PART 1 - GENERAL

1.1 SUMMARY

1. Section includes the equipment, meters and software requirements for monitoring and managing electrical consumption.
2. Electrical Meters
3. Software and operator interfaces.
4. Raceways and boxes.
5. Wires and cables.
6. Identification.
7. Related Requirements and Documents:
8. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
9. Section 26 2713 "Electricity Metering" for equipment to meter electricity consumption and demand for tenant submetering.
10. Section 26 0548 "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.2 ACTION SUBMITTALS

1. Product Data: For each type of product.
	1. Provide details of equipment assemblies. Indicate dimensions, method of field assembly and installation or all components, their location and size of each field connection.
		1. Attach copies of approved Product Data submittals for products (such as switchboards, switchgear, and motor-control centers) that describe the following:
			1. Location of the energy management submeter network components and routing.
			2. Details of power monitoring features to illustrate coordination among related equipment and power monitoring and control options.
			3. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components.
			4. Provide diagrams for all meters: Power, communications interface, and wiring.
			5. Surge Suppression Devices applied on distribution panels, switchboards and service entrances: Data for each device used and where applied.

1.3 INFORMATIONAL SUBMITTALS

1. Field quality-control reports.
2. Design Data:
	1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.
		1. Testing and commissioning reports and checklists of completed final versions of reports, checklists.
		2. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for the system and products.
		3. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
		4. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
		5. Engineering, installation, and maintenance manuals that explain how to do the following:
			1. Design and install new points, panels, and other hardware.
			2. Perform preventive maintenance.
			3. Debug hardware problems.
			4. Repair or replace hardware.

* + 1. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
		2. Owner training materials

1.4 COORDINATION

1. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
	* 1. Match components and interconnections for optimum performance of specified functions.
2. **Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.**
	* 1. **Start-Up and Commissioning.**
			1. **Manufacturer's Service: Engage a factory-authorized service representative to and prewire walk through.**
			2. **Inspect components, assemblies, and equipment installation including connections**
			3. **Commissioning: A factory-authorized service representative for remote or on-site inspection or components, assemblies, and equipment installation including connections, and assist in testing.**
			4. **Post Installation Services: The manufacturer agrees to provide**
				1. **Technical support at no charge shall be made available during normal business hours Monday thru Friday, with a response time no greater than 24 hours.**
				2. **Technical sales and service support from a local factory representative.**
				3. **Contact Jay O’Connor 508.326.2708**

PART 2 - PRODUCTS

2.1 SOFTWARE SYSTEM DESCRIPTION

1. Microprocessor-based monitoring and control of electrical power distribution system loads include:
	1. Electrical meters that monitor and connect to the data transmission network.
	2. System software shall reside on a LAN or WAN: High-speed, multi-access, open, nonproprietary, industry-standard protocols. Communication protocols supported at a minimum shall be:
		1. BACnet MSTP
		2. BACnet IP
		3. Modbus RTU
		4. Modbus TCP/IP
2. Software shall enable access via any web browser and be located on a local area network, a wide area network or the internet via static via TCP/IP. The software must also:
3. Provide access to all functionality via a standard web browser over the internet
	1. Support remote connectivity via a free open VPN connection.
	2. Require username or password authentication and can automatically manage the authorization or expiration of users.
	3. Allow an unlimited number of users to be assigned within the system.
	4. Allow an unlimited number of concurrent web requests subject only to network bandwidth and hardware resources.
	5. Not require software plugins be installed on any web browser used for access.
	6. Support user and group authentication with ability to restrict users or groups to actions only administrators can allow.
	7. Include dynamic graphical user interface (GUI) with access to all historical data.
4. Enable programming to be viewed in real-time, on-demand using a standard browser.
	1. Provide means to interface with all industry standard building automation field controllers and energy monitoring devices.
	2. Require all graphic displays and programming tools built allow local and remote engineering and commissioning using a standard web browser.
	3. Allow custom graphics with animations and ability to view data in real-time.
5. Make base licensing a one-time purchase with no perpetual subscription or annual fees.
	1. Provide unlimited free updates, features, improvements, fixes, and support.
	2. Utilize PostgreSQL database, English language support and context sensitive help.
	3. Provide factory e-learning online training and technical support resources.
6. Configurable automated system backup and/or on-demand.
	1. Configurable file transfer using FTP or SFTP (file transfer protocol and secure file transfer protocol) with automated remote file transfer.
	2. Report and trend log export to PDF (graphical) or CSV
	3. Communication with uninterruptable power supply to perform orderly shutdown of operating system. Network UPS Tools compliant http://www.networkupstools.org
7. The software will have the ability to be pre-engineered and configured prior to set up and on-site commissioning.
	1. Software shall be easily identifiable via version number
	2. All software updates shall be made free and available for the period of the warranty/defects and liability period

