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Los Angeles Department of Water & Power

CUSTOMERS FIRST

December 16, 2020

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

Dear Ms. MacDonald:

Subject: Los Angeles Department of Water and Power Assembly Bill 2514 / Assembly Bill 2227 – Energy Storage System Procurement Targets 2020 Compliance Report

Pursuant to the requirements of Assembly Bill (AB) 2514 (Skinner, Chapter 469, Statutes of 2010) and AB 2227 (Bradford, Chapter 606, Statutes of 2012), the Los Angeles Department of Water and Power (LADWP) hereby submits the enclosed report to the California Energy Commission (CEC) regarding its energy storage (ES) system procurement targets and policies adopted by the Board of Water and Power Commissioners (Board).

Consistent with LADWP's recommendation, on August 15, 2017, the Board adopted a resolution (DWP Resolution No. 018039) authorizing the adoption of the LADWP ES procurement target of 155.4 megawatts (MW) for 2021. The total includes 128.4 MW of transmission-connected, 25 MW of distribution-connected, and 2 MW of customer-connected ES systems. On October 27, 2020, the Board adopted the Energy Storage System Procurement Targets 2020 Compliance Report (Compliance Report) with 309.1 MW of installed ES demonstrating that LADWP has met and exceeded the procurement target of 155.4 MWs of energy storage systems for the second compliance period of December 31, 2020, pursuant to AB 2227.

The enclosed Compliance Report discusses LADWP's ES system procurement target, achievements, and on-going procurement. As of March 2020, LADWP reached 309.1 MW of ES consisting of 301.3 MW of transmission-connected and 7.8 MW of customer-connected ES systems. This report, in conjunction with LADWP's first compliance report submitted on December 20, 2016, fulfills the compliance reporting requirements pursuant to AB 2514 and AB 2227.

For further inquiries regarding LADWP's energy storage goals and achievements, please contact Mr. Simon Zewdu at (213) 367-2525 or via email at simon.zewdu@ladwp.com or Mr. Scott Hirashima at (213) 367-0852 or via e-mail at scott.hirashima@ladwp.com.

Sincerely,

Simon Zewdu Digitally signed by Simon Zewdu Date: 2020.12.14 19:13:54 -08'00'

Simon Zewdu
Director of Regulatory Compliance and Specifications Division

Jason L. Rondou
Director of Clean Grid LA – Strategy Division

GA:ln/eb
Enclosure

25

Item No. 25 - 10/27/20 Agenda
(10/26/20 - Correction from 327MWs to 309.1MWs)

Los Angeles Department of Water & Power

BOARD LETTER APPROVAL

RESOLUTION NO. 021 064

- [x] POWER SYSTEM
- [ ] WATER SYSTEM
- [ ] CAO
- [ ] CFO
- [ ] LEGAL
- [ ] COO
- [ ] SUSTAINABILITY
- [ ]

RELEASE DATE: NOV 25 2020

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

MARTIN L. ADAMS
General Manager and Chief Engineer

DATE: October 5, 2020

SUBJECT: Los Angeles Department of Water and Power's Energy Storage Procurement Target Achievement Updates for Assembly Bill 2514 and Assembly Bill 2227

SUMMARY

California Assembly Bill (AB) 2514 and AB 2227 require the Los Angeles Department of Water and Power (LADWP) to set its own technologically viable and cost-effective energy storage (ES) procurement targets. These targets are to be achieved by the first target date of December 31, 2016, and the second target date of December 31, 2020. LADWP shall submit a report to the California Energy Commission (CEC) demonstrating that it has complied with the ES system procurement targets for December 31, 2020. This is the final compliance report for AB 2514 and AB 2227 to be submitted to CEC by January 1, 2021; the first report on the initial target date was submitted to CEC on December 20, 2016.

City Council approval is not required.

RECOMMENDATION

It is recommended that the Board of Water and Power Commissioners (Board) adopt the attached Resolution, which demonstrates a re-evaluation and new determination by the Board regarding the achievement of meeting and exceeding the LADWP ES procurement target for 2020 as detailed in the attached compliance report. Table 1 provides a breakdown of how LADWP met the ES procurement target set for 2020.

Connection Level	2020 Targets	2020 Achieved
Generation and Transmission	128.4 MW	301.3 MW
Distribution	25 MW	-
Customer	2 MW	7.8 MW
Total	155.4 MW	309.1 MW

Table 1: Energy Storage Targets vs. Achieved

The various projects that helped LADWP achieve procurement goals are provided below:

- Generation and Transmission Level
  - Beacon ES project (20 megawatts [MW] / 10 MW-hour [MWh])
  - Eland Solar + Storage Center (400 MW Solar + 281.3 MW / 1,125 MWh)
- Customer Level
  - John Ferraro Building (JFB) ES system (200 kilowatt (kW) / 800 kilowatt-hour (kWh)
  - Fire Station 28 Battery ES Project (13 kW / 36 kWh)
  - Various Customer Behind the Meter Installations (7.6 MW)

Given the cost reduction and availability of various ES technologies, LADWP has now incorporated ES resources as part of its regular Integrated Resource Planning efforts and all future ES targets will be captured as part of that process.

ALTERNATIVES CONSIDERED

Lithium-ion battery ES systems were chosen primarily to meet LADWP's ES procurement targets. Lithium-ion battery technology was chosen due to its robust industry deployments, ease of integration with renewable technologies, and rapid declining cost. Flow Battery technology and thermal ES solutions were also implemented at behind the meter and customer locaitons because they were found to be cost effective.

Other technologies which were analyzed are pumped hydro, compressed air energy storage (CAES), and large scale thermal energy storage (TES). For rapid deployment and execution, new pumped hydro technology was not considered due to the lengthy Federal permitting process for hydroelectric power plants. LADWP currently owns, operates, and maintains Castaic Power Plant which is capable of generating and storing 1,265 MW of energy for more than six hours depending on operating conditions.

CAES is a re-emerging technology and LADWP is currently evaluating proposals for cost-effectiveness, safety, and feasibility. CAES is not widely deployed on a large scale mainly due to its geographic location requirements. Most deployed CAES projects require an available underground cavern sized appropriately to store the compressed air at over 1,000-pounds of pressure (PSI). CAES is a candidate for integration at Intermountain Power Plant in Utah.

A study for large scale TES was performed to determine feasibility of deployment at LADWP's Valley and Apex Generating Stations. The study concluded that TES is not economically and technically feasible. Therefore, LADWP no longer pursues thermal energy storage at its generating stations.

Ultimately, these technologies were not considered for procurement due to various reasons provided above including the opportunity cost of leveraging Federal Investment Tax Credits (ITC) for combined solar and battery storage proposals.

FINANCIAL INFORMATION

Table 2 provides LADWP's cost of implementing ES solutions for various voltages within the LADWP system.

CONNECTION LEVEL	PROJECT	STORAGE TYPE	CAPACITY	ESTIMATED COST
TRANSMISSSION	138kV System and above	Battery ES	301.3 MW	~$744,860,000
DISTRIBUTION	34.5 kV Circuit	ES	0 MW	$0
BEHIND THE METER	LADWP Side	Battery ES	0.213 MW	~$4,844,000
BEHIND THE METER	Customer Side	Battery ES	7.6 MW	*
		TOTAL	**309.1 MW**	**~$750,000,00**

Table 2: Energy Storage implementation Cost

* Dollars spent by LADWP customers for individual behind the meter ES installations not available.

BACKGROUND

LADWP is a vertically-integrated municipal utility that owns and operates generation, transmission, and distribution resources. LADWP's Clean Grid LA-Strategy Division reviewed, analyzed, and revised ES targets based on cost-effectiveness and ease of procurement to meet regulatory requirements.

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 ES procurement targets if found to be viable and cost-effective by a first target date of December 31, 2016 and a second target date of December 31, 2021. It further required LADWP's Board to adopt ES procurement targets by October 1, 2014 if appropriate.

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 27, 2012, AB 2227 amended AB 2514 and became law. Under this bill, LADWP is required to procure viable and cost-effective ES by December 31, 2016 and December 31, 2020, accelerating second compliance period target date by one year.

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. The energy procurement target for 2021 was accelerated one year to 2020 pursuant to AB 2227.

The attached "LADWP ES System Procurement Targets 2020 Compliance" Report includes ES accomplishments consistent with AB 2514 and AB 2227.

ENVIRONMENTAL DETERMINATION

Determine item is exempt pursuant to California Environmental Quality Act (CEQA) Guidelines Section 15061(b)(3). In accordance with this section, it has been determined that establishing energy storage 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, and therefore that activity is not subject to CEQA. Any action or activity that is planned as a result of or to meet said targets, will undergo its own independent CEQA review.

CITY ATTORNEY

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

ATTACHMENTS

- Resolution
- LADWP ES System Procurement Targets 2020 Compliance Report

WHEREAS, State Assembly Bill (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, AB 2514 further provides that LADWP shall submit a report to the California Energy Commission (CEC), by January 1, 2017 and by January 1, 2021, demonstrating that it has complied with the energy storage system procurement targets and policies adopted by this Board; and

WHEREAS, LADWP submitted its first compliance report to the CEC on December 20, 2016; and

WHEREAS, on August 15, 2017, the Board adopted Resolution No. 018 039 updating LADWP's energy storage procurement target for December 31, 2021 to 155.4 MWs and requiring LADWP to report back to the Board to reevaluate the determinations made regarding the energy storage system procurement target; and

WHEREAS, pursuant to AB 2227, the energy storage system procurement target for December 31, 2021 is accelerated by one year to December 31, 2020; and

WHEREAS, AB 2514 further provides that LADWP shall report to the 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 has re-evaluated the 2020 energy storage system procurement target and has determined that the target can be increased from 155.4 MWs to 309.1 MWs.

BE IT FURTHER RESOLVED that the Board hereby adopts the second compliance report demonstrating that LADWP has met and exceeded the procurement target of 155.4 MWs of energy storage systems for the second compliance period of December 31, 2021, pursuant to AB 2514, and accelerated to December 31, 2020, pursuant to AB 2227.

BE IT FURTHER RESOLVED that LADWP shall report to the CEC that LADWP's energy storage system procurement targets have been met and exceeded and future targets will be established and re-evaluated as part of the LADWP Integrated Resource Planning process.

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 OCT 2 7 2020

Susan A. Rodriguez
Secretary

APPROVED AS TO FORM AND LEGALITY
MICHAEL N FEUER CITY ATTORNEY

JUL 31 2020

By
VAUGHN MINASSIAN
DEPUTY CITY ATTORNEY

LADWP

Energy Storage System Procurement Targets 2020 Compliance Report

Prepared by:

Los Angeles Department of Water and Power

Clean Grid LA Strategy Division

August 2020

ladwp.com

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Introduction

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 a potential to participate in these three functions of the electric grid. On February 7, 2012, the LADWP's Board of Water and Power Commissioners (Board) initiated a process by directing LADWP to determine appropriate procurement targets, if any, of Energy Storage Systems (ESS) that are viable and cost-effective by December 31, 2016 and December 31, 2021.

This request was pursuant to Assembly Bill 2514 (AB 2514) which became effective on January 1, 2011. Assembly Bill 2227 (AB 2227) superseded AB 2514 and accelerated the second target date to December 31, 2020. LADWP's Clean Grid LA Strategy Division reviewed, analyzed, and reexamined energy storage targets based on cost-effectiveness and viability to meet regulatory requirements. This report includes energy storage accomplishments for LADWP consistent with AB 2514 & AB 2227.

Legislative Context

Legislation

Assembly Bill 2514 (Skinner, Chapter 469, Statutes of 2010), amended by Assembly Bill 2227 (Bradford, Chapter 606, Statutes of 2012), is designed to accelerate adoption of energy storage in California's electric grid. AB 2227 accelerated the 2021 target date set in AB 2514 by one year to 2020.

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 (excerpt from California Code, Public Utilities Code - PUC § 2836)

(b)(l) On or before March 1, 2012, the governing board of each local publicly owned electric utility shall 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 December 31, 201 6, and December 31, 2020. As part of this proceeding, the governing board may consider a variety of possible policies to encourage the cost-effective deployment of energy storage systems, including refinement of existing procurement methods to properly value energy storage systems.

(2) The governing board shall adopt the procurement targets, if determined to be appropriate pursuant to paragraph (1), by October 1, 2014.

(3) The governing board shall reevaluate the determinations made pursuant to this subdivision not less than once every three years.

