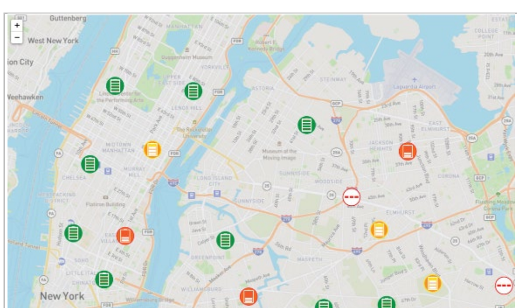
Technical Notes

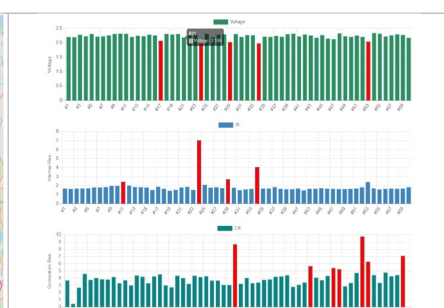
Successful Implementation of Battery Monitoring
for Power Plants and Substations

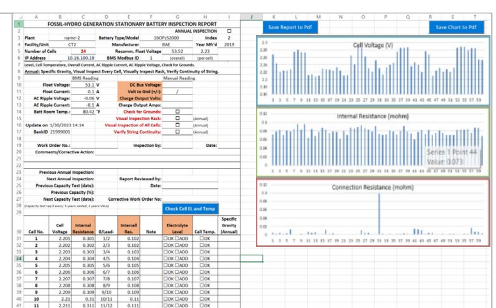
NERC Compliance

Data-Driven Optimal Battery Maintenance





Centralized Dashboard


Real-time Data Visualization


1-click Auto-fill NERC Reporting

Successful Implementation of Battery Monitoring for Power Plants and Substations

There are multiple factors driving utility operators to seek a reliable, validated, and advanced Battery Monitoring System (BMS) for their power plants and substations. The ideal BMS will perform battery tests more accurately and efficiently than human technicians, while being ultra reliable over 20+ year service life for typical vented lead-acid batteries.

1) **Demand for Increased Reliability and Performance of Battery Systems**
   Lead-acid batteries remain the most reliable energy storage option for power plants and substations, and effective battery monitoring can guide proactive maintenance, testing, and replacement to achieve optimal battery service life and reliable operation.

2) **Reducing the Cost of NERC Compliance and Maintenance**
   NERC regulations require scheduled inspections and proper maintenance. Effective monitoring will reduce the risk of regulatory fines, and increase reporting accuracy and efficiency.

> The maximum Penalty amount that NERC or a Regional Entity will assess for a violation of a Reliability Standard Requirement is $1,000,000 per day per violation.

3) **Substation Automation for Increased Accuracy and Improved Efficiency**

   On-site battery measurement and data interpretation requires trained/experienced personnel, which can lead to significant travel and time expenses when dealing with numerous batteries in hundreds of locations. With real-time and accurate data, a battery subject matter expert can remotely supervise effective maintenance activities for hundreds of battery installations.

4) **Lessons from Poorly Maintained Batteries**

   When well-built batteries with 20-year designed life are not properly maintained, they may only last less than half that time. The shortage of experienced technicians can result in delayed identification of battery problems, which can cause operational failures and costly battery replacement.

5) **Upgrade Poorly Designed Legacy BMS**

   Many operators have been disappointed with their installed BMS:
   a) Data is not accurate, or not relevant to battery deterioration. Data and alarms were not utilized to guide the proactive maintenance.
   b) Older BMS are unreliable, and could not withstand harsh environments found in battery rooms, and therefore BMS maintenance cost of legacy systems has been too high. Many of those BMS systems were discarded or abandoned after a few years.
   c) Centralized battery data management from legacy BMS was difficult to implement and not user friendly.

Implementing a reliable and effective BMS is a critical long-term **cost saving** investment for utility operators. However, choosing the right BMS requires significant effort for investigation, discussion, and evaluation.

As a leading provider, BatteryDAQ and its turn-key partner **Concentric/MESA** can help navigate this complex process:

(1) To identify the key requirements for effective battery monitoring to fit your business needs.

