# stem

# PowerTrack<sup>™</sup> EMS Solution

Stem's Edge-to-Cloud Energy Management System for Solar, Energy Storage, and Hybrid Assets





# **Table of Contents**

Introduction	3
Advanced Capabilities	4
Solution Components EMS Edge User Interface	5 6
Control Modes	7
Components And Specifications	9
Edge	9
PowerTrack EMS Edge	9
Unit Controller	13
Historian	14
Peripheral And Auxiliary Components	15
Supervisory Control and Data Acquisition (SCADA)	17
Cloud	19
PowerTrack EMS Cloud	19
Reference Architectures	20
Standalone BESS	21
PV Hybrid	22
Standalone PV	23
Deployment & Commissioning	24
Experience	25
About Stem, Inc.	26

		- -	-			-										-		Ť
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•		•	•		•	•	•	•	•	•			•	•		•	•	•
•	•	•	•		•		•		•	•	•		•	•	•		•	•
•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•		•	•	•	•	•	© Sterr	ı, Inc. 2	2025 ·	2	•

# Complete Edge-to-Cloud Technical Monitoring and Energy Management

The energy sector currently faces increasing complexity in integrating renewable energy resources including solar generation, battery energy storage systems (BESS), and ensuring grid stability while meeting regulatory requirements. Traditional energy management systems often lack the necessary technical capabilities to efficiently monitor and manage these distributed resources.

Stem's PowerTrack Energy Management System (EMS) Solution provides comprehensive technical monitoring and energy management of utility-scale solar, storage and hybrid energy assets through edge-to-cloud integration. The system architecture connects on-site controllers, supervisory control and data acquisition (SCADA) systems, and cloud infrastructure to enable:

- Real-time system configuration and parameter adjustment
- Precise command execution with sub-second response times
- Data collection and analysis for operational optimization
- Standardized communication across multiple protocols
- Centralized management of distributed assets

This integrated approach enables operators to monitor performance metrics, manage control parameters, and optimize operational efficiency across both individual sites and entire energy portfolios. The system supports multiple asset types including standalone BESS, standalone PV, and hybrid installations, with standardized interfaces that reduce integration complexity.

The architecture implements a layered design with distinct edge and cloud components leveraging Stem's industry-leading PowerTrack M&C platform, connected through secure communication channels and utilizing industry-standard protocols to ensure compatibility with existing infrastructure and regulatory requirements.

PowerTrack EMS Solution delivers measurable value to developers, utilities, and IPPs to:



# **Advanced Capabilities**

PowerTrack EMS Solution is designed for reliability, scalability, and ease of use.



### **Real-Time Data Monitoring**

Achieve 100% controller uptime with redundant failover for reliable system performance



### Intuitive User Interfaces

Easy-to-use edge and cloud interfaces simplify operations



### Standardized Data Model

Supports IEEE 1815.2 with multi-protocol compatibility, including DNP3, Modbus, OPC-UA, IEC 61850, and IEC 60870



### **Configurable SCADA Interfaces**

Includes a Human-Machine Interface (HMI) for streamlined control



### **Centralized Portfolio Management**

Manage your entire asset portfolio through a unified cloud platform, extending the capabilities of Stem's industry-leading software



### Scalability

Seamlessly expand from single units to large portfolios



# Project Lifetime Cloud-Based Data Storage

Securely store and access data for the operating life of your assets



### **Industry Compliance and Certifications**

Certified for NA, LATAM, EMEA standards, ensuring global regulatory compliance across operational environments

# **Solution Components**

PowerTrack EMS Solution integrates a modular hardware and software architecture to create a comprehensive energy management system. The implementation utilizes standardized interfaces and communication protocols to ensure interoperability between components. The system architecture consists of the following core elements:

### Architecture Overview:

- Cloud-level components for centralized management and monitoring
- Edge-level components for local control and data acquisition
- Asset-specific components for device integration and control
- Communication infrastructure for secure data transmission



The solution implements a distributed processing model with redundant communication pathways to maintain operational reliability. Component selection can be configured based on specific project requirements, environmental conditions, and operational parameters.

