U.S. Department of Energy

Office of Electricity Delivery and Energy Reliability

Data Analysis for the ARRA SGDP Energy Storage Projects

Update Conference – DOE 2010 Energy Storage Systems Program (ESS)

November 3, 2010

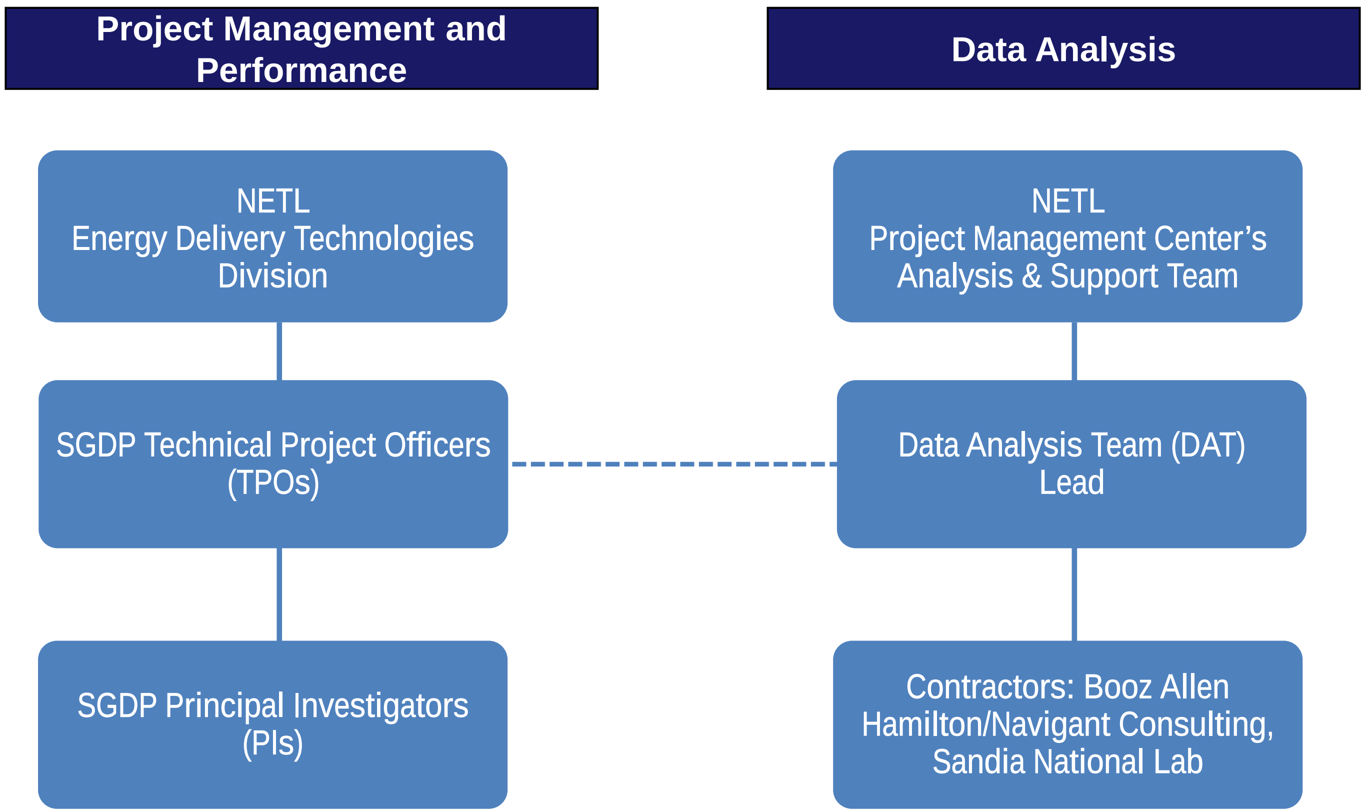
Presenter: Jacquelyn Bean

Organization: DOE-National Energy Technology Laboratory (NETL)

