CPUC Energy Storage Use Case Analysis

[Bulk Storage]

[Pumped Hydroelectricity]

Version 7

Contents

1. Overview Section 3

2. Use Case Description 4

2.1 Objectives 4
2.2 Actors 4
2.3 Regulatory Proceedings and Rules that Govern Procurement Policies and Markets for This Use 4
2.4 Location 5
2.5 Operational Requirements 5
2.6 Applicable Storage Technologies 6
2.7 Non-Storage Options for Addressing this Objective 6

3. Cost/Benefit Analysis 7

3.1 Direct Benefits 7
3.2 Other Beneficial Attributes 10
3.2 Analysis of Costs 11

4. Barriers Analysis and Policy Options 12

5. Real World Example 13

5.1 Project Description 13
5.2 Outstanding Issues 13
5.3 Contact/Reference Materials 13

6. Conclusion and Recommendations 14

1. Overview Section

Several public policy initiatives adopted by California will impact the generation resources available on the grid and provide challenges to the system operator (California Independent System Operator (CAISO)), generators, transmission owners, and end users to maintain current levels of system reliability.

As California moves towards full implementation of the RPS by 2020, there are increasing challenges to integrate variable such as wind and solar, in particular as it relates to changes in system net load, ramping profile and needs as well as impact on overall grid stability. The availability of a strategically located and sizable flexible technology is critical for grid operators to manage the electric system.

It is well understood that variable energy resources provide a sustainable source of energy that uses no fossil fuel and produces zero carbon emissions. One of the constraints of variable generation is that the energy available is less dispatchable when compared to traditional generation. The power-system load is also variable; different types of power-system reserves are required to match changes in generation and demand on a real-time basis.

As more variable energy is added to the power system, additional reserves are required. Flexible and dispatchable generators, such as hydropower, are required to provide system capacity and balancing reserves to balance load in the hour-to-hour and sub-hour time-frame. In addition to system reserves, most balancing authorities have the need for energy storage to balance excess generation at night and shift its use to peak demand hours during the day.

Conventional hydropower projects do this by shutting down units and storing energy in the form of water, and it is the most common form of energy storage in the world. As variable energy output increases and generation must be dispatched to meet the net load demand curve[1] the need for flexible capacity increases to maintain reliability and also to manage steep ramping requirements that did not exist previously. Pump storage is able to respond to this need for flexible capacity through its fast ramping capabilities.

Hydroelectric generation, and specifically hydroelectric pumped storage, is uniquely positioned to facilitate the integration of wind and solar energy. Hydropower is a renewable resource that can balance variable generation by providing relatively large, flexible capacity energy storage and reserves. Hydropower is already the preferred technology providing system reserves throughout the world's transmission systems, and unlike gas turbines it produces virtually zero carbon emissions and has zero fuel cost.

Pump storage specifically is uniquely positioned to provide all the benefits of hydropower without the regulatory and environmental limitations to maintain reservoir levels for safety, recreation and wildlife that exist for a hydroelectric facility.

[1] Load minus wind + solar

2. Use Case Description

This Use Case describes bulk energy storage associated with a hypothetical 300 – 1300 MW energy storage facility that connects to the grid to deliver and receive energy and also provides capacity and ancillary services.

It is assumed that the resource has successfully connected to the grid under California ISO interconnection rules and possesses CAISO-approved telemetry that allows for remote monitoring of the resource and related factors.

2.1 Objectives

Long duration (in excess of six hours), grid scale bulk energy storage offers a way to alleviate output variability and potential instability by: 1) shifting the time when electricity is generated to better match utility demand; 2) balancing renewable generation to provide a more consistent and predictable output level; 3) provide a strategically flexible ramping technology to manage net load; 4) providing voltage support and 5) meeting local and system capacity needs. Additionally, use of storage may potentially avoid curtailment of contracted deliveries from non-utility resources because of oversupply situations.

2.2 Actors

In this Use Case, the storage facility may be owned by 1) the utility; or, 2) a third party that provides backup and reliability under a separate arrangement.