The architectural design supports staged implementation, enabling system expansion from basic monitoring to comprehensive control functionality. All components utilize industry-standard communication protocols to facilitate integration with third-party systems and ensure compatibility with evolving regulatory requirements.



# EMS Edge User Interface

PowerTrack EMS Edge User Interface (UI) provides an operator interface for system configuration, monitoring, and control of solar, energy storage and hybrid assets. This interface serves as the primary interaction point for on-site or remote technical management, offering equivalent functionality to standalone SCADA systems while maintaining compatibility with existing SCADA infrastructure when required.



## Real-time Adaptive Monitoring and Trends

Monitoring point addition capability for immediate asset visualization without system interruption during commissioning. Reduces commissioning cycles and diagnostic intervals while maintaining operational continuity.

### **Advanced Scheduler**

Implements temporal, priority, and mode-based scheduling with day-ahead SOC waypoint targeting. Enables deterministic energy management and optimized dispatch sequencing.

# Advanced PID Tuning with Real-Time Visual Feedback

Graphical parameter adjustment interface with real-time response visualization for control optimization. Remote commissioning capability eliminates on-site tuning requirements.

## Device-Level Site Configuration

Granular configuration architecture with device-specific parameter management. Provides parameter-level control resolution for diverse asset configurations.

# **Control Modes**

PowerTrack EMS PPC offers 12 control modes designed to optimize energy storage and grid integration. These modes are categorized into Frequency Management, Voltage Management, Power Management, and System Control, providing flexible and efficient operation for various grid scenarios.

## **Frequency Management**



Fast Frequency Response (FFR)

Reacts within milliseconds to grid frequency deviations, injecting or absorbing power to rapidly stabilize the grid during sudden changes.



### Frequency Watt Control

Automatically adjusts active power output based on grid frequency, modulating power to help restore balance and enhance grid resilience.



# Power Oscillation Damping

Detects and mitigates power system oscillations by dynamically adjusting power output, improving overall system reliability during transient events.

# Voltage Management



### Automatic Voltage Regulation (AVR) Control

Maintains voltage levels within specified limits through AVR, continuously monitoring grid voltage and adjusting reactive power output to stabilize voltage at the point of interconnection



Volt-VAR Control

Dynamically compensates for reactive power based on voltage levels, following a predefined Volt-VAR curve to maintain optimal voltage profiles across the distribution network.



# VAR Control

Provides a constant level of reactive power support to the grid, addressing known reactive power deficiencies in specific network locations.

# **Power Management**



# Active Power Limiting

Caps active power output at a specified level, managing grid constraints and complying with interconnection agreements



### Fixed Power Factor

Maintains a constant power factor by balancing active and reactive power output to meet specific grid requirements or operational needs.



# Dispatch Regulation Reserve

Participates in grid regulation services by following external dispatch signals, quickly ramping power output up or down to balance supply and demand in real-time.

# System Control



# Dynamic State of Charge (SOC) Control

Optimizes the SOC of the energy storage system based on forecasted grid conditions, energy prices, and system constraints, ensuring the battery is prepared for upcoming events.



# Automatic Generation Control (AGC)

Seamlessly integrates with existing grid control systems by receiving and responding to AGC signals from grid operators, enabling participation in ancillary services markets and supporting grid balancing efforts.



SOC Waypoint

Allows for the user to set a specific SOC % target at a future time and the system will automatically ensure that the target is met at the scheduled time.

The control mode architecture supports simultaneous operation of multiple modes through prioritization algorithms with configurable override conditions. Mode transitions implement bumpless transfer techniques, switching from one control mode to another without causing sudden jumps or disruptions, to maintain system stability during operational changes.