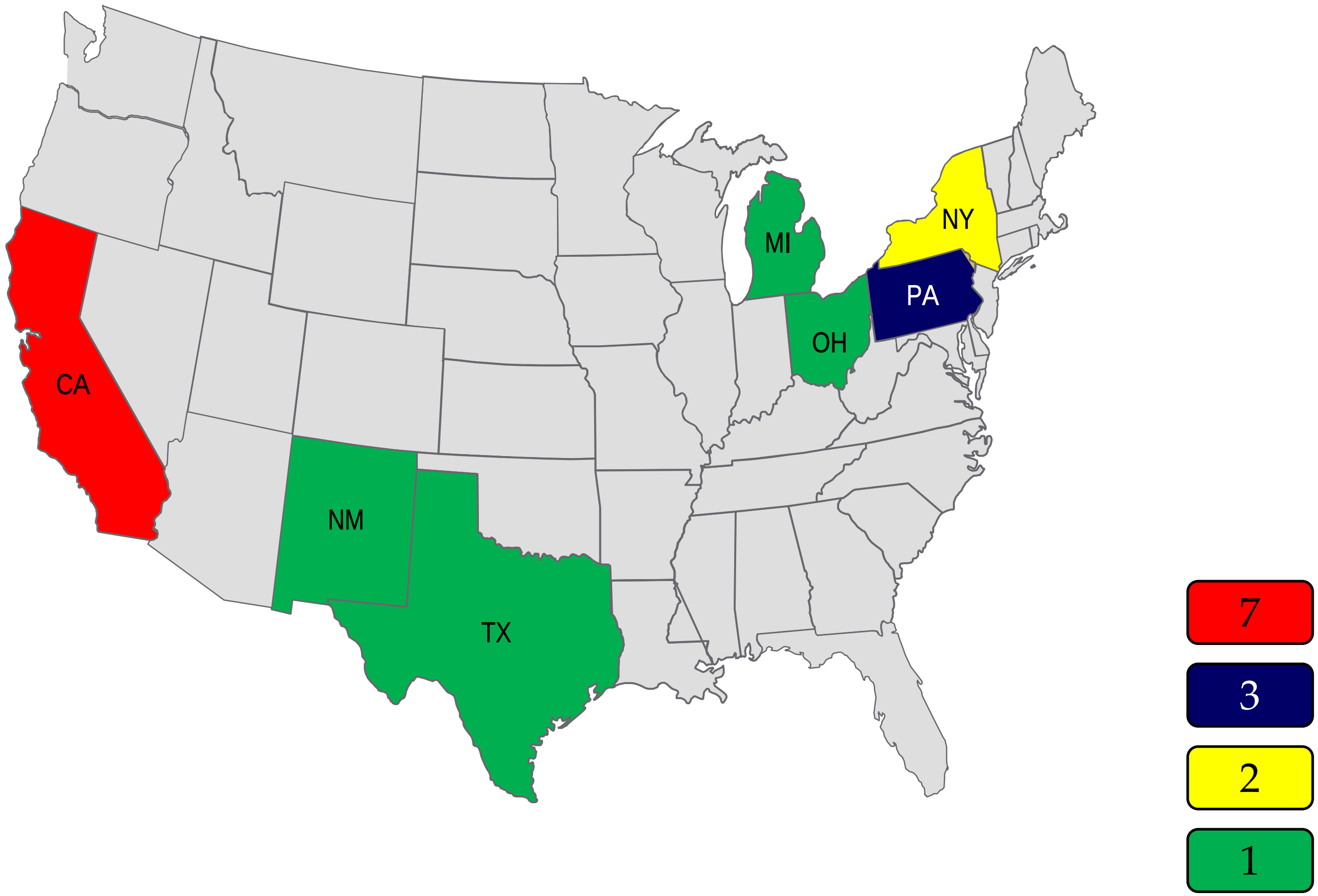
Funded in part by the Energy Storage Systems Program of the U.S. Department Of Energy through *National Energy Technology Laboratory*

Table of Contents

NETL's role in SGDP metrics and benefits reporting



The 16 SGDP energy storage awards will support projects in at least seven states.



* Subject to change

Overview of SGDP energy storage projects

Recipient	Demo States	Storage	Technology Providers	Other Project Partners	Total Value ($)	Project Period	Site
Primus Power Corp.	CA	25 MW/ 75 MWh	Primus Power Corp.	Applied Intellectual Capital Labs; Modesto Irrigation District	46,700,000	2/1/2010 – 1/31/2015	Substation
Southern California Edison	CA	8 MW	A123	CSU Pomona; Quanta Technology	54,856,495	2/8/2010 – 2/7/2015	Substation
Duke Energy Business Services, LLC	TX	24 MW	TBD	EPRI	43,612,464	2/1/2010 – 5/15/2013	Wind farm
Beacon Power Corp.	PA	20 MW	Beacon Power	PJM Interconnection; Midwest Generation	48,127,957	1/1/2010 – 9/1/2013	Industrial
City of Painesville	OH	1 MW/ 8 MWh	Ashlawn Energy	Painesville Municipal Power; American Municipal Power of OH; Concurrent Technologies Corp. – Johnstown	9,666,144	3/1/2010 – 2/28/2014	Coal plant
East Penn Manufacturing Co.	PA	3 MW; 1 MW (1-4 hrs.)	East Penn Manufacturing Co.	PJM Interconnection; Ecoult; PPL Energy Plus; Met-Ed	5,087,269	2/1/2010 – 1/31/2015	Manufacturing campus
Detroit Edison	MI	1.5 MW	A123	KEMA; EDD.; NextEnergy Michigan Research Catalyst; Center; National Grid; Chrysler	10,877,258	1/1/2010 – 12/31/2014	Feeder w/ 500 kW solar PV
Premium Power	CA, NY	2.5 MW	Premium Power	National Grid; Sacramento Municipal Utility District; Syracuse Univ.; SAIC	12,514,660	8/13/2010– 12/12/2013	Substation; University
Public Service Company of New Mexico	NM	2-4 MWh	East Penn Manufacturing Co.	EPRI; University of New Mexico; Northern New Mexico College; Sandia National Lab	6,113,433	2/1/2010 – 2/14/2014	Feeder w/ 500 kW solar PV
Pacific Gas & Electric Co.	CA	300 MW	TBD	EPRI	355,956,300	11/1/2010– 11/1/2018	Porous rock
New York State Gas & Electric Corp.	NY	150 MW	Dresser-Rand Co.	EPRI; Burns & McDonnell Engineering Co. – Inc.	125,006,103	1/1/2010 – 12/31/2014	Salt cavern

Overview of SGDP energy storage projects (cont.)

