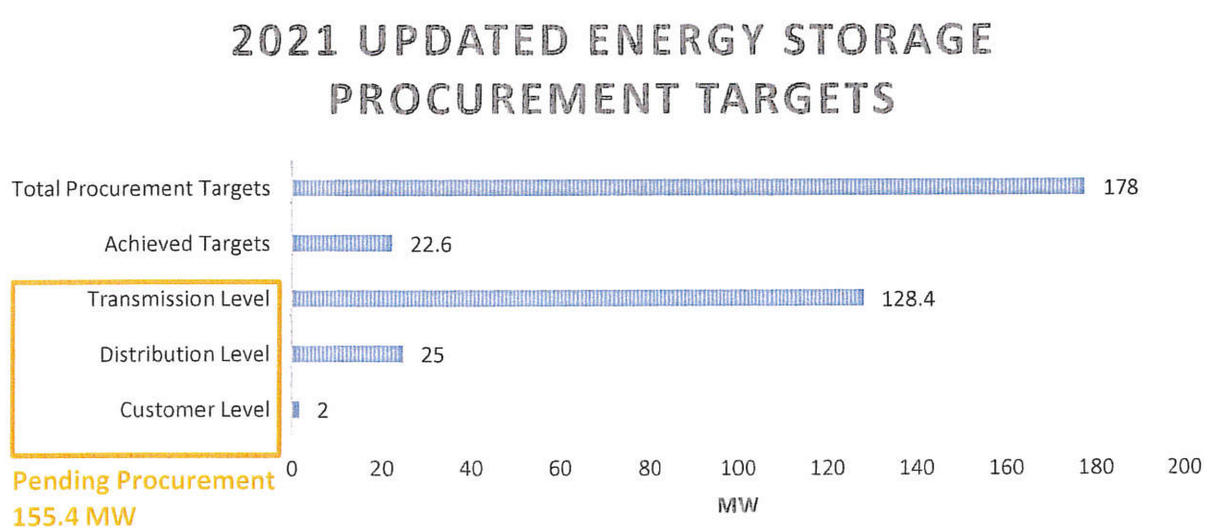


Figure 1 Updated Energy Storage Targets

Transmission Level
Locations on LADWP's transmission system have been identified and classified as potential ES projects sites pending the completion of all system assessment steps delineated under the Energy Storage Target Setting Framework Section of this report.

Transmission level ES procurement is updated to 128.4 MW.

Distribution Level
Locations on LADWP's distribution system have been identified and classified as potential ES projects sites pending the completion of all system assessment steps delineated under the Energy Storage Target Setting Framework Section of this report.

Distribution level ES procurement is updated to 25 MW.

Customer Level
LADWP is in the process of initiating a Distributed Energy Resources (DER) Pilot Project (Pilot). The objective of the Pilot is to demonstrate and evaluate the communication, controls, and software for effectively dispatching behind-the-meter distributed energy resources. Lessons learned and findings from this Pilot will be used to assess and develop DER standards and protocols, distribution operation processes and procedures, and DER deployment policies that enable high penetration of DERs. In order to demonstrate and evaluate the effectiveness and the feasibility of high penetration DER systems which include distributed ES.

Findings from the Pilot will inform LADWP's ES procurement plan that aligns LADWP's distribution system needs with customer values. The first phase of the Pilot is expected to be completed in 2020.

Customer level ES procurement is updated to 2 MW.

LEGISLATIVE CONTEXT

LEGISLATION

Assembly Bill (AB) 2514 (Skinner, Chapter 469, Statutes of 2010), was designed to incorporate energy storage in California. The Public Utilities Code defines an energy storage system as commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy. An energy storage system may be centralized or distributed and accomplish one or more of the following:

- Reduce emissions of greenhouse gases.
- Reduce demand for peak electrical generation.
- Defer or substitute for an investment in generation, transmission, or distribution assets.
- Improve the reliable operation of the electrical transmission or distribution grid.

In addition, an energy storage system shall do one or more of the following:

- Use mechanical, chemical, or thermal processes to store energy that was generated at one time for use at a later time.
- Store thermal energy for direct use for heating or cooling at a later time in a manner that avoids the need to use electricity at that later time.
- Use mechanical, chemical, or thermal processes to store energy generated from renewable resources for use at a later time.
- Use mechanical, chemical, or thermal processes to store energy generated from mechanical processes that would otherwise be wasted for delivery at a later time.

The Public Utilities Code requires the following for each local publicly owned electric utility (POU):

- By March 1, 2012, the governing board of each POU must initiate a process to determine appropriate targets, if any, for the utility to procure viable and cost-effective energy storage systems, to be achieved by the utility by December 31, 2016, and a second target to be achieved by December 31, 2020.

- The governing board of each POU must adopt targets, if determined to be appropriate, by October 1, 2014.

- The governing board of each POU is required to re-evaluate the energy storage target determinations not less than every three years.

- Furthermore, each POU is required to report to the California Energy Commission (CEC) regarding the energy storage system targets and policies adopted by its governing board and are required to report modifications made to those targets as a result of any re-evaluation undertaken.

- Each POU is also required to submit reports to the CEC demonstrating that it has complied with the energy storage targets previously adopted. The first compliance report must be submitted by January 1, 2017, and the second compliance report must be submitted by January 1, 2021.

Consistent with the LADWP's recommendation, on September 2, 2014, the Board adopted a resolution authorizing the implementation of the LADWP's energy storage targets for procurement in 2016 and 2021 consistent of 24 MW and 154 MW, respectively. The resolution also included the recommendation to re-evaluate the procurement targets every three years based on power system needs, regulatory requirements, cost-effectiveness, and feasibility.

Reporting Targets

Pursuant to AB 2514, the Board is required to re-evaluate the energy storage target determinations not less than every three years from the adoption date of September 2, 2014. In line with this, the LADWP energy storage target re-evaluation assessment is scheduled for a review and approval to the Board no later than September 2017 as delineated in the timeline below.

