BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems.	R.10-12-007 Filed December 16, 2010

COMMENTS OF THE CALIFORNIA ENERGY STORAGE ALLIANCE TO ORDER INSTITUTING RULEMAKING PURSUANT TO ASSEMBLY BILL 2514 TO CONSIDER THE ADOPTION OF PROCUREMENT TARGETS FOR VIABLE AND COST-EFFECTIVE ENERGY STORAGE SYSTEMS

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January 21, 2011

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Pursuant Rules 1.4(a) and 6.2 of the California Public Utilities Commission's ("Commission's") Rules of Practice and Procedure, and Ordering Paragraph Number 5 of Order *Instituting Rulemaking Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems* ("OIR") the California Energy Storage Alliance ("CESA")[1] hereby submits these comments to the OIR.

I. INTRODUCTION.

The Commission is to be commended for initiating the first comprehensive proceeding in the nation to initiate policy for California utilities to consider the procurement of viable and cost-effective energy storage systems. CESA agrees completely with the Commission's statement in the OIR that, consistent with the broad discretion provided by AB 2514, "The purpose of this proceeding is to: (1) review, analyze and establish, if appropriate, opportunities for the development and deployment of energy storage technologies throughout California's electricity system; (2) remove or lessen any barriers to such development and deployment; (3) review and weigh the associated costs and benefits of such development and deployment; and, (4) establish

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[1] The California Energy Storage Alliance consists of A123 Systems, Altairnano, Applied Intellectual Capital, Beacon Power Corporation, Chevron Energy Solutions, Debenham Energy, Deeya Energy, East Penn Manufacturing Co., Inc., Enersys, Enervault, Fluidic Energy, General Compression, Greensmith Energy Management Systems, HDR, Inc., Ice Energy, International Battery, Inc., Lightsail Energy, Inc., MEMC/SunEdison, Powergetics, Primus Power, Prudent Energy, Redflow, ReStore Energy Systems, Saft America, Inc., SA, Samsung SDI, Seeo, Silent Power, Sumitomo Electric, Suntech, Sunverge, SustainX, and Xtreme Power. The views expressed in these Comments are those of CESA, and do not necessarily reflect the views of all of the individual CESA member companies. http://www.storagealliance.org.

how those costs and benefits should be distributed." (OIR, p. 4). In response to the Commission's invitation in the OIR to provide the Commission with its views of the issues to be addressed to assist in development of the scope of the proceeding, CESA also suggests that a fifth purpose – procedural and policy coordination with other proceedings and agencies - should be added to the list of the purposes of the OIR. Of course, CESA intends to participate actively in the initial workshop described in the OIR in order to begin putting flesh on the bones of the very high level summary of relevant issues of fact and law provided here. These comments are CESA's initial feedback from the excellent starting point for shaping the issues provided by the White Paper and the guidance in the OIR. CESA plans to continue throughout this proceeding to serve as a consistent and reliable source of energy storage industry information and policy goals and priorities to the staff and the Commission.

II. COORDINATION OF THIS PROCEEDING WITH ALL EXISTING CALIFORNIA REGULATORY ACTIVITY RELATED TO ENERGY STORAGE TO INCREASE OVERALL SYSTEM PLANNING EFFECTIVENESS SHOULD BE ADDED AS A PURPOSE OF THIS PROCEEDING

As the White paper emphasizes, one of the biggest challenges to the development of grid-connected energy storage projects has been the regulatory process itself.[2] Because energy storage is an important, but non-core, focus of the Commission's many active proceedings it often fails to be considered within existing proceedings, and heretofore has never been considered for applications that may cut across procedural boundaries. This proceeding should serve as an "umbrella" to coordinate development of energy storage policy in all of the Commission's existing and future proceedings. Because energy storage is well suited to optimizing California's existing assets and electric power system, this proceeding can address the many applications of storage that span multiple proceedings to achieve this unifying goal, and to utilize scarce Commission staff resources most effectively.

Focus should be on groups of applications of storage technology that may cut across existing policy 'silos', including (a) peak load reduction/management, (b) resource adequacy, (c) renewables integration (including generation shifting to alleviate system capacity constraints, ancillary services), (d) reliability (at both the transmission and distribution level), (e) smart grid

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[2] "The major barrier for deployment of new storage facilities is not necessarily the technology, but the absence of appropriate regulations and market mechanisms that properly recognize the value of the storage resource and financially compensate the owners/operators for the services and benefits they provide." (White Paper, p. 10).

interaction, and (f) distribution and transmission siting priority preferences. Achieving clarity as to how various proceedings should relate to this one should be addressed as early in the scoping process as possible to avoid confusion and delay.[3] The Commission recognizes, of course, that a clear method of interfacing with policies and proceedings of other agencies should also be developed.[4]

III. PRINCIPLES OF TECHNOLOGY AND OWNERSHIP NEUTRALITY SHOULD BE ESTABLISHED AS A FOUNDATION OF THIS PROCEEDING.

AB 2514 specifically requires the CPUC to consider energy storage in all its technology forms, and in all business ownership models.[5] These two basic premises should be an explicit foundation for this proceeding, as technology neutrality and support for multiple ownership/business models will pave the way to a healthy, sustainable grid storage market in California with many participants and market transformational effects. Of course, a diverse market will help support diversity in application as well as competition and lower prices over time.

IV. OPPORTUNITIES FOR DEVELOPMENT AND DEPLOYMENT OF ENERGY STORAGE TECHNOLOGIES THROUGHOUT CALIFORNIA'S ELECTRIC SYSTEM MUST BE CONSIDERED AT THE LEVEL OF SPECIFIC APPLICATION, OR USE-CASES.

Energy storage represents a class of technologies at least as broad as the class of generation technologies called 'renewables', which includes many different categories and subcategories of resources, such as solar (which includes crystalline and thin film photovoltaic and, concentrating thermal technologies), wind, geothermal, biomass etc. Similarly, the class of technologies represented by energy storage includes the following:

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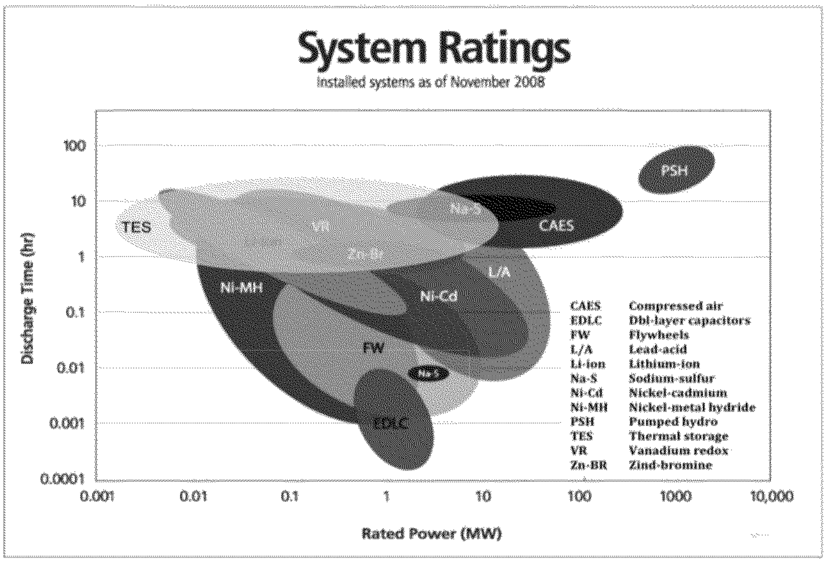
[3] For example, the question of where the dividing line is between storage and generation was raised at the Prehearing Conference held on November 16, 2010, in Pacific Gas and Electric's pumped storage Application (A.10-08-011).

[4] "The Commission notes that the CAISO and the CEC could play important roles in the identification of viable and cost-effective energy storage systems that could be amenable for large-scale deployment in California, and we therefore invite and welcome the active participation of the CAISO and the CEC in this rulemaking." (OIR, p. 7).

[5] Public Utilities Code Section 2835(a)(2).

There are many commercially available energy storage technologies today



The diverse range of energy storage technologies differ significantly in terms of size, duration of capacity, lifecycle and response time. Technology-specific factors such as these will significantly impact the potential value provided by energy storage, and of course, its cost. Given the broad range of technology solutions available and the diversity of their capabilities, evaluating and determining any meaningful procurement targets for energy storage (for example) can only take place at the application level, because it is only at this level that any meaningful cost-benefit analysis can be made.[6]

Energy storage can provide ancillary services and it can serve as an alternative to natural gas-fired peaking power plants for energy and capacity. Please see Appendix B: Energy Storage, a Cheaper and Cleaner Alternative to Natural Gas Peakers, and Appendix C: Energy Storage—a Cheaper, Faster, & Cleaner Alternative to Conventional Frequency Regulation. These are examples of how energy storage may be evaluated at the application or use-case level. Energy storage can provide these benefits not only from a centralized or "bulk" locations, but also from many distributed installations throughout the grid, or sited on the customer side of the meter. Also of fundamental importance is the fact that consideration of the many applications of

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[6] "Storage tends to be an application-specific resource and therefore the costs (and benefits) can vary greatly. One of the complications in developing detailed cost estimates of EES technologies is that the costs of a given technology are greatly influenced by the particular application in which that technology is deployed. Thus, any generalized cost estimates are of questionable value." (p. 4).

energy storage allows the capture of multiple value streams. This reality is one of the great benefits of energy storage that multiple products/services can be provided to the electric power system from the same asset. As the White paper points out, this level of flexibility is also energy storage's greatest challenge, as that is not how our regulatory system is organized.[7] CESA offers the framework in Appendix A for the CPUC to consider in its efforts to begin organizing, determining and prioritizing applications and use cases.

V. MANY ENERGY STORAGE TECHNOLOGIES HAVE BEEN IN USE FOR DECADES AND MANY ARE COMMERCIALLY AVAILABLE TODAY.

There is more than 125 gigawatts of global installed capacity of energy storage today. This includes more than 40 operating pumped storage hydropower projects in the united states, representing over 24 gigawatts of energy storage capacity as well as a number of fairly large successful distributed energy storage projects such as Ice Energy's 53 MW deal with Southern California Public Power Authority in 2009 and Southern California Edison's 10 MW 4 hour SCE Chino storage "peaker" that was successfully operated from 1988-1996, with more and more being announced regularly.