Recipient	Demo States	Storage	Technology Providers	Other Project Partners	Total Value ($)	Project Period	Site
Seeo, Inc	CA	<100 kW	Seeo, Inc.	Univ. of CA, Berkeley	12,392,121	7/30/2010 – 7/29/2014	Lab
Aquion Energy	PA	10-100 kWh	Aquion Energy	Carnegie Mellon University; AES; Duke Energy	10,359,827	8/1/2010 – 07/31/2013	Lab
SustainX, Inc.	TBD	1 MW/ 4 MWh	SustainX, Inc.	AES Energy Storage	10,792,045	6/15/2010 – 12/31/2013	TBD
Amber Kinetics, Inc.	CA	1 MWh	Amber Kinetics, Inc.	AFS Trinity	10,003,015	3/1/2010 – 12/31/2014	TBD
Ktech Corporation	CA	250 kW/ 1 MWh	EnerVault Corp.	JKB Energy; Montpelier Nut Co.	9,528,568	8/6/2010 – 8/5/2013	co-locate w/ dual-axis tracker 180 kW solar PV

* Values subject to change

DOE's Cost Benefit Analysis (CBA) methodology was designed to be flexible enough to accommodate variations across the Smart Grid Programs.

- 32 Smart Grid Demonstration Program (SGDP) projects
  - 16 Energy Storage Demonstrations
  - 16 Smart Grid Regional Demonstrations

- 9 Renewable and Distributed Systems Integration (RDSI) projects
  - Awarded in 2008 to integrate distributed technologies (e.g., PHEVs, wind turbines, solar PV, microgrids, DA systems) to demonstrate 15% peak load reduction on distribution feeders

- 100 Smart Grid Investment Grant Program (SGIG) projects
  - Equipment Manufacturing
  - Customer Systems
  - Advanced Metering Infrastructure
  - Electric Distribution Systems
  - Electric Transmission Systems
  - Integrated and/or Crosscutting Systems

The CBA methodology seeks to quantify the value provided by energy storage technologies.

Data from Impact Metrics, Assumptions, Estimates → **Calculations** → **Forecast & Sensitivity Analyses** →

What data should be tracked to capture benefits?
Annual and Hourly Generation Costs reduced

What equations transform data into monetary value?
Value = Baseline – Project

How can benefits be projected beyond the first 5 years?
X% per year

Illustrative

Build Metrics

Assets → **Storage Applications** → **Mechanisms** → **Benefits** → **Monetary Value**

What is the technology?
Energy Storage (Flow Batteries)

What does the technology do?
Electric Energy Time Shift

How does it do that?
Minimum 2-hour discharge duration

What "goodness" results?
Reduced electricity costs

What is the goodness worth?
$X per year

Table of Contents

DAT expects three key deliverables from Recipients: the MBRP, build metrics, and technology performance reports (TPRs).

Metrics and Benefits Reporting Plan (MBRP)

Draft due 3 months after definitization; final MBRP due one month after draft review

- Lays out the schedule for deliverables submission and equipment deployment
- Identifies and describes storage system performance
- Details applicable metrics and TPR content
- Describes baseline data and development methodology
- Sets expectations for marketplace innovation and collaboration

Build Metrics

Reporting Frequency: Quarterly (starting no later than 6 months after final MBRP)

- Monetary Investments (expenditures, installed equipment costs)
- Jobs created and retained
- Project and system level asset deployment with baseline across categories (AMI, Customer Systems, Distribution, Transmission, DER, Pricing Programs)