# **Components And Specifications**

# Edge

On-Site Hardware and Software: PowerTrack EMS Solution implements an integrated hardware and software architecture for comprehensive management of solar, storage, and hybrid assets. The system architecture utilizes standardized interfaces for component interoperability while supporting customized configurations based on project-specific technical requirements.

# PowerTrack EMS Edge

PowerTrack EMS Edge consolidates energy management system and power plant controller (PPC) functionalities within a unified computing platform. This architectural integration reduces signal latency, eliminates inter-device communication dependencies, and minimizes potential points of failure across the control chain. The implementation standardizes equipment specifications across PV, hybrid, and standalone BESS deployments. The hardware configuration includes industrial-grade power supplies, uninterruptible power backup, managed network infrastructure, redundant communication paths, and auxiliary components, integrated within environmentally rated enclosures configured according to installation site specifications.

### **Key Features**

- Intuitive on-board user interface for rapid configuration
- Real-time monitoring with adaptive point additions
- Advanced PID tuning with visual feedback
- Powerful scheduler with priority-based applications
- Device-level site configuration capabilities
- Integrated PPC for closed loop controls
- Prioritization and ratification of multiple concurrent setpoints

### **Hardware Options**

### Available on industry-leading platforms

See technical specifications on page 12

- Advantech UNO-137 (Industrial PC)
- SEL 3355 (Industrial PC)

#### Stem provides standard and built-to-order panels to meet customer-specific needs

- Firewall Camera RTAC
- Modem
- GPS clock
- Inverter gateway

### **Technical Capabilities**

### **Multi-Mode Control Implementation**

High-performance control execution in complex, concurrent operating modes

### Asset Type Compatibility

Protocol support for BESS, PV, and hybrid system integration with staged deployment capability

### **Response Performance**

Optimized execution cycles for stringent grid interconnection requirements in Hawaii, ERCOT, and EU jurisdictions

### **Control Architecture**

Codesys runtime environment and native PPC algorithms for standardized control implementation

### **Closed-Loop Control Functions**

Simultaneous management of voltage regulation, power output, ramp rate limiting, frequency response functions, auxiliary device control, and inverter coordination

### **Communication Protocol Support**

Implementation of Modbus TCP/RTU, DNP3, OPC-UA, IEC60870 and IEC61850 for heterogeneous system integration

### **Grid Operator Interface**

Direct communication with transmission system operators with comprehensive control event logging for operational verification

### Integration Details

The PowerTrack EMS Edge platform is available in outdoor panel, indoor rack, and outdoor rack configurations with appropriate environmental enclosures. The PPC is integrated within the PowerTrack EMS Edge.



# **Functional Components**

The PowerTrack EMS Edge platform incorporates two primary functional components, the EMS and PPC:

# **Energy Management System (EMS)**

Stem's EMS handles system monitoring, optimization, and high-level control functions.

### **Key Features**

- Advanced scheduler with priority-based energy applications
- Real-time performance monitoring with instant system insights
- Seamless edge-to-cloud telemetry for remote visibility and control
- Historical data logging for long-term analysis and compliance reporting
- Visual PID tuning and flexible control parameter configuration
- Remote commissioning for efficient off-site setup and updates
- Multi-protocol support including Modbus, DNP3, OPC-UA, IEC 61850, and IEC 60870

### **Technical Capabilities**

### Computational Architecture

Implements distributed processing model with configurable resource allocation

### **Data Management**

Utilizes time-series databases with configurable retention policies and compression algorithms

### Integration Framework

Protocol implementation supporting heterogeneous device integration across vendor platforms

### Visualization System

Web-based interface with responsive design supporting both operational and analytical functions

### **Commissioning Tools**

Configuration validation with parameter verification and automated consistency checking



# **Power Plant Controller (PPC)**

The PPC implements active and reactive power control algorithms across multiple operating modes, coordinating command distribution to Power Conversion Systems (PCS) and/or PV inverters. This control module is integrated within the PowerTrack EMS Solution architecture, providing comprehensive power management at grid interconnection points.