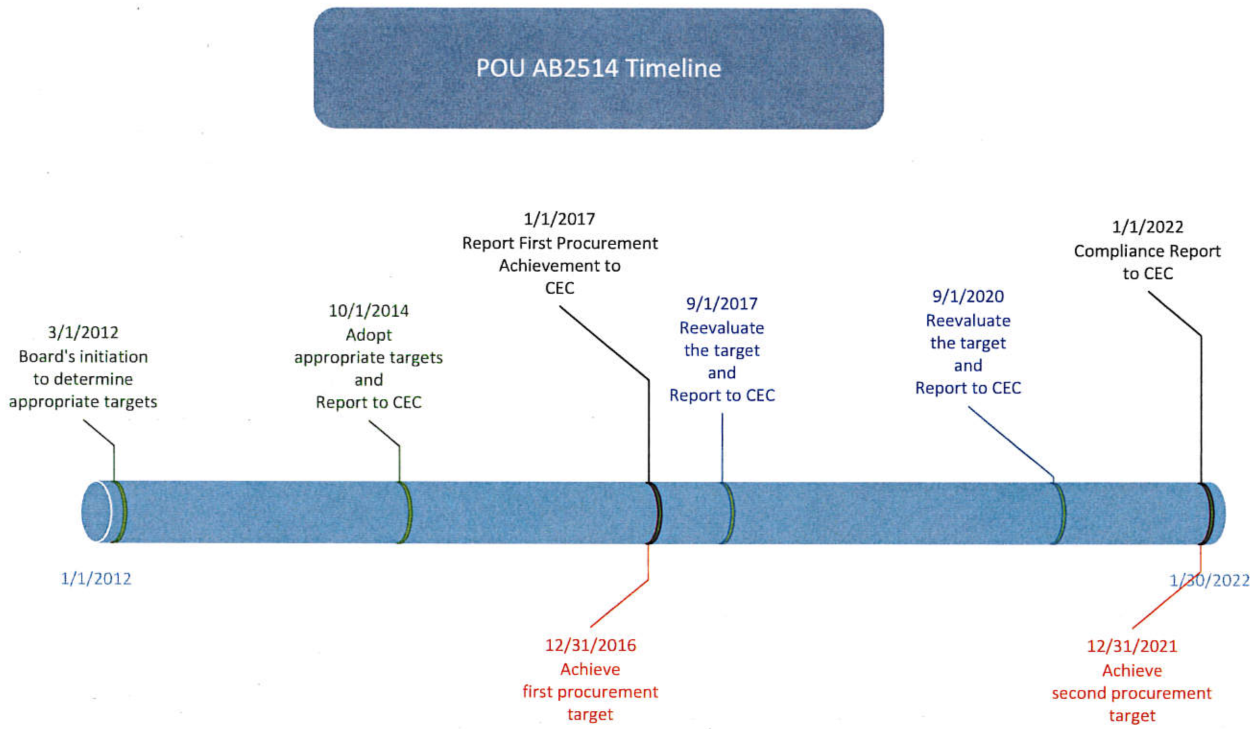


Figure 2: POU AB 2514 timeline

Reporting of new energy storage targets or updates can be sent to:

California Energy Commission

John Mathias

1516 Ninth Street, MS-20

Sacramento, CA 95814

Phone: 916-651-9525

E-mail: John.Mathias@energy.ca.gov

ENERGY STORAGE TARGET SETTING PROCESS OVERVIEW

ENERGY STORAGE TARGET SETTING FRAMEWORK

Setting energy storage targets requires a systematic process. The process begins with an assessment of LADWP grid needs which follows a Four-Step framework—Figure 3.

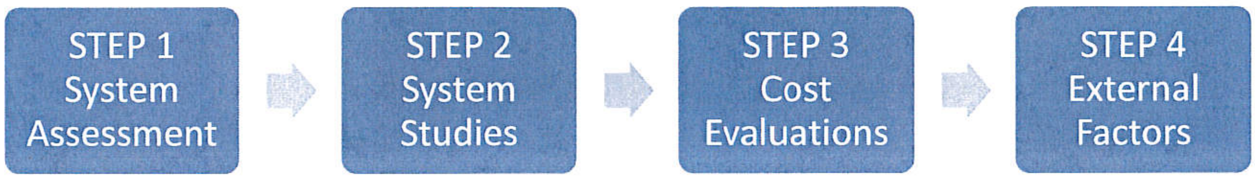


Figure 3 Four-Step framework

The basic steps for energy storage target setting are:

1. Identify system needs
2. Identify energy storage applications, technologies, and perform system studies
3. Evaluate costs
4. Consider external factors i.e. energy storage price projections, energy density, and environmental processes

STEP 1: REVIEW AND ASSESS SYSTEM NEEDS

LADWP evaluates system needs and considers multiple mitigation solutions including conventional and unconventional resources. LADWP power system needs include, but are not limited to list provided below:

- Resolve the stochastic nature of intermittent energy resources
- Resolve larger generation short falls associated with unpredictability of variable energy resources that might lead to large excursions of resource adequacy deficiencies
- Reduce peak demand and evening ramping requirements
- Defer transmission and distribution upgrades
- Defer transmission and generation resource capacity
- Reduce Green House Gas (GHG) emissions
- Improve power system reliability
- Provide voltage support 24/7 in areas where high levels of variable energy resource are injected to the LADWP grid

Through coordination of all LADWP internal stakeholders, LADWP system needs are identified and proceed for further consideration and analysis as alternative to conventional solutions.

STEP 2: IDENTIFY ENERGY STORAGE APPLICATIONS, TECHNOLOGIES, AND PERFORM SYSTEM STUDIES

This step seeks to investigate and understand storage applications and technologies based on modelling and data analytics.

Energy Storage Applications

Energy storage offers a myriad of benefits to customers and the grid. By now, the magnitude of these benefits is well documented and understood by all stakeholders. Specific subsets of storage technologies are suitable for certain applications. The application of renewables alongside storage is one of many models which are being pursued by LADWP. Energy storage is also being deployed in stand-alone grid-level applications. Energy storage applications can be divided into two categories: Power Supply and Energy Supply applications.

Power Supply Application

Energy storage optimized to inject or absorb power for short durations less than one hour can provide frequency response, regulation, synthetic inertia, and other ancillary grid services that are critical for system balancing needs. Although the durations are short, the battery can go through multiple deep cycles per day based on the total energy discharged. Energy storage systems optimized for this application require more equipment for the additional capacity, and a more sophisticated monitoring and control system with tighter integration into LADWP's Bulk Electric System.