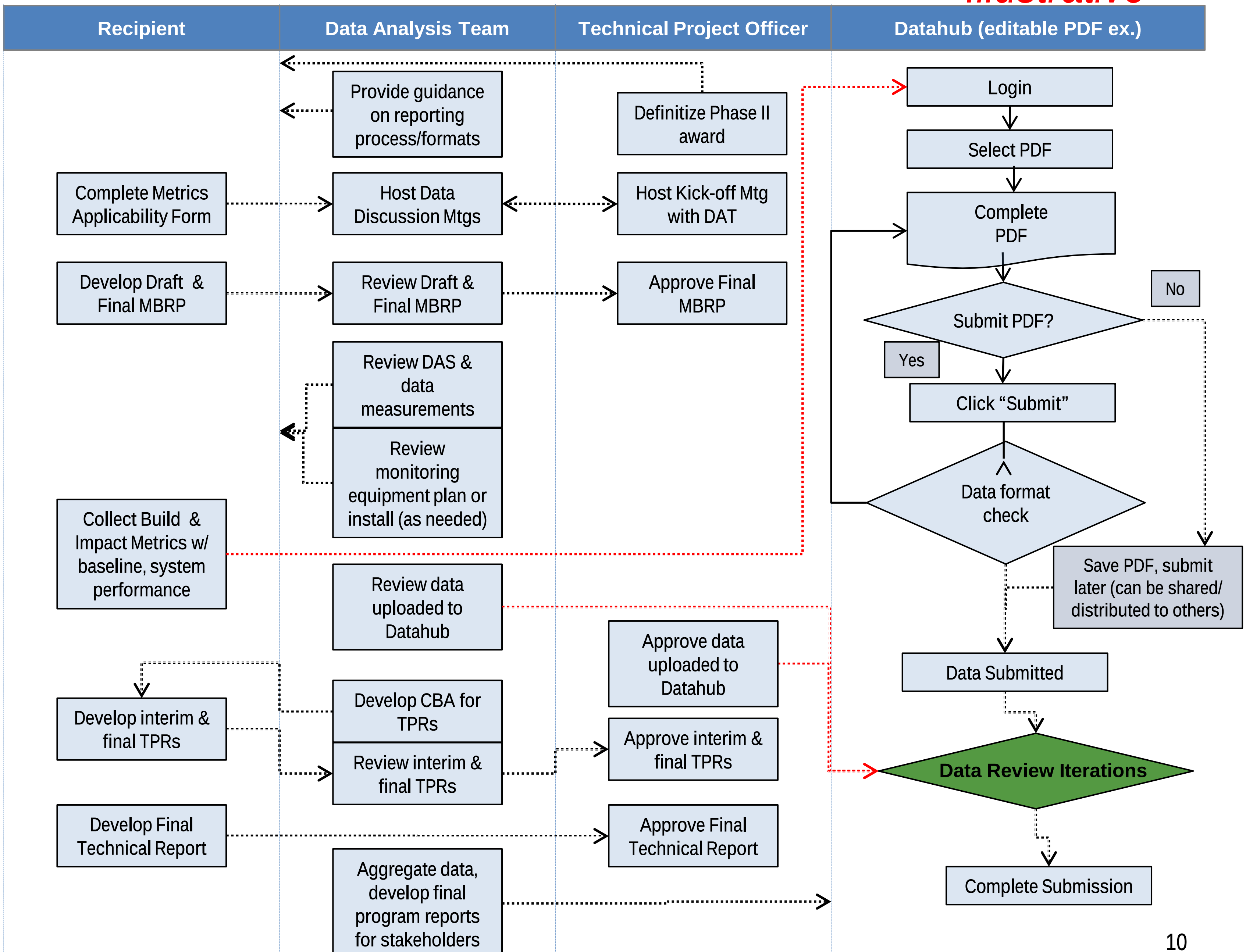
Technology Performance Reports (TPRs)

Reporting Frequency: Varies by Project; interim(s) and final

- Impact metrics findings in TPRs and data with baseline
- Storage system performance descriptions and findings
- Project-specific cost benefit analyses and lessons learned

Data flow

Illustrative



10 out of 16 energy storage projects are definitized*, and DAT has received draft MBRPs from 4 projects.

Recipient	Sect.	Project Title	Award Definitized	Draft MBRPs Received
Primus Power Corp.	2.1	Wind Firming EnergyFarm™	YES	YES
Southern California Edison	2.1	Tehachapi Wind Energy Storage Project	YES	
Duke Energy Business Services, LLC	2.1	Notrees Wind Storage		
Beacon Power Corp.	2.2	Beacon Power 20 MW Flywheel Frequency Regulation Plant		
City of Painesville	2.3	The Painesville Municipal Power Vanadium Redox Battery Demonstration Program		
East Penn Manufacturing	2.3	Grid-Scale Energy Storage Demonstration for Ancillary Services Using the UltraBattery™ Technology	YES	YES
Detroit Edison Co.	2.3	Detroit Edison's Advanced Implementation of A123s Community Energy Storage Systems for Grid Support		
Premium Power	2.3	Distributed Energy Storage System Demonstration	YES	
Public Service Co. of New Mexico	2.3	PV Plus Battery for Simultaneous Voltage Smoothing and Peak Shifting	YES	
Pacific Gas & Electric Co.	2.4	Advanced Underground CAES Demonstration Project Using a Saline Porous Rock Formation as the Storage Reservoir		
New York State Gas & Electric Corp.	2.4	Advanced CAES Demonstration 150 MW Plant Using an Existing Salt Cavern		
Seeo Inc.	2.5	Solid State Batteries for Grid-Scale Energy Storage	YES	
Aquion Energy	2.5	Demonstration of Sodium-ion Battery for Grid-level Applications	YES	
SustainX	2.5	Demonstration of Isothermal Compressed Air Energy Storage to Support Renewable Energy Production	YES	YES
Amber Kinetics	2.5	Demonstration of a Flywheel System for Low Cost, Bulk Energy Storage	YES	YES
Ktech Corp.	2.5	Flow Battery Solution for Smart Grid Renewable Energy Applications	YES	

* Definitized as of 10/29/2010.

Table of Contents

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Table of Contents

BUILD METRICS – MONETARY INVESTMENTS
Equipment Installed Cost Breakout

AMI				Customer Systems					
Monetary Investment	AMI Back Office Systems	Communication Equipment	AMI Smart Meters	Customer Back Office Systems	Customer Web Portals	In Home Display	Smart Appliances	Programmable Controllable Thermostats	Participating Load Control Device
ARRA	-	-	-	-	-	-	-	-	-
Cost Share	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-
Other Assets and Costs that do not align with the categories listed above:									

Electric Distribution									
Monetary Investment	Back Office Systems	Distribution Management System	Communications Equipment / SCADA	Feeder Monitor / Indicator	Substation Monitor	Automated Feeder Switches	Automated Capacitors	Automated Regulators	Fault Current Limiter
ARRA	-	-	-	-	-	-	-	-	-
Cost Share	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-
Other Assets and Costs that do not align with the categories listed above:									