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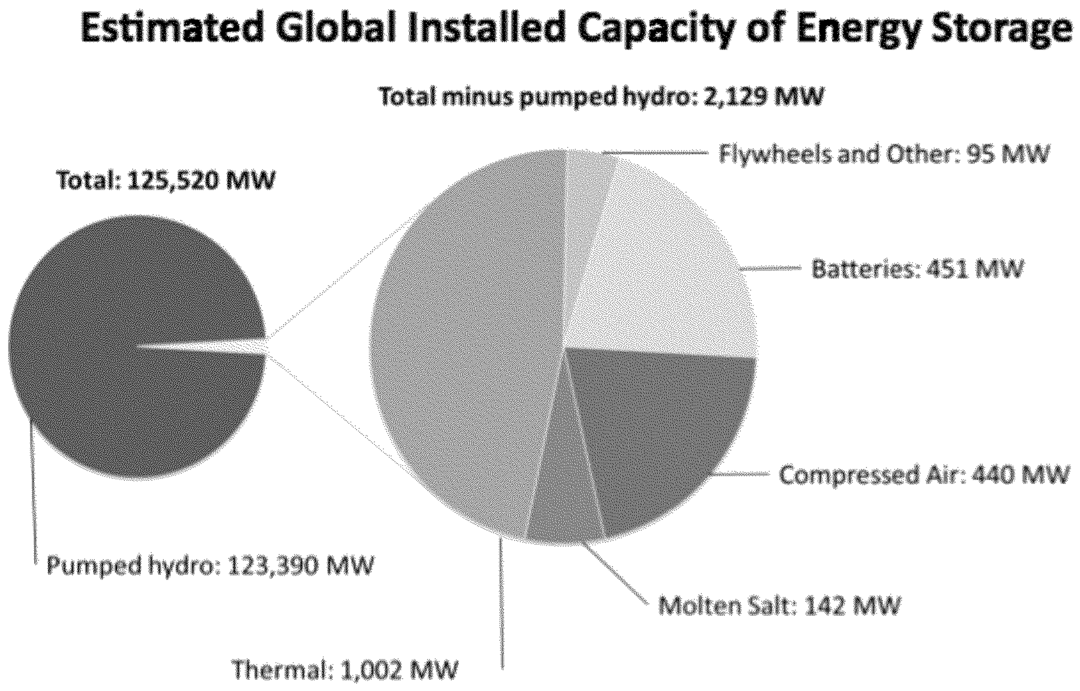
[7] "Regulators are uncertain how EES [electric energy storage] technologies should fit into the electric system, in part because EES provides multiple services such as generation, transmission and distribution. Furthermore, regulators do not yet know how EES costs and benefits should be allocated among these three main elements of the electric system." (White Paper, p. 2).



Source: StrateGen Consulting, LLC research; thermal storage installed and announced capacity estimated by Ice Energy and Calmac.
Note: Estimates include thermal energy storage for cooling only. Figures current as of April, 2010.

More recently, a number of distributed energy storage projects have been announced or are in the process of being implemented:

- 20 MW – A123 Systems Lithium Nanophosphate – Johnson City, New York
- 1MW, 0.5 MWh – A123 Systems Lithium Nanophosphate – Detroit, MI
- 8MW, 32 MWh – A123 Systems Lithium Nanophosphate – Tehachapi, CA
- 20 MW, 5MWh – Beacon Power Flywheels – Stephentown, MA
- 20 MW, 5MWh – Beacon Power Flywheels - Hazel Township, PA
- 20 MW, 5MWh – Beacon Power Flywheels – Chicago Heights, IL
- 15 MW, 10 MWh – Xtreme Power Kahuku, Solid State Dry Cell– Hawaii
- 1.1 MW, 0.5 MWh – Xtreme Power La Ola, Solid State Dry Cell – Hawaii
- 0.6 MW, 3.6 MWh – Prudent Energy VRB-ESS – Oxnard, CA
- 34 residential energy storage + solar homes in a microgrid community- Sunverge Energy ‘2500 R Street’ – Sacramento, CA

VI. THERE IS AMPLE OPPORTUNITY TO DEVELOP POLICIES THAT WILL REDUCE BARRIERS TO DEVELOPMENT AND DEPLOYMENT OF ENERGY STORAGE.

There are numerous specific actions that the CPUC can and should undertake to better align benefits with costs, and thus enable greater deployment of energy storage in a cost-effective manner. A few examples of these kinds of actions are organized below, by major application.

A. *Customer Side of the Meter Distributed Applications.*

1. **Reform retail tariff design.** The structure and, even more importantly, lack of consistency in the existing tariff structure over time presents a formidable barrier to customer side of the meter energy storage projects, where a significant portion of the value provided by energy storage is directly tied to tariff rate differentials at different times of the day. This was a key finding in the PLS Consultants report[8] – a potential solution to this barrier as recommended in that report – would be a storage –focused tariff that would guarantee differentials in electricity costs over time. This could be in the form of a tariff rider or altogether different tariff.

2. **Develop incentives for deployment.**
    a. Develop a standard offer for distributed permanent load shifting
    b. Expand the Self Generation Incentive Program to include standalone energy storage and energy storage coupled with distributed solar.
    c. Allow creative ownership models for customer-sited projects, including customer owned, third party owned and utility owned, similar to how solar PV is deployed today.
    d. Enable retail access to the CAISO's wholesale markets.

B. *Utility sited applications.*

1. Develop utility incentives for deployment of energy storage technology at both the transmission and distribution system levels.

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[8] Statewide Joint IOU Study of Permanent Load Shifting, November 29, 2010

2. Allow utilities full cost recovery for investments in energy storage retail tariff design that encourages load shifting for all customer classes
3. Adopt an increased rate of return on investment to utilities that directly invest in energy storage and procure energy storage-related resources.
4. Develop incentives commensurate with technological risk associated with various storage technologies.
5. Standardization and facilitation of interconnection rules procedures for storage devices.
6. Provide an option for symmetrical market rules for energy transactions (to avoid, for example, paying retail rates for purchases and receiving wholesale prices for sales).

VII. REVIEW AND WEIGH THE COSTS AND BENEFITS OF DEVELOPMENT AND DEPLOYMENT OF ENERGY STORAGE FOR ALL APPLICATIONS AND USE CASES.

Energy storage technologies are capable of providing benefits across a range of time scales, and can serve as substitutes for power grid components that serve different functions across different time scales. Evaluation of benefits should therefore be organized to reflect the differences in the speed of response and the duration of the storage response, particularly since these factors will directly impact energy storage's reliability benefits. There are also benefits of fast-responding storage that respond to a transmission or grid disturbance.[9]

Some of the most significant elements of cost-benefit analysis of energy storage for the Commission's consideration are listed below.

A. *Determine if different cost benefit methodologies need to be developed for different applications, especially bulk vs. distributed since one primarily serves at the transmission level and the other at the distribution or customer level.*

B. *Factor in the many benefits of storage, especially those that bridge procedural and jurisdictional lines.*

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[9] Stability limits on transmission, and Frequency Response (usually met with inertia and "droop response" from conventional generators) can both be improved with fast-acting storage technologies. These are two examples of reliability and transmission limits that are mitigated with a response of 10 seconds to 10 minutes. These are also benefits that are not procured through markets and can be difficult to monetize, or even define their value.

C. *Take all system and environmental benefits associated with energy storage into account, especially the reduction in emissions from cycling thermal units to "fill in" around variable renewable generation and provide marginal peak generation.*

D. *Establish measurement and metering standards as necessary to track benefits from energy storage.*

E. *Factor in the costs and benefits of energy storage as part of existing cost-benefit methodologies.*

F. *Create a methodology to determine resource adequacy value for storage.*

VIII. CONCLUSION.

CESA appreciates this opportunity to respond to the OIR, and looks forward to working with the Commission and other stakeholders throughout the entire proceeding.

Respectfully submitted,

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Date: January 21, 2011

APPENDIX A

This matrix is an attempts to organize use cases for storage systems at the utility, comercial, and residential levels. Data for each use case is broken down into feasible value streams/applications, technical specifications, compensation/ownership models, and applicable incentives.

STRATEGEN
STRATEGIES FOR CLEAN ENERGY

CESA
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	Use Cases	Utility									Commercial					Residential			
		Stationary T&D Deferral	Stationary T&D Deferral "Plus"	Transportable T&D Deferral	Transportable T&D Deferral "Plus"	Centralized Renewable Integration	Distributed Renewable Integration	Peaker Plant Substitution	Frequency Regulation	CES	Off Grid/Microgrid	Commercial UPS /Backup	Commercial PLS	Commercial PLS "Plus"	Commercial PLS "Plus" w/ Renewables	Off Grid/Microgrid	Residential UPS /Backup	Residential PLS	Residentia "Plus"
Value Streams (Benefit Capture % of Gross)																			
Utility Applications	**Electric Supply**																		
	Electric Energy Time Shift		50%		50%					50%									
	Electric Supply Capacity		100%		100%			100%		100%									
	Ancillary Services																		
	Load Following																		
	Frequency Regulation							50%	100%										
	Electric Supply Reserve Capacity		75%		75%			75%		75%									
	Voltage Support		50%		50%					50%									
	Grid Operations																		
	Transmission Support																		
	Transmission Congestion Relief		75%		75%					75%									
	Reliability (15 min. - 1 hour)																		
	Power Quality (10 Seconds)		50%		50%					50%									
	T&D Upgrade Deferral																		
	Stationary	100%	100%																
	Transportable			100%	100%														
	Renewable Integration (Solar and Wind)																		
	Ramping					100%	100%			100%									
	Firming					100%	100%			100%									
	Overgeneration					100%	100%			100%									
	Generation shifting					50%	50%			100%									
	Frequency Regulation					50%	50%			50%									
	Distribution upgrade deferral due to renewables or EVs						100%			100%									
Commercial Applications	Time-of-use energy cost management												100%	100%	100%				
	Demand charge management												100%	100%	100%				
	Demand response												100%	100%	100%				
	Permanent load shifting												100%	100%	100%				
	Onsite renewable integration														100%				
	Onsite renewable generation shifting														100%				
	Retail participation in ancillary services													25%	25%				
	UPS replacement											100%		100%	100%				
	Power Quality (10 Seconds)											100%		100%	100%				
	Emergency backup (islanding)											100%		100%	100%				
Residential Applications	Time-of-use energy cost management																	100%	100%
	Demand charge management																	100%	100%
	Demand response																	100%	100%
	Permanent load shifting																	100%	100%
	Onsite renewable integration																		
	Onsite renewable generation shifting																		
	Retail participation in ancillary services																	25%	25%
	UPS replacement															100%	100%		100%
	Power Quality (10 Seconds)															100%	100%		100%
	Emergency backup (islanding)															100%	100%		100%
Technical Specifications																			
	Storage Size Range																		
	Low range capacity (kW)	250	250	250	250	1,000	25	1,000	250	5	5	5	5	5	5	1	1	1	1
	High range capacity (kW)	10,000	10,000	10,000	10,000	100,000	5,000	50,000	5,000	100	5,000	5,000	5,000	5,000	5,000	20	20	20	20
	Low range duration (h)	2	2	2	2	1	1	4	0.25	1	0.25	0.25	1	1	1	0.25	0.25	1	1
	High range duration (h)	5	5	5	5	4	4	8	2	4	8	8	10	10	10	8	8	10	10
Ownership & Financing																			
	Compensation/Ownership Models																		
	Utility owned, utility sited, rate based	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
	Utility owned, customer sited, rate based	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	No	No	Yes	Yes	Yes	No	No	Yes	Yes
	Merchant owned, utility sited, rate based/service contract	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	No
	Merchant owned, customer sited, rate based/service contract	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes
	Merchant owned, customer sited, site host service contract	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Customer owned, customer sited, customer side of meter value streams	No	No	No	No	No	Maybe	No	No	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes
	Incentives																		
	Federal: ITC, Utility	No	No	No	No	Maybe	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	No	No	No
	Federal: ITC, Customer	No	No	No	No	No	Maybe	No	No	No	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Maybe	Mayb
	Self Generation Incentive Program (SGIP): CA	No	No	No	No	No	No	No	No	No	Maybe	Maybe	Yes	Yes	Yes	Maybe	Maybe	Yes	Yes
	Permanent Load Shifting (PLS): Proposed, CA	No	No	No	No	No	No	No	No	No	No	No	Maybe	Maybe	Maybe	No	No	Maybe	Mayb
	Thermal/PLS	No	No	No	No	No	No	No	No	No	No	No	Maybe	Maybe	Maybe	No	No	Maybe	Mayb
	RPS: MA, HI, PA, CT, OH, NC, NV, MD	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No	Maybe	No	No	No	No