Advanced high-speed control options ensure compliance with complex interconnect standards globally, delivering rapid response for services such as Automatic Frequency Restoration Reserve, Frequency Containment Reserve, Power Oscillation Damping, Fast-Frequency Response, and more.

### **Key Features**

- High reliability for complex multi-mode control applications.
- Simultaneous closed-loop control across all 12 control modes.
- Independent inverter control for challenging site topologies.

### **Technical Capabilities**

**Control Execution Framework** Implements deterministic processing cycles with configurable priority for critical control functions

Response Performance Sub-cycle execution for high-speed grid requirements with configurable response characteristics

**Concurrent Mode Operation** Architecture supports simultaneous execution of multiple control algorithms with conflict resolution

#### **Device Management**

Independent control parameter management for distributed inverter topologies with heterogeneous characteristics

٠	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	٠	
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
٠	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
•	•	•	•	•	•	٠	•	•	•	•	•	•	•	•	•	•	•	•	•	
٠	•	•	•	•	•	•	•	•	٠	•	•	•	•	•	•	•	•	•	•	
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
•	S	<b>ten</b>	'n	•	•	•	•	•	٠	•	•	•	•	•	•	•	•	•	•	© Stem, Inc. 2025 · 11
•	•	•	•		•				•	•	•	•	•	•	•		•	•	•	

Hardware	Advantech UNO-137	SEL 3355				
Туре	Industrial PC	Industrial PC				
General						
Cartification	CE, FCC, UL 61010-2-201,	CE, FCC, 47 CFR 15 B Class A,				
Certification	CCC, BSMI	UKCA, UL				
Dimensions	35 x 105 x 150mm	133 x 288 x 465mm 19" 3U				
Mounting	DIN-rail	Rack Mount				
Power Requirements	10 – 36Vdc	38 – 58Vdc (LV) HV PS Available				
	21W Typical	49W Typical				
Power Consumption	47W Peak	69W Peak				
System Hardware						
Processor	1.6– 1.8GHz	2.5Ghz				
Memory	8GB DDR3, 1600MHz	4-16 GB DDR3, 1333MHz				
Charrente	1 x 2.5" SDD/HDD	4 x Industrial SATA or				
Storage	1 x M.2 B key 2242 SSD	2x Consumer SATA				
I/O						
Serial Ports	2x RS-232/422/485	2 x EIA – 232 Ports				
LAN	2 x 10/100/1000 Mbps IEEE 802.3u (RJ45)	2 RJ45				
USB	3 x USB 3.2 gen 1, 1 x USB 2.0	4 x Rear Panel USB 2.0 2 Front Panel USB 2.0				
loolated DI/O	8 x Digital Input Channels					
Isolated DI/O	8 x Digital Output Channels					
Displays	2 x DP 1.2, up to 4k @ 60Hz	1 x DVI-I 1 x DVI-D 1 x DP 1.1, up to 1920x1200				
Power Connector	1 x 2-pin terminal block	120/240V Terminal Block				
Environment	· ·					
Operating Temperature	-40 – 70°C / -40 – 158°F	-40 – 75°C / -40 – 167°F				
Storage Temperature	-40 – 85°C / -40 – 185°F	-40 – 85°C / -40 – 185°F				
	95%RH @ 40°C/104°F	5% to 95%				
Relative Humidity	Non-condensing	Non-condensing				
Shock Protection	Operating, IEC 60068-2-27, 60G	IEC 60255-21-2:1988 Bump Class 1 Response Class 2				
Ingress Protection	IP40	IP30				

# Unit Controller

The Unit Controller functions as an intermediary control system within the PowerTrack EMS architecture, specifically designed for BESS management at the unit level. It establishes bidirectional communication between the PPC and individual Power Conversion System (PCS) and DC battery block components. The Unit Controller receives control commands from the PPC, executes these commands at the PCS level, and collects telemetry data from both PCS and DC blocks for transmission to the EMS.