Electric Distribution – Distributed Energy Resources (DER)									
Monetary Investment	DER Interface / Control Systems	Communication Equipment	DER / DG Interconnection Equipment	Distributed Generation (DG)	Renewable DER	Stationary Electricity Storage	Plug-in-Electric Vehicles		
ARRA	-	-	-	-	-	-	-		
Cost Share	-	-	-	-	-	-	-		
Total	-	-	-	-	-	-	-		
Other Assets and Costs that do not align with the categories listed above:									

Electric Transmission									
Monetary Investment	Back Office Systems	Advanced Applications	Dynamic Rating Systems	Communication Equipment	PDC	PMU	Line Monitoring Equipment		
ARRA	-	-	-	-	-	-	-		
Cost Share	-	-	-	-	-	-	-		
Total	-	-	-	-	-	-	-		
Other Assets and Costs that do not align with the categories listed above:									

BUILD METRICS
Distributed Energy Resources

BUILD METRICS: Distributed Energy Resources			
Metric	Value		Remarks
	Project	System	
Distributed Generation*	# MW MWh	# MW MWh	Number of units, total installed capacity and total energy delivered
Energy Storage*	# MW MWh	# MW MWh	Number of units, total installed capacity and total energy delivered
DER Interface*	Description	Description	Characteristics of DER interface or interconnection, including information and control capability for utility
Plug-in Electric Vehicle Charging Points	#	#	Number of charging points, capacity, and total energy transacted

*based on Data Discussion Meetings with 9 Recipients

Energy Storage Applications Supported by Project

ENERGY STORAGE APPLICATIONS	
Application	**Applicability to Projects***
Electric Energy Time Shift	YES (6)
Electric Supply Capacity	YES (2)
Load Following	MAYBE (2)
Area Regulation	YES (2), MAYBE (2)
Electric Supply Reserve Capacity	MAYBE (1)
Voltage Support	YES (1), MAYBE (1)
Transmission Support	NO
Transmission Congestion Relief	YES (1)
T&D Upgrade Deferral	YES (1), MAYBE (1)
Substation Onsite Power	NO
Time-of-Use Energy Cost Management	YES (2)
Demand Charge Management	YES (1), MAYBE (2)
Electric Service Reliability	YES (1)
Electric Service Power Quality	NO
Renewables Energy Time Shift	YES (6)
Renewables Capacity Firming	YES (4)
Wind Generation Grid Integration, Short Duration	YES (2)
Wind Generation Grid Integration, Long Duration	YES (2)

*based on Data Discussion Meetings with 9 Recipients

Reference Document – *Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide* (SAND2010-0815, February 2010)
http://www.smartgrid.gov/sites/default/files/resources/energy_storage.pdf

IMPACT METRICS
Electric Distribution Systems

IMPACT METRICS: Electric Distribution Systems			
Metric	Value		Remarks
	Project	System	
Metrics Related Primarily to Economic Benefits			
Hourly Customer Electricity Usage	kWh $/kWh	Not Applicable	Hourly electricity consumption information (kWh) and applicable retail tariff rate
Annual Storage Dispatch*	kWh	Not Applicable	Total number of hours that storage is dispatched for retail load shifting
Average Energy Storage Efficiency*	%	Not Applicable	Efficiency of energy storage devices installed
Monthly Demand Charges	$/kW-month	Not Applicable	Average commercial or industrial demand charges
Distribution Feeder or Equipment Overload Incidents	#	Not Applicable	The total time during the reporting period that feeder or equipment loads exceeded design ratings
Distribution Feeder Load	MW MVAR	Not Applicable	Real and reactive power readings for those feeders involved in the project. Information should be based on hourly loads
Deferred Distribution Capacity Investments*	$	Not Applicable	The value of the capital project(s) deferred, and the time of the deferral
Equipment Failure Incidents	#	Not Applicable	Incidents of equipment failure within the project scope, including reason for failure
Distribution Equipment Maintenance Cost	$	Not Applicable	Activity based cost for distribution equipment maintenance during the reporting period
Distribution Operations Cost	$	Not Applicable	Activity based cost for distribution operations during the reporting period
Distribution Feeder Switching Operations	#	Not Applicable	Activity based cost for feeder switching operations during the reporting period
Distribution Capacitor Switching Operations	#	Not Applicable	Activity based cost for capacitor switching operation during the reporting period
Distribution Restoration Cost	$	Not Applicable	Total cost for distribution restoration during the reporting period
Distribution Losses*	%	Not Applicable	Losses for the portion of the distribution system involved in the project. Modeled or calculated
Distribution Power Factor	pf	Not Applicable	Power factor for the portion of the distribution system involved in the project. Modeled or calculated
Truck Rolls Avoided	#	Not Applicable	Estimate of the number of times a crew would have been dispatched to perform a distribution operations or maintenance function

IMPACT METRICS
Electric Distribution Systems (Cont.)