FERC	ISO	CPUC	CEC
Transmission	Transmission/ Wholesale Markets/ Ancillary Services	Distribution, Generation, Procurement	New power plant sitings (>50MW)
Tx Rates/Tariffs	Grid operations	Dx Rates/Tariffs, RECs	Renewable generation classification for RPS

1.Check vs. NRRI Webinar, "Economic Regulatory Jurisdiction in the US Electric Industry"
2. Confirm with Don

Ownership Models	**Compensation Models**
Utility owned - utility sited	Utility purchase - rate base
	Utility service contract - rate base
Utility owned, customer sited	Utility purchase - rate base
	Utility service contract - rate base
Site Host Owned	Site host capture of Customer side of meter value streams
	Site host service agreement with third party
Merchant owned utility sited	Merchant owned - rate based
	Charged to utility
Merchant owned distributed/aggregated	Merchant owned - rate based
	Charged to utility

APPENDIX B

Energy Storage - a Cheaper and Cleaner Alternative to Natural Gas-Fired Peakers

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Storage is vital in all efficiently functioning commodity markets—storage smoothes the fluctuations in supply and demand and ensures availability during critical periods of high demand. Energy storage systems store energy for use at a later time, when electric power is most needed and most valuable, such as on hot summer afternoons. Energy storage helps integrate intermittent renewable sources, can supplant the most polluting power plants, and enhances grid reliability. There are many ways to store energy, including chemically (batteries), mechanically (flywheels) and thermally (ice).[1]

Due to insufficient energy storage for the electric power grid, utilities must size their generation and transmission systems to deliver the full amount of electricity that consumers demand (or might demand) at any given moment of the year. Owning and operating sufficient assets to serve peak demand - only 5% or less of the hours per year - results in increased emissions and costs to electricity customers.

Energy storage has the unique potential to transform the electric utility industry by improving existing asset utilization, avoiding the building of new power plants, and avoiding or deferring upgrades to existing transmission and distribution networks. Scientists, utility CEO's, and policy makers frequently refer to energy storage as the "Holy Grail" for the electric power industry.

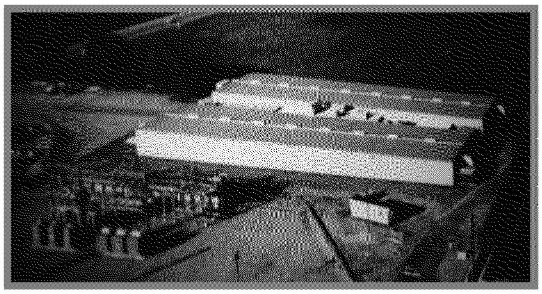
More recently, energy storage has achieved recognition as a foundational element of the Smart Grid[2], and the technical community speaks of energy storage as a key enabling resource to facilitate the transition away from a fossil fuel dominated generation fleet to one that is cleaner, more reliant on renewables, "smarter," and able to accelerate the electrification of the transportation sector.

To help illustrate the cost effectiveness of energy storage as an alternative to natural gas-fired peakers, we compared the cost of a kilowatt-hour (kWh) of electricity generated on-peak by a gas-fired peaker, with the cost of a kWh of electricity provided on-peak by an energy storage system. For simplicity, this comparison selected a commercially available energy storage technology – lead-acid batteries – and used the cost and specifications similar to the large lead-acid energy storage peaking facility shown below. Located in Chino, California, this 10 megawatt (MW), 4 hour duration system successfully demonstrated energy storage's ability to manage peak load from 1988 through 1996.[3, 4]

Energy Storage Technologies Today Can Deliver On-Peak Electricity at a Lower Cost than Gas-Fired Peakers

Gas-Fired Turbine Peaker Plant

Energy Storage Peaker Substitution



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[1] Pumped hydro energy storage, which has been in wide use for many years, is another form of mechanical, or kinetic, energy storage

[2] Title XIII of the Energy Independence and Security Act of 2007 described the Smart Grid as including "deployment and integration of advanced electricity storage and peak-shaving technologies, including plug-in electric and hybrid electric vehicles, and thermal-storage air conditioning"

[3] Energy storage performance specifications based on commercially deployed lead-acid grid storage projects, including the EPRI–funded grid level energy storage demonstration project in Chino, California

[4] EPRI Chino Study TR-101787, *Chino Battery Energy Storage Power Plant: Engineer-of-Record Report* (December 1992)

Assumptions for the gas-fired peaker were taken directly from the CEC's *Comparative Cost of California Central Station Electricity Generation Technologies* model. To calculate the cost per kWh of electricity discharged by an energy storage system, the same 20-year project time horizon and 5% capacity factor were used. Below is a detailed overview of the analysis methodology:

Gas-Fired Peaker Plant[5]

General Assumptions	
Technology:	Simple Cycle Combustion Turbine
Plant Size	49.9MW
Efficiency	37% (9,266 Btu/kWh Heat Rate)
Ownership	POU Owned/Financed
Project Life	20 years
Capacity Factor	5%
Plant, T&D Losses	6% (Centralized Plant)

Costs	Assumptions	LCOG ($/MWh)	LCOG ($/kW-yr)
Fixed O&M	$24/kW/yr	$69	$29
Corp. Taxes	0%	$0	$0
Insurance	0.6% of CAPEX	$23	$10
Property Tax	1.1% of CAPEX	$29	$12
Natural Gas Fuel	$61/MWh	$100	$41
Variable O&M	$0.04/kWh	$5	$2
Subtotal		$227	$93

Costs	Assumptions	LCOG ($/MWh)	LCOG ($/kW-yr)
Installed Cost	$1,394/kW	$265	$109
Grand Total		$492	$203

Energy Storage Peaker Substitution[6]

General Assumptions	
Technology:	Lead-Acid Battery
Plant Size	49.9MW (4h duration)
Efficiency	84% (AC to AC Roundtrip)
Ownership	POU Owned/Financed
Project Life	20 years
Capacity Factor	5%
Plant, T&D Losses	6% (Centralized Plant)

Costs	Assumptions	LCOG ($/MWh)	LCOG ($/kW-yr)
Fixed O&M	$6/kW/yr	$17	$7
Corp. Taxes	0%	$0	$0
Insurance	0.6% of CAPEX	$22	$9
Property Tax	1.1% of CAPEX	$28	$12
Off-Peak Grid Charging	$24/MWh[7]	$48	$20
Variable O&M	$0.04/kWh	$5	$2
Subtotal		$121	$50

Costs	Assumptions	LCOG ($/MWh)	LCOG ($/kW-yr)
Installed Cost	$1,351/kW[8] ($338/kWh)	$256	$105
Grand Total		$377	$155

Levelized Cost of Generation for Energy Storage is Less Than a Simple Cycle Gas-Fired Peaker

Energy Storage Has the Ability to Deliver More than Peaker Substitution Value to the Grid

In addition to cost savings for electricity consumers, energy storage provides multiple value streams above and beyond peaker substitution, making the economic case for energy storage even stronger. For example, by their nature, gas-fired peaker plants cannot be economically sized below 50 MW and therefore are not easily installed in a distributed footprint. Energy storage systems do not have this limitation, opening up the potential for many technical and economical benefits available to distributed energy resources such as reduction of transmission and distribution losses. Additional benefits include electric energy time-shift, voltage support, electric supply reserve capacity, transmission congestion relief, and frequency regulation. Ranges for each of these value streams have recently been quantified by Sandia National Laboratories, and are presented in the chart below in terms of additional benefits per MWh delivered on-peak.

Additional System Benefits of Energy Storage[9]

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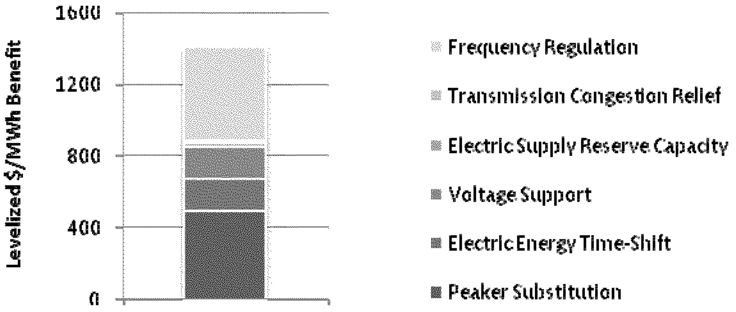
[5] Source: *CEC 2009 Comparative Cost of California Central Station Electricity Generation Technologies* (CEC_COG_Model_Version_2.02-4-5-10)

[6] Source: StrateGen Consulting, Levelized Cost of Generation Model

[7] Assumes most recent sample of average summer off-peak wholesale price from CAISO OASIS database

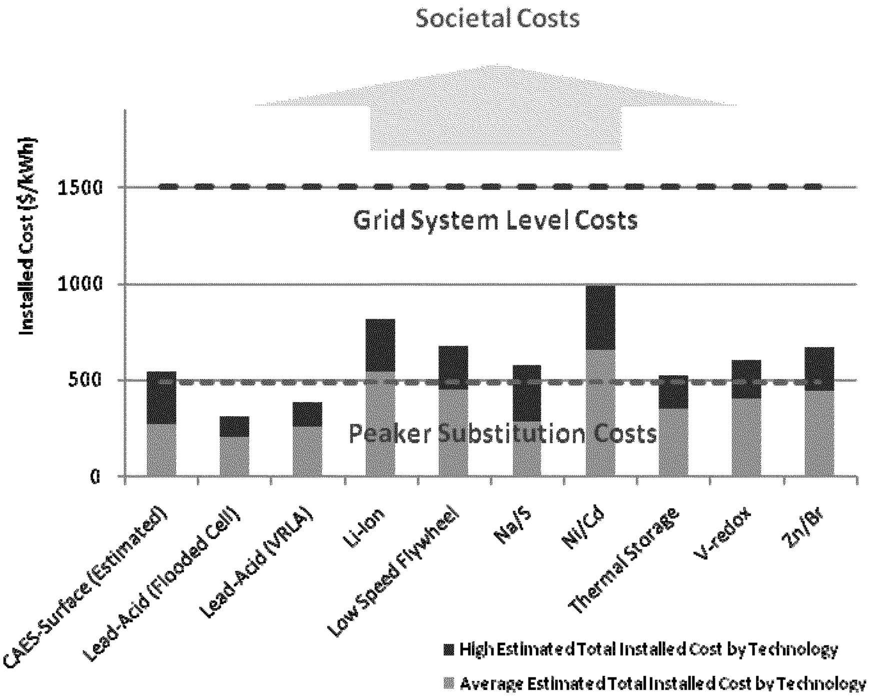
[8] EPRI Chino Study TR-101787, *Chino Battery Energy Storage Power Plant: Engineer-of-Record Report* (December 1992)



Energy Storage is the Most Cost-Effective Resource

When these benefits are factored in and compared to the total installed cost for a range of energy storage technologies, energy storage emerges as a comprehensive, cost-effective system resource.