(2) To compare available technologies, products, and options.

(3) To contact references and learn from their successful implementations.

(4) To arrange trial evaluations.

(5) To budget and plan for full-scale implementation.

The Comprehensive Requirements

While many RFP/RFQ documents for BMS are highly detailed, the major purposes of BMS may not be addressed properly. Or they contain requirements that are not helpful or negatively impact the selection process.

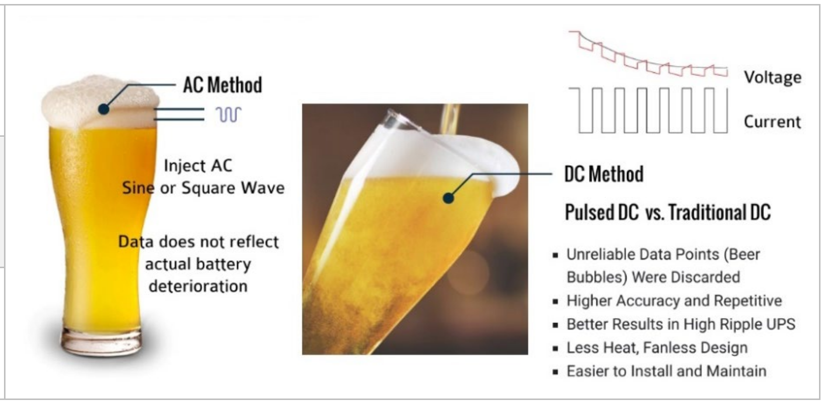
The essential aspects to be considered while preparing an RFP/RFQ include:

1	**Real-time detection of abnormal battery working condition**	Float charging voltage and room temperature are the two most important factors for battery service life. BMS shall monitor string voltage, cell voltage, charging current, ambient and battery pilot temperature. Abnormal voltage and temperature/ventilation alarms should be handled promptly. BMS is not designed to interact with the charger for temperature compensation.
2	**Reliable detection of heterogeneous battery deterioration**	Battery production is a complex and lengthy process, starting from raw material to final product. Shipping, storage, installation, and initial charging can significantly impact battery performance as well. Even batteries produced in the same batch can have subtle variations in their characteristics. Premature failure is not uncommon for any battery brand, and some cells may deteriorate at a faster rate than others. To identify abnormal cell(s) in a string, bar graphs for cell voltage and IR (Internal Resistance) are crucial. There are different methods to test IR, but not all of them are suitable for large vented/VRLA batteries used in power plants and substations.
3	**Reliable monitoring of battery string continuity**	A single bad cell or bad connection can cause battery continuity problems. BMS must be able to deliver a test current passing through the full string and detect any potential issues. A modular design may not be sufficient for this task, as it may not achieve the required micro-ohm resolution. A BMS that provides precise and reliable resistance reading for cell-to-cell and inter-tier connections can help to identify torque or corrosion problems in the early stages, allowing for prompt corrective action.
4	**Data and trending to evaluate end of battery service life**	Evaluating the end of battery service life, replacing cell(s) or an entire string can be a costly decision, and accurate data and trending are essential for making informed choices. A BMS provider should make this process easier for users by providing necessary data, methodology, and training.
5	**Procedure for maintaining the optimal Electrolyte Level**	Vented batteries should be inspected routinely (required 4-month interval by NERC, quarterly recommended by IEEE) for maintaining optimal electrolyte level. As of now, there is no device available to water the batteries automatically and precisely. Therefore, investing in ELM (Electrolyte Level Monitoring) has limited value. Waiting for an alarm from ELM may compromise the optimal level requirements.
6	**Long-term Reliability**	Sentry-6002NEMA is an airtight industrial-grade system allowing for installation in battery room, with a 20+ year designed service life to companion with the best batteries. A modular system with ventilation in the module and phone jack type connection between modules may be prone to corrosion on the circuit board and connectors in the coming years.
7	**Networking and IT Security**	BatteryDAQ's web-based software can be used for both standalone and networked configurations, and has successfully passed IT security scans for deployment in multiple utility networks.
8	**Centralized Dashboard**	Though all BMS can be connected to SCADA systems, SCADA software is not ideal for battery data access and visualization. Drilling down to a battery bank/cell takes too many steps on SCADA. Data among multiple batteries are not on the same page for comparison. Centralized data and data management tools are critical for successful implementation of BMS.
9	**NERC Compliance Reporting**	As NERC requires, the report must be submitted/archived every 4 months (or quarterly) with battery data (obtained manually or automatically from BMS). This process has been simplified and optimized by BatteryDAQ's 1-click Excel Workbook.
10	**Installation**	A detailed MOP (Method of Procedure) can guide trained technicians for successful installation, troubleshooting and commissioning.