IMPACT METRICS: Electric Distribution Systems (cont.)			
Metric	**Value**		**Remarks**
	Project	**System**	
Metrics Related Primarily to Reliability Benefits			
SAIFI	Index	Not Applicable	As defined in IEEE Std 1366-2003, and do not include major event days. Only events involving infrastructure that is part of the project should be included.
SAIDI/CAIDI	Index	Not Applicable	
MAIFI	Index	Not Applicable	
Outage Response Time	Minutes	Not Applicable	Time between outage occurrence and action initiated
Major Event Information	Event Statistics	Not Applicable	Information should including, but not limited to project infrastructure involved (transmission lines, substations and feeders), cause of the event, number of customers affected, total time for restoration, and restoration costs.
Number of High Impedance Faults Cleared	#	Not Applicable	Faults cleared that could be designated as high impedance or slow clearing
Metrics Related Primarily to Environmental Benefits			
Distribution Operations Vehicle Miles	Miles	Not Applicable	Total mileage for distribution operations and maintenance during the reporting period
CO_2 Emissions*	tons	tons	Could be modeled or estimated
Pollutant Emissions (SOx, NOx, PM-2.5) *	tons	tons	Could be modeled or estimated

*based on Data Discussion Meetings with 9 Recipients

DOE Smart Grid and Energy Storage Benefits Supported by Project

Benefit Category	Benefit Sub-category	Benefit	Provided by Project
Economic	Market Revenue	Arbitrage Revenue (consumer)* Capacity Revenue (consumer)* Ancillary Service Revenue (consumer)*	YES
	Improved Asset Utilization	Optimized Generator Operation (utility/ratepayer)* Deferred Generation Capacity Investments (utility/ratepayer)* Reduced Ancillary Service Cost (utility/ratepayer)* Reduced Congestion Cost (utility/ratepayer)*	YES
	T&D Capital Savings	Deferred Transmission Capacity Investments (utility/ratepayer)* Deferred Distribution Capacity Investments (utility/ratepayer)* Reduced Equipment Failures (utility/ratepayer)*	YES
	T&D O&M Savings	Reduced Distribution Equipment Maintenance Cost (utility/ratepayer) Reduced Distribution Operations Cost (utility/ratepayer) Reduced Meter Reading Cost (utility/ratepayer)	NO
	Theft Reduction	Reduced Electricity Theft (utility/ratepayer)	NO
	Energy Efficiency	Reduced Electricity Losses (utility/ratepayer)*	YES
	Electricity Cost Savings	Reduced Electricity Cost (consumer)*	YES
Reliability	Power Interruptions	Reduced Sustained Outages (consumer)* Reduced Major Outages (consumer)* Reduced Restoration Cost (utility/ratepayer)	YES
	Power Quality	Reduced Momentary Outages (consumer)* Reduced Sags and Swells (consumer)*	YES
Environmental	Air Emissions	Reduced carbon dioxide Emissions (society)* Reduced SO_X, NO_X, and PM-2.5 Emissions (society)*	YES
Security	Energy Security	Reduced Oil Usage (society) Reduced Wide-scale Blackouts (society)	NO

*based on Data Discussion Meetings with 9 Recipients

Yes = This benefit was described in the proposal.

Maybe = It is not clear whether this benefit will be demonstrated by the proposed project but DOE believes that it is possible.

No = It does not appear that this benefit will be demonstrated by the proposed project.

Table of Contents

Storage System Performance Overview

Each project team should provide the following four types of storage system performance information via the interim and final TPRs:

1. **System Characteristics** – profiles of the prototype and field demonstration systems.
2. **Data Measurements** – required storage system measurements and recordings, including balance of plant status and external operating environment data over the course of the demonstration.
3. **System Performance Parameters** – technical, economic, and environmental health & safety (EHS) performance characteristics that will be measured or calculated over the course of the demonstration.
4. **Projected Performance Parameters** – performance characteristics that will require extrapolating or forecasting based on data collected during the demonstration. Examples include life cycle cost information and long term capacity degradation.

Performance information described in the Appendix is broadly applicable to storage technologies. However, DAT fully anticipates that they are not universally applicable to all projects involving storage technologies and that some projects will have other technology-specific performance characteristics that should be identified by the project team for inclusion in the technology performance reports.

System Characteristics

- Appropriate system characteristics should be identified and described in the MBRP.

Storage System Characteristics

- Location
- Weight, footprint, and dimensions
- Transportability
- MW nameplate rating (including depth of discharge, operating conditions)
- MWh nameplate capacity (including depth of discharge, operating conditions)
- Energy density
- Specific energy and power
- System components (e.g., storage module, power conversion system, cooling system, balance of plant)

Data Acquisition System

- Recipients are responsible for providing the equipment necessary to ensure the accurate capture and reporting of experimental and demonstration field data and results. Data should be reported to the TPO and the Data Analysis Team (DAT) on an agreed upon schedule. Recipients should retain and house all storage system performance information generated until the conclusion of the project and final reporting.

- Recipients should review and obtain approval from the TPO and the DAT of the following aspects of the Data Acquisition System (DAS) prior to equipment purchase and installation:
    1. 1-line schematic of DAS including:
        - Monitoring points and data to be monitored at each point
        - Type of monitoring equipment needed and number of units needed
        - Communications link between monitoring devices and data repository
        - Amount of on-site storage (back-up) needed
    2. Specifications for DAS components

- Once a prototype or field test system is ready for operation, the Recipient and Data Analysis Team will review the monitoring equipment installation and verify accurate data capture and storage.

Data Measurements

- A description of the Data Acquisition System (DAS) should be included in the MBRP.
- The MBRP should provide a list of all data to be captured by the DAS.
- Each data point should include a description and sampling rates.

