

SRP IBR Monitoring Challenges

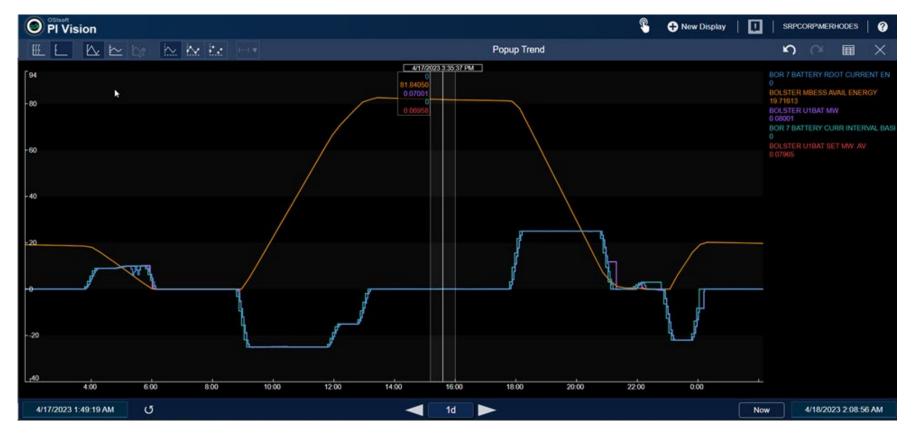


NASPI Work Group Meeting October 2024

SRP OWNED AND OPERATED BOLSTER 25MW TOTAL GENERATION



Bolster Tracking State of Charge and Battery Dispatch



- Blue trace = EMS Ramped DOT
- Orange trace = Bolster Available Energy in MWHrs (State of Charge)
- Purple trace = Bolster Actual Output
- Cyan trace = Bolster Base Schedule



Bolster Site Level Dashboard (PI Data)

	OSIsoft PI Vision						
Θ	<u> Bolster Battery - Megapack Site</u>						
+- ×=	Bolster Battery - Megapack	Site					
-0.	Status:			Megapack Unit:	Γ.		
081	Controller to Inverter CommunicationNORMAL Battery Fault NORMAL	Loss of Battery Meter Communication	n NORMAL OFF	• • <u>MP-1420-1</u> • <u>MP-1420-2</u>			
埢	Measurement:			• • • <u>MP-1420-3</u> • • • <u>MP-1420-4</u>	-		
	Auxilary Load 154679.0 w	Maximum Charge Power	25000000.0 w	[●] [™] <u>MP-1421-1</u> [●] [™] <u>MP-1421-2</u>	-		
	AC Current 26.0 A	Maximum Discharge Power	25000000.0 w				
	AC Voltage 12563.3 V	Command Source	2	° [™] MP-1422-1 ° [™] MP-1422-2			
	Frequency 60.0 Hz	5 5.	95999195.0 wh	• • • MP-1422-3 • • • MP-1422-4			
	Apparent Power 580000.0 vA Reactive Power 580000.0 vAR	5 57	90330189.0 wh	● T MP-1423-1 ● T MP-1423-2			
	Real Energy Exported 42980000.0 wh		-49897.0 w	• T MP-1423-3 • T MP-1423-4			
	Real Energy Imported 36432000.0 Wh	Real Power	-50000.0 w	• T MP-1424-1 • T MP-1424-2			
	Trends:						
			AC Current	● [™] <u>MP-1424-3</u> ● [™] <u>MP-1424-4</u>			
	-1,000		AC Voltage 12,563 V	• T MP-1425-1 • T MP-1425-2	-		
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	-000 MM			● T MP-1426-3 ● T MP-1426-4			
	-400	M		• • • MP-1427-1 • • • MP-1427-2			
	-200			●			
				• T MP-1428-1 • T MP-1428-2			
	4/24/2023 4:11:24 PM 1d	4/25/2023 4:11	:24 PM				

- Site level gives total battery output data including:
 - Auxiliary load
 - Full charge energy (amount of MWHr energy capacity available)
 - Real and reactive power setpoint commands from the site controller to the battery.
- Bolster is made up of 34 "Megapacks" each delivering 700kW
- Right hand side has Megapack overview alarms for:
 - General alarms
 - Critical battery thermal event (potential fire)



Bolster Megapack Level Dashboard (PI Data)