Name	*Role description*
Storage Provider	Energy storage plant owner may provide multiple services, including load leveling, reduction in thermal unit cycling, regulation, firm capacity and contingency reserves. Options could include selling these services for storage rights to a utility, or certain services directly to a RTO/ISO.
Utility	
Grid Operator	

2.3 Regulatory Proceedings and Rules that Govern Procurement Policies and Markets for This Use

Agency	*Description*	*Applies to*
CPUC	Renewable Portfolio Standard Bidding	Utility/Third Party
CPUC	Long-term Procurement Proceeding	Utility
CPUC	Resource Adequacy	Utility
CPUC	Rule 21 Interconnection	Third-party Owner
FERC	Order No. 785 Pay for Performance	ISO/RTO, Third-party Owner
CAISO	Renewable Interconnection Study	Utility/Third Party
CAISO	Flexible Ramping Product	Utility/Third Party

The CAISO has identified through operational studies the need for increased quantities of flexible capacity to manage the electric grid under the 33% RPS. In the active CPUC Resource

Adequacy Proceeding (RA) (11-10-023) a new flexible capacity requirement, beginning with the 2014 RA year, is being evaluated. This important reform to the existing RA program is vital to ensure not only that existing flexible resources continue to be available but that there is incentive for new resources, such as pumped storage, that have these desired attributes will be built. The existing RA program that requires procurement of only generic capacity will not ensure that specialized needs of the grid are met under the 33% RPS, including any specific value that can be provided by pumped storage.

It has also been acknowledged by the CAISO and parties in the above mentioned RA proceeding that a multi-year procurement mechanism for resource adequacy is needed. The CPUC intends to address this issue in the Long-Term Procurement Planning (LTPP) Proceeding. The lack of a multi-year procurement mechanism is a significant barrier to secure financing for capital intensive projects, such as pumped storage and therefore it is important for the Commission to advance this discussion as soon as possible.

The CAISO is also in the process of developing a spot market product for flexible ramp. This is an important development to allow pump storage to be further compensated for fast ramping capabilities but must go hand in hand with the shorter term and longer-term requirements for flexible capacity as part of the RA program that are described above. A spot market product will provide short-term, least-variable cost optimization and procurement of needed energy services, but will not provide assured long-term revenue streams necessary to promote investment.

Balancing authorities rely on access to reserves (i.e., generators standing by to produce more or less power) to balance generation and load requirements. There is a growing need for ancillary services to support grid functions due to changes in the portfolio of generation resources (specifically, the introduction of significant amounts of variable energy resources), but markets for ancillary services are not be developing in all regions of the country.

2.4 Location

Under most scenarios, the bulk energy storage device is located at the site of a cost effective storage resource. For example, sites for the two commercially viable technologies, pumped storage hydroelectric and compressed air energy storage are determined by a number of factors including geologic and topographic conditions, availability of water (for pumped storage reservoirs), surface and subsurface conditions for excavation, tunnels, or project facilities, as well as other features which significantly contribute to the project development costs. Other storage technologies not currently widely implemented that are not dependent upon specific geologic and topographic conditions and may be located based on electric grid needs are generally smaller in scale and can be considered distributed storage.

2.5 Operational Requirements

The expected delivery of capacity, generation and ancillary services from this type of bulk storage facility will be driven by market pricing and system needs. Purchases of energy to recharge the system will take advantage of lower energy prices primarily during the off-peak hours or to support energy imbalances from variable generation. Depending on the final size and configuration of the bulk storage resource, the bulk storage resource will be extremely flexible in how it is operated in both day-ahead and real time markets. The large energy storage capacity of these resources (estimated to range between 2,400 MWh and 22,000 MWh) allows these facilities to potentially play the role of "grid shock absorber" in the day to day operation of the grid and in the case of large system events.

From an operational perspective, California-specific requirements include: (i) coordinated dispatch of bulk storage, either within and utility or RTO/ISO, (ii) organized market signals to facilitate operation of a bulk storage systems, (iii) transmission system needs (something about the ability to facilitate signal dispatch of bulk storage facility without significant congestion areas – without missing the benefit of built storage to alleviate transmission congestion), (iv) [perhaps something about the percentage level of RE penetration]

Pumped storage or bulk storage systems do not need to be dedicated to any specific generator source, and their dispatch can be directed by a utility or RTO/ISO to meet system needs, ranging from unit outages, regulation requirements, emergency power needs, and a variety of ancillary services.