Energy storage systems designed for power supply can provide both power and energy supply applications, depending on the battery size. For example, a 20 MW, 30-minute system can extend discharge duration to 2 hours by limiting power output to 5 MW.

Regulation and Frequency Response: The moment-to-moment reconciliation of the difference between electric supply (power) and electric demand to maintain the stability and accuracy of the system within a given Balancing Authority Area. As shown in Figure 4, when supply momentarily exceeds demand (i.e., excess supply) frequency regulation down is needed to offset the discrepancy. Conversely, when supply is momentarily below demand (i.e., supply shortfall) frequency regulation up is needed to offset the discrepancy.

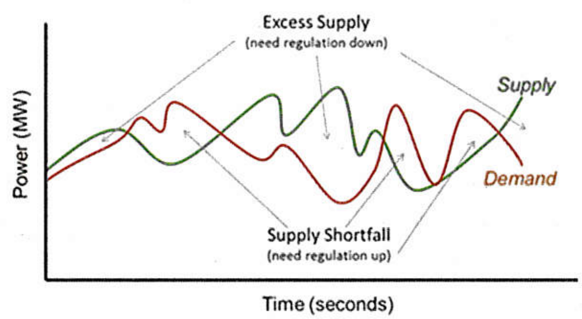


Figure 4: Frequency and regulation service needs due to momentary differences between demand and variable power supply. [Source E&II Consulting]

Grid Stability: Battery storage and inverters improve system reliability in the event of a frequency disturbance by (i) Eliminating the inertia and governor gap of synchronous generators; and (ii) replicating the performance of synchronous generators, Figure 5.

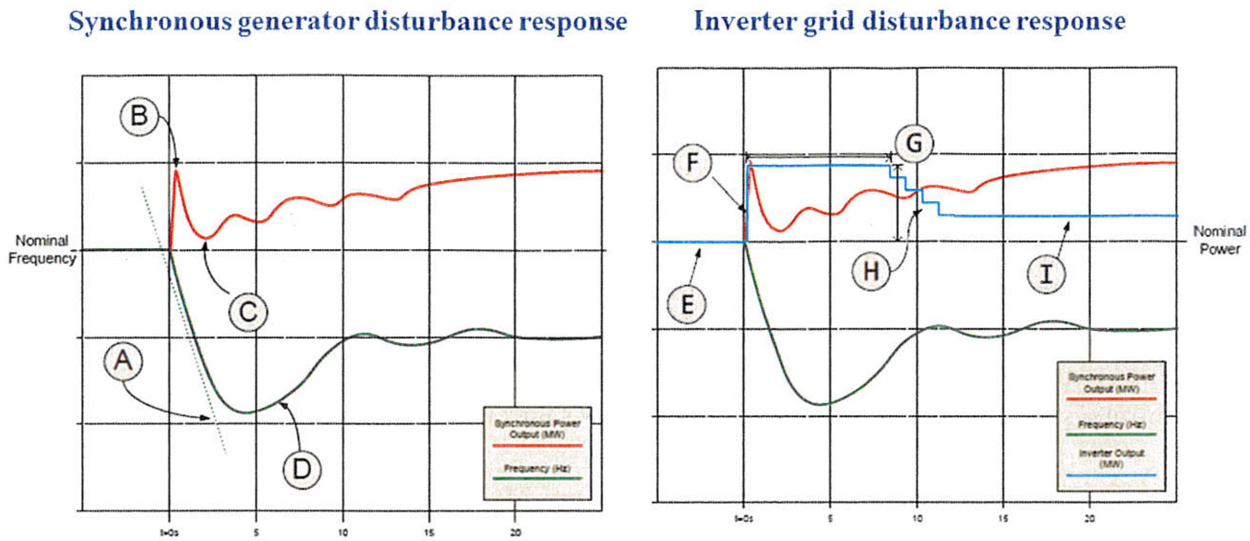


Figure 5: Inertial response comparison between synchronous generator and inverter from battery energy storage—Source[1]: AES Energy Storage

A: Following a lost in generation, grid frequency falls initially in a linear slop according to the summation of mechanical inertia of all synchronous generators on the grid.
B: Each synchronous generator on the grid temporarily produces more electrical power from the same mechanical power being delivered to its turbine
C: The synchronous generator begins to respond in approximately 3-10 seconds if reserve mechanical capability is available.
D: Governor Response is initiated within 3-10 seconds after grid disturbance
E: Nominal dispatched power level
F: Power increase response after just 50ms
G: Power increase may continue according to battery capacity and system conditions
H: Battery power output ramps down in many discrete steps
I: Battery settles to a new dispatch power level

Voltage Support: Battery storage can improve the voltage profile of a transmission line by employing a four-quadrant inverter and specific control algorithms to produce or absorb real and reactive power at the same time. In addition to controlling the voltage on the line, such a system can be used to address other power-quality issues on the line, such as power factor and assisting with the integration of renewable energy resources.

Energy Supply Application

Energy storage optimized for discharge durations longer than one hour per cycle are typically used for peak load shifting, time of use arbitrage, and renewable energy production shifting. This type of battery is typically lower cost than energy storage optimized for power supply because less equipment is required and the controls are simpler. These batteries are normally operated for longer durations but typically only one deep cycle per day.

Energy storage systems designed for energy supply application can only provide energy supply applications.

Peak Shaving: By charging from the grid during periods of low demand and injecting it back to the grid during periods of high demand, the peak loads are reduced and load is shifted (Figure 6). This is similar to energy arbitrage, PV shifting, demand charge management, and upgrade deferral applications.