The software architecture implements a hardwareagnostic design with defined abstraction layers for:

- Inverter/PCS communication
- Battery/DC block management
- EMS system integration

This framework utilizes standardized interfaces for upstream and downstream communication, enabling consistent control methodology across heterogeneous hardware deployments.



### **Key Features**

- Hardware & technology-agnostic: interoperable with top-tier Battery and PCS Suppliers
- Scalable from 125kW to 400MW
- Monitors and controls DC and PCS blocks
- Modular structure for optimal performance and system redundancy
- Validated with real-time hardware in the loop simulator
- Pre-configured Modbus mapping for seamless integration with major OEM systems

### **Technical Capabilities**

- Complete vertical monitoring and control from edge to cloud
- Reduces commissioning time
- Bring-your-own-hardware capability (battery and PCS)

### **Use Cases**

- Hybrid and standalone BESS applications where DC block is paired with PCS
- Only deployable with Stem PowerTrack EMS and PPC

# Historian

The Historian component provides long-term data storage capabilities for deployments where the Edge UI should replace traditional SCADA systems. This module maintains a comprehensive record of system performance and operational metrics throughout the project lifecycle, ensuring data integrity and availability for analysis and compliance purposes. Installation typically requires environmentally controlled conditions to preserve data integrity.

### **Key Features**

- Configurable and adaptable to meet project-specific requirements
- Scalable storage capacity for varying project needs, supporting 5 years of site data retention
- Project lifetime storage options available when required
- Robust data backup and recovery mechanisms
- Secure access controls for data protection
- Compatible with Stem's PowerTrack EMS Solution

### **Use Cases**

- Remote sites with limited connectivity requiring local data storage
- Projects with regulatory compliance requiring extended data retention
- Operations requiring detailed historical performance
  analysis
- Sites using Edge UI as primary monitoring interface
- Applications requiring comprehensive operational records for warranty validation

### **Integration Details**

- Seamless integration with PowerTrack EMS Edge
- Compatible with standard data export formats
- Available in outdoor rated or indoor rack-mounted configurations
- Deployable alongside other Stem control components

### **Benefits**

- Ensures continuous access to historical operational data
- Reduces reliance on cloud connectivity for historical analysis
- Supports detailed performance evaluation and troubleshooting
- Facilitates compliance with data retention requirements
- Enhances operational decision-making with comprehensive historical context

### **Technical Capabilities**

- Storage capacity customized based on project requirements
- Flexible hardware configurations based on deployment environment
- Multiple redundancy options available
- Data compression capabilities to optimize storage efficiency
- Query tools for efficient data retrieval and analysis

# Peripheral and Auxiliary Components

The PowerTrack EMS platform integrates with peripheral measurement and communication devices to provide comprehensive site monitoring capabilities. These components enhance data collection accuracy and system reliability through standardized interfaces and protocols.

### **Integrated Components**

The following sensors and equipment can be integrated with the PowerTrack EMS Solution:

### Meters: Power Quality Meter (PQM), Revenue Grade Meter (RGM)

- Provides high-accuracy measurement for settlement and regulatory requirements
- Hardware: SEL-735, Janitza, Elkor, Accuvim
- Monitors power quality parameters for grid compliance

### Network Infrastructure

- Industrial-grade network switches for reliable data transmission
- Advanced firewall protection for cybersecurity compliance
- Cellular modems for redundant connectivity options

### Meteorological Equipment

- Integrated MET station for comprehensive environmental monitoring
- Temperature and humidity sensors for ambient condition tracking
- Wind and barometric pressure sensors for weather impact analysis
- Pyranometers for solar irradiance measurement
- Module temperature sensors for performance optimization
- Soiling sensors for maintenance scheduling and yield analysis

### **Benefits**

- Enhanced data accuracy for performance verification and warranty compliance
- Comprehensive environmental monitoring for performance analysis
- Secure and reliable network infrastructure for mission-critical operations
- Simplified integration through pre-configured interfaces and standardized protocols

### **Integration Details**

All peripheral components connect directly to the PowerTrack EMS Edge through standardized interfaces, enabling plug-and-play deployment and reducing commissioning time. Data from all sensors is available through both the Edge UI and Cloud interfaces for comprehensive monitoring and analysis.







