Appendix C 2

CPUC Energy Storage Use Case Analysis

[Variable Energy Resource Sited Storage]

[Storage with Wind Farm]

Version 0.1

Contents

1. Overview Section

As California moves towards full implementation of the 33 Percent Renewable Energy Portfolio Standard (RPS) by 2020, there is increasing concern about how high penetration rates of inherently variable resources, particularly from wind and solar, may adversely impact system stability. Beyond the fact that utility-scale development of these resources is generally in places far distant from load centers, and often in remote, sometimes environmentally sensitive locations, the operational characteristics of variable renewable energy complicates integration.

An obstacle to achieving higher levels of penetration of utility-scale renewable energy, especially wind and solar, is the variable nature of generation output from these resources. The times of the day when these resources are most productive do not align with the demand curves for utilities, and sudden shifts in weather patterns can cause intermittent output and potentially impacting grid stability. These weather-related variations may be diurnal (i.e., wind blows strongest at night when demand is low), of shorter duration (wind stops and starts abruptly), or even on an instantaneous basis (passing clouds cause solar power intermittency).

2. Use Case Description

This Use Case describes energy storage associated with a hypothetical 100 MW wind farm that connects to the grid to deliver energy under a long-term power contract, although a similar situation may apply to any large-scale renewable resource.

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 (i.e., generation output, availability, meteorological data, and circuit-breaker status).

2.1 Objectives

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; and 3) providing voltage support. 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, 2) the owner/operator of the wind farm, or 3) a third party that provides backup and reliability under a separate arrangement.

Name	*Role description*
Wind Farm Owner/Developer	
Storage Provider	
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
Other		

Probably some text here…..

2.4 Location

Under most scenarios, the energy storage device is located at the site of the renewable resource, to afford better integration with its operational status. However, given advanced communications technologies, a dedicated storage device is not necessary co-located with the generation, but may reside at a distant location, at a transmission substation, or in the case of a smaller facility, at a distribution substation.

2.5 Operational Requirements

The expected delivery of generation from this 100 MW wind farm is scheduled in advance under a non-binding day-ahead schedule. However, every hour, a new schedule is set, which governs the expectations for the following 24-hour period. At 2 hours prior to the actual operating hour, a binding hourly schedule takes effect.

In one scenario, the 100 MW resource initially generates in conformance with the forward schedule, but because of cloud cover, output begins trending downward and quickly falls below full capacity, triggering a shortfall between scheduled output and actual output.

The grid operator may respond by using Automatic Grid Control to remotely control output from other facilities that are able to provide balancing energy (aka regulating power) to maintain grid frequency stability at 60 hertz.

However, if the balancing issue persists, the ISO will run out of regulating power, as only a limited number of units can provide it.

The ISO may also dispatch energy from its 5-minute market (aka, Balancing Energy Ex-Post Pricing, or BEEP-stack) which represents a real-time market for ancillary services. Storage facilities may be participating in this real-time market, and can supply incremental energy in the same manner as traditional generators.

Alternatively, the storage could be directly tied to the wind farm, and act as a mediating resource without requiring ISO market intervention.

2.6 Applicable Storage Technologies

The potential storage device that appears most applicable to this Use Case is some form of battery, sized to support a portion of the effective capacity of the wind farm – roughly 35 MW. These could be a number of units stacked in a single location, or dispersed but aggregated to act as a single resource.

Commercially viable batteries of this scale include Sodium Sulfur (NAS) and Lithium Ion (Li-Ion). Potentially a compressed air storage (CAES) facility could also provide the right combination of response rate and rated power to accommodate expected wind fluctuations.

In the case of providing longer-term storage solution for a larger set of wind farms on a system wide basis – for example, to store excess wind power generated at night for daytime discharge – it is possible to employ a very large capacity hydro pumped storage facility that is located distantly, but controlled by a central operator (either the utility or ISO).

Storage Type	*Storage capacity*	*Discharge Characteristics*
Batteries (NaS, Li-Ion)	35 MW/100 MWh	Fast response, medium duration
Compressed Air	100 MW+	
Pumped Storage	100 MW+	

2.7 Non-Storage Options for Addressing this Objective

Among options available to address renewable energy variability are:

- A Balancing Energy Market to obtain 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;
- 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 regulation	P	
2. Spin		
3. Ramp	P	
4. Black start		
5. Real-time energy balancing	P	
6. Energy arbitrage		
7. Resource Adequacy		
8. VER[1] / wind ramp/volt support,	P	
9. VER/ PV shifting, Voltage sag, rapid demand support	P	
10. Supply firming	P	
11. Peak shaving: load shift		
12. Transmission peak capacity support (deferral)		
13. Transmission operation (short duration performance, inertia, system reliability)		
14. Transmission congestion relief		
15. Distribution peak capacity support (deferral)		
16. Distribution operation (volt/VAR support)		
17. Outage mitigation: microgrid		
18. TOU energy mgt		
19. Power quality		
20. Back-up power		

[1] VER = Variable Energy Resource

3.2 Other Beneficial Attributes

Benefit Stream	*Y/N*	*Assumptions*
Flexibility (Dynamic Operations)	Y	
Reduced Fossil Fuel Use	Y	
Reduced Emissions	Y	
Increased T&D Utilization		
Reduced T&D Investment Risk		
Power Factor Correction		
Optionality		
Other		
Other		

3.2 Analysis of Costs

Cost Type	*Description*
Installation	
O&M	

3.3 Cost-effectiveness Considerations

Narrative

4. Barriers Analysis and Policy Options

4.1 Barrier Resolution

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

4.1 Other Considerations

5. Real World Example

5.1 Project Description

AES Laurel Mountain Project

This 32 MW integrated battery storage project supports a 98 MW wind farm owned by AES Wind Generation selling regulation services to the PJM Interconnection, by delivering instantaneous response to grid operator requests for power, and balancing generation and demand. The storage also allows the wind facility to control the ramp rate of its generation smoothing out fluctuations in minute to minute output.

The AES Laurel Mountain project consists of 61 GE 1.6 MW wind turbine generators capable of a combined power generation of 97.6 MW combined with 32 MW of A123 Systems energy storage devices (lithium Ion).

Configuration is 16 x 2 MW, with 15 minute discharge capacity.

Location	Laurel Mountain, West Virginia
Operational Status	Online October 2011
Ownership	AES Storage/AES Energy
Primary Benefit Streams	Regulation Services to PJM
Secondary Benefits	Wind Firming
Available Cost Information	Total project cost $239 million; storage component breakout not available

5.2 Outstanding Issues

Description	*Source*
At this point, selling regulations services to grid operator has been more of a benefit that wind firming	AES executive

5.3 Contact/Reference Materials

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AES Wind Generation and AES Energy Storage Announce Commercial Operation of Laurel Mountain Wind Facility Combining Energy Storage and Wind Generation; AES news release, Oct. 27, 2011.

6. Conclusion and Recommendations

Is ES commercially ready to meet this use?

Is ES operationally viable for this use?

What are the non-conventional benefits of storage in this use?
Can these benefits be monetized through existing mechanisms?
If not, how should they be valued?

Is ES cost-effective for this use?

What are the most important barriers preventing or slowing deployment of ES in this use?

What policy options should be pursued to address the identified barriers?

Should procurement target or other policies to encourage ES deployment be considered for this use?