The Public Utilities Code requires the following (excerpt from California Code, Public Utilities Code - PUC § 9506)

9506. (a) A local publicly owned electric utility shall report to the Energy Commission regarding the energy storage system procurement targets and policies adopted by the governing board pursuant to paragraph (2) of, and report any modifications made to those targets as a result of a reevaluation undertaken pursuant to paragraph (3) of, subdivision (b) of Section 2836.

(b) By January 1, 2017, a local publicly owned electric utility shall submit a report to the Energy Commission demonstrating that it has complied with the energy storage system procurement targets and policies adopted by the governing board pursuant to subdivision (b) of Section 2836.

(c) By January 1, 2021, a local publicly owned electric utility shall submit a report to the Energy Commission demonstrating that it has complied with the energy storage system procurement targets and policies adopted by the governing board pursuant to subdivision (b) Of Section 2836.

(d) The Energy Commission shall ensure that a copy of each report or plan required by subdivisions (b) and (c), with any confidential information redacted, is available on the Energy Commission's Internet Web site, or on an Internet Web site maintained by the local publicly owned electric utility that can be accessed from the Energy Commission's Internet Web site.

(e) A summary of the reports required by this section shall be included as part of each integrated energy policy report required pursuant to Section 25302.

LADWP Response

On September 2, 2014, the Board adopted a resolution authorizing procurement of 24 MW of energy storage by 2016 and an additional 155MW by 2021 consistent with the LADWP's recommendation. The Board resolution recommended to re-evaluate the procurement targets every three years based on Power System needs, regulatory requirements, cost-effectiveness, and feasibility. In accordance with this recommendation, LADWP re-evaluated and adopted updated energy storage target on August 15, 2017. This report includes LADWP energy storage procurement accomplishments to-date.

2020 Energy Storage Procurement Targets and Achievements

LADWP has procured a total of 327.8 MW of energy storage, exceeding the 2020 accelerated target of 155.4 MW. A summary of the LADWP energy storage procurement targets and achievements for 2020 is found in Table 1.

Table 1: Energy Storage Procurement Targets and Achievements

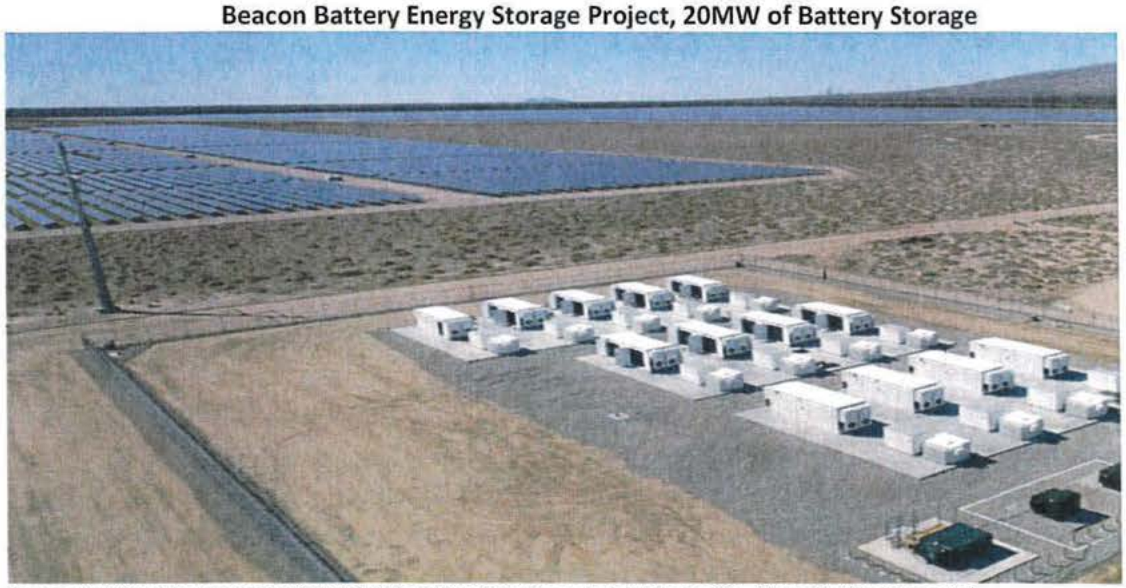
Connection level	2017 Achieved	2020 Targets	2020 Achieved
Generation and Transmission	21 MW	128.4 MW	320 MW
Distribution	-	25 MW	-
Customer	1.6 MW	2 MW	7.8 MW
Total	**22.6 MW**	**155.4 MW**	**327.8 MW**

Transmission level

LADWP's 2020 Transmission and Generation level energy storage targets consist of 128.4 MW. To determine the correct use case of the storage system(s), in 2015 LADWP conducted 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 RPS 50. The study analyzed both hourly and sub-hourly scenarios. MGREPS quantified matrices such as over-generation amounts, regulation, ramping needs, and N-1 stability.

Based on the MGREPS results, LADWP moved forward with procuring and commissioning a 20 MW Beacon Battery Energy Storage Project (BESS) which is designed to perform frequency response, regulation, and voltage support. The BESS is interconnected at LADWP's largest renewable energy corridor which supplies LADWP with over 650 MW of solar photovoltaic (PV) and 135 MW of renewable wind generation. The BESS was commissioned in late 2018.

Beacon Battery Energy Storage Project, 20MW of Battery Storage



Source: LADWP Intake Magazine: First Grid-Scale Battery Gets Connected at Solar Facility, (Photo by Chris Corsmeier)

On October 14, 2017 California Senate Bill 801 (SB 801) required LADWP to determine the cost-effectiveness and feasibility of deploying a minimum of 100 megawatt (MW) of energy storage solution capable of providing a full four-hour energy at the rated output, equivalent to 400 megawatt-hours

(MWh) by June 1, 2018. Furthermore, If LADWP determined that deploying the designated energy storage solution is cost- effective and feasible; SB 801 required LADWP to consider deploying those cost-effective energy storage solutions after June 1, 2018.

In response to SB 801, LADWP conducted a cost-effectiveness study for battery energy storage procurement. The study determined that pairing a 100 MW BESS project with a 200 MW Solar project after 2022 will be cost-effective due to declining battery prices. Pairing solar generation with energy storage allows for dispatchable renewable energy – shifting excess energy to high demand periods – which helps in reducing reliance of gas generation while providing ancillary services for a stable grid. Subsequently, LADWP issued an RFI and evaluated development opportunities for solar plus battery energy storage project proposals from 130 vendors.

On September 10, 2019 the Board approved power purchase agreement (PPAs) for the Eland 1 & 2 solar and storage projects and subsequently the Los Angeles City Council approved the PPAs on November 6, 2019. This project will develop over 400 MW of solar energy generation along with a four-hour 300 MW battery storage system. The energy storage system can store up to 1,200 MWh of renewable energy. From the 130 evaluated proposals, Eland solar and storage project agreement was the most cost-effective and beneficial to help LADWP meet its energy storage procurement targets and renewable goals.

Eland Solar and Energy Storage Project – 400 MW of solar generation and 300 MW of battery storage

Source: City of Los Angeles Announcement: Mayor Garcetti Celebrates Final Approval of Largest Solar and Energy Storage Project in the US, November 6, 2019

Distribution level

LADWP's Distribution level targets include 25 MW of energy storage both on the 34.5 kV and 4.8 kV systems. To better understand the distribution system needs, LADWP conducted the Maximum Distribution Renewable Energy Penetration Study (MDREPS). LADWP studied the PV hosting capacity of distribution circuits and feeders and evaluated 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 generation. The possible impacts of reverse power flow include relay mis-operation and regulator malfunction. The simulation results indicate that at higher levels of PV generation, voltage swells occur on the feeder causing power quality issues. One recommendation of the study is to deploy energy storage systems to feeders with high PV generation that experience voltage swells.

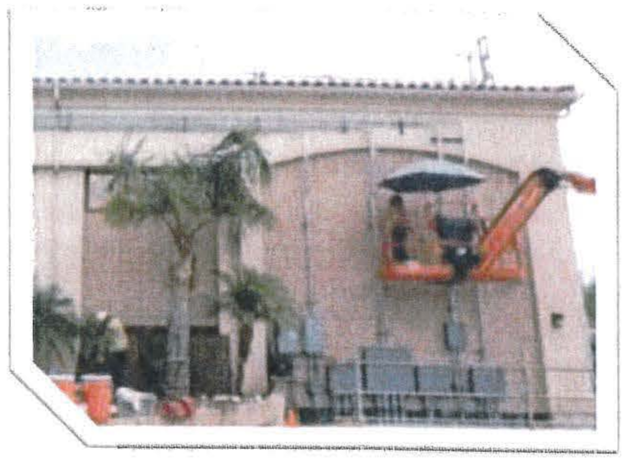
Utility-scale distributed energy storage tends to be less cost-effective to deploy than energy storage at the transmission level, hence distribution solution adoption rates are lower. That being said, LADWP is exploring distribution level energy storage projects on an ongoing basis to determine actual costs, technology viability, communication requirements, and safety. Future distributed energy storage projects may be utilized to explore mini-grid solutions for resiliency purposes.

Customer level/Behind the Meter Energy Storage

LADWP has been working diligently to finalize standards that allow customers install energy storage systems safely, including those paired with rooftop solar systems. As of March 2020, LADWP has interconnected over 7.8 MW of customer-owned energy storage systems. Customer level energy storage helps customers better manage their electricity use.

On the utility side, LADWP installed a 13 kW, 36 kWh pilot BESS at Fire Station 28 in Porter Ranch to increase resiliency of that station. Incidentally, on 3/22/18, there was a power outage due to heavy rain that lasted over 7 hours. The BESS was sufficient to provide backup power to Fire Station 28 during this outage.

Fire Station 28 BESS Project - 13 kW, 36kWh



In the fourth quarter of 2019, LADWP commissioned a hybrid lithium-ion and flow battery energy storage system at its headquarters, John Ferraro Building (JFB) in downtown Los Angeles. The primary goal of this hybrid system is to conduct research and development in a joint project with Electric Power Research Institute (EPRI) to evaluate best application for each technology and gather information on performance, operations, and safety of the systems. This effort will pave the way for deploying multiple large-scale energy storage projects at transmission and distribution level.

John Ferraro Building BESS Project - 100 kW, 400kWh Lithium-Ion, & 100 kW, 400kWh Flow battery

On-going effort in energy storage procurement

LADWP along with the Southern California Public Power Authority (SCPPA) and other SCPPA utility members have the following three solicitations mechanism to investigate and procure potential energy storage technologies and projects.

- LADWP's Request for Information (RFI) for Renewable and/or Distributed Energy Resources
- SCPPA's Renewable Energy and Energy Storage Request for Proposals (RFP)
- SCPPA's Request for Information (RFI) for Transmission Level Energy Storage

As LADWP's resource portfolio transitions to a greater percentage of renewable resources, the need and ability to implement energy storage systems to maximize the benefits of these renewable resources will grow. Through partnership with EPRI and National Renewable Energy Laboratory (NREL), LADWP continues to explore the various types of energy storage technologies at the transmission, distribution, and customer levels. Given the cost reduction and availability of various energy storage technologies, LADWP has now incorporated energy storage resources as part of its regular Integrated Resource Planning efforts to help Los Angeles reach its 100 percent renewable energy goal by 2045. All future studies will consider energy storage assets as resources that can be utilized for reliability purposes.

With the announcement of Los Angeles' Green New Deal Sustainable City pLAn in 2019, LADWP will continue to explore energy storage technologies that will help Los Angeles reach 55% renewable energy by 2025, 80% by 2036, and 100% by 2045.

Conclusion

As of March 2020, LADWP reached 327.8 MW of energy storage procurement exceeding its 2020 accelerated target of 155.4 MW. Due to the increasing cost-competitiveness of energy storage, LADWP has incorporated energy storage as one of the resources available to serve Los Angeles energy needs and also part of the annual integrated resource planning process, helping Los Angeles achieve 100% renewable energy by 2045.

Appendix: SB 801 Report (See Attached)

SENATE BILL 801 REPORT

LADWP's Response to SB 801

LOS ANGELES DEPARTMENT OF WATER AND POWER

April 2018

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INTRODUCTION

California Senate Bill 801 (SB 801) authored by California Senator Stern of District 27 and signed by Governor Brown on October 14, 2017 addresses electrical reliability impacts as a result of reduction in gas storage capacity and gas deliverability resulting from the well failure at the Aliso Canyon natural gas storage facility.