Fossil Fuel Societal, Grid, and Peaking Costs vs. Energy Storage Costs[10,11]



Avoided Costs Realized

Societal Level:

- GHG & Air Quality
- Renewables Integration
- Smart Grid Implementation
- Streamlined Permitting

Grid System Level:

- Electric Energy Time-Shift
- Voltage Support
- Electric Supply Reserve Capacity
- Transmission Congestion Relief
- Frequency Regulation

Peaker Level:

- Peaker Plant Substitution

The bars in the chart above represent the total installed cost per kWh of energy storage capacity by major storage technology, assuming four hours of capacity for each. The red dashed line indicates where storage costs are at cost parity with a natural gas-fired peaker. The green dashed line indicates the grid system level costs avoided with energy storage – in other words, this line is representative of other real system costs that are

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[9] Source: SANDIA Report SAND2010-0815, *Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide*, Jim Eyer & Garth Corey (February 2010)

[10] Assumptions: All energy storage technology costs shown are normalized for a four-hour duration; Technology comparison is for modern energy storage systems only, but does not include pumped hydro or high-speed flywheels which are not designed for long-duration peaking applications

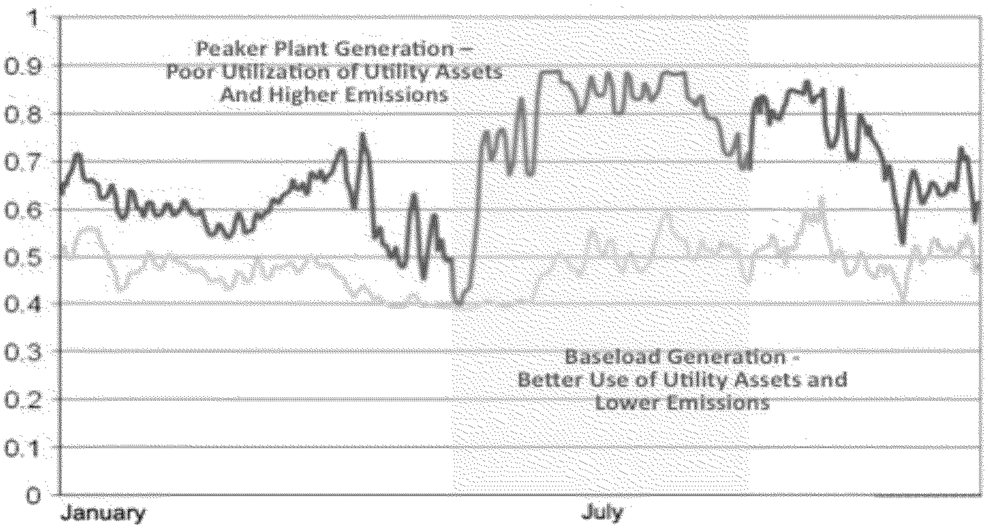
[11] Source: Average estimated total installed cost estimate from: Sandia Report SAND2008-0978, Susan M. Schoenung and Jim Eyer, *Benefit/Cost Framework for Evaluating* (February 2008)

borne by electricity customers. Finally, the blue arrow represents the total societal cost avoided by energy storage, including its ability to help achieve a smart grid, accelerate and facilitate renewables integration, and avoid GHG emissions.

Energy Storage is a Cleaner Alternative to Natural Gas-Fired Peakers

Grid storage displaces less efficient, dirtier peaker generation by time-shifting more efficient, cleaner base-load generation to peak periods. This results in substantial system-wide air quality benefits. The chart below compares actual carbon dioxide (CO_2) emissions of peak vs. off peak generation in Southern California Edison's service territory. Peaker plant generation produces far more CO_2 emissions per MWh than base load generation, especially during the summer months. This is true of California's other utilities as well.

Peak vs. Off-Peak CO_2 Emission Rate (Tons/MWh)[12]



Energy storage usage results in significant air quality benefits. Assuming Pacific Gas and Electric's base load electric mix as the off-peak source of electricity, energy storage would provide 55% CO_2 savings, 85% NOx savings, and up to 96% savings of CO per MWh of on-peak electricity delivered (shown in the chart below). These emissions benefits increase as more off-peak renewable generation comes on-line. Energy storage will also help optimize the use of existing transmission and distribution capacity, enabling the deployment of more renewable energy. Finally, because of its ability to store locally generated power and be remotely dispatched, energy storage is an indispensable component of a more affordable, secure and reliable smart grid.

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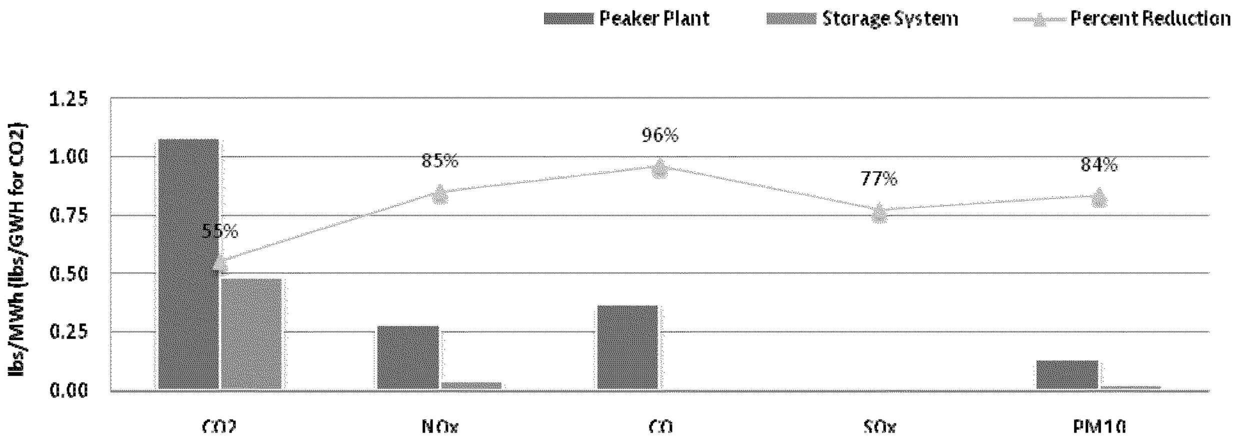
[12] Source: 2006 CPUC Update for Energy Efficiency Proceeding (Brian Horii, E3)

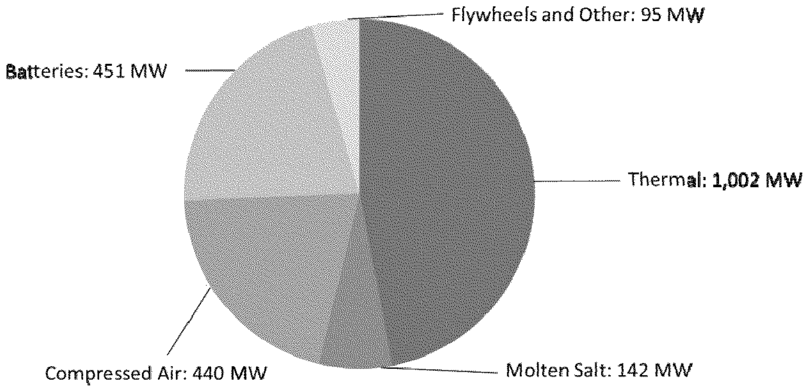
Energy Storage is a Cleaner Alternative to Gas Peakers[13]



Smart, Clean, Cost-Effective Energy Storage: Ready for Deployment

Modern energy storage technologies, some of which have been in existence for decades, cover a wide range of sizes, power (measured in MW), and discharge durations (measured in hours). An energy storage system can be either centralized or distributed and can be utility-owned, customer-owned or third-party owned. Today, there are more than 2,000 MW of installed grid connected energy storage technologies deployed worldwide with a comparable amount under development.[14]

Current Estimated Worldwide Installed Advanced Energy Storage Capacity (2128 MW as of 2010)



Why Isn't Energy Storage Being Widely Used in California?

Current California policy has not kept pace with advances in energy storage, yet energy storage can cost-effectively help address California's many energy policy challenges, such as green house gas emissions reduction, renewables integration, transmission and distribution constraints, increasing peak demand and enabling electric vehicles. Energy storage is particularly relevant, as many of these complex challenges need to be addressed in the near term, and storage technology is currently available and deployable on a large scale.

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[13] Assumptions from CEC Cost of Generation Model for simple cycle peaker and standard combined cycle for off-peak base load; generation mix based on annual report of actual electricity purchases for Pacific Gas and Electric in 2008

[14] Source: StrateGen and CESA research. Excludes pumped hydro capacity, estimated at ~123 GW

Energy Storage - a Cheaper and Cleaner Alternative to Natural Gas-Fired Peakers

Energy storage technologies are well established in other industries and market applications, such as the transportation and consumer electronic industries. Grid storage, a key component of the electric power industry, represents a large new market application for both existing and emerging energy storage technologies. Unfortunately, the electric power industry is a highly regulated industry that has historically overlooked using storage for grid optimization. As a result, current market structure does not allow for the buyer of the storage equipment to easily capture all the value streams provided by storage across the entire electric power system.

The barrier is neither the availability of a reliable energy storage technology nor its cost; the barrier is the current accounting of disaggregated benefits in a deregulated utility industry and lack of clear policy direction to utilities that energy storage is a superior alternative to gas-fired peakers. Thus, while energy storage presents compelling social and economic benefits, California's current market structure has led to underinvestment.

Key State and Federal Policy Recommendations to Realize the Benefits of Energy Storage:
Energy storage can cost-effectively help address California's many near term, complex and inter-related energy policy challenges, such as green house gas emissions reduction, renewables integration, transmission and distribution constraints, increasing peak demand and enabling electric vehicles.

State Recommendations

1) Require utilities to evaluate procurement targets for cost-effective storage deployment (e.g., AB 2514)
2) Encourage diversity in energy storage technology deployment, including market application and ownership options to foster utility, third party, and customer-owned applications
3) Fully implement SB 412 to provide Self Generation Incentive Program (SGIP) incentives for energy storage coupled with solar and used standalone on the customer side of the meter
4) Implement energy-storage focused rulemaking, require consideration of energy storage as a valued system resource in all regulatory proceedings (e.g. distributed generation, smart grid, renewables, and demand response/permanent load shifting)
5) Include energy storage in a standardized cost-effectiveness methodology applicable to all resources
6) Require utilities to include energy storage as a bidding option in peaking capacity Requests for Offers (RFOs)
7) Require storage as part of long term procurement process, including pursuing standard offers for permanent load shifting
8) Explore tariff design that encourages load shifting
9) Increase Feed-in-Tariff price for renewables firmed/shifted with energy storage
10) Accelerate the CAISO's stakeholder processes to achieve comparability of energy storage (implementation of FERC Orders 890 and 719)
11) Consider peak reduction standard for state agency power purchases
12) Clarify net metering rules for renewable energy projects with storage

Federal Recommendations

1) Support extension of the existing federal investment tax credit to energy storage systems (e.g., S.1091)
2) Add energy storage as its own category in the FERC's Uniform System of Accounts

APPENDIX

GLOSSARY[15,16]

Levelized Cost of Generation: According to the CEC, levelized cost of generation of a resource represents a constant cost per unit of generation computed to compare one unit's generation costs with other resources over similar periods. This is necessary because both the costs and generation capabilities differ dramatically from year to year between generation technologies, making spot comparisons using any year problematic. The levelized cost formula used in this model first sums the net present value of the individual cost components and then computes the annual payment with interest (or discount rate) required to pay off that present value over the specified period. These results are presented as a cost per unit of generation over the period under investigation. This is done by dividing the costs by the sum of all the expected generation over the time horizon being analyzed. The most common presentation of levelized costs is in dollars per megawatt-hour ($/MWh) or cents per kilowatt-hour (¢/kWh).

Capacity Factor: The capacity factor is specified as a percentage and is a measure of how much the power plant operates. More precisely, it is equal to the energy generated by the power plant during the year divided by the energy it could have generated if it had run at its full capacity throughout the entire year (Gross MW x 8,760 hours). For the purposes of this analysis, specifically for energy storage, the capacity factor is measured using the number of hours discharged only and does not include the number of hours used to charge the storage system.

