CPUC Energy Storage Use Case Analysis

[Application]

[Distributed Energy Storage – Substation Level]

Version 1.2

Contents

1. Overview Section

Although energy storage systems can be built at the transmission, multi-megawatt scale to provide bulk energy storage applications, smaller, distributed energy storage systems (DESS) placed on the distribution circuits offer several specific advantages that cannot be met with large bulk storage products or more traditional industry solutions.

DESS units can be sited locally with minimum permitting as installations do not require a gas line, water for cooling, or additional transmission lines and significant operation noise. This ability to be sited at a substation or closer to load can help improve service reliability by discharging to serve the load of a specific distribution substation for multiple hours. This provides utilities a defined window of time to fix an outage at a substation without their customers seeing any power interruption or loss of service.

Also, energy storage systems may be able to help resolve issues rising from deeper penetration of customer-owned solar photovoltaic (PV) systems, which is being advanced via several state policies including the California Solar Initiative, Utility-Side (Wholesale) Distributed Generation Programs, and Governor Brown's Clean Energy Plan. Energy storage located on distribution feeders exhibiting high penetration of such distributed resources can provide substantial reliability benefits and cost savings compared to upgrading distribution circuits and equipment, thus helping achieve the levels of PV and DG penetration targeted in the existing state policy.

Additionally, storage at the Distribution level can help solve local voltage and reactive power problems that can occur at the substation and thus improve the stability and efficiency of the distribution equipment for the utility. Distinct advantages are derived from the ability to be sited and sized for location specific challenges. Within the general category of Distribution-level energy storage, there are three applications of specific interest: Distributed Storage Peaker, Energy Storage for Distribution Grid Operations, and Community Energy Storage.

2. Use Case Description

This Use Case describes an energy storage system associated with a battery rated at least 500kW/1,500kWh that connects to the distribution grid at a substation level and is owned and operated by a utility. This Use Case will describe how using energy storage for grid operations and control for mitigating intermittency associated with distributed energy resources; primarily PV systems connected to the distribution system, and protect the transmission system from distribution system disturbances.

2.1 Objectives

The objective of this Use Case is to integrate the targeted levels of penetration for PV systems at the distribution level and achieve the following primary functions:

- Power leveling/regulation on distribution grid with connected variable, renewable energy sources, primarily PV systems
- Power quality

The energy storage system included in this Use Case may have the potential to provide additional secondary functions to the extent that they do not interfere with the primary functions. In order to achieve these secondary functions additional systems, cost and benefits and potential changes to existing regulatory framework might be required. Below are some of the secondary functions identified:

- Peak load shifting/shaving:
    - As needed

  - Daily
- Distribution capacity deferral
- Grid operation to islanded system operation
  - Smoothing electrical transition
- Energy regulation and ancillary services related to CAISO operations, if units are operated as a fleet
- Energy storage for off-peak/on peak energy arbitrage
- Develop accurate cost forecast as a function of PV development for power quality services

As a result, the primary benefit of the energy storage system included in this Use Case is expected to be the mitigation of intermittency associated with PV systems connected at the distribution level. The energy storage system would provide smoothing characteristics to the highly-variable power output of the PV system, while providing voltage support.

2.2 Actors

In this Use Case, the energy storage device is owned and operated by a utility. The Use Case assumes full cost recovery of the investment by the utility under existing ratemaking methodologies.

Name	Role description
Storage Equipment Provider	The provider of component(s) necessary to build an operational facility. This could be a single or multiple parties acting together.
Storage Owner/ Operator	Owns, operates, and maintains resource.
Utility	A load serving entity that procures capacity and energy to serve its retail customers. The utility pays the CAISO for ancillary services based on a percentage of its load. The utility may meet its capacity and energy requirements through long-term contracts.

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

Agency	Description	Applies to
CPUC	General Order 128 – Rules for Construction of Underground Electric Supply and Communication Systems	Utility
CPUC	General Order 95 – Rules for Overhead Electric Line Construction	Utility
CPUC	Rule 21 – Interconnection Standards for Non-Utility Owned Generation	Utility
CPUC	Rule 2 – Description of Service	Utility
IEEE	IEEE1547 – Standard for Interconnecting Distributed Resources with Electric Power Systems	Utility
California Statues	AB2514 – Energy Storage Systems	Utility
CPUC	R.10-12-007 – OIR Pursuant to Assembly Bill 2514 to Consider the Adoption of Procurement Targets for Viable and Cost-Effective Energy Storage Systems	Utility

2.4 Location

The energy storage system in this Use Case is located at a distribution substation. The energy storage device is connected to a distribution feeder. An alternative could be an aggregation of energy storage systems into multiple locations.