SB 801 requires the Los Angeles Department of Water and Power (LADWP) to determine the cost-effectiveness and feasibility of deploying a minimum aggregate total of 100 megawatt(MW) energy storage solution capable of providing a full four hours at a rated output, equivalent to 400 megawatt-hours (MWh) of energy, by June 1, 2018. If LADWP determines that deploying the designated energy storage solution is cost-effective and feasible, it shall consider deploying those cost-effective energy storage solutions after June 1, 2018. (PUC 2836.7)

As stated in SB 801 it is the intent of the Legislature that local governments having jurisdiction affected by this section strongly consider taking immediate actions to support rapid compliance, including by allowing or developing fast-tracked permitting, waiving or adjusting procedural requirements, to support rapid or more rapid site acquisition for energy storage project developments and customer acquisition of energy storage solutions without in any way modifying the obligations of a local government under the California Environmental Quality Act. (PUC 2836.7)

Additionally, SB 801 requires the LADWP to maximize the use of demand response, renewable energy resources, and energy efficiency to reduce demand in the area where electrical reliability has been impacted by the Aliso Canyon natural gas storage facility well failure. (PUC 9616)

Finally under SB 801, LADWP is required to make publicly available electrical grid data necessary or useful to enable distributed energy resource providers to target solutions that support reliability in the area impacted by Aliso Canyon natural gas storage facility well failure. (PUC 9618)

This report documents LADWP's actions relating to the Aliso Canyon Natural Gas Storage Facility well failure in 2015 and the deployment of demand response, renewable energy resources and energy efficiency in areas affected by the well failure as well as data availability outlined in SB 801. Furthermore, it presents the approach and results taken to complete the cost-effectiveness and feasibility of deploying 100 MW, 400 MWh energy storage systems after June 1, 2018.

ALISO CANYON IMPACT & MITIGATION

ELECTRIC RELIABILITY AND OPERATIONAL IMPACT

As one of the 38 Balancing Authorities (BA) in the Western Electricity Coordinating Council (WECC), LADWP is responsible for balancing supply and demand of electricity in its BA area that includes the two load centers, City of Los Angeles and Owens Valley, and transmission and generation assets that span as far as Oregon to the north and Utah to the east. LADWP has 7,880 megawatts of generating capacity, including four gas-fired stations in the Los Angeles Basin. The LADWP BA responsibility also includes supply and load balancing service to the City of Burbank and City of Glendale.

The October 2015 Aliso Canyon Gas Storage well failure significantly impacted the LADWP's electric supply operations not only to assets in the Los Angeles Basin, but also resources across its BA area as a result of uncertainty in gas delivery. Other operational impacts include:

- Increased gas prices volatility
- Instances of gas curtailment
- Increased operational coordination with SoCal Gas and among internal groups required additional resources
- Operational Flow Orders from SoCal Gas due to natural gas surplus or shortage have increased
- Purchase of alternative fuel for emergency backup purposes was introduced
- Weekly emissions testing for permitting to burn alternative fuel was required
- Non-economic dispatch of generating units was required resulting in large economic impact to LADWP
- Introduced Constrained Operation Reliability Schedule for generating resources
- Stopped natural gas hedging for approximately a year leading to financial risk
- Other economic impacts due to changes and mitigation measures introduced as a result of the gas well failure

MITIGATION MEASURES

Subsequent to the well failure, in April 2016, the CPUC, CEC, CAISO, and LADWP prepared the Aliso Canyon Risk Assessment Technical Report and the Action Plan to Preserve Gas and Electric Reliability for the Los Angeles Basin. As part of the Action Plan, the joint agencies undertook several mitigation measures to help improve reliability. In addition to this joint effort, LADWP undertook operational mitigation measures including:

- Changing operating procedures to maximize flexibility, such as curtailing gas hedging and sales of gas-fired energy to preserve its natural gas supply for critical needs within its service area.
- Halting the sales of excess energy to other market participants when LADWP is able to generate electricity at a lower cost than others.
- Curtailing physical hedging of gas supply to avoid being locked into commitments where LADWP is required to buy gas in advance, which enables LADWP to vary the use of gas power to preserve it for critical periods.
- Curtailing block energy and forward capacity sales to retain flexibility and reduce gas use.
- Stop economic dispatch of the gas-fired in-basin generating units.
- Conducted outreach efforts to customers to reduce natural gas and electricity use on hot days.

LADWP also increased the use of Distribution Energy Resources (DER) programs to reduce demand by continuing growth towards meeting its DER goals as detailed in LADWPs 2017 Power Strategic Long-Term Resource Plan, including:

- Conducted a comprehensive Distributed Energy Resources Integration Study (DERIS) to determine the roadmap for integrating distributed energy resources. The study was completed in November 2017.
- Reprioritizing existing Energy Efficiency (EE) programs, including establishing a Memorandum of Understanding with Los Angeles Unified School District to implement energy savings measures,

launching new programs, including AC optimization program, and upstream commercial HVAC program , and enhancing ongoing programs such as the Commercial Direct Install Program, Home Energy Improvement Program and the Energy Savings Assistance..

- LADWP has a goal of 15% EE by 2020 and will continue this aggressive annual pace through at least 2027.
- Accelerating Demand Response (DR) program and launching SummerShift. Enrolling 50 MW of commercial DR and launching a 100 MW peak shifting program, SummerShift for 2016.
- LADWPs DR goal is 200 MW by 2020 and 500 MW by 2026, which will be comprised of residential, commercial, and electric vehicle programs
- In addition to the 1,265 MW of Castaic Pump Energy Storage capacity, LADWP is committed to meet 178 MW of energy storage by 2021.
- LADWP is exploring conducting a pilot project to manage and synchronize DERs. This will include demonstration of Distributed Energy Resources Management (DERMS) capabilities. LADWP is collaborating with other utilities and Electric Power Research Institute (EPRI) in DERMS deployment.

MAXIMIZING USE OF DISTRIBUTED ENERGY RESOURCES & RENEWABLE ENERGY RESOURCES

LADWP is maximizing the use of renewable energy resources through its robust local solar portfolio which supports the adoption of rooftop solar photovoltaics on residential, commercial, and city-owned properties:

- Solar Incentive Program (SIP) in which residential and commercial customers are provided incentive funding to install behind-the-meter rooftop solar systems. The SIP has incentivized approximately 32,000 customers to adopt solar, totaling 237 MW of behind-the-meter customer-owned solar, not eligible for RPS compliance. Currently, of the state-mandated $288M incentive program, approximately $9M remains. Incentives are expected to be fully expended sometime in 2018, but customers may continue to adopt solar without incentives.
- Solar Rooftops Program (SRP) pilot where LADWP installs utility-owned solar panels on customer rooftops in exchange for a monthly lease payment. The SRP pilot, launched in 2017 with a 1 MW target, has resulted in over 500 applications for program participation. Energy produced through the SRP also contributes towards RPS targets and does not impact energy sales.
- Feed in Tariff (FiT) Program where largely commercial and industrial customers are encouraged to sell rooftop solar energy to LADWP through 20-year power purchase agreements. Thus far, FiT has encouraged the execution of power purchase agreements totaling 46 MW of the 150 MW program goal, contributing towards LADWP's RPS targets and not impacting energy sales.
- LADWP has also entered into a research partnership with US Department of Energy's Mission Innovation Initiative and undertaken an ambitious research effort to study the feasibility of a 100% renewable portfolio. The continued deployment of DERs is critical in LADWP meeting growing and increasingly variable electric demand, and in integrating high levels of renewable penetration. This includes mitigating challenges associated with any impacts to electric reliability related to the Aliso Canyon well failure and subsequent limitations on use as a gas storage facility.

LADWP has been aggressively procuring and integrating grid-scale renewable resources as part of its requirement to meet Renewable Portfolio Standards (RPS), these efforts include:

- Recently procured 600 MW of solar generation capacity in Kern County through eight long-term power purchase agreement (PPA), 510 MW of this is in operation as of December 2017, and the remaining 90 MW will be in service in January 2019.
- Procured 180 MW of geothermal generation capacity through two PPAs of which 54 MW is in service as of December 2017.
- LADWP has over 3,000 MW of renewable energy resources capacity in service to date.
- Accelerated implementation of the Beacon Energy Storage System, a 20 MW utility-scale battery storage that will help maximize the integration of renewable generation resources.
- The Los Angeles City Council has directed LADWP to determine how the city can achieve 100% clean energy future. LADWP is currently conducting a comprehensive study to that effect.

Although LADWP has aggressive renewable integration goals it is currently experiencing minimal renewable over-generation. For 2017, only 557 MWhs were curtailed resulting from the 14 over-generation events which accounts for only 1.2% of curtailment events. LADWP's Castaic Pumped Storage with a capacity of 1,265 MW is currently being effectively utilized to mitigate over-generation issues.

DATA AVAILABILITY

SB 801 requires LADWP to make electrical grid data publicly available which is necessary or useful to enable distributed energy resource providers to target solutions that support reliability in the area impacted by the Aliso Canyon well failure. LADWP is not required to make data available that is prohibited from being disclosed pursuant to state or federal law. The data is made available pursuant to California Public Records Act. LADWP has an existing process for public records requests outlined below:

To request copies of public records from the LADWP, download the California Public Records Act – Records Request Form in PDF format and then type the request, save the form, and e-mail it as an attachment to CPRA@ladwp.com.

General Information: Please allow up to ten calendar days to receive a response to your request. Requests may be submitted by regular mail, electronic mail, or facsimile to:

Los Angeles Department of Water & Power
CPRA Clearinghouse
Communications, Marketing, and Community Affairs Division
P.O. Box 51111, Room 1520
Los Angeles, CA 90051-0100
Email: CPRA@ladwp.com
Fax: (213) 367-0532

For access to request form and further information the link below is provided:
https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-financesandreports/a-fr-reports/a-fr-r-cprarecordrequest?_adf.ctrl-state=gqcv0wgxr_4&_afrLoop=273750986216243&_afrWindowMode=0&_afrWindowId=null#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D273750986216243%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dsg9q9d06z_37/

COST-EFFECTIVENESS STUDY FOR ENERGY STORAGE SOLUTION

ELECTRIC POWER RESEARCH INSTITUTE (EPRI) STUDY

LADWP engaged EPRI to perform an in-depth cost-effectiveness study due to EPRI's immense experience with energy storage applications and costs. EPRI's study included LADWP seasonal scenarios as well as operational considerations and restrictions. To evaluate the cost-effectiveness of energy storage, a grid-scale 100 MW lithium ion battery energy storage system (BESS) paired with solar generation was chosen due to its robust industry deployments, ease of integration with renewable technologies such as photovoltaic solar and rapid declining cost. This solar and battery system combination was modeled to be operated by a third party through a power purchase agreement with LADWP. Third party solar and storage developers qualify for the investment tax credit (ITC) unlike LADWP which is an untaxed entity. The ITC may offset up to 30% of the capital expenditures and make the investment much more cost-effective. The maximum ITC restricts the BESS to only charge from solar which limits operational flexibility and grid charging.

EPRI performed economic analysis utilizing StorageVET, a publically available and transparent optimization tool for energy storage benefit cost analysis, as well as other tools. EPRI's study determined that a 200 MW Solar & 100 MW BESS project has a benefit to cost ratio greater than one in 2022 and beyond. The entire study and methodology can be found in Appendix 1.

ALTERNATIVE TECHNOLOGY CONSIDERATIONS

Prior to the cost-effectiveness study performed by EPRI, LADWP considered evaluating cost-effectiveness for various technologies such as pumped hydroelectric power (pumped hydro), compressed air energy storage (CAES) and thermal energy storage (TES). These technologies were not considered for this study due to various reasons. For rapid deployment and execution, pumped hydro technology was not considered for this study due to the lengthy Federal permitting process for hydroelectric power plants. In addition, pumped hydro is more cost-effective for deployment on much larger scale than the SB 801 prescribed 100 MW for 4 hours. LADWP currently owns, operates and maintains Castaic Power Plant which is capable of generating and storing 1,265 MW of energy for more than six hours depending on operating conditions. CAES technology is a re-emerging technology and LADWP is currently evaluating proposals for cost-effectiveness and feasibility for a potential application near Intermountain Power Plant in Utah. CAES is not widely deployed on a large-scale basis mainly due to its geographic location requirements, and most deployed CAES projects require an available underground cavern sized appropriately to store the compressed air at over 1,000-pounds of pressure. As LADWP's transmission and generation resources are located throughout the western United States, CAES may be feasible only at one location which may limit its deployment. To be consistent with the intent of SB 801 to address Aliso Canyon gas leak, CAES is not part of this study. TES was also not considered given that the typical scale for TES is in the residential and commercial customer level, less than 1 MW, and cost attributed to an aggregate of 100 MW would be infeasible.