The software shall be able to log maintenance requests

1. Security
	1. The system shall support remote connectivity via a free open VPN connection.
	2. The software shall produce a client.ovpn certificate for authentication.
	3. Users shall connect to the system using an on-board VPN when connecting via the internet.
	4. The software shall regenerate the client.ovpn certificate every time the Public IP, Ports, or Protocol in the VPN Configuration is changed.
2. Data Storage
	1. Shall be stored in an SQL compliant database adhering to a minimum ANSI-SQL 92/99 standard.
	2. Data retrieval and archiving shall be an automatic function within the software and easily selectable and extracted via the user interface.
	3. Provide hard disk storage for minimum of 5 year’s storage of trend log data and energy data including other meter parameters.
	4. Provide software database to create and maintain all meter data and parameters as BACnet objects. These BACnet objects shall be accessible from any BACnet system.
	5. The system shall include at a minimum a 120GB Solid State Hard Drive for long term data storage.
3. Alarm, Event and Trend Log Notification
	1. The software shall be able to receive BACnet alarm and event notifications and store these in the database in a BACnet format. This shall include the priority assigned to the notification.
	2. Where the notification is a trend log buffer-full notification, the software shall be able to read the trend log buffer from the BACnet system and store in the database in BACnet format.
4. Alarms
	1. The software shall have the ability to create and edit BACnet alarms.
	2. The software shall allow users to view and respond to alarms.
	3. Users shall be able to view a list of all alarms, with the ability to acknowledge and or clear.
	4. Alarm escalation shall occur after a user configurable time period.
	5. Alarms summary shall be viewable on a summary toolbar.
	6. Alarm summary page shall have quick links to a custom graphic display.
	7. Alarms shall be made available on a companion mobile app for IOS or Android.
	8. Meter alarms shall be configurable, viewed and acknowledged through the user interface.
	9. Meter alarms shall be configurable with the following criteria at a minimum:
		1. Grouped by user, group, or meter.
		2. Notifications shall be emailed, or SMS (Short Messaging Service) messaged.
		3. Meter status:
			1. Offline.
			2. Online.
		4. Meter parameter:
			1. Consumption changes.
			2. Instantaneous changes.
			3. Time of day consumption.
			4. Day of week and time delay.
		5. The system shall be capable of “alarm reporting” in report format (PDF) and searchable by the following criteria:
			1. Date.
			2. Message text.
			3. Acknowledgment state.
			4. Alarm state.
		6. BACnet alarms:
			1. Device.
			2. Object type.
			3. Object instance.
		7. Meter alarms:
			1. Meter.
			2. Meter alarm type.
			3. Meter alarm parameter type.
5. SMS Alarming
	1. The software shall allow the transmission of alarms via GSM network in the form of SMS. The communication via SMS shall be two-way communication and will be capable of receiving acknowledgements via SMS.
6. Alarm Escalation
	1. The software shall allow the ability to receive acknowledgments of alarms, if alarms are not acknowledged the software shall have the ability retransmit alarms to the any number of predetermined recipients after a user defined time period has elapsed. A minimum of 12 escalation levels shall be supported.