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[1] "AES Battery Backed Inverter Grid Frequency and Voltage Response" article

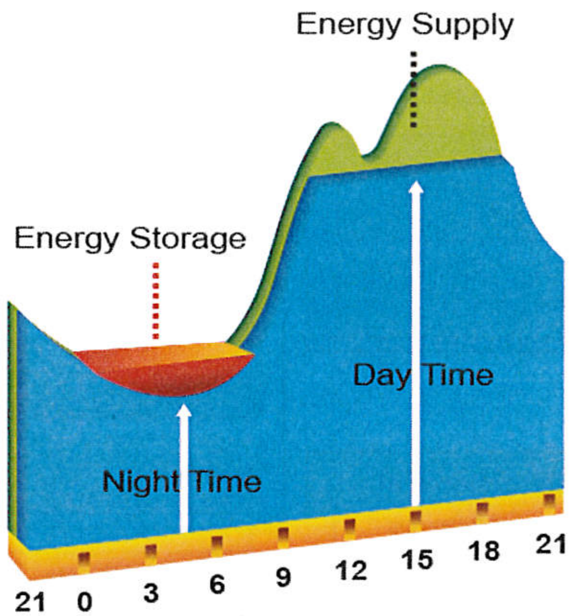


Figure 6: Peak shaving application—Source: Alevo.com

Energy Storage Technology

Energy storage is not a single technology, but rather refers to a suite of diverse technologies. Storage technologies can be classified based on operating and performance characteristics and storage duration. The combination of these characteristics defines the potential application and business models of each storage technology.

Figure 7 classifies the five technologies examined in this report. The five categories are mechanical, thermal, chemical, electro-chemical and electrical storage systems.

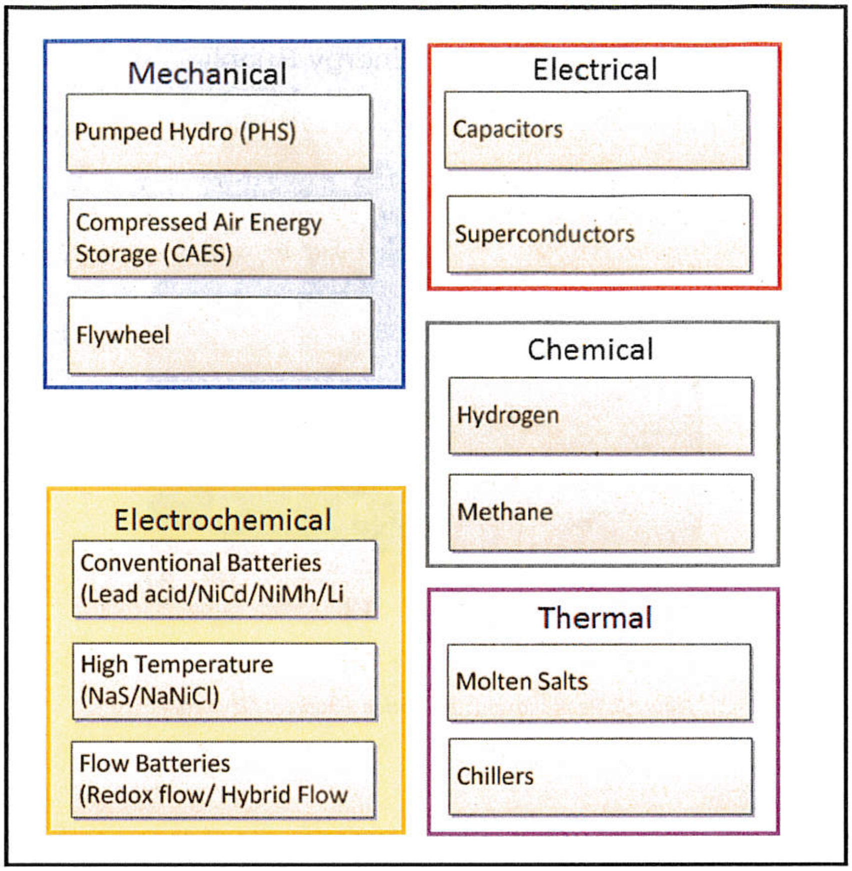
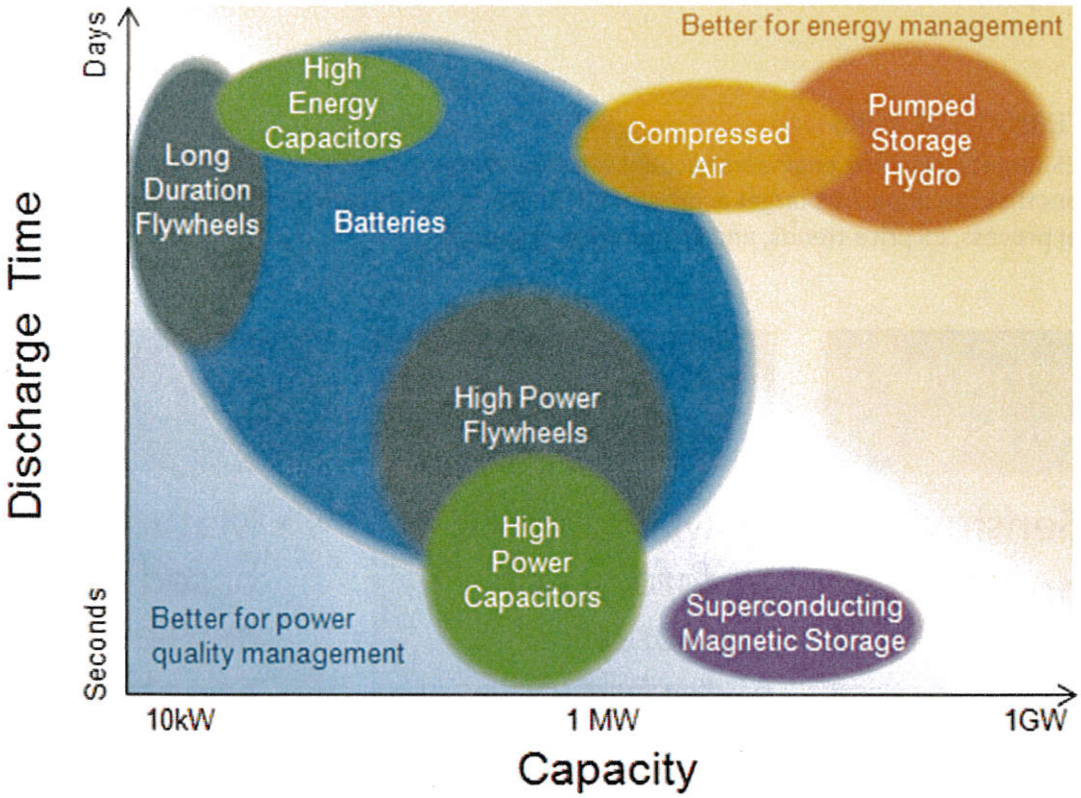


Figure 7: Energy Storage Categorization

Each technology and category has advantages and disadvantages which must be examined in order to identify the proper applications that are most suited to each specific technology. These technologies have a range of different performance characteristics, summarized in Figure 8 below, and based on capacity and discharge time at rated power for each technology type.