Behind the meter battery storage was not considered because this solution would require immense coordination and several years to integrate an aggregate of 100 MWs of energy storage solutions within the Los Angeles Basin due to its dense nature. Additionally, behind the meter storage would require a Distributed Energy Management System to enable LADWP to manage DERs. LADWP currently does not have DERMS software but is exploring implementation of a DER pilot program which includes a DERMS component. A full DERMS software for the LADWP territory may not be available until 2023 and beyond.

FEASIBILITY REVIEW FOR ENERGY STORAGE SOLUTION

FEASIBILITY OF ENERGY STORAGE SYSTEM

LADWP utilized results of EPRI's cost-effectiveness study results to perform a general feasibility of installing a 100 MW Battery Energy Storage System paired with a 200 MW photovoltaic (PV) solar system. The feasibility is dependent on several factors such as: land acquisition, environmental permitting (environmental impact report), incentives, and subsidies for the renewables and storage. These responsibilities are placed on the developer because they develop the project and sell energy to LADWP.

LADWP will need to incorporate the proposed solar and storage project into its budget review, Power Strategic Long-Term Resource Plan and Ten-Year Transmission Assessment to analyze its technical and fiscal impact to LADWP's electrical system and its customers.

FEASIBILITY OF INTERCONNECTION

A 100 MW BESS would be the most cost-effective if interconnected to LADWP's transmission system as outlined in LADWP's 2017 re-evaluation of AB2514 targets. Currently LADWP's transmission system is constrained through reservations and upgrades would be required to host the 100 MW BESS paired with 200 MW Solar. Transmission upgrades are already underway and would be completed by 2022 at which time energy storage solutions become cost-effective. LADWP currently has preferred interconnection locations for renewables projects which are made public. A more detailed study of the BESS' impact to LADWP's transmission system and resource stack is required for a specific project.

Interconnection feasibility also depends on where the solar and storage project is physically located. For an extensive feasibility study, a system impact, facility, and harmonic study will be performed for all power purchase agreement proposals utilized as part of this study through LADWP's Large Generator Interconnection Procedure.

CONCLUSION

While LADWP currently does not have major renewable curtailment issues as renewable integration increases, energy storage will assist in making a greener grid. In response to SB 801, LADWP has evaluated the cost-effectiveness of power purchase agreement proposals. Based on energy storage costs, LADWP plans to continue evaluating and negotiating power purchase agreements in 2018 to initiate procurement in 2019 or before for installation in 2022 and beyond. Nonetheless, a detailed feasibility study incorporating the solar and storage system impact to LADWP's transmission system and resource stack will be required for specific large scale projects. Lastly, LADWP will continue to maximize the use of demand response, renewable energy resources, and energy efficiency to improve the reliability in the area impacted by Aliso Canyon well failure.

Appendix 1: Electric Power Research Institute (EPRI) Cost and Benefit Analysis Report

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

APPENDIX 1

Integrating Energy Storage System with Photovoltaic Generation: Analysis within Los Angeles Department of Water and Power (LADWP) Service Territory to meet SB801 Requirements

EPRI Report

Electric Power Research Institute
P94: Energy Storage and Distributed Generation
March 2018

ELECTRIC POWER RESEARCH INSTITUTE

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CONTENTS

Study Objectives

In February 2018, Los Angeles Department of Water and Power (LADWP) funded EPRI to conduct cost-effectiveness analysis of a 100 MW, four-hour Battery Energy Storage System (BESS) in compliance with California Senate Bill SB 801. The bill calls for a minimum aggregate of 100 MW BESS capable of providing a full four hours at a rated output, equivalent to 400 megawatt-hours (MWh) of energy.

Based on LADWP's input, EPRI's analysis assumes that the procurement would be constructed as a Power Purchase Agreement (PPA) with a third-party developer, who would be able to claim the 30% federal Investment Tax Credit (ITC) incentive. The analysis was performed using LADWP's load demand in which the average load is approximately 3 GW and peak is approximately 6 GW. The analysis also assumes that the location, in proximity to multiple LADWP renewable facilities in California, would be ideal to meet bulk-system requirements.

This report provides details for the following elements of the analysis:

- Grid Services and Scenarios considered
- Input data and assumptions utilized
- EPRI's modeling approach
- Results of analysis for the evaluating and stacking benefits from the grid services

All the scenarios were modeled in EPRI's Storage Value Estimation Tool (StorageVET®) tool.

Grid Services and Scenarios Utilized for the Analysis

Grid Services in SB801 Analysis

The following grid services were considered for this analysis.

- **Energy Discharge constraint (Primary service 1)** to support operational flexibility of renewables generation during evening hours
- **Spinning Reserves commitment constraint (Primary Service 2)** to improve the generation capacity of the system in case of contingencies
- **Real-time Energy Shifting ("Energy Arbitrage")** which identifies low energy price hours and charges the battery to meet the constraints described above in the most economical manner
- **Frequency response** to contribute to frequency stabilization in case of a contingency event

Other grid services that were considered but not analyzed in this analysis include: deferring infrastructure upgrades, flexible ramping, frequency regulation, non-spinning reserve, VAR support, and resource adequacy. The value of deferring infrastructure upgrades was not considered because upgrades for reliability have been planned and are underway in the area of interest. Given LADWP's vertically integrated structure and limited participation in the CAISO market, frequency regulation and resource adequacy were not considered in this analysis.

Analysis Scenarios

For the primary services analysis, the following scenarios were considered:

- *Scenario #1: Unconstrained Case* – Storage charge/discharge and spinning reserves commitment are co-optimized based on real time energy price and spinning reserves price respectively. No constraints are imposed.

- *Scenario #2*: Constrained *Case* – Based on a defined magnitude and time window for discharging energy and offering spinning reserves (as shown in Table 1)
- *Scenario #3: Constrained Case + Restrict charging from the grid* – Based on a defined magnitude and time window for energy discharge and spin commitment (as shown in Table 1) as well as a penalty to restrict charging the storage from the grid

To better understand and verify the results of the optimization, each of three scenarios are optimized **first with real-time energy time-shift only** (Primary Service #1). The results from these cases should be intuitive, as the optimization is only achieving energy time-shifting and daily target State of Charge (SOC) levels. This will allow a clear examination of the model prior to stacking additional services, such as frequency response and spinning reserve.

Stacked benefits of energy storage systems (for all the scenarios described above) with **Spin Commitment Constraint** (Primary Service 2) and **Frequency Response** were analyzed next. The scenarios are optimized based on both real-time energy and spinning reserve prices. Restriction to charging storage from the grid were then introduced in Cases #1 through #4 for both unconstrained and constrained scenarios. All these cases are summarized in Table 3. Cases #1 through #4 were considered for the cost and benefit analysis.

Table 1. Constraints Considered for the Primary Services + Secondary Services

		Price	Dispatch Magnitude (Unconstrained)	Dispatch Magnitude (Constrained)	Dispatch/Charge Time Window (Constrained)
Services	Real-time Energy Shifting ("Energy Arbitrage")	Used real-time hourly incremental pricing data for charging & discharging	Based on energy prices and optimization in StorageVET	Discharge of 85 MW for 4 hours for a total of 340 MWh	• Jan, Feb, Nov, Dec: afternoon hours • Mar, Apr, Oct: Afternoon hours • May, Jun, Jul, Aug, Sep: No Constraints. Use optimal dispatch Charge Time: Lowest real-time energy price hours
	Spinning Reserve	Fixed price based on LADWP's OATT*: a) On Peak b) Off Peak	Based on spinning reserve prices and optimization in StorageVET	Discharge of 85 MW for the Dispatch Time Window specified	• Oct, Nov, Dec, Jan & Feb: Morning to Early afternoon • Mar, Apr: Morning to Early afternoon • May, Jun, Jul, Aug, Sep: Spin Reserve Activated (No constraints on Limits. Use optimal dispatch) Charge Time: Lowest real-time energy price hours
	Non-spinning reserve	Fixed price based on LADWP's OATT: a) On Peak b) Off Peak	0 MW	0 MW	Not expecting to use the battery for non-spinning reserve Charge Time: Lowest real-time energy price hours
	Frequency Response	Fixed price based on LADWP's OATT: a) On Peak b) Off Peak	Frequency response not considered in unconstrained case	15 MW	24 hours/day, every day of the year Charge Time: Lowest real-time energy price hours

*OATT: Open Access Transmission Tariff

Table 2. Other Constraints Considered

Operation Requirement	Requirements (Unconstrained and Constrained cases)	Dispatch/Charge Time Window (Constrained)
State of Charge	Target SOC enforced at the beginning of the day (00:00)	• Jan, Feb, Nov, Dec: 0% SOC at 00:00 • Mar through October: 10% SOC at 00:00
Limit Storage Charging from Grid	Charging from the grid will entail a large penalty in the storage model, in order to prevent the storage system to charge from the grid as much as possible	Limit energy storage system charging from grid always

Table 3. Summary of Unconstrained and Constrained Cases with an Additional Constraint on Restricting Charging from Grid

	Optimization	Type of Constraints Considered		Frequency Response
	Based on real-time energy and spinning reserve prices	**Unconstrained Case + Restrict charging from the grid:** Restrict charging from the grid, optimize with capacity	**Constrained Case + Restrict charging from the grid:** Restrict charging from the grid, enforce minimum discharge, and optimize with remaining capacity	Enforce minimum commitment during seasonal timeframe
Case #1	✓		✓	
Case #2	✓		✓	✓
Case #3	✓	✓		
Case #4	✓	✓		✓

Cost Benefit Analysis was performed for the constrained Cases #1 and #2 and unconstrained Cases #3 and #4 was used for the CBA. All these four cases considered restricted charging from the grid.

Figure 1 shows the dispatch constraints that were used in the analysis. For a typical day in January, a minimum of 85 MW of spinning reserve will be committed for a 6-hour timeframe in the morning, and a minimum of 85 MW will be dispatched during a 4-hour timeframe in the late afternoon. Additionally, exactly 15 MW of frequency response will be committed at all times. The remaining energy and power capacity will be co-optimized to dispatch based on energy and spinning reserve prices.

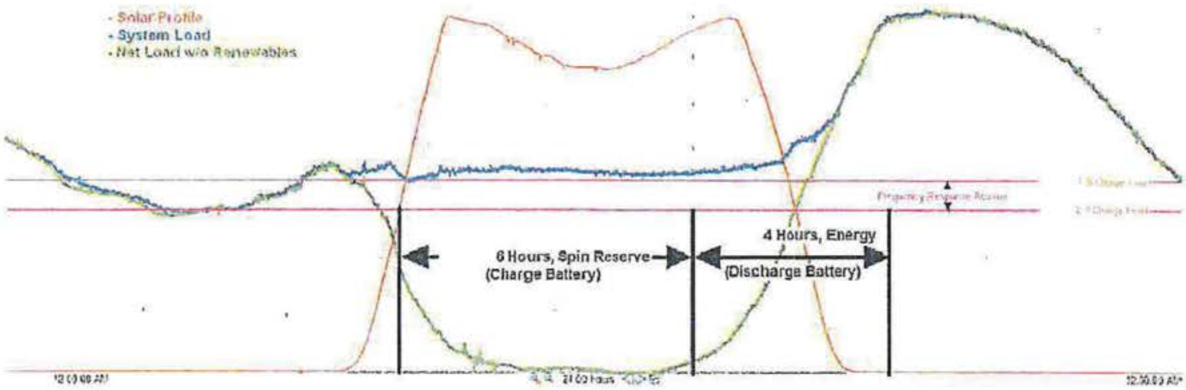


Figure 1: Sample Constrained Dispatch Profile for the Primary Services

Data and Assumptions

PV and BESS System Configuration

Table 4 shows the parameters for the configuration of the DC-coupled BESS and PV system studied in this analysis.