7. Trend logs
	1. The software shall have the ability to create and edit trend logs, including BACnet compliant trend logs, this includes trend intervals and number of stored trend logs before archiving.
	2. The software shall also allow users to view trend logs in graphical form. Trend graphs can be modified to view multiple trends on one graph. The time period of the graph shall be adjustable.
	3. Trend views are trend logs with contextual information which can be saved as a snapshot in time. The software shall allow trend views to be saved and updated at a future point in time.
	4. The software shall allow for the following Graph Options:
		1. Title: Title of graph that appears at the top of the page.
		2. Show time period: This option determines if the graph time period will be displayed as a sub-heading e.g., 01/01/2013 12:00 AM - 07/01/2013 12:00 AM.
		3. Shared Y-Axis on each point: Allow all trends displayed on graph to share the same Y axis, instead of having individual.
		4. Y Axis size: The software shall automatically determine the minimum and maximum Y axis value so as to display the graph at the highest resolution. Users shall have the ability to set a minimum and maximum Y axis if they choose.
		5. Zoom: The software shall allow users to select an area, zoom in on trend views and back out again.
8. BACnet Data Access
	1. The software shall be able to access BACnet data points in attached BACnet building automation controllers. If the BACnet point is writeable, then the software shall support writing user-entered data to the BACnet point.
9. Schedules & Calendars
	1. The software shall have the ability to create and edit BACnet schedules. These shall include standard weekly schedules, holiday schedules and special event schedules.
		1. The software shall also support calendars. Multiple schedules can be linked to a calendar. The calendar may have entered items like public holidays or special events that will override standard schedule entries.
10. Touch Screen, Kiosk and Scrolling Display Support
	1. The software shall support foyer display, kiosk, and touch-screen systems for passive or interactive communications with specific building users, such as tenants, or the general public.
	2. The software shall support connecting a monitor, keyboard, and mouse for the purpose of using the combined hardware and software as a user interface to the system for monitoring, engineering and control of the system.
	3. The software shall support scrolling displays being a list of accessible URLs which are displayed in order for a predetermined time similar to a slide show. The software shall support an unrestricted number of scrolling displays on a per-user basis.
	4. The software display source shall support:
		1. Custom URL’s
		2. Custom Displays
		3. Meter Displays
		4. Bookmarks
		5. Dashboards
		6. Utility Reports
		7. Embedded Video (e.g. Vimeo)
		8. The scrolling display support menu shall support manually navigating the displays, pausing and pinning the control menu.
		9. The end user shall have the ability to create scrolling displays, edit the content, set the timing and order.
		10. Any content in the system shall be able to be used as a scrolling display.
		11. Video output using HDMI or Display Port and VGA.

