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L1000 Distributed Energy Storage System Product Bulletin

Johnson Controls Distributed Energy Storage 301 North Broadway, Milwaukee, WI 53202

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Introduction

The L1000 Distributed Energy Storage System, as shown in Figure 1, is a complete and scalable, battery-based energy storage system from Johnson Controls®, the global leader in batteries and building systems. Johnson Controls draws on its world-class battery expertise, facilities knowledge, and intelligent controls to handle multiple, concurrent applications and deliver the most economic benefit to customers.

Figure 1: L1000 Distributed Energy Storage System

The L1000 Distributed Energy Storage System is an indoor packaged solution that is appropriate for buildings, campuses, enterprises and utility applications. The L1000 Distributed Energy Storage System employs a modular design for a scalable approach built on a common battery module. Batteries are placed into a rack with Johnson Controls' proprietary controls and embedded software. Rack sizes are variable, depending on the need. The batteries can be inserted, meaning they can be snapped in place without the need for an electrician, which eases service. Battery systems have advanced safety and control features as well as capabilities for back-up power, augmenting variable on-site renewable power, reducing demand charges, and peak or seasonal power rates.

All Johnson Controls Distributed Energy Storage systems are built to integrate into building systems providing unmatched customer value. As a leader in building systems, Johnson Controls has built our Distributed Energy Storage controls to integrate into building systems via industry standard protocols, BACnet® and Modbus®. Johnson Controls' *Metasys*® building automation system serves as the control system for the L1000 Distributed Energy Storage System, ensuring that it delivers the optimal system value while coordinating functions with other building systems. The L1000 Distributed Energy Storage System features and benefits include:

- ***Metasys* and Building Automation System Compatibility:** The workload of managing building systems can be significantly reduced by limiting the number of independent systems which need to be deployed, integrated and operated on a daily basis. The L1000 Distributed Energy Storage System was designed to integrate seamlessly into the *Metasys* building automation system or other legacy building automation system via BACnet® or Modbus® for collective monitoring and control.
- **Building Integration:** An energy storage system is able to provide the most value when operating in coordination with the other major energy consuming assets in a facility. Johnson Controls approach to energy storage is to integrate the battery with the building to optimize whole-building performance. As an example, consider one of the primary applications for these facilities – peak shaving. While the battery alone is a good asset for reducing the building's electrical use peaks, the battery system can use other loads in the building (pre-cooling, cycling air handling units, adjusting chilled water temperature) to increase the response to be much more significant. Leveraging existing assets can enhance the return on investment.
- **Multiple Application Support:** The controls for the L1000 Distributed Energy Storage System allow it to concurrently optimize for the application that provides the greatest economic value to the customer including peak shaving, load shifting, frequency regulation and demand response. The system can also be configured to provide backup power.
- **System Sizing Flexibility:** The scalable design of the L1000 Distributed Energy Storage System means that customers do not pay for storage they do not need. Starting at 500kWh, the L1000 Distributed Energy Storage System can be configured in larger sizes to ensure the right amount of storage is deployed for the customer's site.
- **Utility Compatibility:** Integration with utility systems is required to monetize an energy storage system for certain applications (demand response and frequency regulation applications). The L1000 integrates with these systems via standard utility protocols including DNP3 and Modbus®.
- **Remote System Monitoring:** Johnson Controls extends its remote monitoring and onsite service capabilities to the L1000 Distributed Energy Storage System. Johnson Controls provides local and remote real-time monitoring, diagnostics and control of the energy storage system using cellular networks, wireless Internet monitoring, or 1G Ethernet interface.

Applications of Energy Storage

Energy storage is a very effective technology for supporting buildings with a number of different applications aimed at reducing costs and/or providing revenue:

- **Peak shaving:** Peak shaving is focused on reducing the demand charge kW portion of a building's utility bill. With peak shaving, the battery is charged during periods of low demand (overnight, troughs in the day) and then discharged during periods of high demand when the monthly peak consumption could be set. Given the anticipated cycling, duration and power needs of peak shaving, energy storage is very effective. Figure 2 and Figure 3 are examples of a load profile that has more short duration peaks. Building with this type of energy demand profile can benefit more than buildings with a more consistent load from energy storage. Figure 2 shows a 3-hour energy storage system affecting demand of 3-hours for the shorter duration peaks with a peak reduction of 300kW versus Figure 3 with the long duration peak realizing only 200 kW of reduced demand. The higher the peak related to the duration of the peak (shown on a plot as a well-defined peak vs. a flat load), the better the energy storage economics and the better the application.

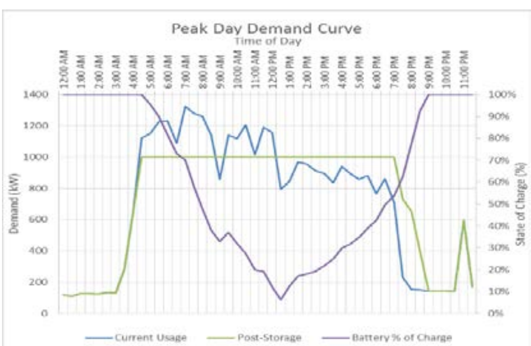

Figure 2: More "Peaky Load" shows 300kW Reduction in Demand

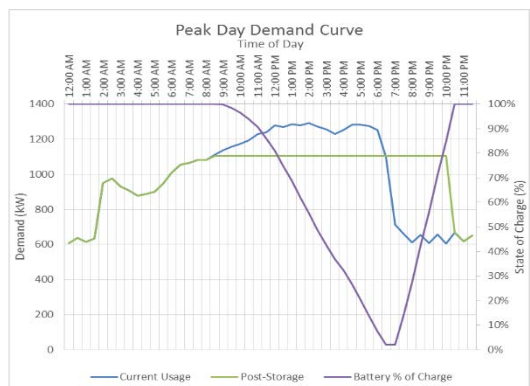

Figure 3: Less "Peaky Load" shows 200kW Reduction in Demand

- **Load shifting:** Load shifting is similar to peak shaving but is more focused on reducing the kWh portion of a utility bill. Load shifting effectively captures the difference between buying energy at low prices and discharging it at higher prices. Load shifting typically provides incremental value to a system that is providing other functionality like peak shaving. An energy storage system is very effective for this as well, similar to peak shaving and is illustrated in Figure 3.
- **Frequency regulation:** Energy storage systems have proven to be a great asset to support frequency regulation (FR). FR is a service that can be provided by buildings to support the grid as it tries to balance supply and demand and maintain 50 Hz or 60Hz depending on the region. Battery systems are well suited as they are able to either absorb excess power or contribute power quickly to help balance frequency.
- **Resiliency/backup:** To improve the resiliency of buildings, batteries play a key role as they can serve as a bridge from renewable energy generation to carbon-based generation and they can act quickly if there is a loss of power. Storage paired with renewable energy sources provides firmness to the renewable energy capacity and can also provide increased resiliency.
- **Power Quality Improvements:** The use of a four-quadrant power conditioning system can increase the power factor off a building's load which may positively impact the demand charge for the facility.

Product Overview

The Johnson Controls L1000 Distributed Energy Storage System is a standalone energy storage system that is intended to be installed indoors and connected to the customer's electrical service. Depending upon customer needs, the system can be purchased as individual components or integrated into a single system. The physical size of the system varies by the amount of energy capacity contained in the system. The L1000 Distributed Energy Storage System can be distributed across a building or a campus allowing these systems fit with existing facilities while operating like a single larger system. This concept of creating a Virtual Power Plant (VPP) by aggregating and dispatching small L1000 systems together eliminates the need to find a large area to house the system and allows future expansion. Figure 4 displays a block diagram of an L1000 Distributed Energy Storage System.