2.6 Applicable Storage Technologies

The potential storage device that appears most applicable to this Use Case is pumped storage hydroelectricity ("pumped storage"). Pumped storage is the most widely installed and well established electric storage technology in the world, currently providing in excess of 98% of grid scale storage. Over 20,000MW of pumped storage is currently in operation in the United States, including the Helms, Oroville (Hyatt-Thermalito is DWR's name for this project) and Castaic projects in California. In Asia and Europe, in excess of 10,000 MW of PSH projects are currently under construction.

In addition, compressed air energy storage ("CAES") is also applicable to this Use Case.

Storage Type	*Storage capacity*	*Discharge Characteristics*
Pumped Storage Hydroelectric	300 MW – 1300MW	6 – 18 hours storage; ramp rates as high as 10-20MW/sec
Compressed Air	100 MW+	

2.7 Non-Storage Options for Addressing this Objective

Among options available to address renewable energy variability are:

- A Balancing Energy Market for incremental/decremental energy in real-time;
- Demand Response programs that incentivize end-users to increase or decrease consumption under pre-specified conditions;
- Generation with flexible ramping capacity to match changes in renewables output;
- Dispatchable generation located to meet local and area-wide capacity needs;

- Various technology upgrades to distribution system, such as static-VAR compensators, and switched capacitor banks to instantaneously adjust to fluctuations in voltage levels cause by abrupt generation variability.

3. Cost/Benefit Analysis

3.1 Direct Benefits

End Use	*Primary/ Secondary*	*Benefits/Comments*
1. Frequency response	P	Large scale pump turbine units provide significant rotating mass, along with other large thermal units, which have historically provided grid stability and system inertia. This is even more critical with the potential for less thermal capacity on the system and more variable supply. Due to the fast response capabilities of pump storage it can also provide significant incremental power when needed to minimize or avoid a frequency disturbance.
1. Regulation		Advanced pump turbine units utilizing variable speed technology provide fly-wheel type response via power electronics to adjust power flow. Fast responding, flexible resources such as pump storage allow the CAISO to meet their regulation requirements, which are forecasted to increase in some hours with 33% renewable integration with fewer resources and at lower cost to the system.
2. Spin	P	Pumped storage stations can provide spinning reserve capabilities in both generation and pumping modes resulting in rapid response (<10 seconds) to system needs.
3. Ramp	P	As demonstrated in the CAISO's renewable integration operational studies, increased frequency and magnitude of ramps across various time frames will result in the need for additional flexible capacity from fast ramping resources to effectively manage the electric grid under the 33% RPS. This need for additional flexible capacity is currently being addressed in the Resource Adequacy proceeding through the development of a flexible capacity requirement. Forward looking longer term requirements are being addressed through LTPP proceeding. Depending on design specifications, advanced pumped Storage facilities can provide exceptional ramping services as fast as 10-20MW per second resulting in 250 – 350 MW of ramping per unit in less than a minute. This is compared to a fast ramping gas fired power plant which move at a rate in megawatts per minute rather than seconds.

4. Black start	P	Virtually all pumped storage stations are able to provide black start services with possibly the most significant example of this capability is the grid restoration following the August 2003 Northeast region blackout. The hydro and pumped storage projects in the region led the restoration efforts.
5. Real-time energy balancing	P	The CAISO renewable integration studies also reflect the need for additional intra-hour load following up and down requirements to address variability and forecast uncertainty under the 33% RPS. Similar to frequency regulation and ramping capabilities, pump turbines can be an energy sink or source in a matter of seconds and be the shock absorber to the grid and truly respond to net load needs.
6. Energy arbitrage	P	Wind energy is expected to peak at night creating increased instances of over-generation that the CAISO will be required to manage. Pump storage can be used to shift production from off-peak to peak periods.
7. Resource Adequacy	P	Pump storage qualifies to provide capacity to the load serving entities through the CPUC's Resource Adequacy program. Due to the fast ramping capabilities described above, pump storage can also be utilized to provide the new flexible capacity requirements that are under development and targeted for the 2014 RA year.
8. VER[2] / wind ramp/volt support,	P	To expand on number 3 above, when large installations of wind are ramping up or down out of correlation with load, large scale pumped storage can respond inversely to mitigate net load ramping rates that can approach over 4000 MW/hour.
9. VER/ PV shifting, Voltage sag, rapid demand support	P	
10. Supply firming	P	
11. Peak shaving: load shift	P	See energy arbitrage
12. Transmission peak capacity support (deferral)	S	Transmission usage is optimized. Wind has a 30% capacity factor when pump storage is used to firm and shape deliveries. The usage of the transmission line is also increased which reduces the burden on ratepayers to support the transmission costs associated with variable generation.
13. Transmission operation (short duration performance, inertia, system reliability)	S	See frequency regulation
14. Transmission congestion relief	S	See transmission peak capacity support
15. Distribution peak capacity support (deferral)		
16. Distribution operation (volt/VAR support)		
17. Outage mitigation: microgrid		
18. TOU energy mgt		