Table 4 PV and BESS system configuration

Parameter	Value
BESS Power capacity	100 MW
BESS Energy capacity	400 MWh
BESS Roundtrip Efficiency	85%
PV Nameplate Rating	200MW
Shared PV+BESS Inverter	300MVA

PV Generation, Load Profiles, and Real-Time Energy Price

EPRI obtained the following data from LADWP:

- PV system generation profile in 2017 for area of interest, with nameplate rated capacity of 200 MW
- Real-time (RT) energy prices data, which was obtained by averaging 15-minute energy prices on an hourly basis. Energy prices during three seasonal periods were compared, as provided by LADWP.
- Hourly demand profile corresponding to Los Angeles Basin Area
- LADWP Open Access Transmission Tariff (OATT)

Figure 2 shows seasonal variations of PV generation compared to the LADWP System Load. The color shaded indicates the timeframe in which a minimum discharge constraint will be enforced in this analysis. For the winter months (January, February, November, and December), the LADWP load encounters a steep load increase in the late afternoon as the PV production decreases drastically. During this time frame, the average PV production for the 200 MW system reduces by 108 MW, while the average system load increases by 306 MW in just 4 hours.

Though the effects are less significant, some ramping can be seen in later months of March, April and October, where the average system load increases by 92 MW early evening hours. During the same period, the average PV production drops 60 MW per hour until the sun disappears.

For the summer months, the ramping effects do not seem to be prevalent during late afternoon hours. Hence, no minimum discharge is enforced during these months. However, it should be noted that the maximum load during these months are higher than those of other months.

For the summer months, the ramping effects do not seem to be prevalent during late afternoon hours. Hence, no minimum discharge is enforced during these months. However, it should be noted that the maximum load during these months are higher than those of other months.

As Figure 2 indicates, the timeframe specified in this analysis coincides with the timeframe of most significant ramping flexibility needs for the system.

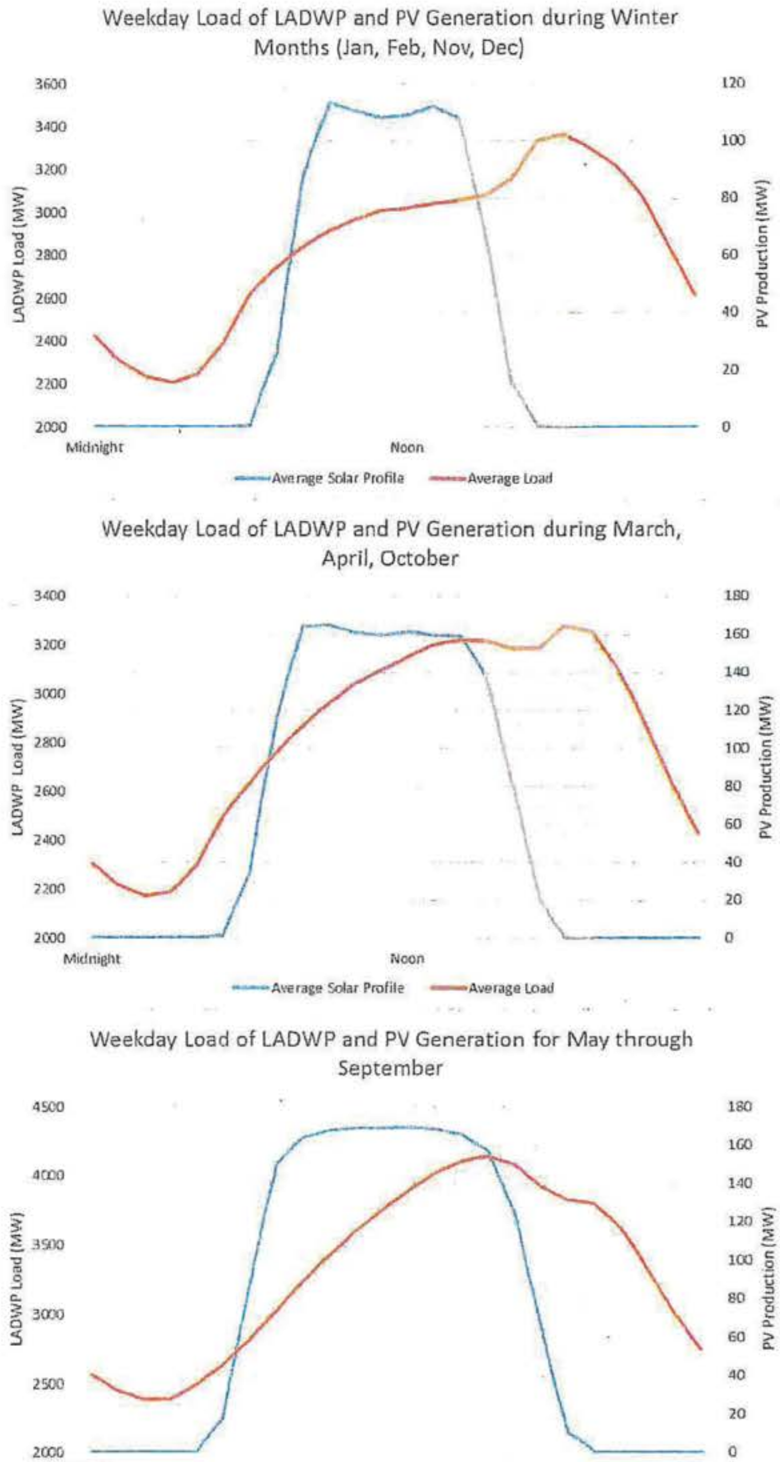


Figure 2. Seasonal Variations of PV Generation and LADWP System Load

This model does not consider any degradation of the BESS, as it is assumed the independent power producer (IPP) will be contractually obligated to ensure the BESS retains its specifications over the course of the PPA. Therefore, the system will remain at 100 MW and 400 MWh for its entire lifetime. Additionally, the cost of replacement is also included in the PPA prices. This cost-benefit analysis assumes the IPP is responsible for all capital expenses (CAPEX), fixed and variable expenses related to operation and maintenance (O&M) of the system and replacement costs

Modeling Assumptions

- *For all Three Scenarios*: To ensure storage system effectively captures energy generated from PV system, the daily target state of charge (SOC) of the BESS system is set to be:
  - 0%, fully empty, for all winter months (January, February, November, December) and
  - 10% for non-winter months (March through October)

- *Scenario #3: Constrained Case + Restrict charging from the grid*: To qualify for the ITC, the storage system must only charge from the PV system, and no charging from the grid is allowed in this model. Even though the BESS can charge 5% of the capacity from the grid, LADWP intends to reserve this limit for unexpected days of under-generation from the PV system.
- Utilizes PPA Proposals cost data received by LADWP from storage vendors, the number of charge/discharge cycles that the storage system is subjected to is limited to a maximum of 365 over the course of the year

Cost Benefit Analysis (CBA) Assumptions

The PPA for this project is 20 years and the PPA prices per unit of energy produced by solar does not change over the 20-year contract period. The prices shown for storage are provided by LADWP and are assumed to include the capital cost, operational expenditure, maintenance and system augmentation costs of the storage system per unit energy capacity, based on the Commercial Operation Date (COD). Average PV energy prices and storage prices were considered for each COD.

Overall Analysis Framework

Figure 3 through Figure 7 describes the overall steps that were utilized for Cases 1 through Case 4 as described in Table 3.

StorageVET® provides a combination of energy dispatch and spin commitment profiles which, when offered, will yield the highest benefit for the storage system. The other results available include the number of deep and shallow cycles of charge/discharge the storage system performs because of this co-optimization.

Constrained and Unconstrained Analysis Cases with an Additional Constraint on Restricting Charging from Grid

The four cases considered include:

- **Case #1: Constrained** Case + **Restrict Charging from the Grid** + **No Frequency Response** whereby the storage system can commit to full 200MW of Spin reserves during summer
- **Case #2: Constrained** Case + **Restrict Charging from the Grid** + **Frequency Response** whereby the storage system can commit to full 185MW of Spin

- Case #3: **Unconstrained** Case + **Restrict Charging from the Grid** + **No Frequency Response** whereby the storage system can commit to full 200MW of Spin
- Case #4: **Unconstrained** Case + **Restrict Charging from the Grid** + **Frequency Response** whereby the storage system can commit to full 185MW of Spin

Figure 3 depicts the overall procedure for the **Constrained+ Restrict Charging from the Grid** Case #1 (Min. Discharge Constraint – Primary Service 1 + Spin Commitment Constraint – Primary Service 2). For the **Constrained+ Restrict Charging from the Grid Case #1**, a restriction is imposed for charging from the grid in addition to the optimization function including the amount of spin commitment and energy charge and discharge that the storage system must provide during certain hours of the day throughout the year. Once these constraints are satisfied, the storage system co-optimizes for energy time-shifting and spinning reserve services with the residual headroom it is left with. Thus, the storage system meets the energy and spin related constraints and then co-optimizes for energy time-shifting and spinning reserves using energy charged mostly from PV. The discharge constraints for the primary service are illustrated in Table 1.

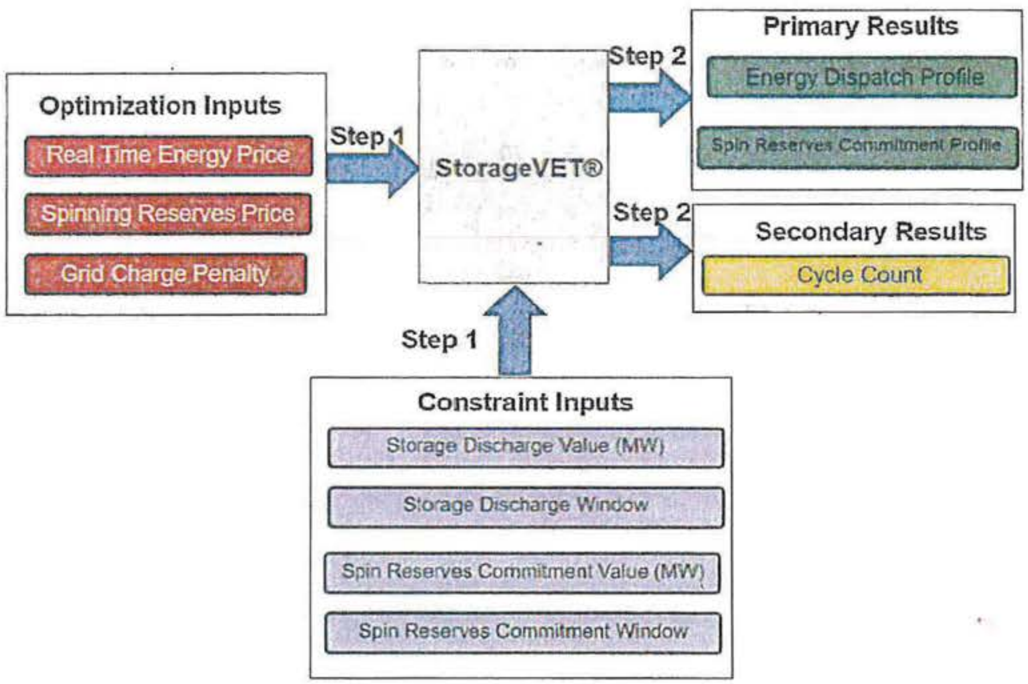


Figure 3. Methodology for Constrained Cases #1

Constraints related to energy discharge and spin commitment have mutually exclusive periods of activity and hence don't have a conflict with each other.

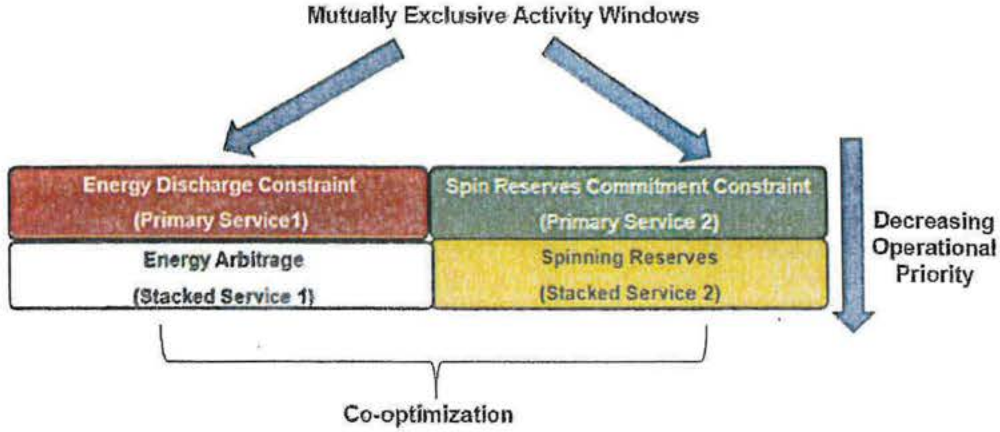


Figure 4. Operational Priority of Constraints

Figure 5 through Figure 7 depicts the overall methodology for Cases 2 through Case 4.