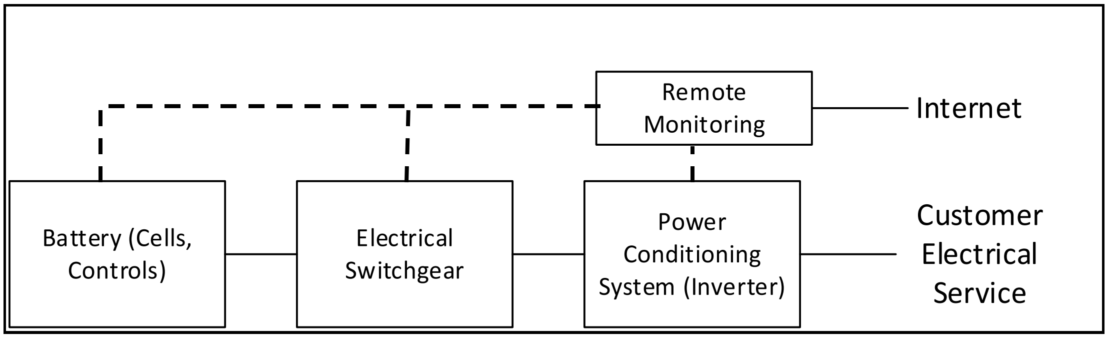

Figure 2: L1000 Distributed Energy Storage System Block Diagram

Battery

The battery is the main component of the L1000 Distributed Energy Storage System. As shown in Figure 5, a battery consists of three main pieces including:

- Battery cells that store energy.
- Battery modules that hold a set of battery cells.
- Battery management system that controls the flow of the energy into and out of the batteries.
- Battery rack that holds the battery components.

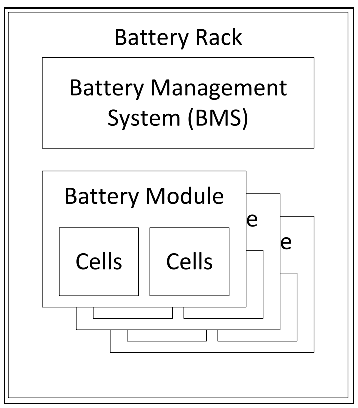

Figure 3: Battery Block Diagram

A battery consists of many battery cells, enclosed in a set of battery modules. A battery management system controls the flow of energy into the cells. The energy holding capacity of a battery cell is dependent upon the materials used in the battery cell. Johnson Controls offers multiple types of battery cells. The main chemistry makeup of batteries is Lithium Ion technology. Johnson Controls offers an energy cell that is optimized to charge/discharge slowly over a period of 4 or more hours, and a power cell that is optimized to charge/discharge quickly over a period of 30 or more minutes. Table 1 presents the battery cell characteristics. By supporting multiple cell types, the L1000 Distributed Energy Storage System can be tailored to its application.

Table 1: Battery Characteristics

Characteristic	Energy Cell	Power Cell	Units
Capacity @ 25° C	63	63.9	Ah
Total Energy @ 25° C	236	234	Wh
Energy Density (gravimetric)	193	202	Wh/kg
Temperature Range	-30 to +60 -22 to +140	-30 to +60 -22 to +140	°C °F
Li-ion Chemistry	NMC/Graphite	NMC/Graphite	
Min Full Discharge Time	1	0.5	hrs
Min Full Charge Time	1	0.5	hrs

The building block of a battery system is the battery module. The battery module houses and interconnects a set of battery cells and creates the smallest replaceable unit in a battery. Johnson Controls offers an energy module and a power module. The modules are designed to be characterized by the National Electrical Code (NEC) as low voltage devices so that special electrical handling is not required. Table 2 displays the battery module characteristics. Different modules contain the ability to store 6 kWh of total energy in a package that can be handled without special electrical training.

Table 2: Battery Module Characteristics

Characteristic	Energy Module	Power Module	Units
Capacity @ 25° C	126	128	Ah
Total Energy @ 25° C	6.5	6.6	kWh
Nominal Voltage	49.7	51.5	Vdc
Voltage Range	42 – 58.8	42 – 59.5	Vdc
Dimensions (W x H x D)	445 x 110 x 578 17.5 x 4.33 x 22.75	445 x 110 x 592 17.5 x 4.33 x 23.3	mm in
Weight	47 104	47 104	kg lbs
Part Number	EM6	PM6	

A battery management system controls the flow of energy into the cells. The energy holding capacity of a battery cell is dependent upon the materials used in the battery cell. Johnson Controls offers multiple types of battery cells with different chemistries. The main chemistry makeup of batteries is Lithium Ion technology. Johnson Controls offers an energy cell that is optimized to charge/discharge slowly over a period of 4 or more hours, and a power cell that is optimized to charge/discharge quickly over a period of 30 or more minutes. The final component of a battery is the battery rack. This component houses the battery to provide structural integrity and provides space for cooling the batteries.

Johnson Controls offers three energy racks and two power racks. Some racks have higher energy density for applications where space is limited. Table 3 displays the battery rack characteristics.

Table 3: Battery Rack Characteristics

Characteristic	Energy Racks			Power Racks		Units
Total Energy @ 25° C	45	91	137	46	92	kWh
Nominal Voltage	725	725	725	721	721	Vdc
Voltage Range	588 - 823	588 - 823	588 - 823	588 - 823	588 - 823	Vdc
Dimensions (W x H x D)	520 x 1880 x 425 20.5 x 74 x 16.7	520 x 2000 x 670 20.5 x 78.8 x 26.4	520 x 2000 x 945 20.5 x 78.8 x 37.2	520 x 1880 x 425 20.5 x 74 x 16.7	520 x 2000 x 670 20.5 x 78.7 x 26.4	mm in
Weight	435 959	707 1559	1305 2877	472 1040	758 1671	kg lbs
Part Number	BU-50E	BU - 100E	BU-125E	BU-50P	BU-100P	

Power Conditioning System

In energy storage systems like the L1000 Distributed Energy Storage System, equipment that converts battery energy, which is direct current (DC) to alternating current (AC) energy used in a facility or electric grid, is called a Power Conditioning System (PCS). Within this industry, a PCS is sometimes called a storage inverter (or bi-directional inverter) since it performs the same function as a photovoltaic (PV) inverter (converts from DC to AC) in addition to being able to charge the battery (converts from AC to DC). Customers can order an L1000 Distributed Energy Storage System either with or without a PCS. Johnson Controls can supply the PCS, but some customers have their standard PCS vendors. The battery is ordered using a Battery Unit (BU) product code (for example, BU-100P) while a PCS can be ordered using a PCS product code (for example, PCS-250).