[2] VER = Variable Energy Resource

19. Power quality		
20. Back-up power		

Following is a description of the operating modes of pumped storage from a 1996 study which is still relevant today:[3]

Peaking Capacity

A pumped storage plant contributes to the total peaking capacity of the system. If peaking capacity is not provided by a pumped storage project, it has to be provided by gas turbines or other generating resources. The available peaking capacity of a pumped storage plant may be considered to be the capacity of the plant at minimum head or at some designated intermediate head. For this capacity to be considered as firm, it must be available for a time period which varies depending on the electric system being served and the mix of other resources on the system.

Peaking and Pumping Energy

For the hours of pumped storage generation on the electric system, pumped storage provides peaking energy to the system. The revenues from the peaking energy produced are partially offset by the cost of the pumping energy. The pumping energy costs are the applicable off-peak rates for the generating units used for the pumping duty.

Operation of a pumped storage project results in load leveling with associated benefits to the electric system. One important benefit is the reduction of minimum operating load requirements of the thermal plant during off-peak hours.

Load Regulation

During the generating cycle, a pumped storage project is suitable for continuous matching of the system generation with the system loads, as is a pumped storage project with variable-speed units during the pumping cycle. Depending on the generation mix of the system or its interconnections to other utilities, this attribute of pumped storage can be of great value. Electric systems that have pumped storage plants available use them for minute-by-minute area-control, load regulation and frequency control. These uses are particularly important in electric systems with a large installed base of thermal units.

Load Following

Nearly every electric system that has pumped storage finds great value in its fast pick-up or shedding of load (ramping) and its large load change capability. This reduces the need for scheduled purchases and operation of old thermal plants at reduced load.

Spinning and Standby Reserves

The criteria for the definition of spinning and standby reserve vary according to the system being served. Generally, a resource qualifies as *spinning reserve* if it is operating synchronized and can be brought to full load in a short time, that is, a pumped storage unit in spin-generating mode ready to be loaded, or operating at part load.

[3] Hydroelectric Pumped Storage Technology, International Experience, Prepared by Task Committee on Pumped Storage of the Committee on Hydropower of the Energy Division of the American Society of Civil Engineers. 1996. Library of Congress Catalog Card No: 95-51218. ISBN 0-7844-0144-6

Standby reserves are resources that can be brought on-line and loaded quickly, generally in 5-10 minutes. Most pumped storage projects in a shutdown condition, with sufficient energy stored in the upper reservoir, qualify as standby reserves.
Pumped storage project in spinning and standby reserve modes are available to provide system frequency control, and to respond to and correct low frequency occurrences.

Improved Efficiency and Reduced Maintenance Costs Elsewhere in the System
The off-peak-pumping load provided by a pumped storage project generally results in less cycling of the thermal units and fewer stops and restarts of these units. This results in improved operating efficiency and reduced maintenance costs of the thermal units.

Voltage Regulation
Depending upon the needs of the system, a pumped storage project can operate in condenser mode to generate or absorb reactive power as may be required for system voltage regulation. This is much more effective for plants located near the load centers.

Transmission System Benefits
A pumped storage project itself also provides many transmission system benefits. For example, a pumped storage project located near a load center may provide the reserve capacity needed to permit more effective utilization of the interconnecting transmission system. Also, a pumped storage project may contribute to the system reliability by redistributing the power flows.

Air Quality Benefits

A pumped storage project itself has no emissions to the atmosphere and generally contributes to air quality improvements or geographical shifting of the emission, depending upon the source of power for the pumping energy. Generally, a pumped storage project provides for more efficient utilization of the thermal units and fewer stops and starts, thus contributing to overall reduced emissions. Also, pumped storage reduces emissions during the hottest periods of the day by offsetting some of the generation that would otherwise be required from thermal plants.

Ease of Operation
Operation of an electric system is much easier when pumped storage units are available because of their quick response to rapid changes in load.