Soling Sensors

© Stem, Inc. 2025 · 15



# **MET Station Technical Specifications**

### Hardware

RS485 Bus hub	4x RS485, opto-isolated
RTD Measurement module (optional)	6-channel temperature measurement (Pt100, Pt1000)
Power supply unit (optional)	85-264 V AC to 24 V DC including a AC surge protector
Electrical Data	
Power supply	24 V DC
	85-264 V AC
Power consumption	max. 48 W at DC supply
	max. 80 W at AC supply
Interfaces	4x RS485 Bus (HD), Modbus-RTU
	3xRS485 Bus (HD), Modbus-RTU, 6x RTD measurement channels,
	Pt100 and Pt1000
Data Transfer	
Protocol	Modbus-RTU
Data rate	19,2kBit/s standard; up to 115,2 kBit/s possible
Recommended cable for	Li2YCYv (TP) 4x2x0,5
connection	
to EMS	
Conformity	
Standards	EN 60950-1, EN 61000-6, UL 62368-1:2014 Ed.2,
	CSA C22.2#62368-1:2014 Ed.2
Mechanical Data	
Degree of protection	IP66 / NEMA 4X when mounted with mounting frames
Dimensions, H X W X D	647 x 436 x 250 mm
Weight	14 kg
Cabinet	UV-resistant glass-reinforced polyester, lockable
	vvali mounting, pole mounting
Amplent Conditions	
Operation temperature	-20 - 50 °C / -13 - 140 °F
Storage temperature	-30 - 70 °C / -22 - 158 °F
Relative humidity	up to 95 %, non-condensing

# Supervisory Control and Data Acquisition (SCADA)

PowerTrack EMS Solution provides an optional SCADA system that features real-time monitoring, control, and analysis capabilities for power plant equipment. The architecture integrates at both edge and cloud levels, providing comprehensive operational visibility across all connected assets. Built on the Ignition platform, the system features real-time human-machine interface with configurable polling rates, OPC-UA connectivity for PLC integration, and SQL database functionality.

The PowerTrack EMS Edge UI delivers standard SCADA capabilities, with additional functionality available through Induction Ignition systems for projects requiring specialized configurations.

### **Key Features**

- Real-time updates (<1 second data)
- At-a-glance view of site operations, device alarms, trending tools, and flexible data export
- OPC-UA server native capability for 3<sup>rd</sup> parties
- Tiered polling rates
- Hot standby redundancy
- Standard and custom KPIs
- Automatic data recovery from dataloggers after comms outage
- Alarm module (<1 second activation time) with user-designated hierarchy

### **Technical Capabilities**

#### **Data Acquisition Framework**

Implements sub-second data collection with configurable polling frequencies for critical parameters.

#### Interface Architecture

Web-based visualization system with responsive design for operational monitoring and control.

#### **Redundancy Implementation**

Supports hot standby configurations with automatic failover for mission-critical applications.

### **Data Management**

SQL and time-series database integration with configurable retention policies and query optimization.

### Alarm Processing

Hierarchical alarm management with configurable priority structures and notification pathways.

### **Control Integration**

Direct communication with transmission system operators for grid control functions.

### **Integration Details**

The SCADA module is available as a standalone system for specialized applications. It supports deployment in various environmental configurations including control room installations and remote site implementations.