The size of the PCS is measured by its Continuous Output Power, which is the power that can be continuously supplied by the PCS to the facility. When matched to the capacity of the Battery Unit, the nominal duration of the system can be determined. For example, if a PCS-250 with a 250 kW continuous output is attached to a BU-1000 battery which has a 1 MWh capacity, then the nominal duration of the system is 4 hours (1000 kWh/250 kW = 4 hrs). The PCS offered by Johnson Controls all match the L1000 Distributed Energy Storage System batteries, but not all BUs can be connected to any PCS. Caution should be used when a customer supplied PCS is connected to an L1000 Distributed Energy Storage System Battery Unit since a BU needs to match to the PCS characteristics for proper operation. The matching is dependent upon the battery voltage output and the PCS voltage input and the expected output of the system. To remove some of this confusion, Johnson Controls offers System Unit (SU) products that combine a matched BU with a matched PCS. As shown in Table 4, the L1000 Distributed Energy Storage System can be purchased with one of four PCS options. Other PCS options are possible. Please consult with Johnson Controls for available options suited to your needs and power requirements.

Table 4: L1000 Distributed Energy Storage System PCS Characteristics

Characteristic	PSC-50	PCS-125	PSC-250	PCS-500
Continuous Output Power, (kVA/kW)	50/50	125/125	263/250	609/560
Frequency (Hz)	50/60			
Nominal Utility Grid Voltage, (Vac))	480 Vac, 60 Hz, 3P, 4 wire WYE interconnection			

Electrical Switchgear

Between the BU portion of the L1000 Distributed Energy Storage System and the PCS is the electrical equipment that routes energy and allows portions of the system to be isolated for maintenance and service. Within the industry, a PCS is sometimes called a storage inverter (or bi-directional inverter) since it performs the same function, for example, as a photovoltaic (PV) inverter (converts from DC to AC) in addition to being able to charge the battery (converts from AC to DC). The electrical switchgear consists of electrical wiring or bus bars, isolation and fault detection equipment, and disconnect switches. Bus bars are electrical conductors that carry the electrical current from the battery to the inverter. Isolation and fault detection equipment are safety devices that ensure that the L1000 Distributed Energy Storage System shuts down if there is ever a potential electrical short in the system. Disconnect switches isolate the battery from the PCS and the PCS from the customer's electrical grid to prevent unsafe conditions during system maintenance. Equipment size and electrical characteristics depend on system storage capacity. System storage capacity requirements are based on the specific application involved and the size of the facility where the system will be installed.

Remote Monitoring

The L1000 Distributed Energy Storage System is designed to be monitored remotely to ensure proper operation and provide alerts, using taskbar icons, email, text messages, or a remote operation center, based on user-configurable warning and alarm levels.

Two options to connect the L1000 system with a remote monitoring center including:

- Via the Internet on a customer owned network.
- Via Wi-Fi, cellular, or hardwired ethernet through an Internet service provider.

Heating, Ventilation, and Air Conditioning (HVAC)

The L1000 Distributed Energy Storage System performs at optimal efficiency around a specified temperature range. The operating temperatures of the different battery racks are in a range of approximately 25º C/77 ºF. HVAC system size depends on system storage capacity. System storage capacity requirements are based on the specific application and the size of the facility involved. Table 5 lists the L1000 System Environmental Characteristics.

Table 5: L1000 Distributed Energy Storage System Environmental Characteristics

Characteristic	Energy Racks	Power Racks	Units
Recommended Operating Temperature	+18 to +28 +64 to +82	+18 to +28 +64 to +82	ºC ºF
Operating Temperature	-10 to +40 +14 to +104	-10 to +40 +14 to +104	ºC ºF
Storage Temperature	-25 to +70 -13 to +158	-25 to +70 -13 to +158	ºC ºF
Max Relative Humidity	< 95%	< 95%	%
Operating Elevation	< 3000 < 9842	< 3000 < 9842	m ft

L1000 Distributed Energy Storage System Sizes

Customers can order one of two system sizes to accommodate their needs including battery only or integrated system. The integrated System Units (SU) includes a battery rack, switchgear, and an inverter as a single package. If the sizes offered do not meet a customer's needs, multiple L1000 BUs can be interconnected. The Distributed Energy Storage System Sizing Tool can be used to determine the required storage capacity for a particular customer. Table 6 lists the standard L1000 BU and SU models.

Table 6: L1000 Distributed Energy Storage System Battery Models

Model	Energy (E)	Power (P)	PCS
BU-50	45 kWh	46 kWh	None
BU-100	91 kWh	92 kWh	None
BU-125	137 kWh	N/A	None
Model	**Energy (E)**	**Power (P)**	**PCS**
SU-50/50	45 kWh	46 kWh	50 kW
SU-50/100	91 kWh	92 kWh	50 kW

Multiple racks of smaller batteries are connected together to create a larger battery. For example, a 500 kWh battery could be created by wiring together six 91 kWh (BU-100) battery racks.

Compatibility

The L1000 Distributed Energy Storage System is designed to be compatible with the electrical systems found in commercial buildings and interconnect to a building control system and/or a utility control system. Customers can monitor the L1000 Distributed Energy Storage System through the *Metasys* building automation system or other BACnet® enabled control system. In addition, a Cloud-based interface is provided for remote system monitoring. Utilities can monitor the L1000 Distributed Energy Storage System using standard utility protocols communicating to the controls within the L1000 Distributed Energy Storage System.

Specifically, the L1000 Distributed Energy Storage System supports the following interfaces:

- Utility systems integration via DNP3 and OpenADR standard protocols.
- Building Automation system integration via BACnet® protocol.
- Battery, PCS and balance of system device integration via Modbus®, ModbusTCP, and CAN standard protocols.
- Remote monitoring and VPP integration via HTTPs/RESTful API.

Controls

Johnson Controls Energy Storage Controls provide a modular cloud based software suite of energy storage applications and intelligent energy analytics. Controls can be ordered as a single application configuration or as a co-optimized, multi-energy storage application suite that can aggregate the building and battery as a combined energy storage resource.

The Johnson Controls system is for building integrated applications. The core of the system is a turnkey energy storage operating system which integrates the key system components, provides standards-based connectivity and native integration into the *Metasys* controls. The operating system uses a Network Integration Engine (NIE) to provide alarming and trending. All subsystems (PCS, security, fire) are preconfigured and automatically integrated into the *Metasys* system via Modbus®/ BACnet®. This enables the customer to leverage their investment *Metasys* system and provides a field tested, turnkey energy storage system.

On top of the operating system are model-predictive controls which use historical data from the building automation system to develop a day-ahead load profile. The day-ahead load profile prepares by assessing the weather, occupancy schedules, holiday schedules, real time pricing data and the way the building and its largest energy consuming assets operate.

After compiling the assessment, the control system then determines the most economically valuable deployment of the energy storage system, along with other building assets. For example, if the control system determines that the load tomorrow is likely to set a peak, it reserves the full capacity of the storage system for the period when that is likely to occur. If the day is not determined to be a peak day, the control system anticipates the value of other services (like ancillary services or demand response) and chooses to participate in those services.

The final piece is that the control system does this operation in combination with building mass, effectively making the building a larger battery. There is significant value in being able to leverage the mass of the building (walls, tables, carpet) to store thermal energy to have a far more pronounced response to a demand event. Leveraging building systems along with the battery provides the most optimal sizing and deployment of energy storage systems in behind-the-meter applications.

Controls Architecture

Figure 6 shows an example of the *Metasys* system configuration that includes an L2000 and L1000 Distributed Energy Storage System.