Black Start Capability
The black start capability of a pumped storage project contributes to system reliability and restart in case of system-wide failure of the transmission or generation system.

3.2 Other Beneficial Attributes

Benefit Stream	*Y/N*	*Assumptions*
Flexibility (Dynamic Operations)	Y	As described in section 3.1 above pump storage has the capability to provide a multitude of products and services to the electric grid including fast response regulation, load following, frequency response and operating reserves.
Reduced Fossil Fuel Use	Y	Using pump storage to provide fast ramping services to

		assist in managing the integration of renewable resources has an added environmental benefit as the fuel source is renewable and therefore does not compromise other state policy goals such as the green house gas program.
Reduced Emissions	Y	Same as above
Increased T&D Utilization	Y	Transmission usage is optimized. Wind has a 30% capacity factor when pump storage is used to firm and shape deliveries. The usage of the transmission line is also increased which reduces the burden on ratepayers to support the transmission costs associated with variable generation.
Reduced T&D Investment Risk		
Power Factor Correction		
Optionality		
Other		
Other		

3.3 Analysis of Costs

Cost Type	*Description*
Installation	Costs to engineer, procure equipment and construct PSH facilities vary widely, based primarily on project size and site specifics. It is anticipated that fully installed projects, including financing costs during construction (2012 $) will likely be in a range of $1200 - $2500/kw and a range of $85 - $250/mwh of storage capacity.
O&M	[need assistance to describe elements and cost range
Transmission	Transmission costs to interconnect PSH facilities will depend on size and location of project.

3.4 Cost-effectiveness Considerations

Commercially viable bulk storage can provide capacity, energy and ancillary services at costs potentially comparable to thermal generating resources if external costs of greenhouse gas emissions are captured. In addition, bulk energy storage may be able to reduce curtailment of intermittent renewable resources. Detailed modeling work is necessary to fully capture all the cost-effectiveness attributes of bulk energy storage such as pumped storage.

4. Barriers Analysis and Policy Options

4.1 Barrier Resolution

Barriers Identified	*Y/N*	*Venue for Resolution*
System Need	Y	LTPP, TPP
Cohesive Regulatory Framework	Y	CPUC, CAISO
Evolving Markets	Y	CPUC, CAISO, FERC
Resource Adequacy Value	Y	CPUC
Cost Effectiveness Analysis	Y	CPUC, CAISO
Cost Recovery Policies	Y	CPUC, CAISO, FERC
Cost Transparency & Price Signals	Y	CPUC, CAISO, FERC
Commercial Operating Experience	N	
Interconnection Processes	Y	CAISO, FERC

4.1 Other Considerations

Under the portion of the FERC's *Avista* decision (Avista Corp., 87 FERC ¶ 61,223) a third party generally may not sell ancillary services at market-based rates to a public utility that is purchasing ancillary services to satisfy its own open access transmission tariff (OATT) requirements to offer ancillary services to its own customer. A third party can overcome this prohibition only by providing a market power study that demonstrates a lack of market power for the particular ancillary service in the particular geographic market. Market power studies can be both highly complicated and very expensive for an energy storage provider to undertake. The result of the *Avista* policy is that is currently inhibits the development of new energy storage facilities, as well as the deployment of existing storage into the unorganized ancillary services markets.

Policy changes are needed to support the timely development of grid-scale energy storage products to support integration of increasing wind and solar generation and provide grid reliability. These policies changes include modifying the *Avista* restriction and creating market products that allow flexible energy storage resources to provide regional or grid-scale services that help meet electric requirements, including very fast responding systems that provide critical capacity during key energy need periods.

5. Real World Example

5.1 Project Description

E.ON Waldeck 2+ is a proposed 300MW Pump Storage Project (PSP) located on Lake Edersee in Waldeck, Germany. Waldeck 2+, with an expected COD of 2016, will take advantage of the existing infrastructure at the site, originally built for Waldeck 2 (COD 1975) with 480 MW's and Waldeck 1 (COD 2009) with 135 MW's. The project, with an IRR above 10%, benefits from three major revenue components:

1. Wholesale Market Trading – arbitrage between high and low spot markets
2. Reserve Market Trading
3. Portfolio Effect – beneficial effect on the E.ON fleet by optimizing the hydro-thermal portfolio operation with increased efficiency and flexibility