The Comparison of Available Technologies and Product

Internal Resistance Measurement Methods

AC Method	AC Method has difficulty getting meaningful internal resistance data for lead acid batteries, especially for high capacity 2V cells, online with ripple.
DC Method	Traditional DC method produces low resolution readings with obvious shifting among cells, and not repeatable day-to-day, difficult to compare.
Pulsed DC	BatteryDAQ has developed and validated the pulsed DC method. Accurate and repeatable, data correlates with battery deterioration.



BatteryDAQ NEMA vs Modular

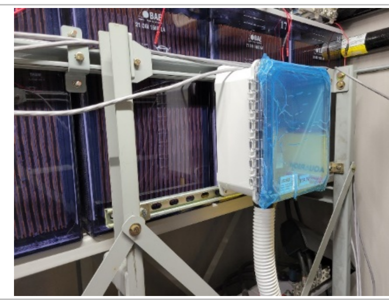
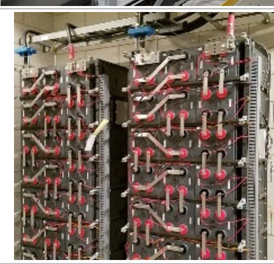
	BatteryDAQ All-in-one	**Modular (Wired or Wireless)**
Corrosion	Sentry-6002NEMA is designed to be installed in the battery room for long-term reliable operation. 700+ units installed and validated since 2013.	Modules and the controller (built for comfortable datacenter with ventilation slots on enclosure) will not withstand the harsh environment. Corrosion will build up on PCB and inter-module connectors. This weakness has been proven by existing installations. It is not fixable.
Power Supply	Unit is powered by the battery bank, not individual cells, or sections. Unit can record the full discharge course even some cells may fall below zero at the late course of discharge.	Each module is powered by individual or multiple cells. During a discharge, if one weak cell exists, that module may lose power, the entire system may stop working.
Internal Resistance	Pulsed DC Method, data is relevant to battery deterioration. High resolution for high-capacity cells.	AC method or equivalent to AC method. Data is not correlated to battery deterioration. Low resolution, artificial data.
Inter-cell and inter-tier connection resistance	Connection resistance is measured separately from internal resistance with high resolution. A bar graph provides easy spotting of inter-cell and inter-tier problems.	May not be able to detect inter-cell connection resistance problems. Test current does not passthrough the string so it cannot detect continuity problem.

Data Management and Visualization

BatteryDAQ Web-Based	**PC Based software**
Access data with a web browser from anywhere inside the secured network, means no need for any software installation.	Need to install software on Windows computer. Can only access from dedicated computer.
Validated in multiple secured utility networks.	Difficult to meet IT Security requirements
Data is stored in local SD card, available via web access.	Data is saved in the database. Difficult to access.
Web-based centralized dashboard, data backed up to file server.	Not available

Field Proven Products

BatteryDAQ provides a full line of products to cover all battery applications in power plants and substations.