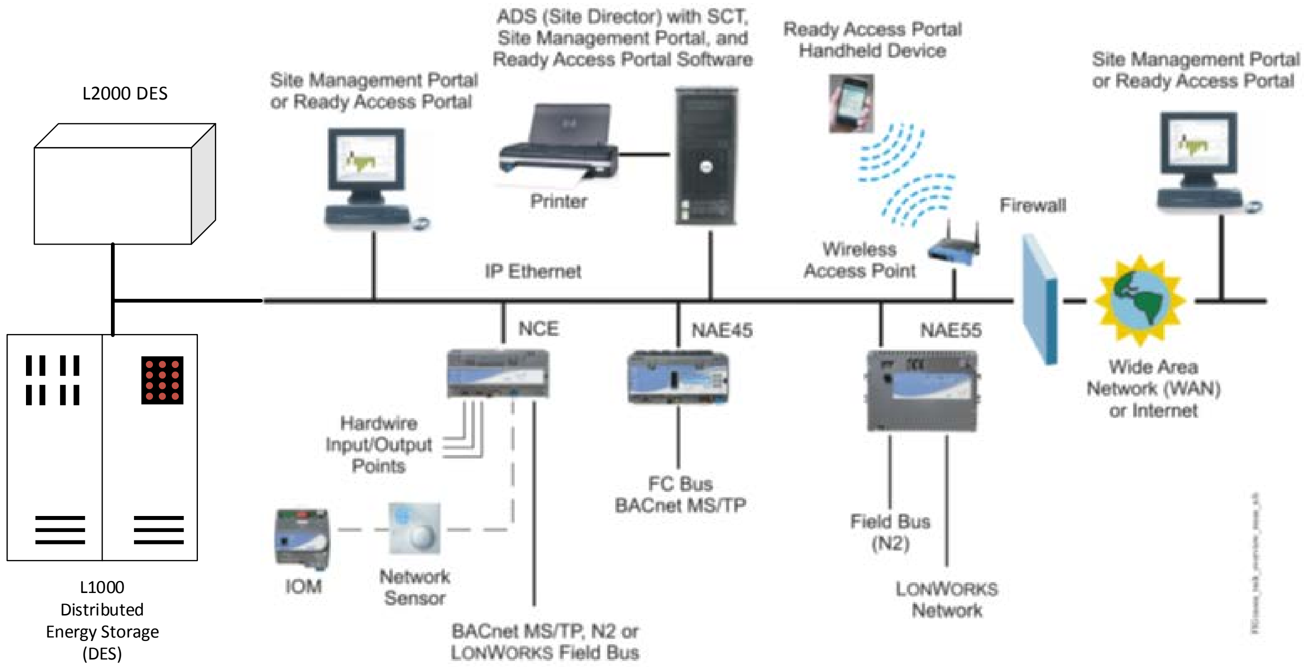

Figure 4: Example Metasys System Configuration

Utility Systems Integration

Johnson Controls L1000 Distributed Energy Storage System can communicate directly to a utility, Demand Response Aggregator, or ISO Market Participant in order to participate in utility incentive programs and markets. Since electrical energy needs to be consumed as it is produced, there are number of programs that are designed to allow customers help a utility match its electrical supply to the customer electrical demand. These programs provide an incentive to reduce power consumption based upon a utility signal or a market that allows participants to bid in to provide a set of energy centric utility services. To enter these markets, the L1000 Distributed Energy Storage System has a set of communications options that allow a utility or its agent to control the charge/discharge of the system. For direct utility communications, the L1000 Distributed Energy Storage System can act as a DNP3 client over TCP/IP. DNP3 is an open, standards-based communications protocol between Intelligent Electronic Devices (IEDs) like the L1000 Distributed Energy Storage System and utility control stations for the electric utility industry.

Remote Systems Monitoring

The L1000 Distributed Energy Storage System is designed with remote monitoring in mind. This enables the Johnson Controls operations team or a designated service provider with real time monitoring as well as the collection historical verification data. Remote monitoring collects both subsecond interval data and change of value telemetry and alarm data. A standards based identity management system provides secure authentication and authorization to assure the right users have access to the right data. A remote monitoring user interface provides the following system views:

- **Secure Authentication Screen –** Provides Active Directory authentication and access to site and role specific information. Figure 7 shows the Secure Authentication Screen.

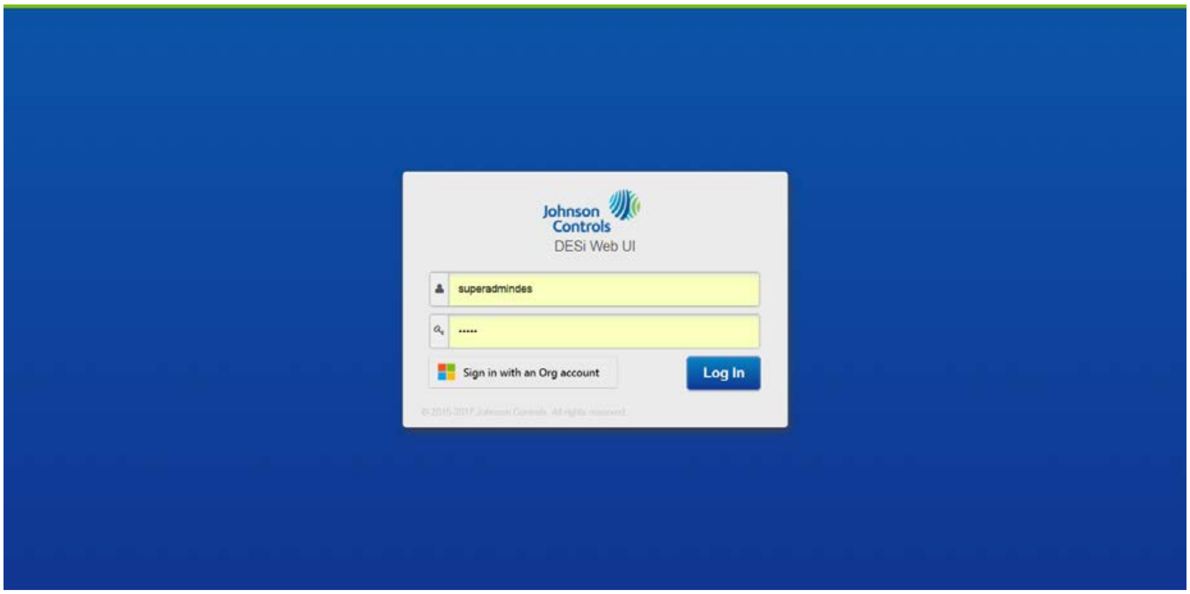

Figure 5: Secure Authentication Screen

- **Mapview Screen –** Provides an at-a-glance view of all sites mapped to their location. Each mapped site is color coded to indicate its state and provide an operator a summary view of the state of the systems they are authorized to view. Tooltips show additional site details and links to view detailed information. Figure 8 presents a mapview screen.