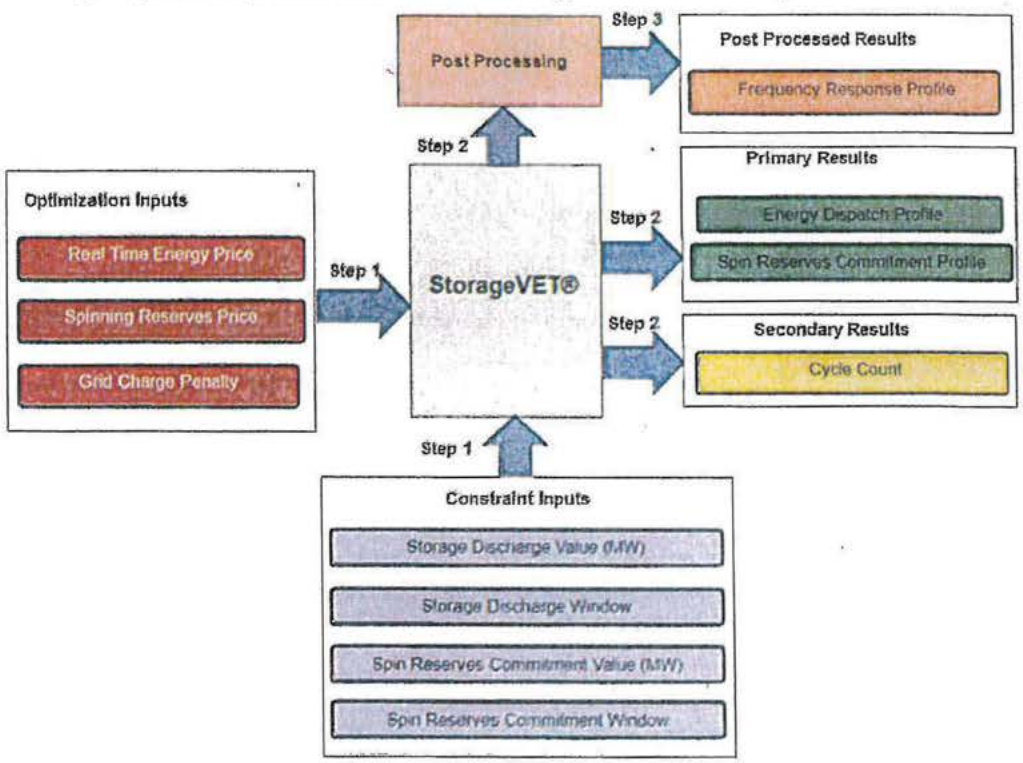


Figure 5. Methodology for Cases #2: Constrained Case + Restrict Charging from the Grid + Frequency Response

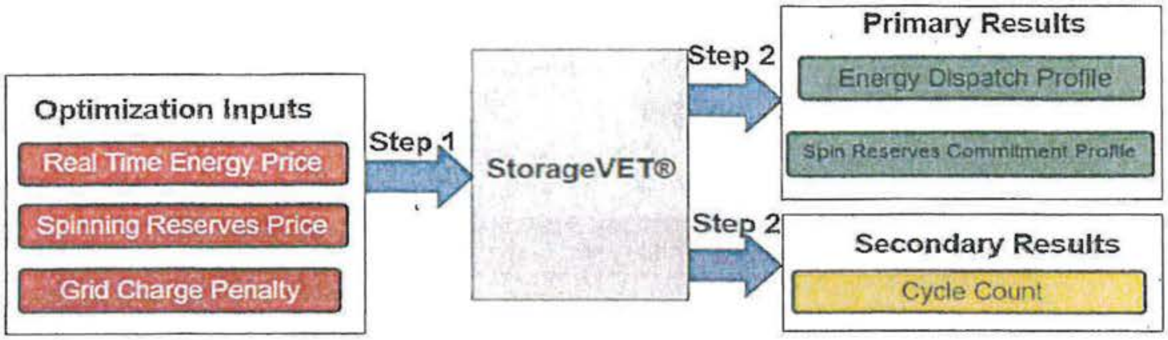


Figure 6. Methodology for Cases #3: Unconstrained Case + Restrict Charging from the Grid + No Frequency Response

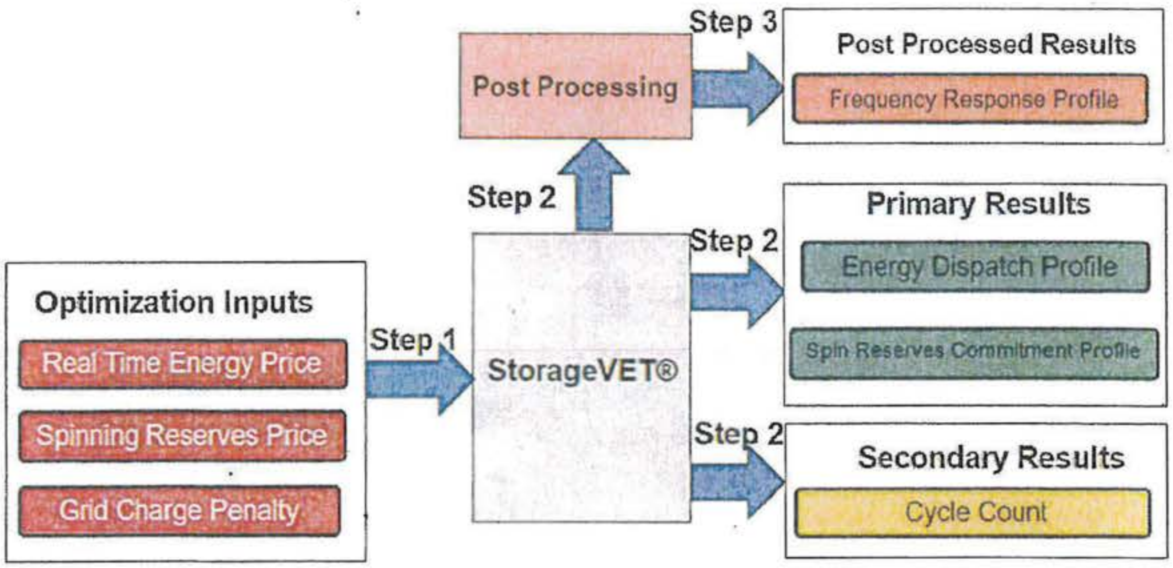


Figure 7. Methodology for Cases #4: Unconstrained Case + Restrict Charging from the Grid + Frequency Response

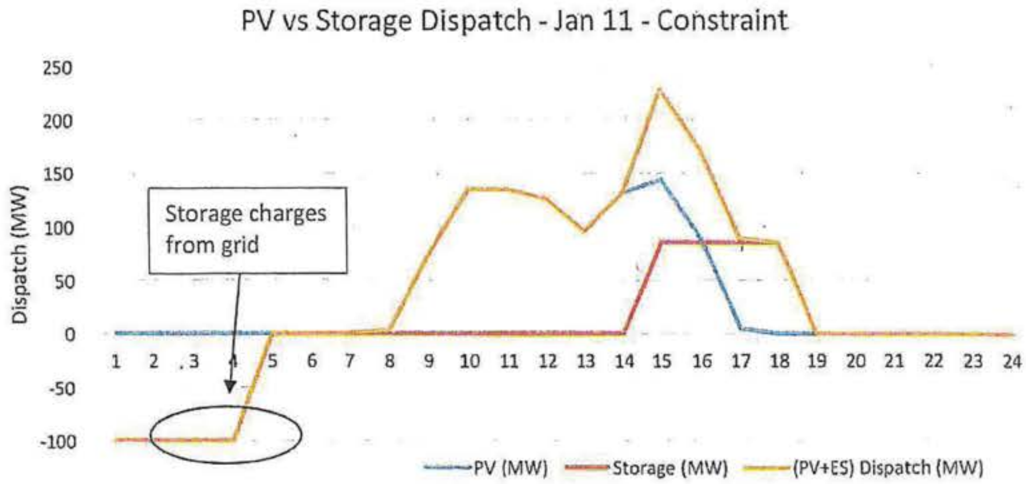
Analysis Results

The following sections outline the different sensitivity results from all the cases outlined in Table 3. In all the figures included negative ("-") value means storage charge and positive ("+") value means storage discharge.

"Constrained + Restrict charging from the Grid" Case #1: Optimizing Energy Storage Charge & Dispatch during winter

In these cases, a grid charging restriction is imposed which limits charging from the grid as much as possible. This change in charging trend can be observed by comparing the storage activity summary in the "Constrained" and "Constraint + Restrict charging from the Grid" case for the same day in January.

It can be observed that in the constrained case, the storage charges from the grid during the early hours of the day (low energy price). However, in the "Constraint + charging from the Grid" case, the storage charging profile follows the PV profile and never charges from the grid during the course of the day.



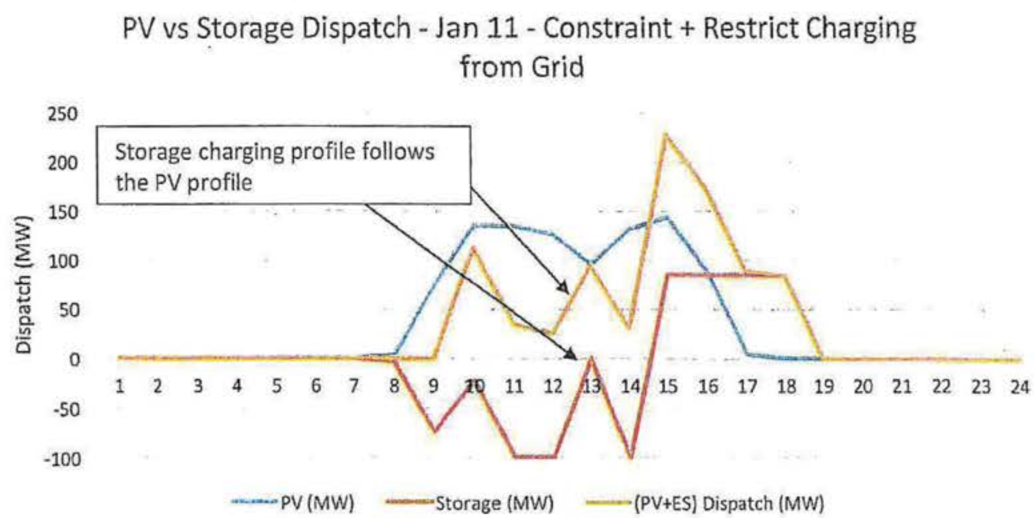
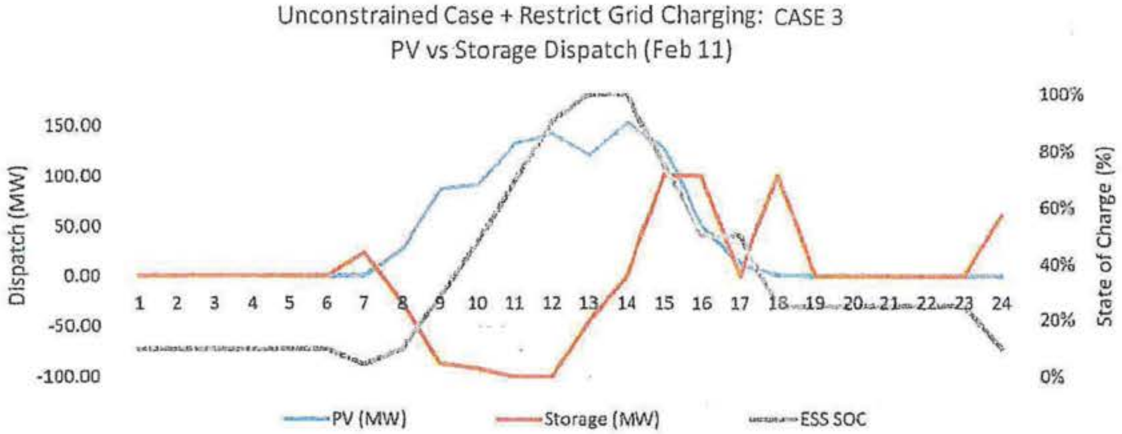


Figure 8. Comparison of Dispatch between the Constrained Case versus Constrained + Restrict Charging from the Grid Case

The results from Cases 2 through 4 are depicted in the figures below.