8	sisoft PI Vision				Ŷ	🕂 New Display	👖 sr
$\widehat{\mathbf{v}}$	Bolster Battery - Megapack Unit Asset: MP-1420-1	2					<u>[~/`</u>
+- + x=	Bolster Battery - Megapack Unit: MI	P-1420-1 Max Battery Ten	nperature:41 °C Abi	ient Temperature: <mark>34</mark> °C	Back to Megapa	ack Site	
881	Status:			Voltage:			
Ð	AC Breaker Status CLOSE Door Switch Bat OverTemp Warning NORMAL Grid Uncomp Breaker Irrational NORMAL HV Interlock Breaker Ready to Close OFF Inverter Fault Bus Cntl Prolonged Fault NORMAL Keylock Ope Coolant Low NORMAL Low State of	bliant _{NORMAL} Loss of Co Broken _{NORMAL} Remote SI t _{NORMAL} Thermal E	omms NORMAL hutdown NORMAL vent Active NORMAL ENABLE	284 284 282 286 920 283 283 284 284 284 285 286 286 286 286 286 286 286 286		4/25/2023 4:11:34 PM	Voltage V 3 Voltage V 2 Voltage V Voltage 4 V
	Frequency59.991 HzAvail Charge Power791800 wAvail Discharge Power791800 wAvail Discharge Power791800 wReal Power Target-786 wReal Power Output0 wReactive Power Target0 VARReactive Power Output15899 VAR	State of Energy Usable Energy Remaining Usable Energy To Be Charged Usable Full Pack Energy Norminal Charge Power Norminal Discharge Power Norminal Full Pack Energy	96 % 2686200 Wh 101599 Wh 2790000 Wh 758400 W 2790000 Wh	1,000 1,000 1,000 -900 -800 -800 -700 -600 -500 -400 -300 -100 -0 -100 -0 -100 -0 -100 -0 -100 -0 -101 -0 -102 -0 -103 -0 -104 -0 -105 -0	Id	4A Inver 5A	rter A Current rter B Current rter C Current

- Megapack level gives
 - Digital statuses
 - 480V AC breaker
 - Internal fault detection
 - Numeric data
 - Available power
 - Nominal power
 - Nominal energy
 - Real and Reactive Power command targets
 - Trending analog data
 - 480V AC voltage
 - 480V AC current
 - DC voltage



Battery Maintenance Semi-Live Dashboard (PI Data)

Tesla Maintenance performed on 4 Megapacks. Notice the PI point notifications that changed state in the green boxes.

()	Pl Vision				<u></u>	🕂 New Display 🛛 🚺 Sf
\bigcirc	Bolster Battery - Megapack Unit	Asset: MP-1420-1 ▼				
+- ×=	Bolster Battery - Mega	apack Unit: MP-1420-1	Max Battery Temperature:	41.2 °C Abient Temperature: 28 °C	Back to Mega	pack Site
081	Status:			Voltage:		
8 €	AC Breaker Status OPEN Bat OverTemp Warning NORM Breaker Irrational NORM Breaker Ready to Close OFF Bus Cntl Prolonged Fault NORM Coolant Low NORM	AL Grid Uncompliant NORMAL AL HV Interlock Broken ALARM Inverter Fault NORMAL AAL Keylock Open OPEN	ISO Failure Loss of Comms Remote Shutdown Thermal Event Active Disabled Over Temp	DISABLE NORMAL 50 5/14/2023 9:21:47 AM		AC VolAvg 0 V AC A Voltage 0 V AC A Voltage 0 V AC B Voltage 0 V DC Voltage 0 V
	Measurement:			Inverter Curren	it:	
	Frequency 59	9.698 Hz State of Energ	y 10 %	-900		
	Avail Charge Power 0	W Usable Energy	y Remaining 0 Wh	- 800		
	Avail Discharge Power 0	w Usable Energy	y To Be Charged 0 Wh	-600		
	Real Power Target 0	w Usable Full Pa	ack Energy 0 Wh	- 500		
	Real Power Output 0	w Norminal Char	rge Power 758400			<u>~1</u>
	Reactive Power Target 0	VAR Norminal Disc	tharge Power 758400	0 w		
	Reactive Power Output 0	VAR Norminal Full I	Pack Energy 281700			5/15/2023 9.21.47 AM