Electric Energy Time-Shift: Electric energy time-shift involves purchasing inexpensive electric energy, available during periods when the price is low, to charge the energy storage plant so that the stored energy can be used or sold at a later time when the price is high. This is also sometimes referred to as "arbitrage."

Voltage Support: An important technical challenge for electric grid system operators is to maintain necessary voltage levels with the required stability. In most cases, meeting that challenge requires management of a phenomenon called "reactance." Reactance occurs because equipment that generates, transmits, or uses electricity often has or exhibits characteristics like those of inductors and capacitors in an electric circuit. To manage reactance at the grid system level, grid system operators rely on an ancillary service called "voltage support." The purpose of voltage support is to offset reactive effects so that grid system voltage can be restored or maintained.

Electric Supply Reserve Capacity: Prudent operation of an electric grid includes use of electric supply reserve capacity ("reserve capacity") that can be called upon when some portion of the normal electric supply resources become unavailable unexpectedly. In the electric utility realm, this reserve capacity is classified as an ancillary service.

Transmission Congestion Relief: In many areas, transmission capacity additions are not keeping pace with the growth in peak electric demand. Consequently, transmission systems are becoming congested during periods of peak demand, driving the need and cost for more transmission capacity and increased transmission access

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[15] Source: CEC 2009 Comparative Cost of California Central Station Electricity Generation Technologies Report

[16] Source: SANDIA Report SAND2010-0815, Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Jim Eyer & Garth Corey (February 2010)

charges. Additionally, transmission congestion may lead to increased use of congestion charges or locational marginal pricing for electric energy.

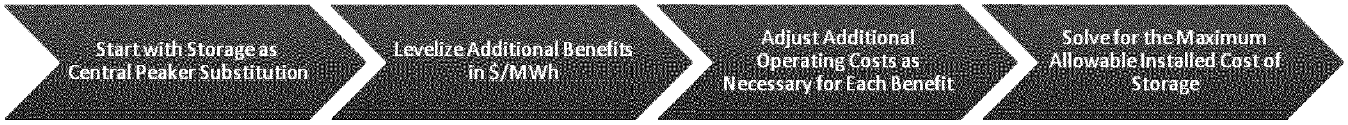
Frequency Regulation: regulation is used to reconcile momentary differences between supply and demand. That is, at any given moment, the amount of electric supply capacity that is operating may exceed or may be less than load. Regulation is used for damping of that difference.

ANALYSIS METHODOLOGY: PEAKER VS. ENERGY STORAGE

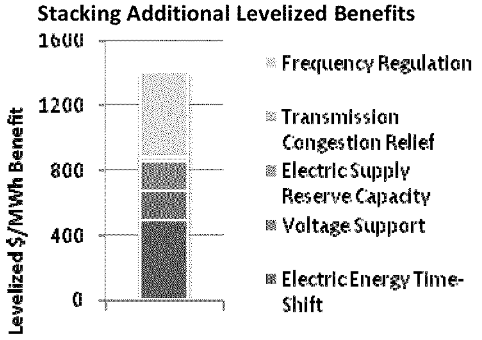
For further examination of the analysis above and access to the spreadsheet model used for the above analysis, see the following website: http://storagealliance.org/work-presentations.html

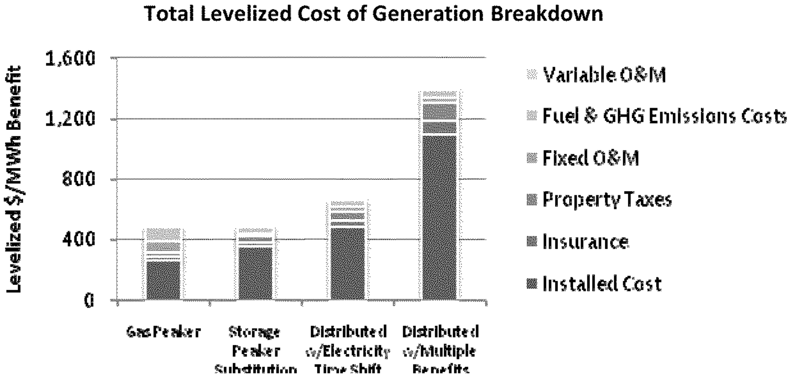
ANALYSIS METHODOLOGY: ADDITIONAL BENEFITS

Unlike a single-use centralized peaker plant, energy storage can be used for a multitude of applications beyond those of simple peaker plant substitution. When reasonable and "stackable" additional benefits are factored into the maximum allowable installed cost, energy storages' 'cost effective' price point increases. This means that energy storage technologies that are technically capable of capturing these additional benefits should be cost effective even at higher installed costs.



To help illustrate the impact of additional value streams to the maximum allowed installed cost of grid-integrated storage, we utilized the midpoint of the Sandia report benefit estimate for each value stream[17], and utilized the same 20 year time horizon and targeted return for investors and solved for the maximum *increase* in installed cost of the storage system resulting from these added benefits. The incremental allowable installed cost for energy storage was then added to the maximum allowable installed cost per kWh of energy storage capacity calculated for the peaker substitution. To be conservative, we further adjusted operating assumptions for each benefit to allow for increased transaction and maintenance costs for distributed systems to arrive at the final installed cost/kWh capacity of the energy storage system, as indicated in the chart below.


Stacking Additional Levelized Benefits


Total Levelized Cost of Generation Breakdown

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[17] Source: SANDIA Report SAND2010-0815, Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide, Jim Eyer & Garth Corey (February 2010)

APPENDIX C

Energy Storage—a Cheaper, Faster, & Cleaner Alternative to Conventional Frequency Regulation

CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

Introduction

Energy storage systems store energy for use at a later time—for as little as several seconds to many hours—when electric power is most needed and most valuable. There are a number of available or emerging technologies, from mechanical storage (e.g., flywheels), to chemical storage (e.g., batteries), to thermal storage (e.g., ice).[1] By ensuring availability during periods of high demand, enhancing grid reliability, and smoothing fluctuations in supply and demand, energy storage technologies play a critical role in an efficiently functioning grid. Recently, energy storage has gained attention as a fundamental component in addressing climate change given their ability to displace fossil-fueled peaking power plants and enable integration of renewables into the grid. Due to the "fast response" nature of some energy storage technologies, they are ideally suited to meet grid stability and reliability challenges as providers of grid support, or "ancillary" services.

Key points of this white paper include the fact that greater use of energy storage can lower overall system and ratepayer costs while reducing unwanted emissions of CO2 and other greenhouse gases. Further, in order to foster the wider use of energy storage we must rethink how energy storage is compensated and reflect the superior performance of storage for selected applications. Finally, energy storage assets must have a reasonable certainty of being paid for 10-years or more in order to encourage access to project-based debt on reasonable market terms.

To illustrate the value of energy storage in the ancillary services frequency regulation market, the California Energy Storage Alliance (CESA) selected a specific ancillary service – frequency regulation – and compared the performance of a flywheel kinetic energy storage device with a conventional baseload combined cycle combustion turbine (CCGT). We use flywheels as our comparison technology due to commercial availability and access to data from an existing facility. However, a number of other energy storage technologies can provide frequency regulation, and examples of existing and developing projects are also described below.

Ancillary Services

One of the key challenges in grid management is maintaining reliability. As demand and supply vary throughout the day, the entity responsible for coordinating, controlling, and monitoring the electric power system – typically an Independent System Operator (ISO) – is tasked with maintaining the real time balance between generation and usage of electricity, or load. In addition, the ISO must adjust generation to manage appropriate power flows based on transmission constraints and control voltages, and restart the system in the event of a collapse.[2] These objectives are achieved through various forms of ancillary services. According to the California Independent System Operator (CAISO), ancillary services support the transmission of energy from generation to load by ensuring system reliability, and include the following: regulation up, regulation down, spinning reserve, non-spinning reserve, voltage support, and black start.[3,4]

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1 Other examples of energy storage technologies include ultracapacitors, pumped hydro, and compressed air energy storage.
2 Kirby,B. (2007). *Ancillary Services: Technical and Commercial Insights.* Prepared for Wartsila.
3 CAISO (2010) *Business Practice Manual for Definitions & Acronyms*.
4 Definitions of each ancillary service are provided in the glossary.

CESA * 2150 Allston Way, Suite 210, Berkeley, CA 94704 * 510.665.7811 * www.storagealliance.org

A123 Systems * AIC/East Penn * AltairNano * Beacon Power * Chevron Energy Solutions
Debenham Energy * Deeya Energy * EnerSys * EnerVault * Fluidic Energy * General Compression Greensmith
Energy Management Systems * HDR * Ice Energy * International Battery * Lightsail Energy
MEMC/SunEdison * Powergetics * Primus Power * Prudent Energy * ReStore Energy Systems * Saft Samsung
SDI * Seeo * Silent Power * Suntech * Sumitomo Electric * Sunverge * SustainX * XtremePower

SB_GT&S_0459220

Why Ancillary Services Are Important

As states implement increasingly aggressive renewable portfolio standards (RPS), increasing the share of intermittent resources like solar and wind, one challenge will be maintaining grid reliability. In 2010, the California Energy Commission (CEC) modeled the variability and system performance related to 20% and 33% renewable energy penetration. Results indicate that system performance degrades "significantly" in the 20% renewables scenario, and becomes "extreme" in the 33% scenario.[5][6] This increase in variability will in turn require a substantial increase in ancillary services, in particular frequency regulation. Frequency regulation includes both "regulation up" and "regulation down," and is defined below:

- Regulation Up: An increase in electricity output in response to direct digital control (Automatic Generation Control, or AGC) signals in order to maintain the target system frequency. In other words, an online resource that can respond rapidly to fluctuations in the system load.[7] AGC is used to maintain the Area Control Error (ACE), which is the deviation from the ideal frequency and output. Associated reliability standards are defined by the Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Corporation (NERC).[8]
- Regulation Down: A decrease in energy output in response to ACG signals in order to maintain system frequency. Regulation Up and Regulation Down fulfill similar objectives, but are considered separate services, each with its own reliability criteria.[9]

Without taking energy storage into account, the amount of regulation necessary for conventional generating resources to maintain system performance at an acceptable level during morning and evening "ramp" hours for the 33% scenario in 2020 is 3,000-5,000 megawatts (MW). In comparison, in 2008 the CAISO required approximately 390 MW of regulation up capability, and 360 MW in regulation down capability.

Additional analyses suggest similar outcomes. In a study focused on wind generation capacity, the New York ISO (NYISO) concluded that for every 1,000 MW increase in installed wind generation (between the 4,250 MW and 8,000 MW penetration level), the regulation requirement will increase by 9%, necessitating additional capacity.[10] Traditionally, ancillary services are provided by conventional thermal power plants, pumped hydro, or other generating resources. In California, the 2009 regulation requirement was 419 MW[11] and the CAISO predicts that to meet the 33% RPS by 2020, it will require 1,114 MW[12] of regulation. In other words, in order to ensure grid reliability, we will either need to build additional conventional generating units such as fossil-fuel emitting combustion turbines, or integrate non-generation resources such as energy storage into existing grid infrastructure. Energy storage is a more effective way of meeting the increasing demand for ancillary services at a lower cost—in both economic and environmental terms—than these traditional resources.

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[5] Based on ACE excursions and NERC control performance standards. CEC 2010

[6] KEMA (2010). *Research Evaluation of Wind Generation, Solar Generation, and Storage Impact on the California Grid.* Prepared for the California Energy Commission, Public Interest Energy Research Program.