1. Visualization and Custom Displays
	1. The software shall allow for creation of custom graphics either within the web browser or offline with a graphics tool.
	2. Image files such as JPG, PNG, and GIF visible on a standard web browser will be supported,
	3. Software shall support animated graphics (GIF), for example to indicate a fan that is in operation.
	4. Software shall allow live trend graphs and reports to be embedded into custom display pages.
	5. Any custom display created can be selected as the home page for any user or group.
		1. Custom display pages shall display links to other pages, for example to navigate to floors, zones or various equipment pages. The display pages shall allow for live point data to be viewed or written to. The point data shall allow engineering units to be displayed.
	6. Points where applicable, shall allow direct access to trends, alarms, and schedules.
2. Graphics Library
	1. The software shall come with a graphical library of images for HVAC equipment. This shall, include graphics such as Chillers, Boilers, Air Handlers, Fan Coil Units and VAVs, and shall have incorporated applicable graphics such as fans, coils, dampers, and pumps.
3. Automatic Software Backup
	1. The software shall allow for automatic backups to be created.
	2. The software shall back up the following at minimum:
		1. Database/configuration, display files, images, and documentation.
		2. Control programming
		3. Schedules
		4. Alarms
		5. BACnet trend logs
		6. Energy logs
		7. License
4. System Restore
	1. In the event of a hardware failure or damage, system backups shall be used to restore the system back to the state at the time of backup.
5. FTP / SFTP Remote Archiving
	1. The software shall allow auto and manual backups to be configured to be sent to a remote server, using either FTP or SFTP protocols.
6. User Activity
	1. The software shall allow for user activity reports detailing all the user activities within. User reports will be filtered according to user, date, and different user activities.
7. 4.22. Time
	1. System time shall be based on system location settings and automatically update for daylight savings based on the locale.
		* 1.
8. Commissioning Tools
	1. The software shall aid in commissioning and interrogation of the attached network devices.
		1. Modbus Client: Allows for low level troubleshooting of Modbus hardware. It will allow for testing whether or not the software can communicate to a Modbus device and determine parameter registers.
		2. BACnet Read Property: Allows the properties of a BACnet device to be read. The results can optionally be exported to a CSV or PDF files.
		3. Network Ping Utility: A low-level network diagnostic tool which is useful for checking if an IP address is currently reachable. Failures can indicate the remote device being off, there is misconfigured network settings somewhere, cables are loose, there is an equipment failure, and network or routing faults.
9. ENERGY MANAGEMENT
	1. Metering Information
		1. The software shall retrieve at a minimum from each meter the Kilowatts (KW) and Kilowatt hours (KWh). This data is retrieved as it occurs for presentation, analysis, trending, and reporting via the software package.
	2. Meter Data Acquisition
		1. Software shall connect to electric, water, gas and BTU meters via BACnet or MODBUS.
		2. The software shall also connect to pulse output meters using BACnet or Modbus. 5.3.
		3. Manual Data Input
			1. The software shall support CSV upload.
			2. The software shall support manual data entry.
	3. Virtual/Calculation Meters
		1. The software shall allow creation of calculation meters based on physical meters or other calculation meters.
		2. The software shall allow the following types of meters to be created:
			1. Physical Meters: Adding of multiple physical meters.
			2. Forecast Meter: The software shall allow for user defined forecast data to be entered. This will allow a forecasted value to be tracked against the actual for comparison.
		3. Manual Meter: The software shall allow for manual entry of meter data, i.e., a meter created using data received from monthly utility bills, which must be manually entered.
		4. Calculation Meter:
			1. Aggregate: An aggregate meter is the sum of all associated meters.
			2. Custom: Custom calculation meters require the calculation expression or equation to be defined. Available calculation operators are +, -, \*, /, ().
			3. Portion: A meter configurable to a specified percentage of a given parent meter.
			4. Remainder: A meter that is the remainder of a parent minus its child meters.
	4. Data Retrieval
		1. The software shall permit users to drill down to/from sub-meters to a selected meter following physical hierarchy or aggregate meter hierarchy.
	5. Meter Condition Alarming
		1. The software shall allow for the configuration of alarms for a meter, and also enable notifications and emails to alert users of alarm events associated with given meter.
		2. Alarm Conditions to include:
			1. Configuration Changed
			2. Meter Online
			3. Meter Offline
		3. Condition Alarming based on settings such as:
			1. Instantaneous maximum and minimum values
			2. Consumption over interval
			3. Consumption over time
		4. Tolerance Levels
			1. The software shall allow the ability to specify the delay period of alarms.
	6. Tariff Descriptions