# SCADA User Interface



Visualize data to extract key insights more easily with fully customizable charts



### At-a-glance view of site operations

	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	•	•	•	•	•	•	•	•	•	•	•	•	•	
	•	•	•	•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	• © 5	Stem, Ir	nc. 202	25 · 18	•
		•	•		•	•								



# Cloud

# PowerTrack EMS Cloud

The PowerTrack EMS Cloud extends the capabilities of Stem's industry-leading PowerTrack™ M&C software platform, providing remote monitoring and control functionality. This integrated cloud component enables centralized management of distributed assets while maintaining detailed visibility into individual site performance metrics, all within the unified PowerTrack environment. The system implements enterprise-grade infrastructure with standardized interfaces for edge system integration and third-party data exchange.

### **Key Features**

- Portfolio overview dashboard focused on critical site metrics for efficient multi-site monitoring
- Enhanced site-level monitoring providing comprehensive real-time performance data
- Real-time alert monitoring system for 24/7 fault detection and notification
- Cloud historian for secure lifetime project data storage and retrieval
- Remote site and device configuration capabilities, eliminating the need for physical presence
- Remote dispatch functionality allowing power commands and schedules to be sent from cloud to edge
- Intuitive visualization tools for performance analysis and reporting
- Role-based access controls for secure, appropriate system access

### **Technical Capabilities**

### Service Availability

Implements redundant architecture with 99.9% uptime guarantee and regional failover capabilities.

### Security Implementation

Utilizes encrypted communications with multi-factor authentication and role-based access controls.

### **Scalability Architecture**

Supports thousands of connected assets with configurable data retention and processing capabilities.

### **Data Management**

Automated backup procedures with configurable retention policies and recovery mechanisms.

### **Interface Compatibility**

Web-based platform supporting standard browsers and mobile device access with responsive design.

### **Communication Framework**

Configurable data transmission frequencies with store-and-forward capability during connectivity interruptions.

### **Integration Details**

stem

The cloud platform implements standardized APIs for integration with PowerTrack EMS Edge deployments, Stem's SCADA and historian solutions, and third-party analytics systems. The architecture supports configurable data export to external platforms through standard protocols and formats.



PowerTrack EMS Cloud UI Hybrid Dashboard

# **Reference Architectures**

PowerTrack EMS supports multiple architecture configurations to meet your project's specific requirements. Our reference designs provide proven, field-tested templates that accommodate diverse deployment scenarios while ensuring optimal performance, reliability, and scalability.

### **Standardized Communication**

Each reference architecture incorporates standardized communication protocols and industrial-grade network infrastructure. PowerTrack EMS supports **Modbus TCP/RTU, DNP3, OPC-UA, IEC61850,** and **IEC60870,** ensuring compatibility with a wide range of equipment manufacturers, optional SCADA systems, and utility interfaces.



# Standalone BESS

PowerTrack EMS delivers comprehensive technical monitoring and management for standalone battery energy storage systems, with flexible integration options that adapt to various battery systems and power conversion systems. The architecture includes intelligent site control, high-speed communication networks, and seamless cloud connectivity. This configuration optimizes performance across multiple operating modes and market applications while ensuring compliance with interconnection requirements.



# **PV Hybrid**

PowerTrack EMS seamlessly orchestrates solar and storage assets in hybrid configurations. The system's PPC coordinates operations between PV and BESS components to maximize energy yield, optimize dispatch, and ensure grid compliance. This architecture enables sophisticated functionalities including solar shifting, smoothing, firming, and clipping recapture while maintaining precise control over energy flows.



- Configurable operating priorities based on market conditions
- Enhanced revenue capture through multi-application stacking
- Optimized battery cycling to extend system lifetime
- Coordinated response to grid events and interconnection •
- requirements •



EMS: Energy Management System UI: User Interface PPC: Power Plant Controller SCADA: Supervisory Control and Data Acquisition PCS: Power Conversion System BESS: Battery Energy Storage System PV: Photovoltaic

# Standalone PV

PowerTrack EMS offers sophisticated control capabilities for standalone solar installations, providing advanced power plant control and grid integration functionality. This architecture leverages intelligent inverter management, meteorological data integration, and grid monitoring to ensure optimal performance and compliance with evolving interconnection requirements.