PI Vision Θ Bolster Battery - Megapack Site Bolster Battery - Megapack Site +-×= Status: Megapack Unit: ∎∖ Controller to Inverter CommunicationNORM Loss of Battery Meter Communication NORMAL MP-1420-1 P MP-1420-2 Battery Fault Smart Inverter Active MP-1420-3 MP-1420-4 あ Measurement MP-1421-1 MP-1421-2 351103.0 w 19703493.0 w Auxilary Load Maximum Charge Powe AC Current 19703493 0 v MP-1421-3 MP-1421-3 MP-1421-4 AC Voltag Command Source МР-1422-1 Р МР-1422-2 60.0 Hz Full Charge Energy 73631795.0 wr MP-1422-3 MP-1422-4 19730000 0 M Remaining Energy 39724989.0 1 MP-1423-1 MP-1423-2 Reactive Power Command to Battery 0.0 VAR Real Power Command to Battery • T MP-1423-3 • T MP-1423-4 Real Energy Imported 38211000.0 w MP-1424-1 MP-1424-2 Frend MP-1424-3 MP-1424-4 P-1425-2 MP-1425-1 MP-1425-3 MP-1425-4 MP-1426-1 MP-1426-2 • T MP-1426-3 • T MP-1426-4 MP-1427-1 P MP-1427-2 MP-1427-3 • MP-1427-4 MP-1428-1 MP-1428-2 14/2023 9:22:00 AM 5/14/2023 9:22:00 AM ശ 1d

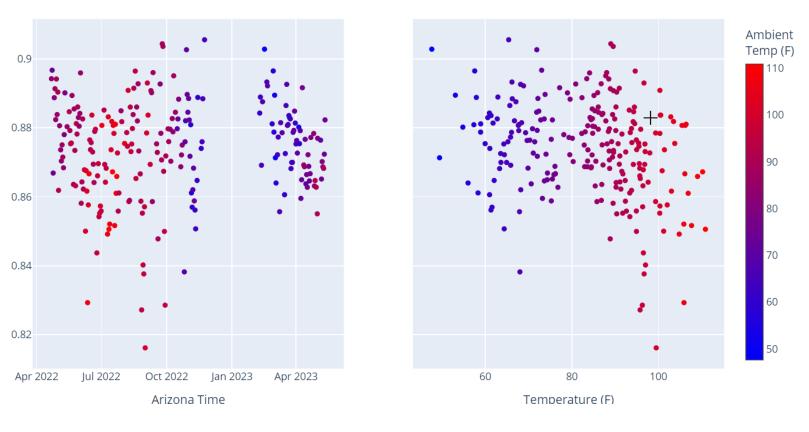


EPRI Storage Performance and Reliability Foresight Project (PI Data)

RTE vs. Time and Temperature

RTE vs Time and Temperature:

How does the total RTE change over time and over varying ambient Arizona temperatures. Particularly important with global warming trends and sustained high temperatures.



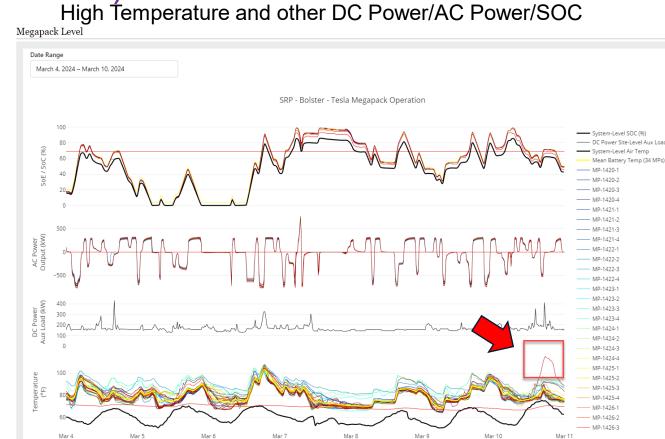


EPRI Storage Performance and Reliability Foresight Project

(PI Data)

Lifetime/Instantaneous and Unit Contribution Data





Plans to add new PPA Operated BESS data to Foresight Analytics Wiki



Real Time Value of PI Data

• Alarm trigger: Current State of Charge has reached to 95% of current available energy for greater than 10 seconds.

Alert - Bolster Battery Charge High

PD PGPMC - DEPT ID To Matthew E Rhodes

Retention Policy SRP Deleted Items (60 days)

Start your reply all with: Thank you! Approved. Just got this.