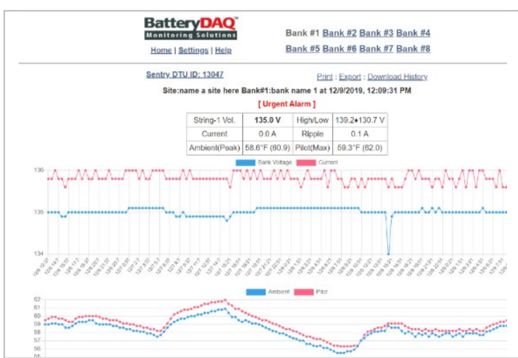
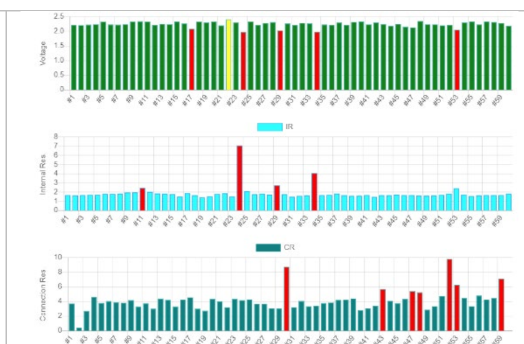
Model	Product Photo	Applications	Installation Example
Sentry-6002NEMA		VRLA or Vented **125V**, up to 60 cells per string **250V**, up to 120 cells per string NiCad Version 100x1.2V per unit	
Sentry-2402NEMA		**-48V** Vented Cells 23x2V or 24x2V Installed in Battery room. [Standard Sentry-2402 in NEMA enclosure]	
Sentry-2402		Communication Power **-48V** VRLA 23x2V or 24x2V Installed on battery rack	
Sentry-1012		**125V** VRLA 9x12V or 10x12V Installed on battery rack	
Sentry-NB8		Communication Power **24V or -48V** 6V / 12V VRLA 1 or 2 strings, 2 or 4 batteries per string	
Sentry-NB4		Communication Power **24V or -48V** 6V / 12V VRLA 1 string, 2 or 4 batteries	

Project Examples

Project	Monitoring Product Selection
Substations Typical battery rooms have 125V and -48V, 2 strings of 58x2V, 1 string of 23x2V Vented batteries. Other battery rooms have different battery configurations. 200 substations	Each typical room has: 2 units of Sentry-6002NEMA 1 unit of Sentry-2402NEMA 1 DTU pre-installed in a Sentry-6002NEMA unit Other battery rooms have different number of BMS units and settings. One Master-800 to manage 200 substations
Power Generation Plant Battery Room, VRLA Control Power, 125V (60x2V) Pump Power, 240V (120x2V) F&G Power, 24V, 12x2V Control Power, 24V, 12x2V	1 unit of Sentry-6002NEMA 2 units of Sentry-6002NEMA, configured for 120x2V 2 units of Sentry-1202 for 24V 1 DTU per room to collect data from all Sentry units 1 Master-800 to manage batteries for multiple generators on one site
Control/Switchgear Power 125V with 10x12V VRLA (some 9x12V)	1 Sentry-1012 per rack, data/alarm is collected to SCADA. 1 Master-800 to manage multiple batteries.
Communication Power in substations 300 locations, 4x12V VRLA, most 1 string, some 2 strings	1 Sentry-NB4 for each cabinet (Sentry-NB8 is utilized for some sites with 2 strings of 4x12V) 1 Master-800 for centralized management

Data and Alarm Management

Web-based software has been fine-tuned for data review. 20+ years battery data is archived in SD card.