2.5 Operational Requirements

The operational requirements for this Use Case are the following:

- Measurement device detects fluctuations in power output of the PV array and sends a signal to the battery controller.
- Battery controller charges or discharges the energy storage device in response to the signal.
- The energy storage device can supply and absorb both Watts and VARs, as required.
- Charge/discharge cycle is determined by the desired daily operational needs to mitigate the power output fluctuations of the PV array.
- Energy storage device can operate autonomously or via DERMS control system.
- Discharge capacity will be based on the durations of the power output fluctuations of the PV array.
- Communication would be required between the energy storage device, various monitoring devices located primarily at or near the substation and control systems at either the substation or back-office such as the Distribution Management System (DMS).
- Devices at the substation would physically communicate to the data or control center through the Wide Area Network using different wired and wireless networks (e.g. fiber optic, microwave, WiMAX, or cellular).
- Network layer communication between the substation devices and the data or control center would use TCP/IP standards or serial-based connections.
- Application layer protocols will depend on specific implementations by manufacturers.
    - Example protocols currently in use are MODBUS, DNP, HTTP/S, and Windows Remote Desktop Protocol (RDP).

The following are some of the elements participating in the operations of this Use Case:

Name	*Role description*
Energy Storage Device	These are devices that can quickly store or discharge energy for grid operation and control such as batteries, flywheels, and aggregated plug-in electric vehicles.
PV System	PV systems installed operated parallel to the distribution grid
Distribution Management System	Application(s) use by the storage provider to monitor, control, and optimize the performance of the distribution system.
Distributed Energy Resource Management System (DERMS)	DERMS is an advance software application that optimizes resource utilization in response to system operational events, environmental and equipment conditions, and market conditions. DERMS includes several different, but integrated, software components that incorporate advanced optimization algorithms to dispatch demand and supply side resources.
Measurement Device	These are devices that can measure voltage or other power quality indicators that would provide information about the condition of the distribution system

2.6 Applicable Storage Technologies

Storage Type	*Storage capacity*	*Discharge Characteristics*
Batteries	Driven by operations with a typical minimum size of 500 kW/1,500kWh (0.5MVA/1.5MVAh). Larger systems will depend on operational needs and sitting capabilities.	Driven by operations. Response time varies based on system requirements. For example, these devices given the power electronics interface to the grid can start to operate when given a signal within cycles.
Flywheels	Driven by operations with a typical minimum size of 500kW/125kWh (0.5MVA/0.125MVAh). Larger systems will depend on operational needs and sitting capabilities.	Driven by operation. Response time varies based on system requirements.

2.7 Non-Storage Alternatives for Addressing this Objective

Name	*Role description*
Dynamic VAr Device	Power electronics based VAr device
Increase circuit capacity	Conventional alternative
Voltage Regulators	Autotransformers with power electronics interface. Not commercially available today.
Load Tap Changers	Power electronics based switch. Conceptual today.
Line Capacitors	Capacitors with power electronics interface. Conceptual today.
Smart Inverters	PV inverters with two quadrant operation capabilities

3. Cost/Benefit Analysis

3.1 Direct Benefits

The primary benefits identified below are those related to the objectives of this Use Case. Secondary benefits identified in this Use Case correspond to additional functionality that may be achieved by the energy storage devices but outside the scope of this Use Case. In order to achieve these secondary benefits additional systems, costs and potential changes to existing regulatory framework might be required.

End Use	***Primary/ Secondar***	***Benefits/Comments***

	y	
1. Frequency regulation	Secondary	Aggregation of energy storage devices to provide regulation services to CAISO
2. Spin		
3. Ramp	Secondary	Aggregation of energy storage devices to provide fast ramping services to CAISO
4. Black start	Secondary	Aggregation of energy storage devices to provide fast ramping services to CAISO
5. Real-time energy balancing		
6. Energy arbitrage	Secondary	Charge energy storage device during off-peak hours and discharge the energy storage device during on peak hours
7. Resource Adequacy		
8. VER[1] / wind ramp/volt support,	Secondary	Providing voltage support to mitigate fluctuations of power output
9. VER/ PV shifting, Voltage sag, rapid demand support	Secondary	Mitigate intermittency associated power output of PV systems
10. Supply firming	Secondary	Firming the power output from intermittent renewable energy generation such as wind and solar
11. Peak shaving: load shift	Secondary	Reduce feeder peak load by charging the energy storage device during off-peak hours and discharging the energy storage device during peak hours
12. Transmission peak capacity support (deferral)		
13. Transmission operation (short duration performance, inertia, system reliability)	Secondary	Provide support by aggregating energy storage devices
14. Transmission congestion relief		
15. Distribution peak capacity support (deferral)	Secondary	Economic value associated with deferring circuit upgrades by discharging battery during peak load hours, thereby keeping circuit load within the feeder rating
16. Distribution operation (volt/VAR support)	Primary	Supply or absorb VARs as needed to support voltage regulation
17. Outage mitigation: microgrid	Secondary	Smooth transition to islanded operation and provide energy supply for the microgrid
18. TOU energy mgt		
19. Power quality	Primary	Maintain voltage, flicker and harmonic content within distribution limits
20. Back-up power	Secondary	Provide black start or energy supply

3.2 Other Beneficial Attributes

[1] VER = Variable Energy Resource

Benefit Stream	Y/N	Assumptions
Risk Reduction	Y	Mitigation of the risk associated with the integration of high penetration levels of PV by customers which could create failures to customer's equipment. From a utility perspective, operational flexibility and maintaining voltage within acceptable operational limits.