[7] Kirby 2007

[8] CAISO 2010

[9] CAISO 2010

[10] NYISO (2010). *NYISO Wind Generation Study.*

[11] PG&E (2010, August 24). *Pacific Gas and Electric Company, Long Term Procurement Plan Proceeding: Renewable Integration Model Results and Model Demonstration.* Slides presented at the CPUC Renewable Integration Workshop.

[12] CAISO (2010, October 22). *ISO Study of Operational Requirements and Market Impacts at 33% RPS, Continued Discussion and Refinement of Step 1 and Step 2 Simulation Methodology.* Slides presented at the CPUC Renewable Integration Workshop #2.

Energy Storage is More Effective than a Combustion Turbine

Of the ancillary services listed above, energy storage is particularly suited to performing frequency regulation. First, many energy storage technologies, such as flywheels or batteries, have extremely fast response rates. Maintaining grid stability and reliability requires balancing the output of generating units with demand. Frequency regulation maintains this balance through a rapid increase or decrease in output, matching generating power to load.[13] It naturally follows that a faster response would enable more accurate and effective regulation. Figure 1 below compares the ability of a flywheel and a conventional generator to perform frequency regulation. While the flywheel has the ability to "chase the ACE" almost instantaneously, the generator responds more slowly, often working against the ACE.[14]

There are two reasons why encouraging fast response resources to provide regulation can result in fewer total MW capacity of regulation that needs to be procured. First, resources that are more flexible and can ramp more quickly will reach their dispatch target faster and can then be re-dispatched more often. Thus, fast regulation resources provide much greater ACE correction than more ramp-limited resources. Second, because slower-ramping resources cannot switch directions quickly, they sometimes provide regulation in a counterproductive direction and, as a result, actually add to the ACE, requiring dispatch of other resources to counteract it.

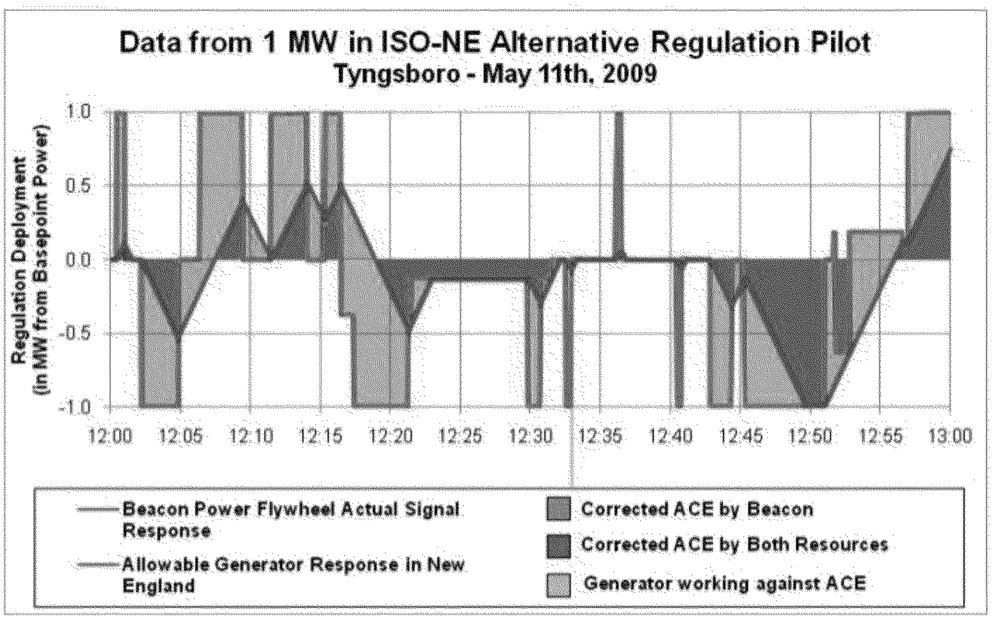

Figure 1: Regulation Performance of a Flywheel vs. Conventional Generation
Source: Beacon Power Corporation.

These fast response rates also lead to higher efficiency, meaning that a MW of energy storage is not equivalent to a MW of conventional generation. The Pacific Northwest National Laboratory (PNNL) defines an "ideal" fast

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[13] Most system frequencies around the world are set to 50 or 60 Hz. Source: Lazarewicz, M. and Ryan, R. (2010). *Grid Scale Frequency Regulation Using Flywheels.* Beacon Power Corporation.

[14] KEMA 2010

responding resource as one with "instantaneous response and unlimited energy."[15] For example, according to These fast response rates also lead to higher efficiency, meaning that a MW of energy storage is not equivalent to a MW of conventional generation. The Pacific Northwest National Laboratory (PNNL) defines an "ideal"fast responding resource as one with "instantaneous response and unlimited energy."[16] For example, according to PNNL, an ideal resource is 2.7 times more efficient than a combustion turbine. Although some energy storage technologies, such as flywheels, have energy limitations, they experience a very high relative efficiency when compared with combustion turbines, steam turbines, or combined-cycle turbines.[17] PNNL concluded that with faster Regulation resources on the grid the CAISO could reduce procurement of regulation by as much as 40%. A recent CEC study supports these claims, concluding that "on an incremental basis, storage can be up to two to three times as effective as adding a combustion turbine to the system for regulation purposes."[18] This means that a 100 MW storage unit can be as effective as a comparable 200-300 MW combustion turbine. Figure 2 demonstrates the effectiveness of different resources in performing frequency regulation.

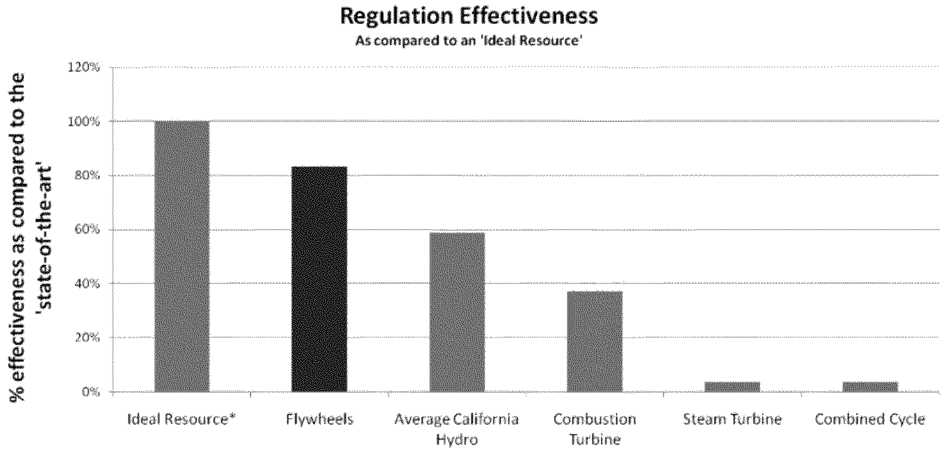

Figure2: Regulation Effectiveness of an "Ideal Resource"
Source: Beacon Power Corporation

Use of conventional resources not only requires more MWs to provide the same service, but can also lead to additional indirect costs that are often not taken into account when comparing systems. For example, the increased need for ancillary services will put stress on existing equipment, leading to additional maintenance costs and potentially reducing generator life. This increased use will also lead to more greenhouse gas emissions, as generation resources are forced to remain on-line to meet regulation requirements, and will be "ramping up," which is less efficient than standard generation.[19] As we add renewables to the grid to increase our use of clean energy, energy storage can maximize the value of those resources without compromising emissions reduction goals. Figure 3 represents potential emissions savings from the use of energy storage.

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[15] Makarov, Y., Ma, J., Lu, S., and Nguyen, T. *Assessing the Value of Regulation Resources Based on Their Time Response Characteristics.* Prepared by Pacific Northwest National Laboratory for the California Energy Commission.

[16] Makarov, Y., Ma, J., Lu, S., and Nguyen, T. *Assessing the Value of Regulation Resources Based on Their Time Response Characteristics.* Prepared by Pacific Northwest National Laboratory for the California Energy Commission.

[17] Makarov et al 2008

[18] KEMA 2010

[19] KEMA 2010

Flywheel Emission Savings Over 20-year Life: CA-ISO					
	Coal		Natural Gas		Pumped Hydro
	Baseload	Peaker	Baseload	Peaker	
CO2					
Flywheel	91,079	91,079	91,079	91,079	91,079
Alternate Gen.	322,009	608,354	194,534	223,997	123,577
Savings (Flywheel)	230,930	517,274	103,455	132,917	32,498
Percent Savings	72%	85%	53%	59%	26%
SO2					
Flywheel	63	63	63	63	63
Alternate Gen.	1,103	2,803	0	0	85
Savings (Flywheel)	1,041	2,741	-63	-63	23
Percent Savings	94%	98%	n/a	n/a	27%
NOx					
Flywheel	64	64	64	64	64
Alternate Gen.	499	1,269	80	118	87
Savings (Flywheel)	435	1,205	16	54	23
Percent Savings	87%	95%	20%	46%	26%

Figure3: Emissions Savings from the Use of Energy Storage
Source: Beacon Power Corporation

How Energy Storage is 2.5X More Effective than Generation

The following provides a simplified example of how energy storage can be two to three times more effective than a combustion turbine.

Assume regulation is only procured from a gas turbine with a 5.1% per minute ramp rate, allowing the turbine to move from zero output to full output in about 20 minutes.[20] Imagine that a system operator experiences a sudden generation loss. To meet NERC requirements, the operator must bring on 25 MW in additional generation within the next ten minutes.[21] In other words, over the next ten minutes, the system operator needs a 2.5 MW per minute ramp rate total from all generators providing regulation. If the only regulation generators are gas turbines with a 5.1% ramp rate, there needs to be 49.1 MW of these gas turbines online to meet the operator's ramp requirement. In contrast, 25 MW of energy storage could provide the full 25 MW of additional power within 20 milliseconds.

The essentially immediate availability of energy storage allows system operators to maintain ACE while providing enough time to call up traditional generators (on spinning or non-spinning reserve) in an orderly manner. In the scenario above, 25 MW of energy storage provided the performance equivalent of 49.1 MW of natural gas turbines, or 1.9 times the amount of generation. The multiplier could be higher (for example, if the system operator didn't find out about the problem until a few minutes later) or lower (for example, if there are faster generators online). Over a wide variety of scenarios and a wide variety of turbine models, studies have found that, on average, energy storage provides 2.5x the performance of a combustion turbine.[22]

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[20] Represents an unscientific midpoint from GE's brochures. Not GE's fastest unit, but there are also many old turbines in CAISO that would bring down the average.

[21] NERC CPS2 requirements

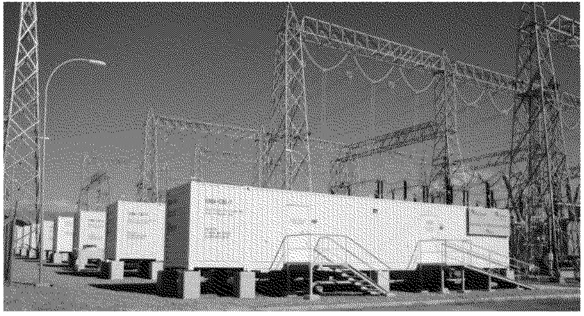
[22] Makarov et al 2008

Energy Storage is Here Today

Despite misconceptions that energy storage is only a technology of the future, numerous successful energy storage projects are operating today. Below is a sample list of ten projects including A123, Altairnano, Beacon Power, and Xtreme Power systems that provide energy storage frequency regulation project examples currently underway.