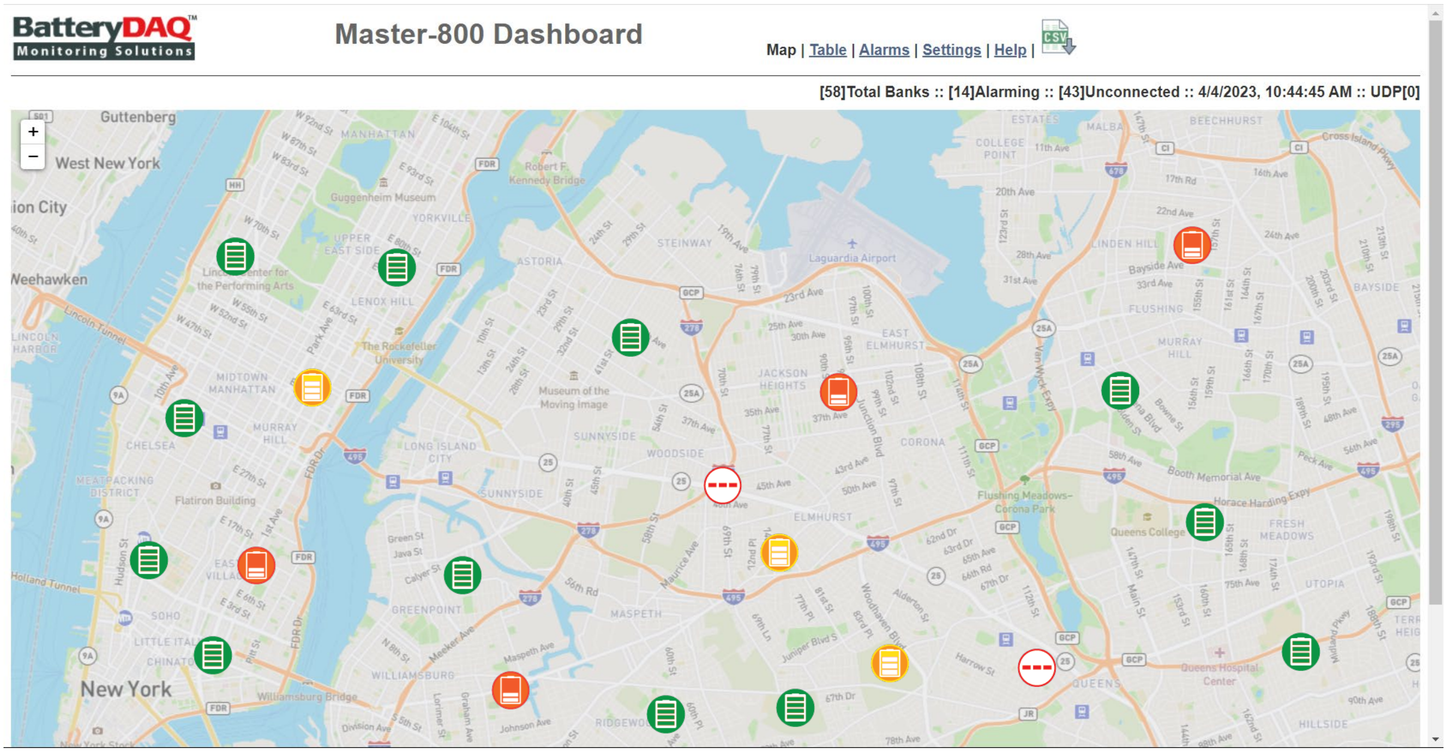
		
Instant access to most recent 3-day data for quick alarm response	Colored bar graph for cell data. Easy to spot weak cell(s) and connection(s).	Built-in feature for easy load test recording.

Centralized Dashboard

In addition to supporting the integration of battery data and alarms to existing SCADA or other software systems, BatteryDAQ offers a concise dashboard which can run in parallel with SCADA to manage hundreds of sites.

Map Viewer

The interactive map displays the status of all installations, and users can access the dashboard via any web browser within their private network, without the need for any PC software.

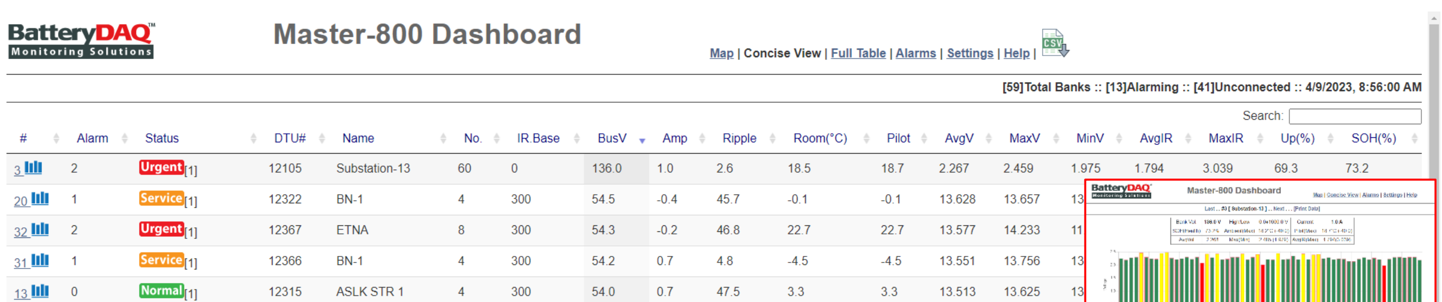


Normal	Service Alarm	Urgent Alarm	Not Connected

[Stations/sites on map are for illustration only. Nothing to do with any utility operator.]