Source: U.S. Energy Information Administration, based on Energy Storage Association.
Note: This figure shows approximate representation of each storage type's technological characteristics. Some types, especially "batteries", encompass many technologies within the general shape.

Figure 8: Mapping storage technologies according to performance characteristics

SYSTEM STUDIES

Successful energy storage projects start with sound planning. As part of the planning process, planning engineers perform system studies to evaluate an existing system, or investigate facilities and/or upgrades required to integrate energy storage into the grid. These system studies are applicable to large scale energy storage system and include Reliability Assessment, Interconnection System Impact Study (SIS) and Facilities Studies. Reliability Assessment investigates how energy storage can be used to meet system energy needs and provide essential ancillary services (Regulation and Frequency Response, Reserve Requirement, and Voltage support).
Interconnection System Impact Study includes conceptual design, load flow, short-circuit, harmonics, and system stability analyses. Components of Facilities Studies include mitigation solutions to adverse impact identified in the SIS, costs associated with required mitigation solutions and the project schedule.
For smaller scale ES, distribution planning engineers ensure the project adhere to LADWP interconnection requirements and industry best practices.

STEP 3: COST EVALUATION

Evaluating the economics of energy storage can be quite challenging due to the numerous use cases of energy storage. Most utility resource model software do not yet have the capability to effectively model the multiple use cases of storage. Various literatures support deployment of Energy Storage (ES) to the grid through analysis of life cycle or levelized cost only for storage components without considering the costs at a system level and energy exchange between generation source and storage when ES is coupled with variable energy resources. As such, a comprehensive cost evaluation approach is indispensable to assess the economic merits of ES projects.

LADWP evaluates energy storage projects based on their Installed Cost, Lifetime Cost, Levelized Cost of Energy (LCOE), and the Net Present Value (NPV) of the investment. The latter, NPV, includes both cost estimated revenue and deferral value of the investment.

STEP 4: EXTERNAL FACTORS

In setting up ES targets, planning engineers account for influences or variables referred hereto as External Factors that can impact ES target achievement. These External Factors might include environmental process, ES price trends, and ES maturity—Figure 9.

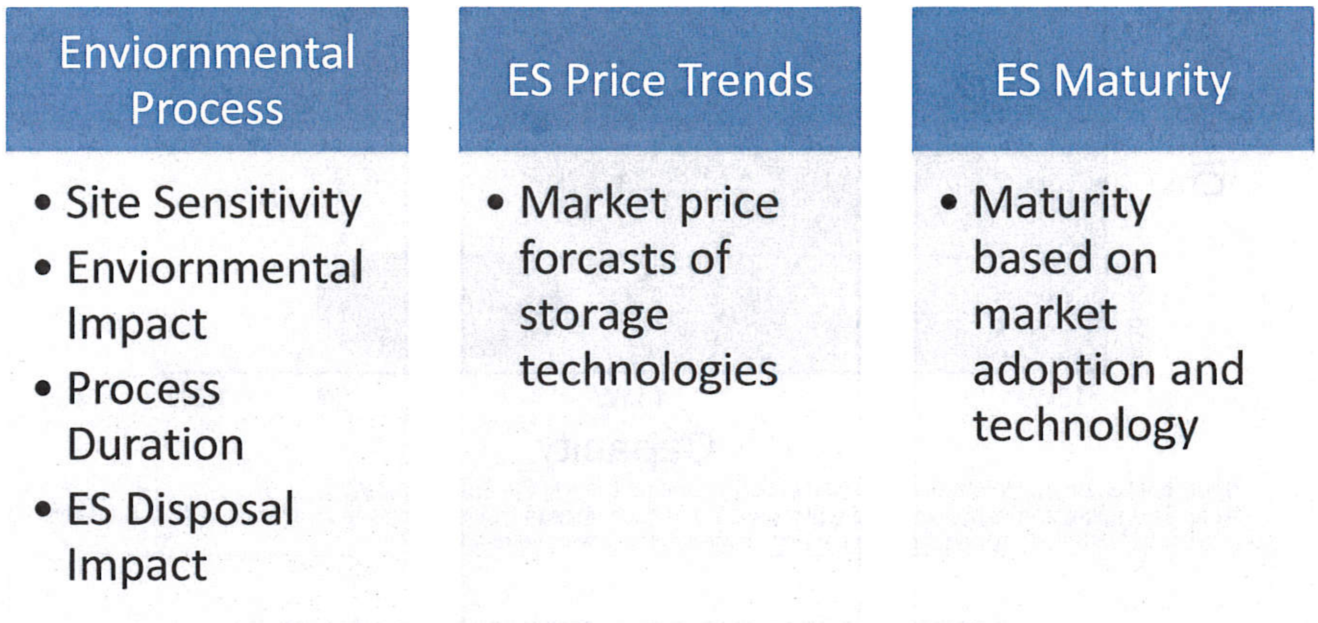


Figure 9: External factors impacting ES targets

Environmental Process

Depending on the technology, location, scale, and size, ES facilities can have significant environmental and societal impacts. Locating ES projects in sensitive areas can make the environmental licensing of the project difficult and expensive. Therefore, project impacts can affect the rate of ES deployment. Environmental impacts of ES disposal are also of concern when evaluating projects.

ES Price Trends

Lithium Ion battery ES system costs have noticeably been declining and could be as low as $400 per kilowatt-hour by 2020 and $300 per kilowatt-hour 2025—roughly half of today's cost—see Figure 10. ES price trends, among other factors, help LADWP planning engineers identify the most economical ES projects that suits the system needs, enhances reliability and offer value to customers.