Figure 9 represents the impact of imposing a penalty for grid charging as a part of the optimization. This involves a comparison of cases with and without grid charge restriction, whereby for a same given day, it can be observed that the storage system does not charge from PV in Case 3, in spite of the low energy price in the morning. However, without grid charge restriction, the storage system charges from the grid during the early hours of the day due to the low energy price.



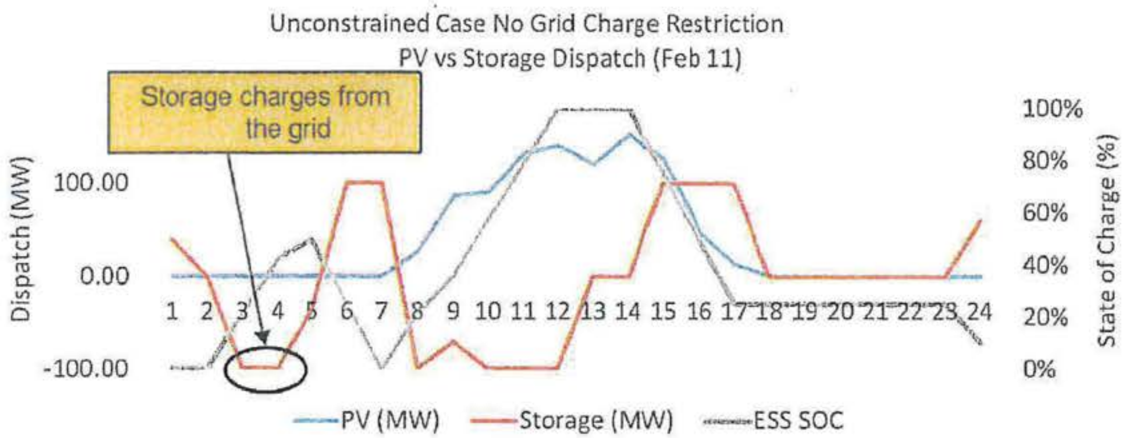


Figure 9. Unconstrained case Dispatch Operation with and without the Restriction to Charge from the Grid

Figure 10 explains the storage operation methodology when frequency response is offered as a service, in addition to spinning reserves and energy. This is illustrated as a comparison between Cases 3 and 4. In Case 3, since the storage system offers only spinning reserves and energy, it can commit up to a maximum of 200 MW during certain hours of the day, provided it is also charging during those hours. However, in Case 4, the storage system also offers frequency response service of 15 MW capacity throughout the day, hence it can only commit to 185 MW as a part of its spinning reserves.

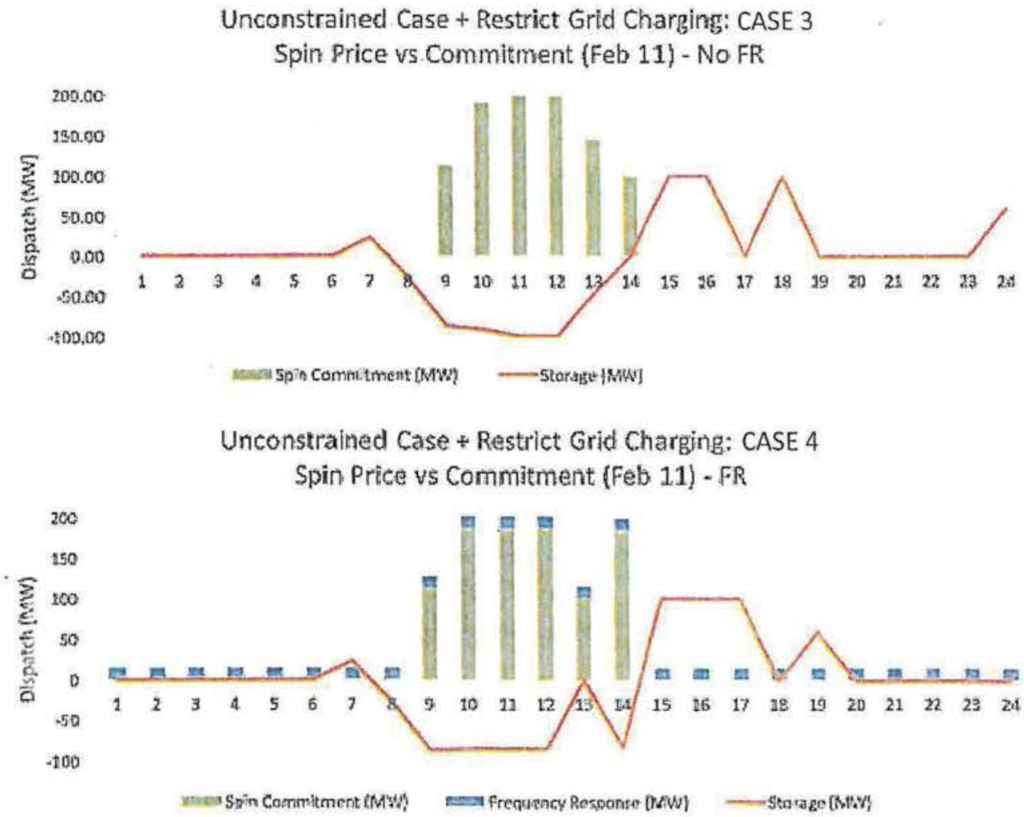


Figure 10. Unconstrained case + Restrict Grid Charging with and without Frequency Response

Figure 11 and Figure 12 illustrate the storage operation difference during different seasons when it is restricted from grid charging. During winter, the storage is subjected to both discharge and spin commitment constraints. However, the storage system's SOC is 0% at the beginning of the day and hence it must charge to reach a minimum of amount of SOC to offer 85 MW of spin reserves at 8:00 hours. Hence, it starts charging from PV and with the energy capacity it has, it offers spinning reserves through the afternoon while also charging simultaneously to reach the 85% minimum SOC required to meet the energy dispatch constraint later in the afternoon. Throughout the day, it also offers 15 MW of frequency response. This profile is depicted in Figure 11 provided below.

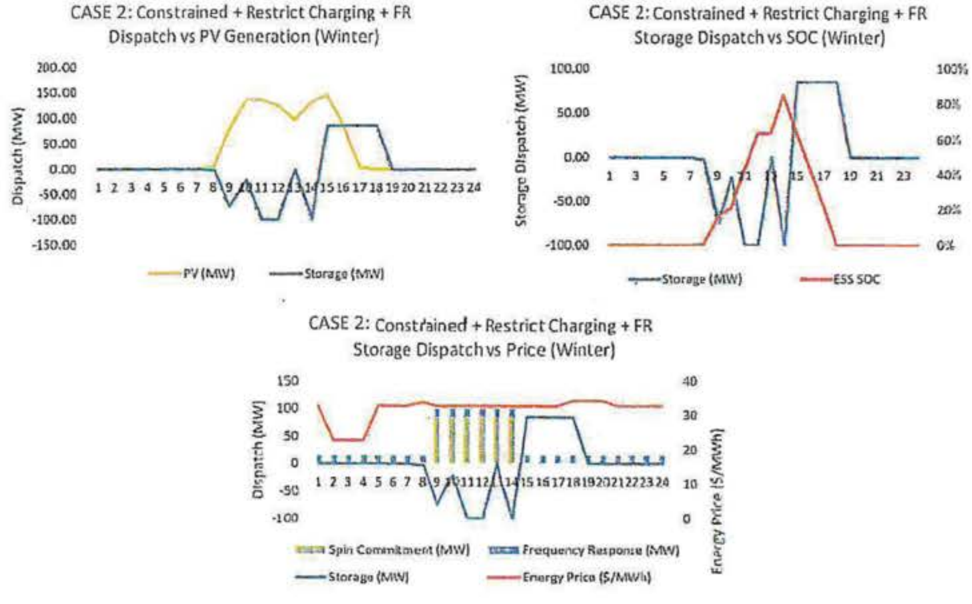


Figure 11. Case 2: Constrained case + Restrict charging + Frequency Response (Winter Case)

Figure 12 illustrates the storage operation during a day in summer. During summer, the storage system is not subjected to any energy or spin related constraints. It starts the day at a 10% SOC which is equivalent to 40 MWh energy capacity. So, it can only offer up to 40 MW of Spin, which it does until PV is available to it for further charging. Hence, it starts charging further once PV is available to it and with the SOC it has it offers up to 185 MW of spin, while also charging in parallel reaching a maximum SOC of 60% during this period. Later in the day, it discharges 200 MWh over a two-hour period and ends the day at 10% SOC.

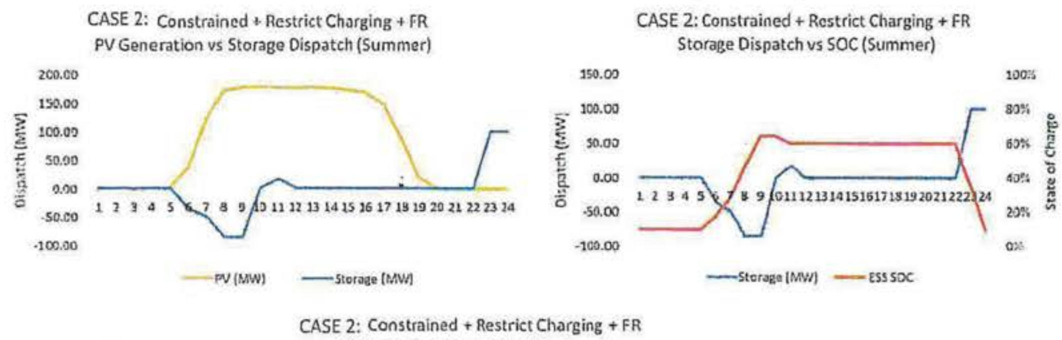


Figure 12. Case 2: Constrained case + Restrict charging + Frequency Response (Summer Case)

Cycle Counting

It is hard to estimate the total number of storage charge and discharge operations that will aid in quantifying the degradation of a battery over time. This requires a special approach. StorageVET makes use of a rainflow-counting algorithm, to quantify how many charging-discharging cycles has the battery undergone during certain time-period (e.g., a day). The outcome of the rainflow algorithm is the number and depth of charging cycles that the battery underwent. For instance, if the storage performs one complete charge and discharge cycle, then the algorithm would update the cycle counter as 1 for the depth of discharge bucket between 90% and 100%. This information is used to characterize the battery state of health after a period of operation.

The number of cycle counts for the Cases 1, 2, 3 and 4 are shown in Table 5 through Table 8. For Case 1, it can be observed that the storage system performs 61 cycles which are between 0% and 5% depth of discharge. These cycles are termed as shallow cycles and don't impact the state of health of system significantly. Hence, its **"effective cycle count"** is only 1.53. It can also be observed that the storage system performs 125.5 **"full cycles"** which degrades the state of health of the system significantly. This is reflected in the **"effective cycle count value"** of 119.23. These deep cycles are performed primarily because of the energy discharge constraint imposed.

Table 5 Cycle Count for Case 1: Constrained + Restrict Charging from the Grid + No Frequency Response

Depth of Discharge	No. of Cycles	Weighing Factor	Effective Cycles
0 < x < 0.05	61	0.025	1.53
0.05 <= x < 0.1	13.5	0.075	1.01
0.1 <= x < 0.15	9	0.125	1.13
0.15 <= x < 0.2	5	0.175	0.88
0.2 <= x < 0.3	1	0.25	0.25
0.3 <= x < 0.4	0	0.35	0.00
0.4 <= x < 0.5	9.5	0.45	4.28
0.5 <= x < 0.6	5	0.55	2.75
0.6 <= x < 0.7	6	0.65	3.90
0.7 <= x < 0.8	10.5	0.75	7.88
0.8 <= x < 0.9	172	0.85	146.20
0.9 <= x <= 1	125.5	0.95	119.23
Total			**289**

Like Case 1, the storage system performs large number of shallow and deep cycles over the course of the year owing to the different services it is offering in Case 2. The major reason for the deep cycles is due to the constraint imposed on energy discharge.