Data Measurements
• Operational mode • Import energy signal • Export energy signal • kW input • kW output • Voltage • VAR • Amp • kWh • Frequency • Power factor • Battery system state of charge • Response time • Number of cycles • Harmonics • Hourly electricity price • Regulation price (regulation only) • Demand response revenue (load shifting only) • Congestion charges (load shifting only)

System Performance Parameters

Storage System Performance Parameters

Technical

- Scheduled maintenance down time
- Down time associated with State of Charge (SOC)
- Unscheduled down time
- Plant availability**
- Number and duration of failure incidents
- Energy dispatched on day-to-day and lifetime basis
- Round-trip efficiency (RTE)
- Ability to follow Automatic Generation Control (AGC) signal (regulation only)
- Ramp rate (charge/discharge)
- Capacity degradation

Economic

- Engineering and design costs
- Capital cost (i.e., equipment capital and installation) ($)*
- Capital cost ($/kWh & $/kW)*
- End of life disposal cost ($)**
- End of life value of plant and equipment**
- Operating cost (activity based, non-fuel, by application plus monitoring)
- Maintenance cost (by cost category)

Environmental Health & Safety (EHS)

- Operating temperature
- Flammability
- Material toxicity
- Recyclability
- Other

*To be reported at the start of operations
**To be reported only at the end of operations

Performance Parameter Definitions –Technical

STORAGE SYSTEM PERFORMANCE PARAMETERS: Technical		
Metric	**Value**	**Definition**
Scheduled maintenance down time	%	Ratio of the time that the energy storage system is down for scheduled maintenance divided by the total timeframe. Example: If the system was down for scheduled maintenance 50 hours out of 30 days (720 hours), then the “scheduled maintenance down time” would be 6.9% = (50/720*100).
Down time associated with State of Charge (SOC)	%	Ratio of time that the energy storage system has been charged/discharged to the limit and is unable to respond to a signal divided by the total timeframe minus scheduled maintenance down time. Example: If the energy storage system was at the SOC limit for 5 hours and the system was down for scheduled maintenance 50 hours out of 30 days (720 hours), then the “down time associated with SOC” would be 0.7% = (5/(720-50)*100) .
Unscheduled down time	%	Ratio of the unscheduled down time divided by the total timeframe minus scheduled maintenance down time. Example: If the system was down for 10 hours due to unscheduled incidents and down for 50 hours for scheduled maintenance out of 30 days (720 hours), then the “unscheduled down time” would be 1.5% = (10/(720-50)*100).
Plant availability**	%	Ratio of the total timeframe minus scheduled maintenance down time minus down time associated with SOC minus unscheduled down time divided by the total timeframe minus scheduled maintenance down time. Example: If the system was down for 50 hours due to scheduled maintenance, 5 hours due to down time associated with SOC and another 10 hours for unscheduled down time out of 30 days (720 hours), then the “plant availability” would be 97.8% = ((720-50-5-10)/(720-50)*100).

*To be reported at the start of operations
**To be reported only at the end of operations

Performance Parameter Definitions –Technical (cont.)

<table>
<tr><th colspan="3">STORAGE SYSTEM PERFORMANCE PARAMETERS: Technical</th></tr>
<tr><th>Metric</th><th>Value</th><th>Definition</th></tr>
<tr><td>Number and duration of failure incidents</td><td># and hours</td><td>Date and time of the failure incidents including a description of the general cause and duration.

Example list:
1. August 1, 2010, 14:38, Inverter down – 49:38 hours
2. October 20, 2010, 07:45, Fault in system – 23:51 hours
3. January 15, 2011, 11:05, Communication board failure – 2:09 hours

Note: This is a summary list and the details of each of these failure incidents will be tracked and available for review.</td></tr>
<tr><td>Energy dispatched on day-to-day and lifetime basis</td><td>kWh</td><td>Energy dispatched on day-to-day basis accumulated for entire project.

Example table:
<table>
<tr><th colspan="3">ENERGY DISPATCHED</th></tr>
<tr><th>Date</th><th>kWh</th><th>Cumulative kWh</th></tr>
<tr><td>August 1, 2010</td><td>557</td><td>557</td></tr>
<tr><td>August 2, 2010</td><td>330</td><td>887</td></tr>
<tr><td>August 3, 2010</td><td>129</td><td>1,016</td></tr>
</table></td></tr>
<tr><td>Round-trip efficiency (RTE)</td><td>%</td><td>Ratio of total energy storage system output (discharge) divided by total energy input (charge) as measured at the interconnection point.

Example: If the total output was 5,000 kWh, but the total energy input was 6,500 kWh, then the “round-trip efficiency” would be 76.9% = (5,000/6,500*100). Note: supplemental loads and losses (e.g., cooling, heating, pumps, DC/AC and AC/DC conversions, control power, etc.) consumed the 1,500 kWh.</td></tr>
</table>

*To be reported at the start of operations
**To be reported only at the end of operations

Performance Parameter Definitions –Technical (cont.)