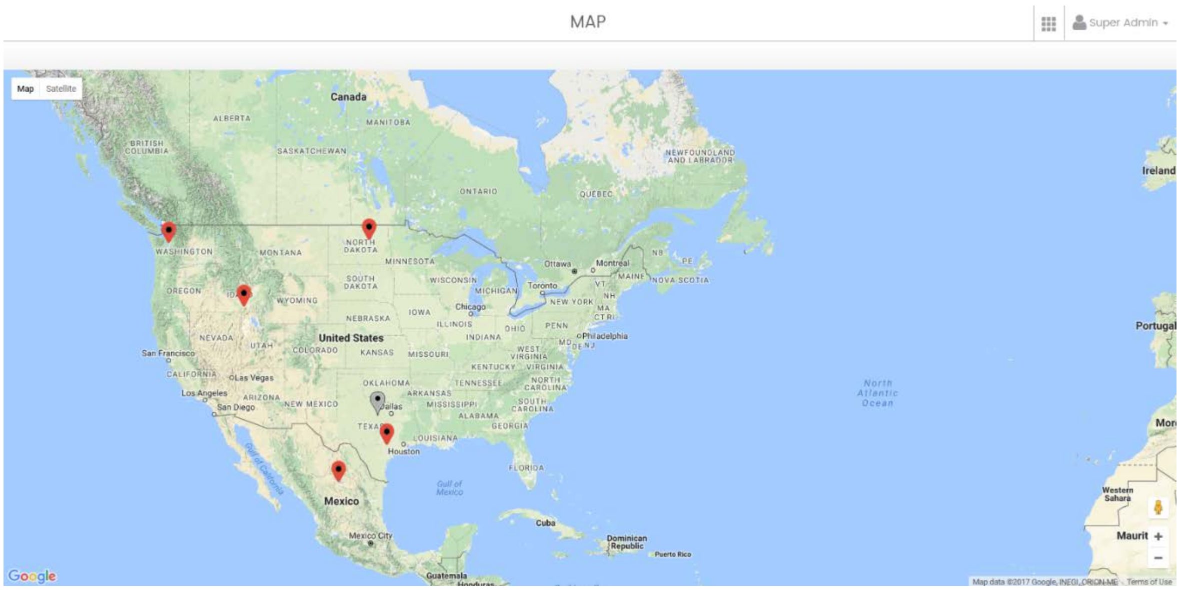

Figure 6: Map View

- **Overview Screen –** Provides an executive summary of the aggregated data within a VPP or a specific site. Energy, power, state of health, alarm and key performance indicator trends are displayed and updated in real time. Figure 9 displays the DES Overview screen.

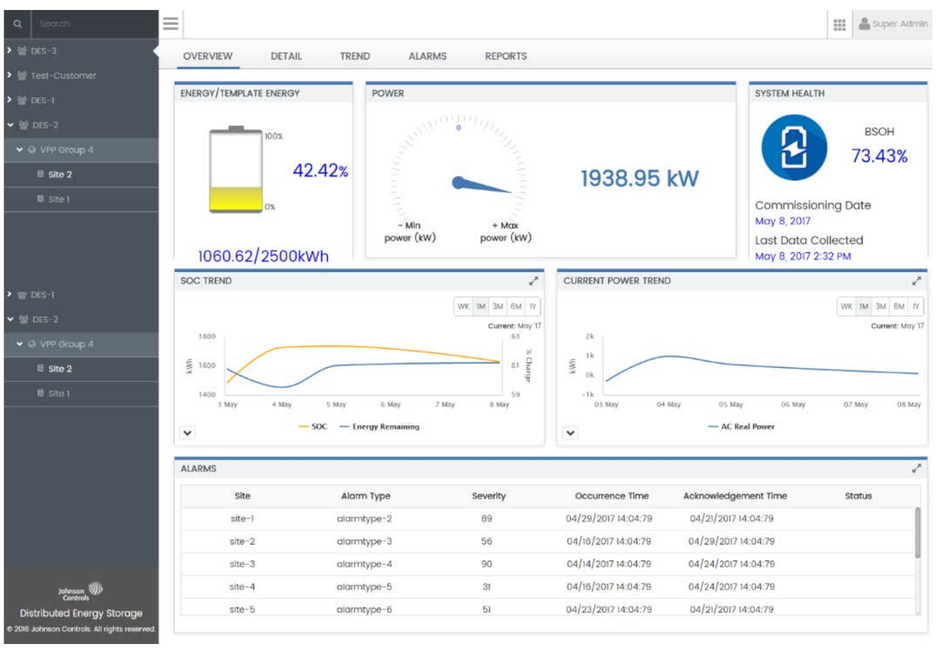

Figure 7: DES Overview

- **Details Screen –** Provides a detailed view of all telemetry points collected from the combined systems (battery, PCS, enclosure, security, and environment). Figure 10 illustrates the DES Details screen.

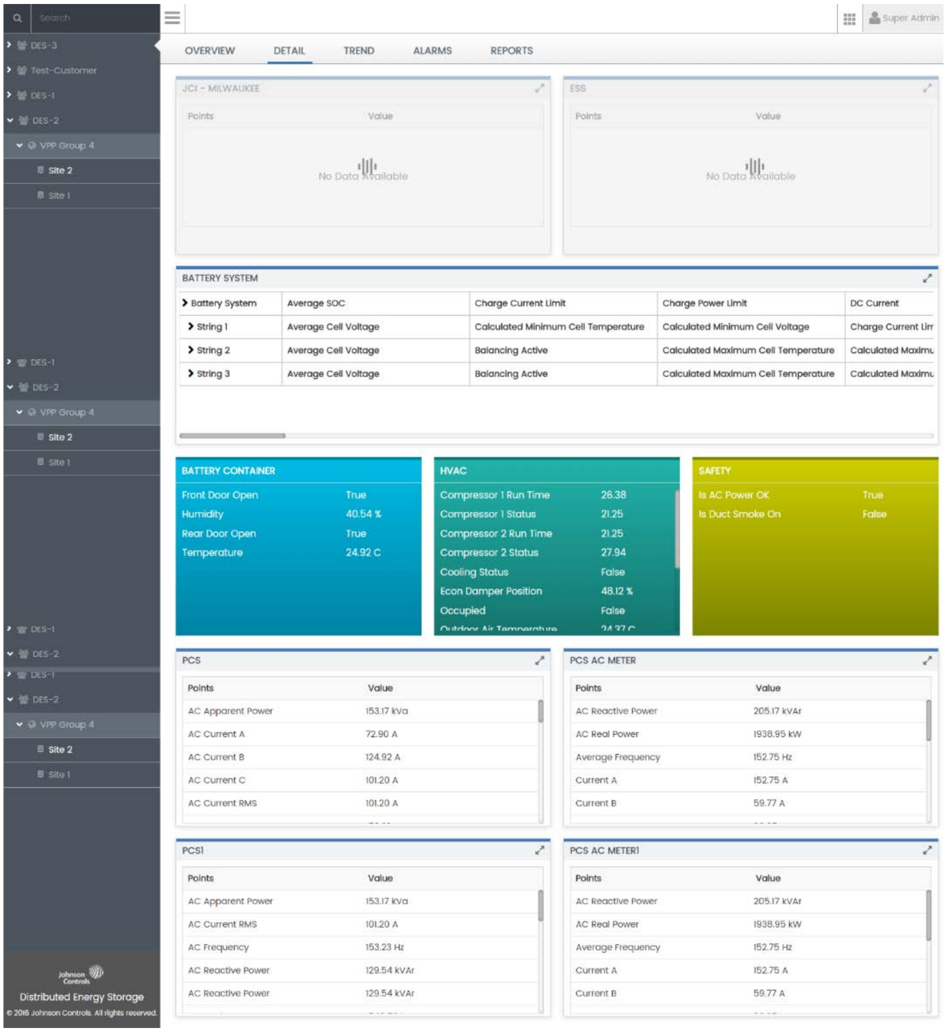

Figure 8: DES Details screen

- **Trend Screen –** Provides ad hoc charting of any telemetry points. The user is able to select multiple telemetry points and timeframe and plot each on an ad hoc trend. Users can save trend configurations for future use. Figure 11 illustrates the DES Trend screen.