State of Energy Warranty Performance A 2023-05-12 15:09:18.000 Battery Charge High

Start Time: 5/12/2023 3:09:18 PM US Mountain Standard Time (GMT-07:00:00) Value at Start Time: 95.005 Charged Threshold for Notification: Above 95% Max Charge for >10 seconds. Event Details:<u>Event Details Hyperlink</u>

ALERT - Bolster Battery Unexpected Power Output Shift				
PGPMC - DEPT ID To Matthew E Rhodes				
Retention Policy SRP Deleted Items (60 days)				
Start your reply all with: Just got this. Thank you! What is this about? () Feedback				
Event: Bolster Battery Unexpected Power Output Shift Threshold for Alert: Battery output dropped by more than 600kW within 2 seconds.				
Event Start Time: 5/8/2023 11:14:34 PM US Mountain Standard Time (GMT-07:00:00) Notification Send Time: 5/8/2023 11:14:43 PM US Mountain Standard Time (GMT-07:00:00)				
Event Details: <u>Event Details Hyperlink</u> PI Server: pmcafprod				
 Power output (MW) has changed by 600kW in less than 2 seconds. One Megapack is 700kW. 				
Notifications come from analytics outside				

of PI, not raw PI data*

Feed

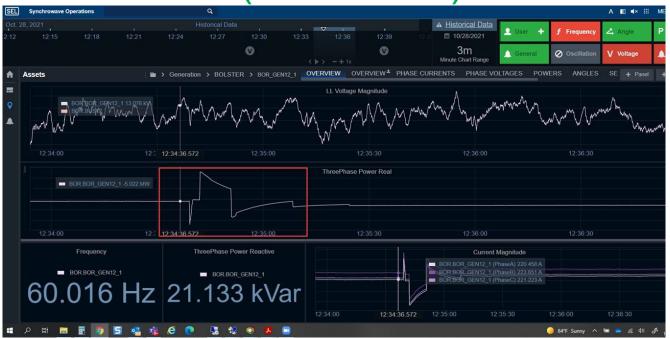


Value Realized and Actions Taken (PMU Data)

Unexpected power output shift alarm

- Megapack dropout
- Ramped operation plateau ACE effect.





Megapack dropout – Action: Submit a service ticket to Tesla to investigate.

ACE Effect – Action: Contact SRP EMS teams or check ACE PI Vision display to investigate ACE action for verification of ramping commands interruption and prevent aggravating system balancing issues.



SRP THIRD PARTY OWNED AND OPERATED (POWER PURCHASE AGREEMENTS) **BESS+PV HYBRID BESS+PV CO-LOCATED BESS STANDALONE PV STANDALONE** WIND STANDALONE ~2000MW TOTAL GENERATION



Power Purchase Agreement IBR Resource Data

Main Controls: MW Setpoint, Ramp Rate, Grid Charging Enable

Basic Data (Using)

- ESS Owner high/medium voltage and feeder status
- ESS high/medium voltage meter data
- ESS Aggregate Output
- PV Aggregate Output (if installed)
- POI Aggregate Output
- Unit Data
 - AVR status
 - Remote/Local Status
 - Battery metering data

<u> Critical Data (Using</u>

- Ambient Temperature
- Humidity
- BESS Ramp Rate
- BESS SOC
- BESS Max Charge/Discharge MW and MVAR
- BESS Available Energy Capacity
- BESS Max Energy Capacity
- BESS Frequency Response MW
- BESS Number of Inverters Online

Advanced Data (NOT AVAILABLE)

- Individual Battery Data
 - Battery Cell Temperature
 - Battery Cell Voltage
 - Battery Failure Codes
- Individual Inverter Data
 - Inverter Failure Codes