#### Standalone PV configuration delivers:

- Precise active and reactive power control at the point of interconnection
- Ramp rate control for smooth power transitions
- Dynamic voltage regulation and frequency response
- Curtailment management based on grid conditions or market signals
- Comprehensive monitoring and performance analysis
- Seamless expansion capability for future storage addition



EMS: Energy Management System UI: User Interface PPC: Power Plant Controller SCADA: Supervisory Control and Data Acquisition PV: Photovoltaic

# **Deployment & Commissioning**

### **Project Delivery**

Stem provides comprehensive deployment and commissioning support throughout your project lifecycle, from initial development through commercial operations. Our experienced team ensures successful implementation while maximizing system performance and reliability.

#### **Project Management Excellence**

Each project receives a dedicated Project Manager who serves as your single point of contact, ensuring seamless coordination, proactive issue resolution, and efficient communication throughout all phases. Our structured approach maintains schedule adherence and optimal cost management.

#### **Project Engineering**

Each Project Manager is supported by a team of expert engineers to support design, configuration, and commissioning of the EMS and auxiliary components.

#### Our team delivers:

- Provide EMS, PPC, and SCADA solution support in addition to consulting and standardization services.
- Comprehensive IFC design packages including panel assemblies, network communication, and control diagrams.
- All configurations are completed, tested, and commissioned by a team of Electrical, Networking, and Control system engineers.
- Factory Acceptance Testing (FAT) of controllers, cybersecurity equipment, and SCADA Equipment
- Remote and onsite commissioning.
- Customer Site Acceptance Tests (SAT) and Utility Witness tests.

### Production

All hardware is procured and assembled in Stem's UL-Listed Production Facility located in Longmont, Colorado. Stem prioritizes inassembly configuration and testing, reducing commissioning timelines and improving time-to-data for customers.

### Our team delivers:

- Procurement and assembly of control panels.
- Hardware testing and verification, including pull tests, fuse checks.
- Electrical testing, including wire continuity tests and High Potential testing (Hipot).
- Network configuration and IP checks.
- Edge-to-Cloud configuration and testing, including controllers, firewalls, and cellular devices.

From initial design to final commissioning, Stem's experienced professionals ensure your PowerTrack EMS Solution is properly configured, thoroughly tested, and optimized for long-term performance.

Our structured methodology and extensive experience minimize risk while accelerating your project's path to successful operation.



# Experience

Stem remains the leader in the management of solar, hybrid, and storage assets and portfolios. Together with our customers, we are leading the clean energy transition towards a more resilient energy future.

### **Industry Expertise**

With over 28 GW of solar assets and 6+ GWh of storage assets under management across more than 50 countries, Stem delivers unparalleled expertise in complex hybrid energy systems. Our global presence spans multiple continents with deep market knowledge in diverse regulatory environments and utility interconnection requirements.

### **Dedicated Support**

Our expert team brings specialized assistance in:

- Utility-scale operations and management
- Complex grid integration and compliance
- Regulatory navigation across diverse markets
- Remote commissioning and troubleshooting
- Performance optimization and revenue enhancement
- Comprehensive training and knowledge transfer

With over a decade of experience deploying more than 1,000 systems in the field, our team provides unmatched support from project development through the entire operational lifecycle of your assets.



About Stem, Inc.

# Stem (NYSE: STEM) is a global leader in Al-enabled software and services that enable its customers to develop, deploy, and operate clean energy assets.

Stem offers a complete set of solutions that transform how solar and energy storage projects are developed, deployed, and operated, including an integrated suite of software and edge products, and full lifecycle services from a team of leading experts.

More than 16,000 global customers rely on Stem to maximize the value of their clean energy projects and portfolios. Learn more at stem.com.

To book a meeting contact NA: sales@stem.com EMEA: EMEA-sales@stem.com