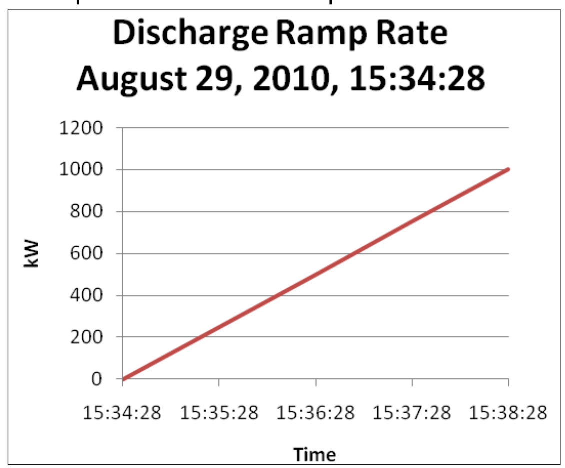
STORAGE SYSTEM PERFORMANCE PARAMETERS: Technical		
Metric	**Value**	**Definition**
Ability to follow Automated Generation Control (AGC) signal (load following only) and Area Control Error (ACE) signal (area regulation only)	Minimum, Maximum, and Average Difference (%)	Ratio of the kWh provided by the energy storage system divided by the kWh required by the AGC/ACE at intervals. Example: If the ACE signal requires discharge of 100kWh but the energy storage system only provides 80kWh during that 4 second interval, the ability to follow the ACE signal would be 80% = (80kWh/100kWh *100) *Note: This is a summary number and the details of each of these incidents will be tracked and available.*
Capacity degradation	%	Ratio of energy capacity at the end of the time period divided by the capacity at the beginning. Example: If the total energy storage system capacity at the end of the project had a capacity of 4,000 kWh and at the start of the project was 5,000 kWh, then the “capacity degradation” would be 20% = ((5,000-4,000)/5,000*100). Note: for battery systems, this measurement is taken on the device DC bus. Otherwise it is at the interconnection point.

*To be reported at the start of operations
**To be reported only at the end of operations

Performance Parameter Definitions –Technical (cont.)

<table>
<tr><th colspan="3">STORAGE SYSTEM PERFORMANCE PARAMETERS: Technical</th></tr>
<tr><th>Metric</th><th>Value</th><th>Definition</th></tr>
<tr>
<td>Ramp rate (charge/discharge)</td>
<td>kW/sec Graph and Table</td>
<td>
The change in power charged and discharged over time to meet the variations in power requirements. Graphically (with resolution of 100 ms) demonstrate the energy storage system's sustainable maximum ramp rate (kW/sec). List the number of times that the energy storage system did not meet the requested ramp rate on a daily basis.

Example Details: August 29, 2010, 15:34:28, Maximum Discharge 0kW – 1,000kW achieved in 4 seconds.

Example of Associated Graph:


Example Table:
<table>
<tr><th colspan="4">RAMP RATE NOT MET</th></tr>
<tr><th>Date</th><th>Ramp Rate</th><th>Charge</th><th>Discharge</th></tr>
<tr><td>August 1, 2010; 10:45:37</td><td>500 kW/sec</td><td>X</td><td></td></tr>
<tr><td>August 1, 2010; 16:30:04</td><td>750 kW/sec</td><td></td><td>X</td></tr>
<tr><td>August 3, 2010; 18:32:21</td><td>900 kW/sec</td><td></td><td>X</td></tr>
</table>
</td>
</tr>
</table>

*To be reported at the start of operations
**To be reported only at the end of operations

Performance Parameter Definitions – Economic

STORAGE SYSTEM PERFORMANCE PARAMETERS: Economic		
Metric	**Value**	**Definition**
Engineering and design costs	$	The cost associated with engineering and design for the demonstration project implementation.
Capital cost (i.e., equipment capital and installation)*	$	Total installed first cost of fielded system, breaking out major categories including equipment (i.e., major equipment components, related support equipment, and initial spare parts) and costs associated with shipping, site preparations, installation, and commissioning.
Capital cost*	$/kWh & $/kW	Total installed first cost of fielded system, normalized by energy storage capacity and peak power output.
End of life disposal cost**	$	Total cost of dismantling and removing the fielded system, including (if applicable) decontamination long-term waste storage, environmental restoration and related costs.
End of life value of plant and equipment**	$	Resale or salvage value of plant and all associated equipment.
Operating cost (activity based, non-fuel, by application plus monitoring)	$/kW-month	Activity based, average monthly total of all direct and indirect costs incurred in using the system, excluding the cost of purchased electricity and including third-party monitoring if applicable.
Maintenance cost (by cost category)	$/kW-month	Activity based, average monthly cost of maintaining the fielded system.

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Performance Parameter Definitions – Environmental Health & Safety

STORAGE SYSTEM PERFORMANCE PARAMETERS: Environmental Health & Safety		
Metric	**Value**	**Definition**
Operating temperature	°F	Degrees Fahrenheit at which the energy system normally operates.
Flammability	°F	Material flammability ignition temperature and ignition energy.
Material toxicity	--	Qualitative discussion on materials toxicity.
Recyclability	%	Percent of the material from the energy storage system expected to be recyclable at the end of life. Example: If there are four tons of lead that can be recyclable from the original five tons installed, then the lead "recyclability" would be 80% = (4/5*100).
Other	TBD	List and describe any other EH&S issues.

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Projected Performance Parameters

- Projected Performance Parameters should reflect estimates based on results of testing and demonstration activities.
- The MBRP should include a discussion of these parameters and provide details of how each parameter is defined for the technology and the approach that will be used to provide estimates over the course of the project.

Projected Performance Parameters
• Cycle life (define basis for estimation, e.g. based on 80% capacity degradation, or other metrics) • Calendar life (define basis for estimation) • Total life cycle maintenance cost • Total life cycle operating cost • Capacity degradation • Capital cost ($/kWh over lifetime)