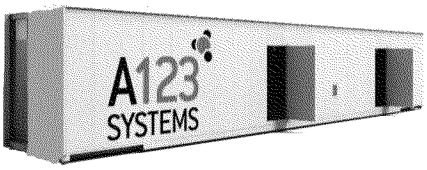
A123

Los Andes Energy Storage



Project Details	
Technology:	Lithium Nanophosphate
Plant Size:	4MWh (12MW)
ISO:	Chile
ISO Market Share:	N/A
Operational Date:	2009

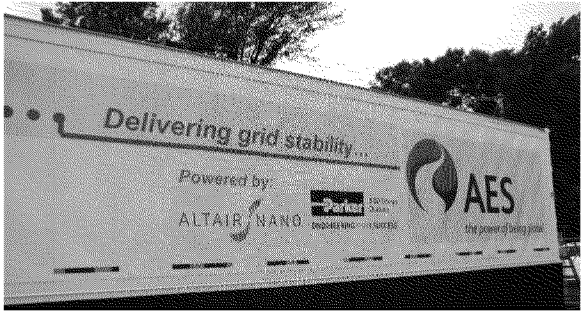
Johnson City[23]



Project Details	
Technology:	Lithium Nanophosphate
Plant Size:	20 MW, 8 MW (in operation now)
ISO:	NYISO
ISO Market Share:	N/A
Operational Date:	December 2010

AltairNano

AltairNano PJM Project



Project Details	
Technology:	Lithium Titanate
Plant Size:	250MWh (1MW)
ISO:	PJM
ISO Market Share:	0.1% of Regulation Market
Operational Date:	2008

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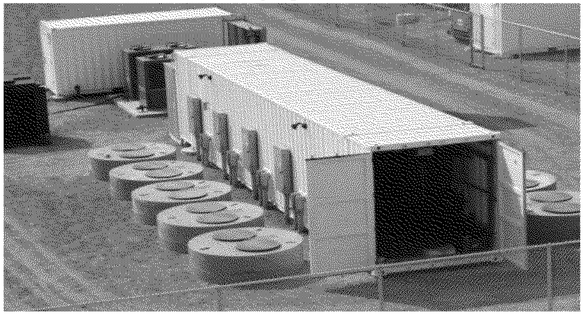
[23] Unofficial project name at this time

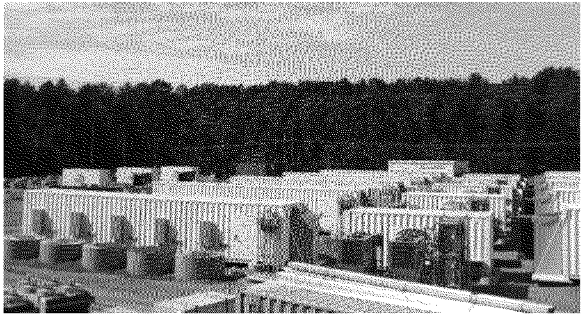
Beacon Power

3 MW, Tyngsboro, MA



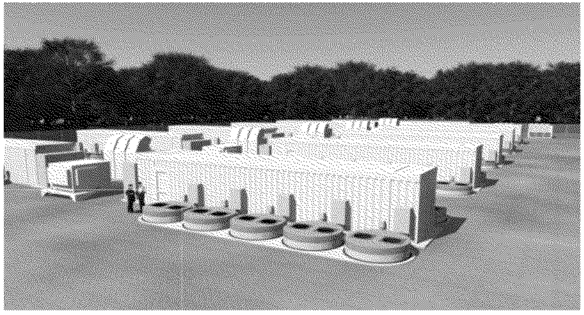
Project Details	
Technology:	Flywheels / Beacon Power
Plant Size:	750 kWh, 3 MW
ISO:	New England ISO
ISO Market Share:	2% Regulation Market
Operational Date:	November 2008

20 MW, Stephentown, MA



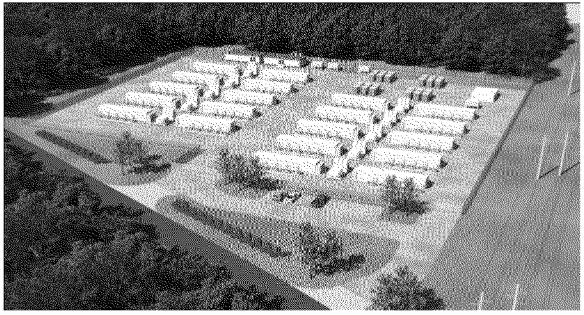
Project Details	
Technology:	Flywheels / Beacon Power
Plant Size:	5 MWh, 20 MW
ISO:	New York ISO
ISO Market Share:	10% of Regulation Market
Operational Date:	December 2010

20 MW, Hazle Township, PA



Project Details	
Technology:	Flywheels / Beacon Power
Plant Size:	5 MWh, 20 MW
ISO:	PJM Interconnection
ISO Market Share:	2% of Regulation Market
Operational Date:	2011/12

20 MW, Chicago Heights, IL



Project Details	
Technology:	Flywheels / Beacon Power
Plant Size:	5 MWh, 20 MW
ISO:	PJM Interconnection
ISO Market Share:	2% of Regulation Market
Operational Date:	2012

Xtreme Power

Xtreme Power KWP 1

Project Details	
Technology:	Solid state dry cell
Plant Size:	1 MWh (1.5 MW)
ISO:	MECO
ISO Market Share:	15% of MECO Regulation Market
Operational Date:	2010

Xtreme Power Kahuku

Project Details	
Technology:	Solid state dry cell
Plant Size:	10 MWh (15 MW)
ISO:	HECO
ISO Market Share:	10% of HECO Regulation Market
Operational Date:	2011

Xtreme Power La Ola

Project Details	
Technology:	Solid state dry cell
Plant Size:	0.5 MWh (1.1 MW)
ISO:	MECO
ISO Market Share:	50% of Regulation Requirement
Operational Date:	2011

Case Study: Modeling CCGT vs. Flywheel for Frequency Regulation

The following case study models a conventional baseload CCGT plant participating in the CAISO frequency regulation market and compares it side-by-side with a flywheel system also participating in the CAISO frequency regulation market. The ultimate goal of this modeling simulation is to compare the merchant-owned financial returns and greenhouse gas (GHG) impacts of the CCGT and flywheel projects.

The base case modeling results indicate that the flywheel achieves significantly higher financial returns and GHG savings. The flywheel has a 26% internal rate of return (IRR) and a lifetime carbon emissions of 69,975 tons whereas the CCGT has a 15% IRR and a lifetime carbon emissions of 986,595 tons. An overview of the assumptions and results are listed in Table 1 below:

Table 1: Case Study Assumptions and Results

Project Specifications	*Flywheel*	*CCGT Baseload*
Plant Ownership Model	Merchant	Merchant
Project Tenor (yr)	20	20
System Capacity Dedicated to Regulation (MW)	20	20
Plant Heat Rate (Btu/kWh)	N/A	7,050.0
Heat Rate Degradation	N/A	0.0
Capacity Degradation	0.00%	0.24%
Plant Parasitic Losses	2.00%	2.90%
Efficiency	87.00%	N/A
Efficiency Degradation	0.00%	N/A
CAPEX ($/MW)	1,900,000	600,000
OPEX		
Fuel Cost - Conventional ($/MMBtu)	N/A	4.31
Fuel Cost - Storage ($/MWh)	50.00	N/A
Fuel Cost Escalation Rate	1.53%	1.53%
Carbon Price ($/ton)	0.00	0.00
Carbon Price Escalation Rate	0.00%	0.00%

Revenue Assumptions	*Flywheel*	*CCGT Baseload*
Average Regulation Clearing Price ($/MW/h)	33.41	33.41
Regulation Clearing Price Escalation Rate	3.5%	3.5%
Comparative Performance Factor	2.5	1.0

Base Case Results	*Flywheel*	*CCGT Baseload*
IRR	25.7%	14.6%
Payback Period (yr)	3.9	8.1
Lifetime Carbon Emissions (tons)	69,975	986,595

The base case does not include a carbon price. One can reasonably assume that some form of a carbon pricing regime will be imposed upon the CAISO and other markets within the next few years. Given that the flywheel produces approximately 14x less carbon emissions than the CCGT and assuming a carbon price of $17/ton[24] (0% p.a. escalation rate), the financial results are substantial to the CCGT, whereas on the flywheel, the carbon price

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[24] Based on EU ETS future price data

should have little effect as seen in Figure 4 below:

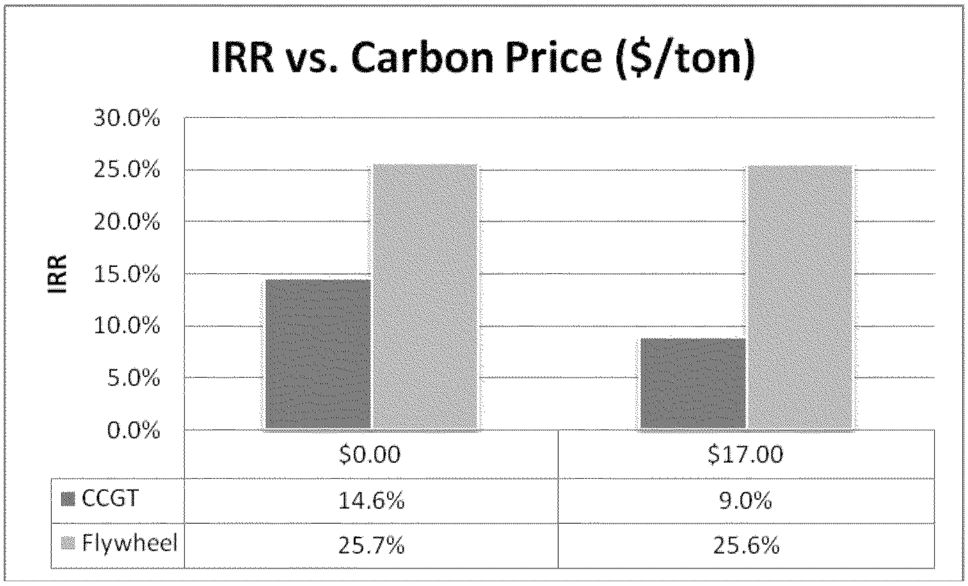

Figure4: IRR and Carbon Price Comparison

Performance is a fundamental driver of the modeling results. Assuming 2.5x performance for the flywheel is critical, as explained above in the "How Energy Storage is 2.5X More Effective" section. Below in Figure 5 depicts the sensitivity to the performance factor assumption:

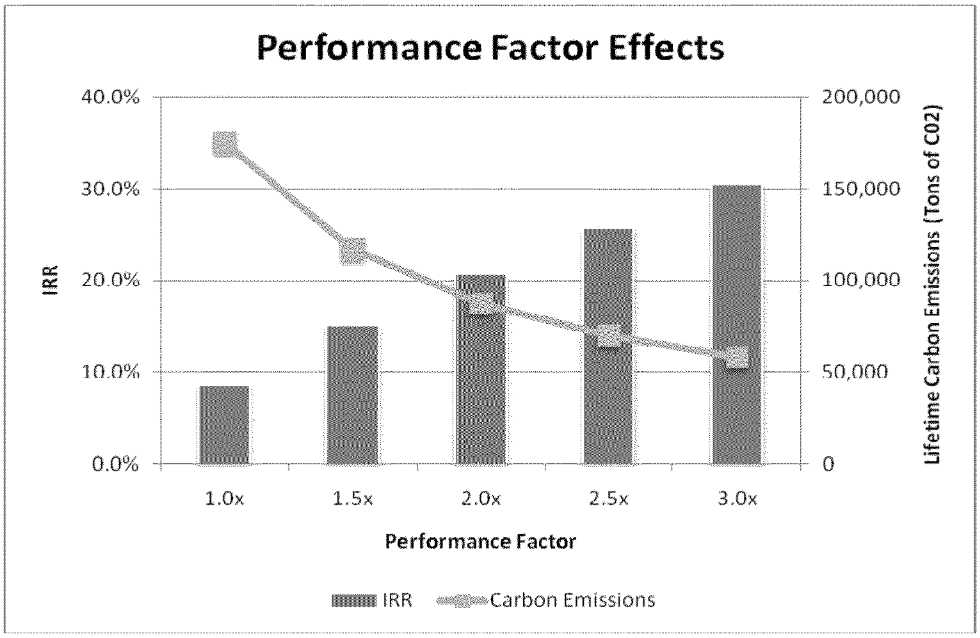

Figure5: Performance Factor Effects on IRR and Emissions

Assumptions for the CCGT plant come from the CEC's Levelized Cost of Generation (LCOG) Model[25] as well as KEMA's report: *Cost Comparison for a 20 MW Flywheel-based Frequency Regulation Power Plant.*[26,27] Assumptions for the flywheel system were also taken from the previously cited KEMA report, as well as operating data from Beacon Power, the owner-operator of the system.