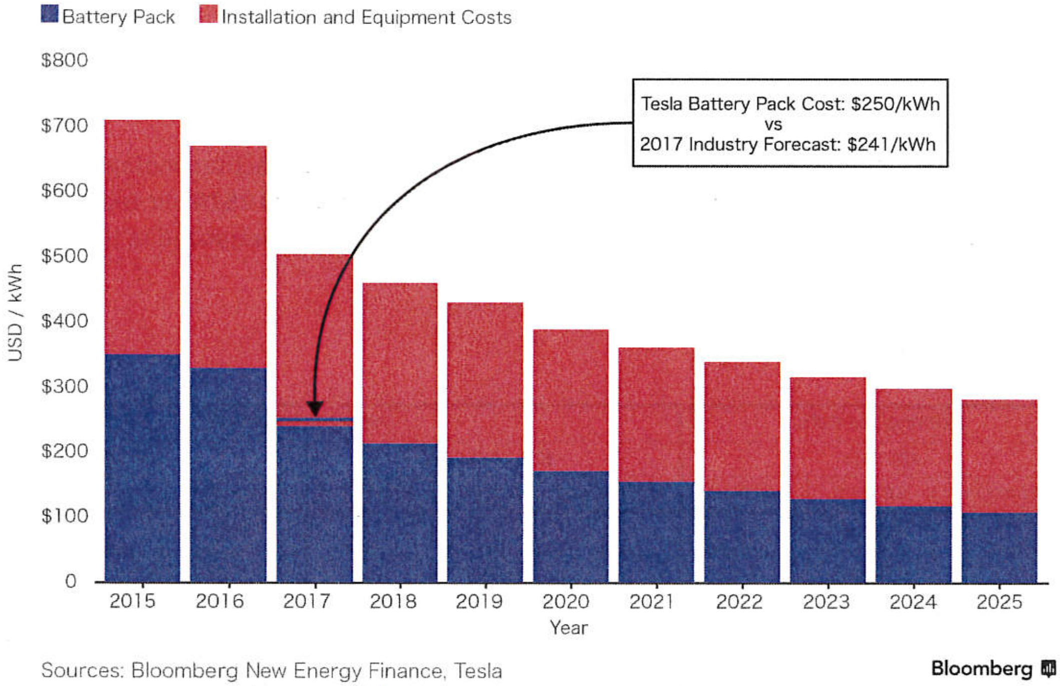


Figure 10: ES price projection—Source[2]: Bloomberg

ES Maturity

External Factors such as the maturity of the ES technologies—Figure 11— impact the widespread adoption of ES.

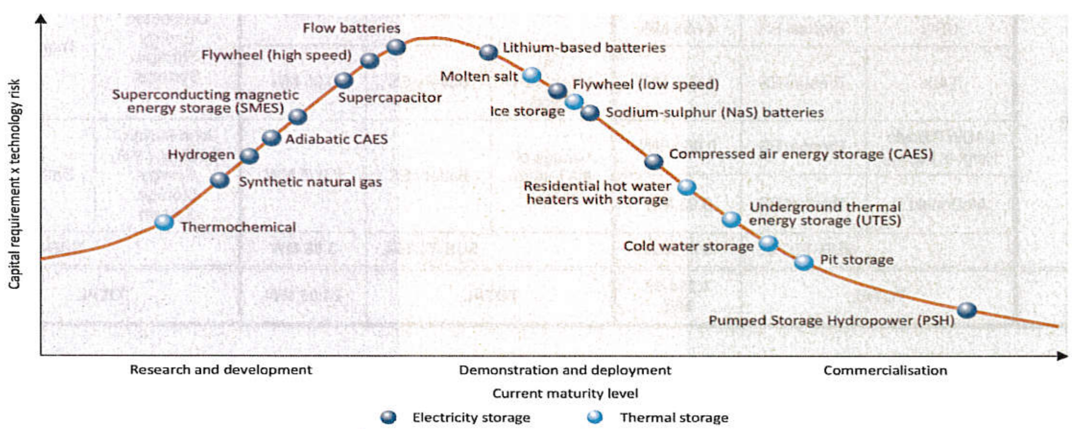


Figure 11: ES technology maturity—Source[3]: IEA Energy Storage Technology Roadmap 2014

[2] https://www.bloombergquint.com/technology/2017/03/17/tesla-s-169-million-battery-play-is-just-the-beginning
[3] https://www.greentechmedia.com/articles/read/is-an-energy-storage-tsunami-about-to-wash-over-california

REVIEW OF EXISTING ES TARGETS

AB 2514 TARGETS

LADWP used the above mentioned Energy Storage Target Setting Framework to select technologically viable and cost-effective Energy Storage (ES) procurement targets in response to AB 2514. In September 2014, the Board approved LADWP ES targets for procurement in 2016 and 2021 summarized in the Table 2 below.

Table 2: AB 2514 targets set in 2014

CONNECTION LEVEL	EXISTING TARGETS			PROPOSED TARGETS					
	PRE 2010			2016 TARGETS			2021 TARGETS		
	LOCATION	ES TYPE	CAPACITY	LOCATION	ES TYPE	CAPACITY	LOCATION	ES TYPE	CAPACITY
GENERATION	Castaic	Pumped Hydro Storage	1,275 MW	Castaic	Pumped Hydro Storage	21 MW	Valley Generating Station	Thermal ES	60 MW
		SUB-TOTAL	1,275 MW		SUB-TOTAL	21 MW		SUB-TOTAL	60 MW
TRANSMISSION	None			None			Beacon Solar Project	Battery ES	30 MW
							Springbok Solar Projects	Battery ES	20 MW
								Sub-Total	50 MW
DISTRIBUTION	None			None			Distribution Circuit	Battery ES	4 MW
								SUB-TOTAL	4 MW
CUSTOMER	UCLA	Thermal ES	4.375 MW	LAX	Thermal ES	3 MW	Distributed Energy Storage Systems	Thermal ES	40 MW
	USC	Thermal ES	4.668 MW						
	TAIX	Thermal ES	0.004 MW	LA Downtown (Pilot)	Battery ES	0.05 MW			
	LADWP Boyle Heights Facility	Thermal ES	0.006 MW	Garage of the Future (Pilot)	Battery ES	0.025 MW	John Ferraro Building (JFB) Energy Storage System	Battery ES	0.3 MW
	McDonald's	Thermal ES	0.03 MW						
		SUB-TOTAL	9.08 MW		SUB-TOTAL	3.08 MW		SUB-TOTAL	40.3 MW
	TOTAL		1,284.08 MW	TOTAL		24.08 MW	TOTAL		154.3 MW