Table Viewer

The summary table enables users to easily identify alarm sites, and prioritize battery services by sorting.



#	Alarm	Status	DTU#	Name	No.	IR.Base	BusV	Amp	Ripple	Room(°C)	Pilot	AvgV	MaxV	MinV	AvgIR	MaxIR	Up(%)	SOH(%)
3	2	Urgent[1]	12105	Substation-13	60	0	136.0	1.0	2.6	18.5	18.7	2.267	2.459	1.975	1.794	3.039	69.3	73.2
20	1	Service[1]	12322	BN-1	4	300	54.5	-0.4	45.7	-0.1	-0.1	13.628	13.657	13				
32	2	Urgent[1]	12367	ETNA	8	300	54.3	-0.2	46.8	22.7	22.7	13.577	14.233	11				
31	1	Service[1]	12366	BN-1	4	300	54.2	0.7	4.8	-4.5	-4.5	13.551	13.756	13				
13	0	Normal[1]	12315	ASLK STR 1	4	300	54.0	0.7	47.5	3.3	3.3	13.513	13.625	13				

Individual Bank

Users can drill into each battery bank without leaving the dashboard to access remote site.

Installation Examples

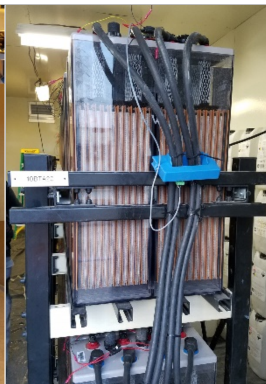

Easy Installation

Wall Mounting (Popular)

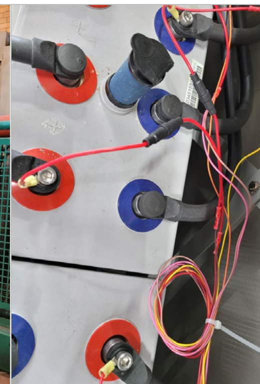

Mounted on Battery Rack

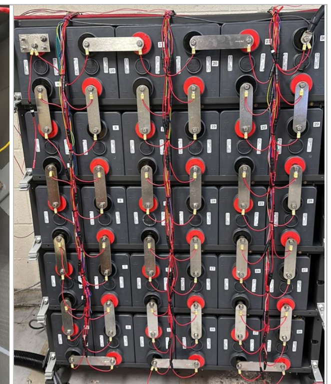

Unistrut on Rack


ATEX Battery Room


Current Transducer

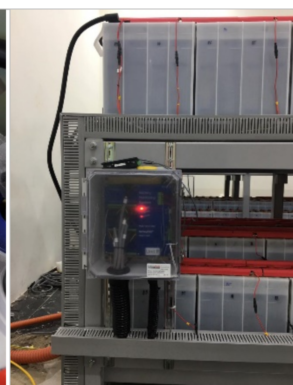

Unistrut on Beam


Wiring-1


Wiring-2

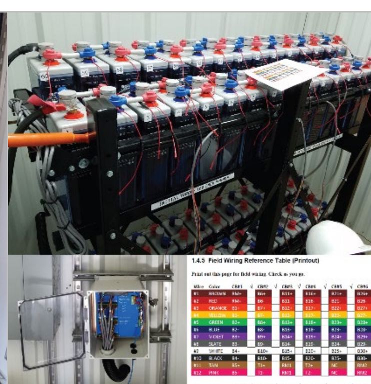

Protected Leads


Reliable Connection


NiCad Batteries


Cable Arrangement


Onsite Training


Wiring Instruction


Smooth SCADA integration