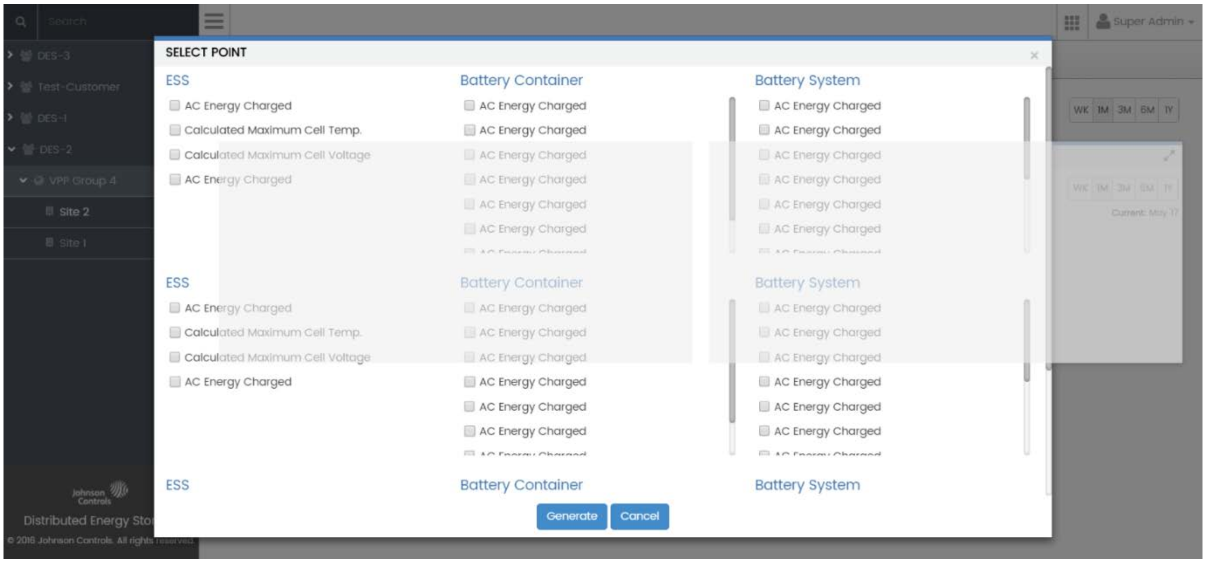

Figure 9: DES Trend screen

- **Alarm Screen –** Provides a detailed summary view of all alarms, faults, and warnings collected from connected devices, applications, and communication busses. Aggregate views show state of alarms for each site, site views show alarm description, timestamp of alarm event and clear event, as well as alarm priority. Figure 12 displays the Alarm screen.

ALARMS

Site	Alarm Type	Severity	Occurrence Time	Acknowledgement Time	Status
Site 1	alarmtype-1	101	04/28/2017 09:04:43	04/28/2017 09:04:43	On
Site 2	alarmtype-2	39	04/22/2017 09:04:43	04/19/2017 09:04:43	Off

Figure 10: Alarm screen

- **Reports Screen –** Provides a configuration page to generate a custom report. Custom reports can be used for performance validation, troubleshooting, and KPI verification. Reports can be generated by alarm, telemetry point, or device type as well as time and date range filters. Figure 13 displays the DES Reports screen.

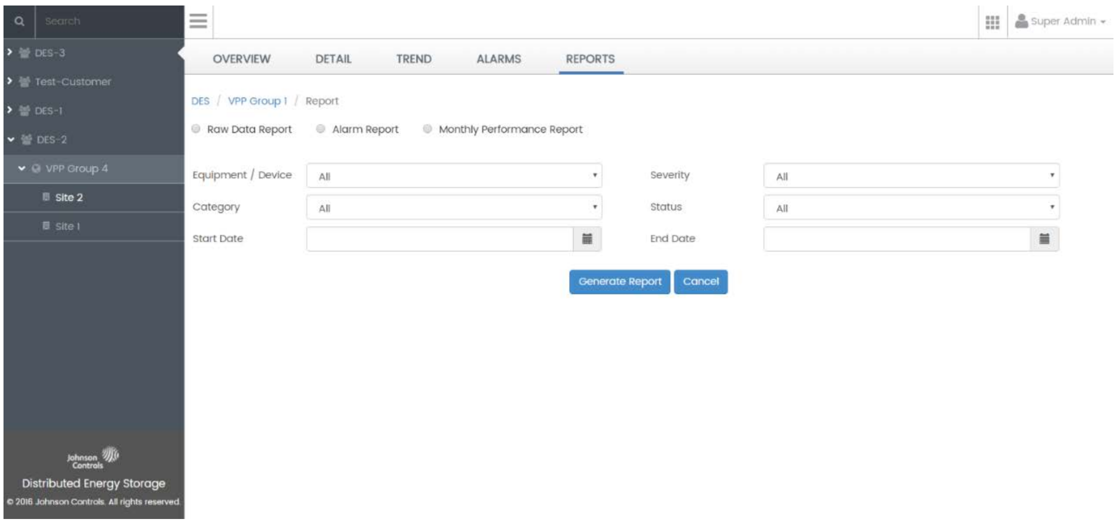

Figure 11: DES Reports Screen

Battery to Building Interconnection

To maximize the benefits of the system, the L1000 Distributed Energy Storage System should be integrated directly into the Johnson Controls *Metasys* system extended architecture Building Control System (BCS). After integrated, the L1000 Distributed Energy Storage System becomes another asset used in managing a facility's energy performance. By interconnecting the L1000 Distributed Energy Storage System to the *Metasys* system, the performance of *Metasys* standard applications like Demand Limiting can be enhanced by using the L1000 Distributed Energy Storage System as an energy source to reduce energy consumption at critical times. When using the advanced applications provided by the L1000 Distributed Energy Storage System controls software, the integrated system can optimize the whole building performance and simplify participation in energy markets.

The *Metasys* system extended architecture is an Internet-based system that allows day-to-day building operators using a browser to access the system's user interface. The *Metasys* system user experience is a portal into a site. It can be tailored to fit the needs of all potential system users. The user experience provided by the *Metasys* system can evolve and scale to match the needs of any single facility or campus of multiple buildings.

A *Metasys* site comprises one or more *Metasys* devices on a continuously connected IP network. A site's primary network consists of one or more engines. Engines can be Network Automation Engines (NAEs), Network Integration Engines (NIEs), Network Control Engines (NCEs) or Lonworks Control Servers (LCSs). These engines are described in further detail in the *Metasys* system literature. The L1000 Distributed Energy Storage System controls is interconnected directly to this network and communicates as a peer to the *Metasys* devices. When interconnected, the data within the L1000 Distributed Energy Storage System is displayed, acts, and can be manipulated in the same manner as any of the *Metasys* devices. It can be included in any *Metasys* control scheme using the same rules as any other *Metasys* device.

Degradation/Augmentation

The energy storage capacity of a battery cell degrades with use. The amount of degradation is dependent upon how often the system is used and other environmental characteristics. Figure 14 displays two capacity retention examples; one based on 30 full charge/discharge cycles per year and one based on 365 full charge/discharge cycles per year. For both examples, two curves are shown: an expected capacity retention curve and a warranty curve. The expected capacity retention curve is the anticipated degradation of the original system over the life. If a customer chooses to purchase an extended warranty, the warranty curve serves as the basis that the degradation is measured against. This means that the warranty covers slightly less capacity than the anticipated performance.