The assumptions listed above are utilized to generate the financial and GHG results using StrateGen's comparative financial model. StrateGen's model, including detailed assumptions for the CCGT plant and flywheel system, is available on CESA's website:

http://www.storagealliance.org/work-whitepapers.html

California Barriers

Recent CAISO tariff changes have improved wholesale market access for energy storage. For example, July 2010 amendments reduced the minimum ancillary resource capacity from 1MW to 500 KW; reduced the continuous energy requirement from 2 hours to 30 minutes for spinning and non-spinning reserves and regulation up and down in real time (60 minutes day-ahead); and converted to measurement of continuous energy from the time a resources reaches its award capacity instead of the end of a 10 minute ramp requirement.[28] Further refinements in this direction would reduce or eliminate barriers to storage while simultaneously providing additional savings to California ratepayers. Additional barrier lowering measures have been identified, including dispatch-based compensation, a long-term capacity mechanism, a further reduction in the continuous energy requirement, and adjustments to the dispatch algorithm.

Prices paid for fast response regulation do not yet sufficiently reflect the quality of the service provided, despite the fact that energy storage-based resources follow ACG signals more accurately and can reduce the overall need for, and cost of, regulation services.[29] To attract investment in fast response storage technologies, the market must pay the true monetary value of the speed and accuracy that energy storage resources provide to the grid. For equivalent MW capacities, a faster, more accurate system will deliver greater grid reliability benefits than a slower, less responsive system Therefore, the compensation given to faster systems should reflect this additional value.

While recent tariff amendments have removed many legacy market assumptions, some rules still reflect the limitations of traditional generation. The current continuous energy requirement of 30 real time and 60 minutes day ahead remains greater than necessary for providing highly effective frequency regulation. More generally, the procedures, business practices and manuals of the CAISO do not fully accommodate energy storage as a valuable asset class. For example, the CAISO's Energy Management System (EMS) presently cannot

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25 CEC (2009). Comparative Cost of California Central Station Electricity Generation Technologies. (CEC_COG_Model_Version_2.02-4-5-10)

26 KEMA (2007). Cost Comparison for a 20 MW Flywheel-based Frequency Regulation Power Plant. Prepared by KEMA Inc. for Beacon Power Corporation.

27 According to the CEC, levelized cost of generation of a resource represents a constant cost per unit of generation computed to compare one unit's generation costs with other resources over similar periods. This is necessary because both the costs and generation capabilities differ dramatically from year to year between generation technologies, making spot comparisons using any year problematic.

28 132 FERC ¶ 61,211 (2010)

29 Kirby, 2007

accommodate a negative power dispatch, a capability that will be needed to integrate energy storage.[30] Rules and systems that recognize the unique strengths of both new energy-neutral systems and traditional energy generation resources will be able to fully utilize both in the most economical manner.

The current market structure treats regulation services like a spot market, i.e., there are no long-term purchase agreements for regulation services. Consequently, it is impossible to obtain project financing for energy storage regulation assets because the capital markets will not provide debt financing without some level of revenue certainty. In contrast, traditional generators are financed on the basis of long-term power purchase agreements (PPAs). With PPA-backed financing in place based on its primary wholesale energy function, a generator has the option to provide part of its operating range in the form of regulation services (a secondary function). A long-term resource adequacy-type payment for regulation-only energy storage systems would help overcome the project financing barrier similar to conventional generators.

Suggested California Policy Changes

To achieve greater deployment of energy storage for regulation and reduce costs to ratepayers, the CAISO should:

- Structure payments for ancillary services that reflect the actual regulation impact on the grid versus nameplate power rating of the resource. Appropriate price signals must be built into the Regulation markets using "pay-for-performance" compensation that values the speed and accuracy with which a resource responds to a regulation control signal. The ISO-NE currently does this by incorporating a regulation performance factor in its payments to regulation resources called "mileage," which quantifies the amount and speed of energy transferred between the resource and the grid. The more energy transferred, the more useful regulation work is performed, and the higher the payment should be to the resource. Thus, we recommend the CAISO adopt a Regulation compensation mechanism that has two components: (1) a performance payment ("mileage") based on the speed and amount of energy transferred by the resource in response to a control signal, and ultimately the actual regulation value to the grid compared to conventional resources, and (2) a capacity (or reserve) payment based on the amount of MW that a resource makes available to provide regulation.
- Implement Regulation Energy Management (REM), as described in the CAISO's *Regulation Energy Management Draft Final Proposal* dated January 13, 2011, which removes the barriers to storage providing regulation by using the 5-minute real-time energy market to manage the state of charge of resource. REM will enable resources with 15-minute storage capability to continuously provide Regulation service for a full hour – and for hours in succession, almost without limit.
- The CAISO should work with the CPUC to ensure that those needs are reflected in Load-Serving Entity (LSE) RA obligations. This is necessary for two reasons. First, like capacity and energy to meet current resource adequacy requirements, the ability of new technologies or existing technologies/facilities to provide the additional needed services will be greatly enhanced by (and may require) revenue certainty from long-term contracts. Second, , it makes sense to plan in advance for expected Regulation needs through reflection of those new needs in resource adequacy requirements.
- Employ a regulation dispatch algorithm that selects fast resources before slow resources in order to minimize the total amount of regulation capacity required in the balancing area. This in turn will reduce the cost of regulation to ratepayers. The NYISO's regulation tariff selects "fast first" and this feature

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[30] Negative power dispatch provides both injection and withdrawal of energy.

should be adopted as best practice for energy storage-enabling tariffs.

- Adopt conforming changes to tariffs and business practice manuals to modify language that may preclude non-generation resources from providing regulation.

At the same time, the California Public Utilities Commission (CPUC) should:

- Continue collaboration with CAISO stakeholder processes, and closely interrelated CPUC retail rulemaking proceedings, including demand response, long-term procurement and resource adequacy.
- Include interaction between wholesale and retail aspects of ancillary services and adoption of enabling rules and policies as part of the scope of the CPUC's recently opened Energy Storage Rulemaking.

Glossary

Unless otherwise noted, the following definitions are taken from the CAISO *Business Practice Manual for Definitions and Acronyms.*

Ancillary Services: Regulation, Spinning Reserve, Non-Spinning Reserve, Voltage Support and Black Start together with such other interconnected operation services as the CAISO may develop in cooperation with market participants to support the transmission of energy from generation resources to loads while maintaining reliable operation of the CAISO controlled grid in accordance with WECC standards and good utility practice.

Area Control Error (ACE): The sum of the instantaneous difference between the actual net interchange and the scheduled net interchange between the CAISO balancing authority area and all interconnected balancing authority areas, taking into account the effects of the CAISO balancing authority area's frequency bias, correction of meter error, and time error correction obligations.

Automatic Generation Control (AGC): Generation equipment that automatically responds to signals from the ISO's EMS control in real time to control the power output of electric generators within a prescribed area in response to a change in system frequency, tie-line loading, or the relation of these to each other, so as to maintain the target system frequency and/or the established interchange with other areas within the predetermined limits.

Black Start: The procedure by which a generating unit self-starts without an external source of electricity thereby restoring a source of power to the CAISO balancing authority area following system or local area blackouts.

California Independent System Operator (CAISO): See "Independent System Operator."

Combined Cycle Combustion Turbine (CCGT)[31]: An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. This process increases the efficiency of the electric generating unit.

Federal Energy Regulatory Commission (FERC)[32]: The Federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification. FERC is an independent regulatory agency within the Department of Energy and is the successor to the Federal Power Commission.

Independent System Operator (ISO)[33]: An independent, federally regulated entity established to coordinate regional transmission in a non-discriminatory manner and ensure the safety and reliability of the electric system.

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[31] U.S. Energy Information Administration Energy (EIA) Glossary. Available online at http://www.eia.gov/glossary/index.cfm

[32] EIA Glossary

[33] EIA Glossary

New England Independent System Operator (ISO-NE): See "Independent System Operator."

New York Independent System Operator (NYISO): See "Independent System Operator."

Non-Spinning Reserve: The portion of generating capacity that is capable of being synchronized and ramping to a specified load in ten minutes (or load that is capable of being interrupted in ten minutes) and that is capable of running (or being interrupted).

North American Electric Reliability Corporation (NERC)[34]**:** A nonprofit corporation formed in 2006 as the successor to the North American Electric Reliability Council established to develop and maintain mandatory reliability standards for the bulk electric system, with the fundamental goal of maintaining and improving the reliability of that system. NERC consists of regional reliability entities covering the interconnected power regions of the contiguous United States, Canada, and Mexico.

Regulation Down: Regulation reserve provided by a resource that can decrease its actual operating level in response to a direct electronic (AGC) signal from the CAISO to maintain standard frequency in accordance with established reliability criteria.

Regulation Up: Regulation provided by a resource that can increase its actual operating level in response to a direct electronic (AGC) signal from the CAISO to maintain standard frequency in accordance with established reliability criteria.

Spinning Reserve: The portion of unloaded synchronized generating capacity that is immediately responsive to system frequency and that is capable of being loaded in ten minutes, and that is capable of running for at least two hours.

Voltage Support: Services provided by generating units or other equipment such as shunt capacitors, static VAR compensators, or synchronous condensers that are required to maintain established grid voltage criteria. This service is required under normal or system emergency conditions.

Western Electricity Coordinating Council (WECC)[35]: The WECC is responsible for coordinating and promoting bulk electric system reliability in the Western Interconnection, including the provinces of Alberta and British Columbia, the northern portion of Baja California, Mexico, and all or portions of the 14 Western states between.

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[34] EIA Glossary

[35] Western Electricity Coordinating Council Website. "About Us." Available online at http://www.wecc.biz

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of ***Comments of the California Energy Storage Alliance to Order Instituting Rulemaking Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems*** on all parties of record in proceeding ***R.10-12-007*** by serving an electronic copy on their email addresses of record and by mailing a properly addressed copy by first-class mail with postage prepaid to each party for whom an email address is not available.

Executed on January 24, 2011, at Woodland Hills, California.

Michelle Dangott

Michelle Dangott

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