3.3 Costs

Cost Type	Description
Installation	• Equipment (battery, PCS) • Associated equipment (switches, transformers, cable) • Communications and metering equipment • Infrastructure (pads, trench/conduit) • Electrical construction • Measuring equipment
O&M	• Maintenan(inspection, repairs) • Training • Spare parts

3.4 Cost-effectiveness Considerations

TBD

4. Barriers Analysis & Policy Options

4.1 Barrier Resolution

Barriers Identified	Y/N	Policy Options / Comments
System Need	N	
Cohesive Regulatory Framework	N	
Evolving Markets	N	
Resource Adequacy Value	N	
Cost Effectiveness Analysis	Y	Phase 2 of R.10-12-007 will establish the cost-

		effectiveness methodology for this Use Case. Currently working with the Commission and interested stakeholders. Some of the benefits identified are difficult to monetize with no clear opportunities to establish a framework for realizing the benefits. Markets required for some benefits are still not developed.
Cost Recovery Policies	Y	Rate base cost recovery and cost allocation mechanisms for energy storage devices still undefined. Decisions for approval of energy storage cost recovery are pending in front of the Commission with a different timeline for each IOU. Secondly, absent clear regulatory policy toward cost recovery, IOUs are hesitant to make investments in energy storage at the needed levels.
Cost Transparency & Price Signals	Y	Absent appropriate rate design no driver for new investments in distributed energy storage devices. For example, net energy metering customers utilize the grid for energy storage, power quality and reliability services receiving these services free of charge. Therefore, customers lack a clear price signal that allows them to make a business decision regarding their own energy storage needs.
Commercial Operating Experience	Y	Limited operating experience by utilities. Few devices have been deployed in pilot application outside labs. History of performance of deployed devices in the field is very limited. In addition, other applications has been in operation for many decades and unknown at this point how much of the existing experience can be transferable to operate these new devices.
Interconnection Processes	N	
Commercial Readiness	Y	Devices still in the early product cycle. Not ready for plug-and-play (Plug-and play being defined as the availability to take any manufacturer device and insert it into the distribution system with minimal to no system modifications). Financial stability of some of the suppliers is at risk. Commercial focus on delivering devices without a complete control solution. Predefined autonomous algorithms not readily available.

4.2 Other Considerations.

None

5. Real World Example

5.1 Project Description

5.1.1 San Diego Gas & Electric (SDG&E)

SDG&E is installing advanced energy storage devices that will mitigate the impact of intermittent renewables, as well as provide SDG&E with experience developing, implementing and operating new energy storage. The scope of the project includes developing utility scale size energy storage devices at substations systems (typically 500kw/1,500 kWhr), and distributed energy storage on distribution feeders. The scope of this Use Case only covers energy storage devices at substations.

The current projects that are in progress will contain the following:

- Installations targeting circuits that have high penetration levels of PV systems and high loading levels
- Energy storage device sites will be based on the available space near the circuits and where the device would assist the circuit the most.
- Installation will occur once the device locations are confirmed and any necessary permits are granted.

The benefits identified for the current project are the following:

Primary Benefits:

- VER/PV Smoothing
- Power Quality

Secondary benefits:

- Distribution Peak Capacity Support (Deferral)
- Peak Shaving
- VAR Support
- Frequency Regulation
- Arbitrage
- Cost Forecasting

Based on the recent SDG&E 2012 Smart Grid Annual Report, one substation battery has been installed as of June 30, 2012 in the service territory with another installation in process. Deliveries of additional batteries are scheduled for the second half of 2012, with additional orders for 2013.

5.2 Outstanding Issues

5.2.1 San Diego Gas & Electric (SDG&E)

Description	Source
Pending Approval of SDG&E 2012 GRC Application	CPUC
Status: One unit deployed and in operation at the Borrego Springs microgrid project (500kW/1,500kWh). Another unit (500kW/1,500kWh) installed at another substation but not yet in operation.	SDG&E
Any benefits beyond primary function might require additional cost, systems and proper regulatory framework	Various

5.3 Contact/Reference Materials

5.3.1 San Diego Gas & Electric (SDG&E)

Thomas O. Bialek, PhD., P.E.
Chief Engineer
tbialek@semprautilities.com

6. Conclusion and Recommendations

Is ES commercially ready to meet this use? Commercially available but not plug-and-play ready

Is ES operationally viable for this use? Yes

What are the non-conventional benefits of storage in this use? Complying with targeted penetration levels of PV systems established in state policy

Can these benefits be monetized through existing mechanisms? If not, how should they be valued? There are some evaluation tools available, but require further analysis

Is ES cost-effective for this use?. Existing deployments of energy storage devices under this Use Case are being analyzed on a the least cost, best fit approach as these devices are supporting the levels of penetration of PV systems established by state policy.

What are the most important barriers preventing or slowing deployment of ES in this use case? Plug-and-Play systems designed to meet a solution, regulatory certainty and lack of price signals.

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

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