Table 6 Cycle Count for Case 2: Constrained + Restrict Charging from the Grid + Frequency Response

Depth of Discharge	No. of Cycles	Weighing Factor	Effective Cycles
0 < x < 0.05	58	0.025	1.45
0.05 <= x < 0.1	11	0.075	0.83
0.1 <= x < 0.15	5	0.125	0.63
0.15 <= x < 0.2	3.5	0.175	0.61
0.2 <= x < 0.3	1	0.25	0.25
0.3 <= x < 0.4	0	0.35	0.00
0.4 <= x < 0.5	5	0.45	2.25
0.5 <= x < 0.6	11.5	0.55	6.33
0.6 <= x < 0.7	6.5	0.65	4.23
0.7 <= x < 0.8	15.5	0.75	11.63
0.8 <= x < 0.9	175	0.85	148.75
0.9 <= x <= 1	111	0.95	105.45
Total			282.39

In the unconstrained + restrict charging from the grid case with no frequency response (Case 3), the cycling is driving by energy time shift

Table 7 Cycle Count for Case 3: Unconstrained + Restrict Charging from the Grid + No Frequency Response

Depth of Discharge	No. of Cycles	Weighing Factor	Effective Cycles
0 < x < 0.05	111.5	0.025	2.79
0.05 <= x < 0.1	24.5	0.075	1.84
0.1 <= x < 0.15	7.5	0.125	0.94
0.15 <= x < 0.2	5.5	0.175	0.96
0.2 <= x < 0.3	3.5	0.25	0.88
0.3 <= x < 0.4	2	0.35	0.70
0.4 <= x < 0.5	13	0.45	5.85
0.5 <= x < 0.6	7	0.55	3.85
0.6 <= x < 0.7	6	0.65	3.90
0.7 <= x < 0.8	11.5	0.75	8.63
0.8 <= x < 0.9	87	0.85	73.95
0.9 <= x <= 1	209	0.95	198.55
Total			302.8

The cycling profile for Case 4 is very similar to Case 3 in terms of number of shallow cycles. However, the number of deep cycles performed has reduced significantly, as depicted in Table 8 provided below.

Table 8 Cycle Count for Case 4: Unconstrained + Restrict Charging from the Grid + Frequency Response

Depth of Discharge	No. of Cycles	Weighing Factor	Effective Cycles
0 < x < 0.05	105	0.025	2.63
0.05 <= x < 0.1	17	0.075	1.28
0.1 <= x < 0.15	6	0.125	0.75
0.15 <= x < 0.2	3	0.175	0.53
0.2 <= x < 0.3	3.5	0.25	0.88
0.3 <= x < 0.4	2	0.35	0.70
0.4 <= x < 0.5	10.5	0.45	4.73
0.5 <= x < 0.6	11.5	0.55	6.33
0.6 <= x < 0.7	7	0.65	4.55
0.7 <= x < 0.8	11.5	0.75	8.63
0.8 <= x < 0.9	137.5	0.85	116.88
0.9 <= x <= 1	143.5	0.95	136.33
Total			284.2

It can also be observed that, in all the four cases (Case 1, Case 2, Case 3 and Case 4), the number of effective cycles the storage system performs over the course of the year is less than 365, which considers PPA Proposal costs that LADWP has received from storage vendors.

Energy Storage Charging Profile Comparison

In order to make sure that the project meets the Federal Incentive Tax Credit (FITC) criteria, an important requirement for LADWP was to ensure that most of the charging of the storage system comes from PV as opposed to the grid. This has been reflected in the Cases 1 to 4. To understand if the storage system met this requirement, a comparison of how the storage charged over the course of the year was analyzed for the different use cases as tabulated in Table 9 below.

Table 9 Energy Storage Charging Comparison (PV versus Grid)

Case	PV	Grid
Case 1 Constrained + Restricted Charging from Grid + No Frequency Response	98.27%	1.73%
Case 2 Constrained + Restricted Charging from Grid + Frequency Response	98.25%	1.75%
Case 3 Unconstrained + Restricted Charging from Grid + No Frequency Response	100%	0%
Case 4 Unconstrained + Restricted Charging from Grid + Frequency Response	100%	0%

In Cases 3 and 4, where the storage is not subjected to any discharge or spin commitment related constraints, it can be observed that it charges entirely from PV. This is a result of the penalty imposed on grid charging.

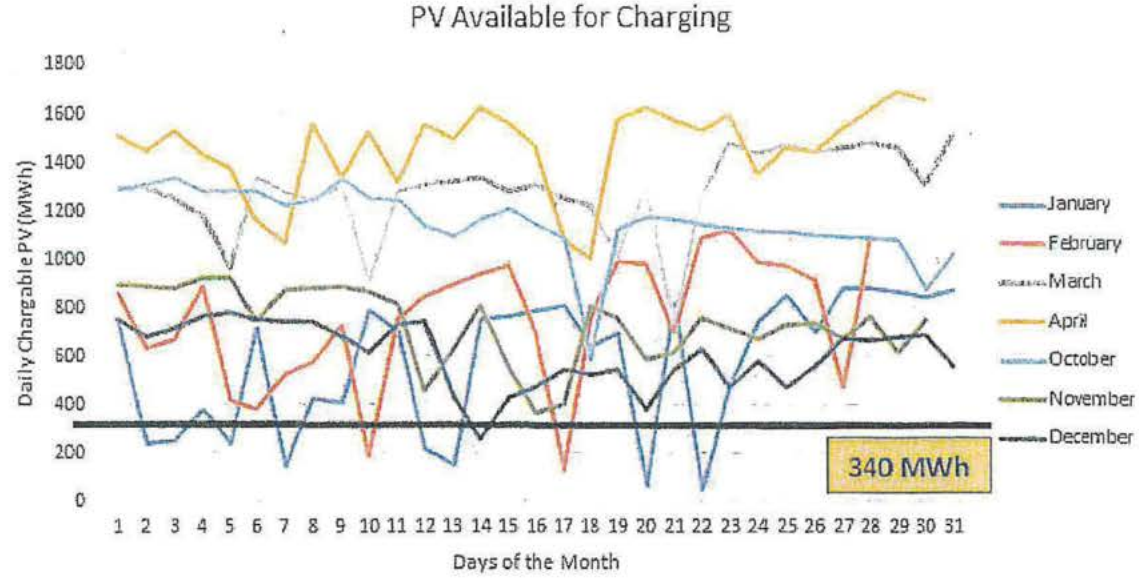


Figure 13 Amount of PV Energy (MWh) available for charging during the days with the discharge constraint

However, in Cases 1 and 2, we can observe that it is not possible to achieve 100% charging from the grid. The reason for this observation is there are certain days, where the amount of PV energy available for charging is less than 340 MWh, which is the minimum amount of energy required to meet the energy discharge constraint. On these **"Cloudy Days"**, the storage must charge from the grid to meet the 340 MWh daily energy target. This is illustrated in the Figure 13 above. The black horizontal line represents, the daily energy target (340 MWh) and there are 11 days on which the PV availability fails to meet this threshold.

Cost and Benefit Analysis (CBA)

Using storage dispatch and commitment results from StorageVET, PV generation profile, as well as PV and storage prices, the cost and benefit of the system is analyzed over the 20-year period. As discussed previously, the solar PPA price and energy storage system CAPEX costs depend on the year of the COD, between 2019 and 2023.

Financial parameters

The CBA was conducted assuming a discount rate of 5%, and an inflation rate of 2%.

Solar and Storage Costs

The cost of the system can be broken down by two main parts: cost of the PV generation and cost of the storage system. The cost of the PV generation is calculated by multiplying the PPA price in $/MWh with the hourly PV production in MWh, and adding that value for all hours of the year. LADWP provided the PV generation profile for the year 2017 and this was assumed to remain constant 20-year period.

The cost of the storage system is calculated by multiplying an all-in, one-time cost (in $/kWh) by the system energy capacity of 400MWh. This all-in cost provided by LADWP is assumed to include the capital cost, operational expenditure, maintenance and system augmentation costs of the storage system per unit energy capacity, and depends on the Commercial Operation Date (COD). An alternative approach could be to use PPA prices per unit ($/MWh) of energy dispatched by storage. The results from this alternative approach may differ from the approach using an all-in cost. Only the results using the all-in cost are shown in the analysis for five different COD.

The CBA is conducted for a 20-year time horizon corresponding to the duration of the PPA.

The solar prices utilized in the CBA are provided by LADWP based on the average of PPA proposal prices. Five different scenarios are considered, corresponding to five different PPA start years: 2019, 2020, 2021, 2022, and 2023. Storage cost is net present worth assumed as a CAPEX during the first year of the contract. The solar and storage prices are dependent on the start year, but remain constant throughout the 20 years.

- The solar price (in $/MWh) is applied to the solar power generated throughout the 20 years. Based on the estimated hourly solar output, an annual solar cost can be calculated. This cost corresponds to annual payment made to the project developer for utilizing the solar asset. In this analysis, this annual payment is assumed to be constant in nominal terms over the 20-year period.
- The storage price (in $/kWh) is applied to the size of the storage project (here, 400MWh). This cost corresponds to a one-time upfront payment made to the project developer for utilizing the storage asset throughout the 20-year period.

The annual PV and one-time storage costs were calculated based on the average solar and storage prices provided by LADWP for each of the five PPA start years considered.

Project Benefits

Three main streams of benefits were considered in the analysis:

- Energy benefit from real-time energy time-shift
- Spin benefit from spinning reserve commitment
- Frequency response for commitment

Project benefits for the three services ranged from $25 to $30 million for each year, depending the case. The expected revenues are provided for each of the four storage cases considered:

- Unconstrained + Restrict Charging from Grid + No Frequency Regulation
- Unconstrained + Restrict Charging from Grid + Frequency Regulation
- Constrained + Restrict Charging from Grid + No Frequency Regulation
- Constrained + Restrict Charging from Grid + Frequency Regulation

CBA Calculations

There are four (4) Storage Use Cases ('Unconstrained+ Grid Penalty + No FR', 'Unconstrained+ Grid Penalty + FR', 'Constrained + Grid Penalty + FR'), and five (5) PPA Start Years (2019, 2020, 2021, 2022, and 2023); this corresponds to 4x5 = 20 scenarios to be analyzed. For each of these 20 scenarios, the present worth (PW) of the costs and benefits is calculated for each of the 20 years considered.

The NPW results show that for the input assumptions previously stated, the project is not expected to result in a benefit-to-cost ratio greater than 1 if the PPA is to start in 2019, 2020, and 2021. However, it is expected to be have benefit-to-cost ratio greater than 1 if the PPA starts in 2022 or 2023. Table 13 provides the corresponding Benefit-to-Cost Ratios (BCR).

Table 10. Benefit-to-Cost Ratios for scenarios considered.

	Benefit-to-Cost Ratio				
PPA starts in:	2019	2020	2021	2022	2023
Unconstrained+ Restrict Charging from Grid + No FR	0.645	0.800	0.908	1.181	1.208
Unconstrained+ Restrict Charging from Grid + FR	0.684	0.849	0.963	1.252	1.280
Constrained + Restrict Charging from Grid + No FR	0.588	0.729	0.827	1.076	1.100
Constrained + Restrict Charging from Grid + FR	**0.627**	**0.778**	**0.883**	**1.147**	**1.174**

Table 11 shows the Levelized Revenue Requirement (LRR) over the 20-year period calculated for start years of 2019, 2020, and 2021. The LRR represents the size of the additional annual benefit stream, constant in nominal terms that would be required to yield a benefit-to-cost ratio greater than 1 for each of these years. For example, if the PPA was to start in 2019, an additional, constant benefit stream of about $17 million would be required to make the project break-even, for the *Constrained Restrict Charging from Grid + FR* case.

Table 11. Annual LRR for 2019, 2020 and 2021.

	Levelized Revenue Requirement [illegible]		
PPA starts in:	2019	2020	2021
Unconstrained+ Restrict Charging from Grid + No FR	$16 M	$7 M	$3 M
Unconstrained+ Restrict Charging from Grid + FR	$14 M	$6 M	$1 M
Constrained + Restrict Charging from Grid + No FR	$19 M	$10 M	$6 M
Constrained + Restrict Charging from Grid + FR	**$17 M**	**$8 M**	**$4 M**

Consistent with the results above, the PPA storage price is below the break-even price for start years 2022 and 2023 (that is, the benefit-cost ratio is greater than 1), and above the break-even price for start years 2019, 2020 and 2021 (the benefit-cost ratio is less than 1).