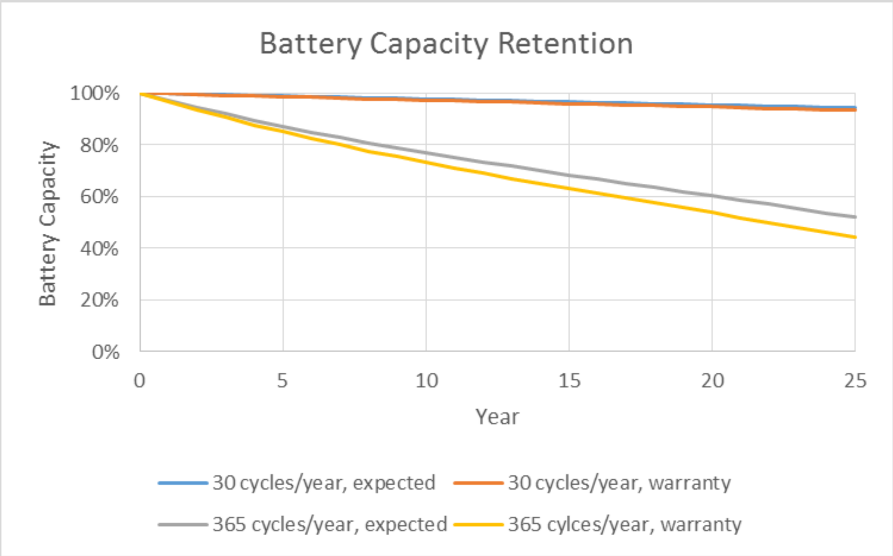

Figure 12: Battery Capacity Retention

To offset anticipated degradation of a battery system augmentation is a typical strategy. Augmentation is the process of adding additional capacity at select times to the system to ensure it meets a customer-desire threshold for total capacity. Figure 15 shows two strategies for providing a minimum battery capacity, 9MWh in this example. The first strategy does not include augmentation, but instead provides substantial oversizing of the battery. In the second case, the battery capacity is augmented twice in order to retain the required capacity. As a result, the initial battery size is smaller. As part of the system modelling, Johnson Controls will provide a recommended approach to ensuring capacity that meets the financial needs of the customer.

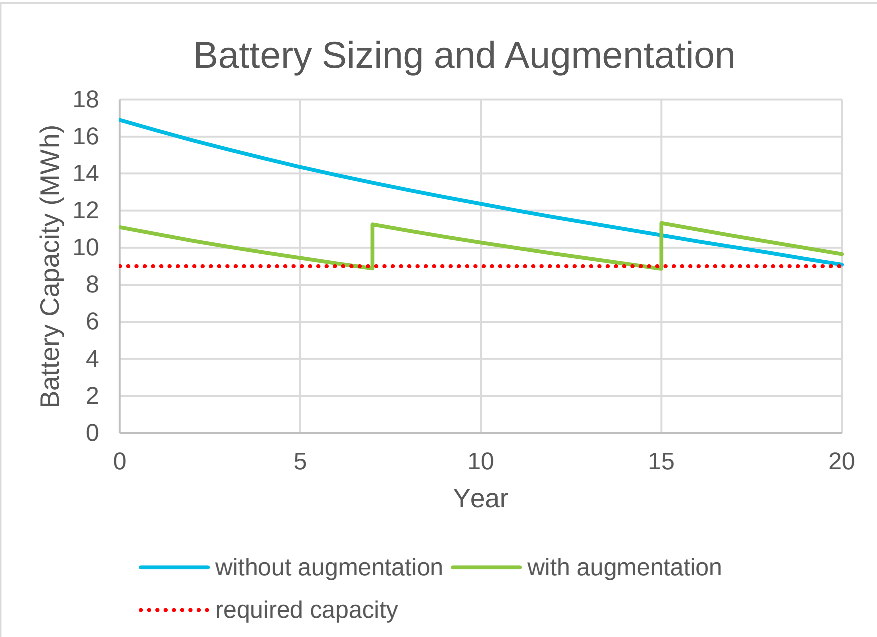

Figure 13: Battery Sizing and Augmentation

System Sizing Tool

Determination of the optimal storage system requirements for a given site requires an energy modeling system. Johnson Controls has a well-developed software tool that determines the optimal size of a storage system given the building constraints and energy profile. To ensure the energy storage system delivers the modelled results, it is important that the actual control methodology used in delivering value should be modeled rather than a generic expected function. Johnson Controls tools evaluate total value of an energy storage system including the rate of degradation given expected use profile for the energy storage system. Augmentation of storage over time will be related to the expected number of cycles that the application requires and the expected degradation rate of the batteries. Consideration of battery life is critical to understanding the total benefit versus total cost.

Technical Specifications

Table 7 provides the L1000 Distributed Energy Storage System Energy Battery Units specifications.

Table 7: L1000 Distributed Energy Storage System Energy Battery Units specifications

Characteristic	BU-50E	BU-100E	BU-125E
Nameplate Storage Capacity (kWh)	45	91	137
Usable Storage Capacity (kWh)	40.5	81.9	123.3
Maximum Charging Power (kW)	45	91	137
Maximum Discharging Power (kW)	45	91	137
Output Power (kW)	Dependent upon PCS Selected, See PCS Specifications		
DC Voltage Range (Vdc)	588 - 823	588 - 823	588 - 823
AC Output Voltage (Vac)	Dependent upon PCS Selected, See PCS Specifications		
Aux Power Input (Vac)	24 Vdc, 250W (max)		
Building Interface *[optional]*	Johnson Controls *Metasys* system, ASHRAE BACnet®		
System Monitoring	Local and Remote		
Operating Temperature	0 ºC to +40ºC (System derates if temperature is below 18ºC or above 28ºC) +32 ºF to +104 ºF (System derates if temperature is below +64ºF or above +82ºF)		
Operating Humidity	5% - 85% Relative Humidity, Non-Condensing		
Dimensions (W x H x D) (mm/in)	520 x 1880 x 425 20.5 x 74 x 16.7	520 x 2000 x 670 20.5 x 78.8 x 26.4	520 x 2000 x 945 20.5 x 78.8 x 37.2
Weight (kg/lbs)	435 / 959	800 / 1764	1305 / 2877

Table 8 displays the L1000 Distributed Energy Storage System Power Battery Unit specifications.

Table 8: L1000 Distributed Energy Storage System Power Battery Unit specifications

Characteristic	BU-50P	BU-100P
Nameplate Storage Capacity (kWh)	46	92
Usable Storage Capacity (kWh)	41.4	82.8
Maximum Charging Power (kW)	92	184
Maximum Discharging Power (kW)	92	184
Output Power (kW)	Dependent upon PCS Selected, See PCS Specifications	
AC Output Voltage (Vac)	Dependent upon PCS Selected, See PCS Specifications	
Aux Power Input (Vac)	24 Vdc, 250W (max)	24 Vdc ,250W (max)
Building Interface *[optional]*	Johnson Controls *Metasys system*, ASHRAE BACnet®	
System Monitoring	Local and Remote	

Characteristic	BU-50P	BU-100P
Operating Temperature	0 °C to +40°C (System derates if temperature is below 18°C or above 28°C) +32 °F to +104 °F (System derates if temperature is below +64°F or above +82°F)	
Operating Humidity	5% - 85% Relative Humidity, Non-Condensing	
Dimensions (W x H x D) (mm / in)	520 x 1880 x 425 20.5 x 74 x 16.7	520 x 2000 x 670 20.5 x 78.7 x 26.4
Weight (kg/lbs)	472 1040	758 1671

Table 9 presents the L1000 Distributed Energy Storage System PCS System Unit specifications.