SRP NOT RESPONSIBLE FOR INTERNAL PLANT MONITORING

NEED FOR ADVANCED IBR MONITORING FROM THE SITE LEVEL



SRP ADVANCED IBR MONITORING RESEARCH

DCE OPTIMA FOA Topic Area SRP Participation: Demonstration Utility: Primary Investigator: Pacific Northwest National Laboratories (PNNL) POEC OPTIMA FOA Topic Area Poict Titie: Wave Apps: Distributed Waveform Analysis Platform for Grid Oparation Applications Operators Operators Sele Description: This project aims to provide insights from high-speed resources. The project aims unit devide part demonstrate Wave Apps, a distributed measurement-based provide insights needed to integrate larger annuals of a best prince of thigh-value applications by analyzing POW measurements to cally within substations. The results of these analyses will be streamed in best provide insight seeded resources. The project aims will devide part demonstrate Wave Apps, a distributed measurement-based resources while advancing secure and economic operation and reducing environmental impacts of electricity generation. DPG OPTIMA FOA Topic Area SRP Participation: Demonstration Utility. Primary Investigator: Arizona State University (ASU) Poject Titie: DASH-IBR: Dynamic Assessment of System Health for IBR-dominant Power Systems Project Titie: DASH-IBR: Dynamic Assessment of System Health for UBR-dominant Power Systems that have large annunts of inverter-based resources. These of electricity operators is in analysis and visita and unshaysis and operators and enonstrate wave Apps available of use of the project aims to devide part demonstrate treat-durate phaser measurement, units, digital fault recorders and relays: and operators is inverter-based resources. These of electricity operators is inverter-based resources. These of electricity operators is the project aims to devide part demonstrate for electricity operators is ana operational usity envinomment milling particity and security of p		
DDE OPTIMA FOA TOPIC Area Project Description: This project aims to provide insights from high-speed, point-on-wave (POW) measurements to grid operators so they can effectively monitor and platform that will enable a variety of high-value applications by analyzing POW measurement locally within substations. The results of these analyses will be streamed to integrate larger amounts of inverter-based resources. The project team will develop and demonstrate Wave Apps, a distributed measurement-based platform that will enable a variety of high-value applications by analyzing POW measurements locally within substations. The results of these analyses will be streamed to heplatform's contract for coordination, alarming, and visualization. This will provide operators with insights needed to integrate larger amounts of renewable resources while advancing secure and economic operation and reducing environmental impacts of electricity generation. DDE OPTIMA FOA Topic Area SRP Participation: Demonstration Utility; Primary Investigator: Arizona State University (ASU) Project Title: DASH-IBR: Dynamic Assessment of System Health for IBR-dominant Power Systems Project Title: DASH-IBR: Dynamic Assessment of System Health for IBR-dominant Power Systems Assessment Tools for Grid Operators (ASU) Project Title: DASH-IBR: Dynamic Assessment of state University (ASU) Project Totics: Dash-IBR: Dynamic Assessment of System Health for IBR-dominant Power Systems Project Description: This project aims to develop and demonstrate real-line tools for bulk power systems that have large amounts of inverter-based resources. These tools for bulk power system share a hazy measurement units, digital fault recorders and relays, and energy management systems. The real-lime monitoring, analysis and operator-supro		SRP Participation: Demonstration Utility; Primary Investigator: Pacific Northwest National Laboratories (PNNL)
Assessment Tools for Grid Project Description: This project alms to provide insight molting respect, point-wave (POW) measurements locally within substations. The results of the patforms central component for coordination, alarming, and visualizations. This will develop and demonstrate Wave Apps, a distributed measurement-based platform that will enable a variety of high-value applications by analyzing POW measurements locally within substations. The results of the patforms central component for coordination, alarming, and visualization. This will provide operators with insights needed to integrate larger amounts of renewable resources while advancing secure and economic operation and reducing environmental impacts of electricity generation. DOE OPTIMA FOA Topic Area 3: SRP Participation: Demonstration Utility; Primary Investigator: Arizona State University (ASU) Project Title: DASH-IBR: Dynamic Assessment of System Health for IBR-dominant Power Systems Project Description: This project aims to develop and demonstrate real-time tools for bulk power systems that have large amounts of inverter-based resources. These tools will help to identify emerging security risks and unstable system dynamics, provide complete situational awareness, and recommend mitigations. This will be to advanced analytics engine that ingest large amounts of data from wide-area phasor measurement units, digital fault recorders and relays, and energy management systems. The real-time monitoring, analysis and operator-suport tools will be demonstrated in an operational utility environment with real-time data. This project has the potential to enhance the reliability, stability, and security of power systems that run mostly on inverter-based resources. Project Description: Advisor / Data Support Project Description: Advisor / Data Support <td< td=""><td></td><td>Project Title: Wave Apps: Distributed Waveform Analysis Platform for Grid Operation Applications</td></td<>		Project Title: Wave Apps: Distributed Waveform Analysis Platform for Grid Operation Applications
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