This new project also address three major challenges of the German generation market – the need for energy storage (by 2030, 30% of the electricity will be generated from renewables), reserve (there is an increasing need for ancillary services due to the growth of volatile/unpredictable renewable energy growth) and flexibility (Germany's generation portfolio is currently dominated by thermal power plants that are less flexible than PSP's. The project will provide shorter start-up times, higher load gradients and black start-up capability for short term reserve products, and frequency control for the German Grid)

Location	Waldeck, Germany
Operational Status	Preparing of final tender documents for equipment, Planned Commercial Operation 2016
Ownership	E.ON
Primary Benefit Streams	Wholesale Market Trading – specifically Energy Arbitrage
Secondary Benefits	Reserve Market – contributing to the reserve markets in Germany. Additional benefits are performance optimization of the E.ON fleet.
Available Cost Information	CAPEX: $329M, project takes advantage of civil works already existing on site.

5.2 Outstanding Issues

Description	*Source*
None. This project is viewed favorably by the environmentalists as well as the public. All required licenses and permits are in place.	E.ON Executive

5.3 Contact/Reference Materials

Dr. Klaus Engels
VP Asset Risk and Governance
T +49 871 694-4010

F +49 871 694-4008
M +49 170 8562698
klaus.engels@eon.com

E.ON Generation Fleet
E.ON Wasserkraft GmbH
Luitpoldstraße 27
84034 Landshut

6. Conclusion and Recommendations

Is ES commercially ready to meet this use?
Yes.
Pumped storage has a long history of successful development in the U.S. and around the world. Globally, there are approximately 270 pumped storage plants either operating or under construction, representing a combined generating capacity of over 127,000 megawatts (MW). Of these total installations, 36 units consist of adjustable-speed machines, 17 of which are currently in operation (totaling 3,569 MW) and 19 of which are under construction (totaling 4,558 MW). Advanced technology using adjustable -speed pump-turbines have been used since the early 1990s in Japan and the late 1990s in Europe. There are also to CAES plants in operation today, one in the United State and one in Germany – both have been in operation for nearly 30 years.

Is ES operationally viable for this use?
Yes. Bulk energy storage using advanced pumped storage technology is operationally viable for this use.

What are the non-conventional benefits of storage in this use?

Can these benefits be monetized through existing mechanisms?
- Transmission yes, but on day-ahead and spot markets
- Grid security, no.

If not, how should they be valued?

Is ES cost-effective for this use?
Depending on the specific details of the resource site, bulk energy storage may be cost-effective for this use. Therefore, it is important to develop quantitative tools to evaluate cost effectiveness.

What are the most important barriers preventing or slowing deployment of ES in this use?
The capital intensive nature and relatively long development cycle require both long term procurement plans that can value the benefits of pumped storage as well as multi-year procurement processes and or long-term contracts.

What policy options should be pursued to address the identified barriers?
As discussed above, the most important policy options for California regulators include: 1) the addition of a flexible capacity requirement into the RA program, 2) multi-year procurement and/or long term contracts for resource adequacy and other capacity-related ancillary services 3) further development of spot market products to procure flexible ramping and load following to complement the requirements added to the resource adequacy program.

Federal policy changes that should be considered include modifying the *Avista* restriction and creating market products that allow flexible energy storage resources to provide regional or grid-scale services that help meet electric requirements, including very fast responding systems that provide critical capacity during key energy need periods.

In addition, a lack of a national energy policy may lead to changing independent system operators (ISO) market rules and product definitions that may have a significant impact on the value of ancillary services, including those related to energy storage. FERC Orders 890 and 719 required ISOs to modify their tariffs and market rules so all non-generating resources, such as demand response and energy storage, can fully participate in established markets. However, these are typically real-time or day-ahead markets and there are no long-term value streams where a bulk storage project can attract investors seeking revenue certainty through long-term power purchase agreements or defined value streams (EPRI, 2010)."

Should procurement target or other policies to encourage ES deployment be considered for this use?
We don't believe that procurement targets are necessary to encourage ES deployment for this use. However, as elaborated above, policy changes are necessary to encourage cost effective deployment of energy storage for this use. Primarily, the State needs to recognize that most bulk energy storage technologies that are cost effective for this use are capital intensive and would provide benefits to ratepayers and project owners if multi-year procurement and long term contracts were used to support construction and operation of these assets. In addition, better tools are required to evaluate cost effectiveness.