Table 9: L1000 Distributed Energy Storage System PCS System Unit specifications

Characteristic	SU-50/50E	SU-50/50P	SU-50/100E	SU-50/100P
Nameplate Storage Capacity (kWh)	45	46	91	92
Usable Storage Capacity (kWh)	40.5	41.4	81.9	82.8
Maximum Charging Power (kW)	50	50	50	50
Maximum Discharging Power (kW)	50	50	50	50
Output Power (kW)	50	50	50	50
AC Output Voltage (Vac)	480, 60 Hz, 3P, 4 wire WYE interconnection			
Aux Power Input (Vac)	24 Vdc, 250W (max)			
Building Interface *[optional]*	Johnson Controls *Metasys system*, ASHRAE BACnet®			
System Monitoring	Local and Remote			
Operating Temperature	0 °C to +40°C (System derates if temperature is below 18°C or above 28°C) +32 °F to +104 °F (System derates if temperature is below +64°F or above +82°F)			
Operating Humidity	5% - 85% Relative Humidity, Non-Condensing			
Dimensions (W x H x D) (mm/in)	1460 x 1880 x 585 57.5 x 74 x 23	1460 x 1880 x 585 57.5 x 74 x 23	1460 x 1880 x 670 57.5 x 74 x 26	1695 x 2080 x 600 66.7 x 82 x 23.6
Weight (kg/lbs)	925 2040	888 1958	1253 2762	1211 2670

Table 10 presents the L1000 Distributed Energy Storage System PCS Characteristics.

Table 10: L1000 Distributed Energy Storage System PCS Characteristics

Characteristic	PCS-50	PCS-125	PCS-250	PCS-500
Continuous Output Power, (kVA/kW)	50 / 50	125 / 125	263 / 250	609 / 560
Frequency (Hz)	50 / 60			
Nominal Utility Grid Voltage, (Vac)	480, 60 Hz, 3P, 4 wire WYE interconnection			
Power Factor Range (±)	0.5 lead or lag			

Characteristic	PCS-50	PCS-125	PCS-250	PCS-500
Total Harmonic Distortion (THD) @ Full Power (%)	< 5			
DC Voltage Range (Vdc)	550 - 850	550 - 850	550 - 850	550 - 850
Maximum Efficiency (%)	96	96	96	98.9
CEC (%)	TBD	TBD	NA	98.5
Max Consumption (VA)	1516 (1 sec)/835	3227 (1 sec)/1455	TBD	TBD
Standby Consumption (W)	370	370	TBD	TBD
Grid Forming	Optional	Optional	Yes	No
Regulatory Listings	UL-1741/UL-1547	UL-9540/UL-1547	UL-9540/UL-1742	UL-9540/UL-1743
Marking	TBD	CE	CE, ETL	CE, ETL
Operating Temperature	-20°C to 40°C -4°C to 104°C			
Operating Humidity	0% - 95% Relative Humidity, Non-Condensing			
Altitude	De-rated over 2,000m above sea level			
Audible Noise (dBA @ 1 m)	< 55	< 55	< 65	< 77
Dimensions (W x H x D) (mm / in)	940 x 610 x 585 37 x 24 x 23	1270 x 2032 x 1524 50 x 80 x 60	915 x 966 x 1982 36 x 38 x 78	2820 x 889 x 2261 111 x 35 x 89
Approx. Weight (kg/lbs)	453/1000	2100/4630	2000/4410	1600/3530

Ordering Information

Table 11 provides the L1000 Distributed Energy Storage System ordering information.

Table 11: L1000 Distributed Energy Storage System Ordering Information

Battery Units	Description
L1000-BU-50E	47 kWh Energy Battery
L1000-BU-100E	91 kWh Energy Battery
L1000-BU-125E	137 kWh Energy Battery
L1000-BU-50P	46 kWh Power Battery
L1000-BU-100P	92 kWh Power Battery
System Units	**Description**
L1000-SU-50/50E	47 kWh Energy Battery with 50kW inverter
L1000-SU-50/100E	91 kWh Energy Battery with 50kW inverter
L1000-SU-50/50P	46 kWh Power Battery with 50kW inverter
L1000-SU-50/100P	92 kWh Power Battery with 50kW inverter
Power Conditioning System	**Description**
L1000-PCS-50	480 VAC, 50 kVA Bidirectional Inverter
L1000-PCS-125	480 VAC, 125 kVA Bidirectional Inverter
L1000-PCS-250	480 VAC, 250 kVA Bidirectional Inverter

Power Conditioning System	Description
L1000-PCS-500	480 VAC, 500 kVA Bidirectional Inverter
Remote Monitoring Units	**Description**
L1000-RMU-CELL	Cellular network remote monitoring interface
L1000-RMU-WIFI	Wireless Internet monitoring interface
L1000-RMU-ETH	1G Hardwired Ethernet interface

Warranty Information

In order to ensure the proper operation of its L1000 Distributed Energy Storage System products according to specifications, Johnson Controls backs all its Distributed Energy Storage System products with standard warranties which protect customers in the event of design or manufacturing defects over the specified term. In addition to its standard warranty, Johnson Controls offers extended performance warranties for periods of up to 10 years. Benefits and terms of the extended warranties, which can include product capacity, availability and performance guaranties, are dependent upon the configuration and intended application.

End of Life Information

All batteries lose capacity over time and need to be replaced. When discarded, batteries can contribute to landfills and can potentially cause environmental concerns. Johnson Controls believes in environmental stewardship and has helped create a recycling system that ensures millions of vehicle batteries are properly recycled and avoid landfills. Currently, in the US and Europe more than 95 percent of conventional vehicle batteries are recycled. As advanced batteries, such as those used in the L1000 Distributed Energy Storage System age, Johnson Controls intends to reclaim as much of the battery components as possible and safely dispose of any remains. Please contact Johnson Controls DES organization to determine appropriate disposal options.

Related Documentation

For Information On	See Document
L1000 Distributed Energy Storage System Installation Guide	*Part No. 24-1000-0001*
L2000 Distributed Energy Storage System Installation Guide	*Part No. 24-1000-0002*
Remote Software Controls	*Distributed Energy Storage System Software User's Guide LIT-12012521*
Dimensional Drawings	*L1000 Distributed Energy Storage System Technical Bulletin (LIT-12012515)*
L2000 Applications	*L2000 Distributed Energy Storage System Product Bulletin LIT-12012514*
L2000 Commissioning	*Part No. 24-1000-0003*

Glossary

4G LTE Fourth Generation Long Term Evolution cellular network

AC Alternating Current

BU Battery Unit

DC Direct Current

DES Distributed Energy Storage

DESS Distributed Energy Storage System

DNP3 Distributed Network Protocol

FR Frequency Response

HVAC Heating Ventilating Air-Conditioning

IEEE Institute of Electrical and Electronics Engineers

kVA Kilo-Volt Ampere Reactive

kWH	Kilowatt-Hour
L2000	Outdoor DESS Product Line
Li-ion	Lithium Ion
Modbus	Modicon Bus Protocol
PPE	Personal Protective Equipment
PCS	Power Conditioning System
SU	System Unit
THD	Total Harmonic Distortion
UL	Underwriters Laboratories

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