2016 TARGETS AND ACHIEVEMENTS

LADWP's approved targets for 2016 consist of 21 MW of pumped hydro at the Castaic Pumped Hydro Power Plant and 3 MW of Thermal Energy Storage (TES) at the Los Angeles International Airport (LAX). The 21 MW pump storage target was achieved by making modifications to the existing pumped hydro units, increasing their capacity.

The LAX TES is a project conceived by the airport authority in collaboration with LADWP. Under the current LADWP Energy Efficiency (EE) program, LADWP incentivizes installed TES capacity. The targeted TES capacity by LAX was 3 MW. Post commissioning performance measurement indicates that, due to TES's operational configuration and its dependence on ambient temperature, the installed TES capacity is 1.25 MW as shown**Error! Reference source not found.** below. Therefore, LADWP claims 1.25 MW of installed TES capacity towards its
3 MW TES target.

Additionally, multiple customers have installed behind the meter energy storage systems within LADWP's service territory. LADWP has worked closely with the energy storage installers to assure compliance to current interconnection requirements. LADWP's behind the meter installations include over 227 kW of battery energy storage, providing customers with peak shaving, self-consumption of solar PV, and backup capabilities. One of these projects is located at the newly built LADWP La Kretz Innovation Campus; a facility demonstrating Los Angeles's commitment to renewable power and sustainability. The campus uses 150 kW of utility built solar to charge its 60 kWh battery promoting innovation and the self-consumption of renewable energy.

Table 3 2016 AB 2514 ES target status

PROJECT NAME	COST	TARGET CAPACITY	STATUS	ACHIVEMENT
Castaic Pumped Hydro Storage Power Plant Unit 1 Upgrade	$41,000,000	21 MW	Complete	21 MW
LAX Thermal ES Incentive	$2,022,000	3 MW	Complete	1.25 MW
LA Downtown (Pilot)	-	50 kW	Complete	60 kW
Garage of the Future (Pilot)	-	25 kW	Complete	9 kW
Behind the Meter (Batteries)	-	-	Complete	158.4 kW
Behind the Meter (TES)	-	-	Complete	97 kW
Total	**$43,022,000**	**24.08 MW**		**22.57 MW**

STATUS OF ES TARGETS

Generation Technical Consideration

In the 2014 Energy Storage Development Plan, LADWP committed to determining the feasibility of Thermal Energy Storage (TES) for turbine air inlet chilling at its generating facility (Study). The targeted capacity was set to 60 MW as shown in Table 2. In 2016 LADWP contracted with WorleyParsons to initiate the Study which included an expanded scope to analyze both Valley Generating Station (VGS) and Apex Generating Station (Apex) located in Los Angeles and Las Vegas, Nevada, respectively. The study was completed in early 2017. The Study found the projects to be economically and technically not feasible.

Valley Generating Station[4]

Simulations and economic analysis compared TES at VGS against existing evaporative cooling and alternative energy storage options. Factors other than cost went into the decision, including forecasted Capacity Factor (TES use is tied to turbine operation), transmission limits, lack of a business case and revenue streams, performance benefit limited to hot temperature peak load days, favorable weather conditions in Southern California, high auxiliary loads from chillers and pumps, increased complexity and Operations and Maintenance challenges compared to evaporative cooling system, and more. Findings indicating too many operating constraints and limited benefits determined that turbine air inlet chilling with TES was not cost-effective.

Apex Generating Station

TES was not considered feasible at Apex due to high ambient temperatures and continuous baseload schedule. Table 4 from below shows net energy produced with TES is less than the existing system over a 24 hour period. The Heat Rate also goes up, which means it is burning fuel less efficiently.

[4] 2017 Valley Generating Station Gas Fired Thermal Energy Storage Summary Report completed by WorleyParsons on behalf of LADWP.

Table 4 24 Hour Summary Results, Chiller +TES vs Evap Cooler-Typical Summer Day

	Evaporative Cooler	Chiller + TES
Total Net Power Produced Over 24 Hour Period (MW-hrs)	10,834	10,680
Equivalent Heat Rate Over 24 Hour Period (Btu/kW-hr)	6,350	6441
Percent Change in Total Net Power Produced		-1.42%
Percent Change in Equivalent Heat Rate		1.44%

Based on the VGS and Apex TES study results, LADWP will not proceed with the 60 MW Generation TES.

Transmission Technical Consideration

LADWP's 2021 Transmission level energy storage targets consist of two phases totaling 50 MW. Phase I is a 20 MW ES whereas Phase II is 30 MW. To determine the correct use case of the storage system(s), in 2015 LADWP contracted with DNV GL to conduct the Maximum Generation Renewable Energy Penetration Study (MGREPS). The study was geared to identify the grid impacts of Variable Energy Resources (VERs) in multiple Renewable Portfolio Standards (RPS) scenarios—up to 50% RPS target. The study analyzed both hourly and sub-hourly scenarios. MGREPS quantified matrices such as over-generation amounts, regulation, ramping needs, and N-1 stability. Figure 12 describes key findings of MGREPS. MGREPS illustrates that ES can reduce the maximum Reliability Based Control (RBC) excursions from 18 minutes to less than 4 minutes in presence of a 50 MW ES.

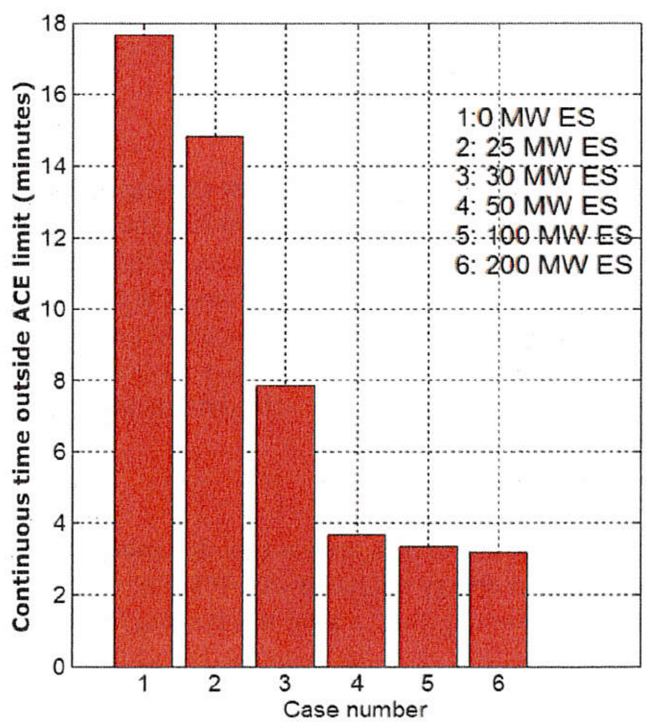


Figure 12 Effect of ES on system reliability

The cost of energy storage is not easily comparable with the costs of alternative resources such as conventional generation due to the fact that ES does not produce electricity. ES has the greatest value when electricity stored is relatively cheaper than when it is discharged to the grid. Levelized Cost of Electricity (LCOE) can provide a good insight of the overall system costs. Further, if the value of the services provided by storage can be quantified, then the Net Present Value of the project is calculated. Using an estimated value of storage benefits, Figure 13 calculates the NPV of the Beacon ES project. The model assumes LADWP can sell or use year-round Regulation services from the ES system. The positive NPV of $390,000 suggests the investment is cost effective.

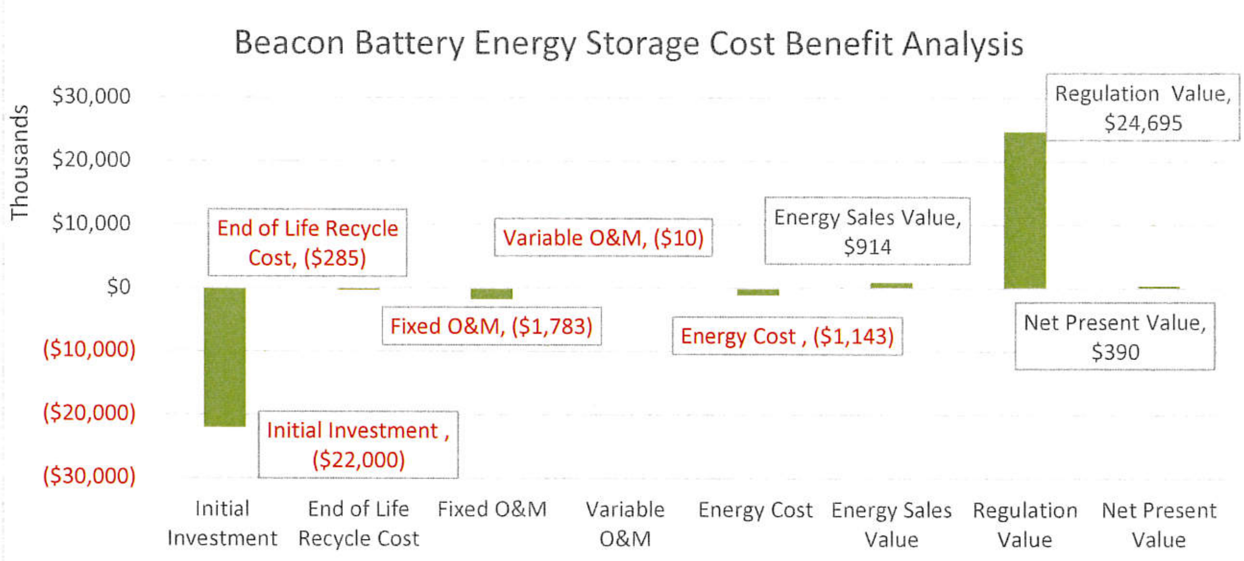


Figure 13: Beacon Battery Energy Storage Cost Benefit Analysis

Based on the above results and upon Board approval LADWP will moving forward with Phase I, a 20 MW Battery ES system which is planned to perform frequency response, regulation, and voltage support consistent with findings from MGREPS. The system is planned to be commissioned in early 2018.

Distribution ES Technical Consideration

LADWP's 2021 distribution level ES targets include 4 MW of energy storage both on the 34.5kV and 4.8kV systems. To better understand the distribution system needs, LADWP contracted with Black and Veatch to conduct the Maximum Distribution Renewable Energy Penetration Study (MDREPS). LADWP studied the PV hosting capacity of distribution circuits and feeders and determined the impacts of high PV penetration. Modeling exercises simulated and tracked thermal overloads, voltage swells, and reverse power flow. The study findings indicate that there is reverse power flow—from load to distributing station—even during very low PV penetration. The possible impacts of reverse power flow include relay and regulator malfunction and degradation power quality. The recommendations of the study include energy storage for high penetration feeders with voltage issues.

LADWP is planning distribution level energy storage proof of concept projects to determine actual costs, technology viability, logistics, communication and dispatchablility requirements, safety, design and maintenance standards.

LADWP is proceeding with ongoing distribution system analyses to firm up distribution level energy storage targets.

Customer ES Technical Consideration

LADWP is in process of completing a Distributed Energy Resources Integration Study (DERIS) to determine the most cost-effective means of utilizing distributed energy resources namely, energy efficiency, energy storage, electric vehicle charging, and demand response technologies collectively referred to as distributed energy resources (DER) to meet the LADWP's reliability, safety, and affordability standards. LADWP's behind the meter ES efforts include multiple battery energy storage systems at testing center, and solar plus storage projects such as the soon to be commissioned Fire Station 28 innovation project.

LADWP will proceed with the implementation of DERIS recommendations to promote a safe and reliable proliferation of DER which include behind the customer meter energy storage systems.