		1. The software shall be capable of maintaining a detailed description of a tariff including, but not limited to, volume charges, demand charges, metering and supply charges, government levies and charges. Charges shall be able to be based on volume blocks, time of use, seasonal rates, peak and off-peak and other common billing regimes.
		2. Each meter shall be able to have an associated tariff which allows a utility bill to be created for that meter. This bill can be used to compare actual utility bills or to generate invoices for tenants for metered services.
		3. The software shall maintain in the database records of invoices sent and be able to generate a per-tenant statement of charges made.
	7. Demand Limiting / Load Shedding
		1. The software shall support demand limiting / load shedding to ensure that electrical maximum demand is not exceeded.
		2. The software shall write to MODBUS or BACnet, in either binary or analog. ● Delay timers will be used to set the time before an event is triggered and before an event is returned to normal.
		3. The user shall be able to create a hierarchy of loads to be shed in a prescribed manner. The software shall provide a minimum of 10 demand limiting points.
	8. Meter Commissioning
		1. The software shall allow commissioning actions to be entered and maintain a record of each commissioning activity. The Commissioning activities that shall be stored as a minimum are:
			1. Comment:
			2. Name/Initials:
10. 6. REPORTING
	1. The software shall at a minimum report on:
		1. Hourly consumption.
		2. Daily consumption.
		3. Weekly consumption.
		4. Monthly consumption.
		5. Yearly consumption.
		6. Aggregate of multiple meters or meter parameters.
		7. Benchmarking Normalization (Square feet and number of people)
		8. Comparison between meters, buildings, time periods across all or some of the meters and buildings.
		9. Reporting (in tabular, graphical – charts & line graphs) for water, gas and electrical utilities.
	2. Energy Trend logs
		1. Energy Breakdowns (gas and electric) as total energy usage
		2. Electricity breakdown into costs sections defined by the user.
		3. Breakdown of each meter as total energy.
			1. Power Factor
			2. Demand (kW)
			3. Real Time (kWh)
			4. Voltage
			5. Amps
		4. Upload energy data from external sources (.CSV).
	3. Reports General
		1. The software shall support the generation of reports including text and charts. These shall be generated either as HTML displays than can also be generated as a PDF document. The generation of downloadable underlying data in the form of CSV files shall be provided where possible.
		2. The user shall also have the ability to email reports to other users on demand or have the ability to create an automatic email. For example, a monthly report will be automatically emailed on the first day of the new month for the previous month.
		3. Custom reports that are created will also have the ability to be saved to a reports library and will be generated using the same time period as the original. For example, if report is created for the current week, then the following week when the report is run it will be for that current week.
	4. Reports Library
		1. The software shall support preconfigured reports & shall be able to be generated as required and, to allow these to access the expected time periods, terms such as “yesterday”, “last week”, “last 3 quarters” and “last season” shall be supported.
		2. The software shall provide reports which show comparisons across multiple meters or across multiple time periods.
11. HARDWARE
System hardware shall be scalable bases on project size and requirements. Three main groups to include:
	1. Premium Class: Suitable for projects that contain up to 500 meters and 1000 BACnet devices:
		1. Intel i5-3570K processor or better
		2. 8GB RAM minimum, recommend 16GB
		3. 2 x 1TB enterprise/server grade drive (E.g., Western Digital WD RE4)
		4. 1Gbit Fast Ethernet connection Case with at least a 300W power supply
		5. Supported UPS
	2. Enterprise Virtual Environments: Suitable for projects that contain over 500 meters and over 1000 BACnet devices:
		1. Base installation of Debian Wheezy (64 bit)
		2. Processor/Virtual Processor: 4 cores or more
		3. Memory/Virtual Memory: 16GB RAM minimum, 32GB recommended
		4. 1GBit fast Ethernet connection
		5. Remote root (or equivalent) access, web connection to Debian repositories for OS setup and configuration
	3. Server Grade Enterprise System: Suitable for projects that contain over 500 meters and over 1000 BACnet devices:
		1. Dell PowerEdge R320/T320 or equivalent
		2. Intel Xenon Processor E5 2.20 GHz, 10M Cache, 6.4 GT/s, 80W
		3. 16GB RAM minimum, 32GB RAM recommended
		4. 2 x 1TB (enterprise/server grade) drive
		5. 1Gbit Fast Ethernet connection
		6. Supported UPS

NOTE: All connectivity to the software hardware shall be through IP (TCP or UDP) and not require a keyboard and display to allow the platform to be installed in inaccessible areas such as a corporate server room. All software updates and changes to the software shall be capable of being performed remotely using the network.

1. COMMUNICATIONS
	1. The system shall support BACnet IP & MS/TP:
		1. Ports that can be enabled or disabled in software.
		2. Operate in accordance with BACnet MS/TP protocol rev 14.
		3. Each port can have adjustable baud rates (9.6k, 19.2k, 38.4k, 76.8k and 115k). o Use on board diagnostic tools for setup and troubleshooting.
	2. The system shall support BACnet Routing:
		1. Support BBMD with unrestricted number of BDT table entries.
		2. Operate in accordance with BACnet protocol rev 14.
		3. Support a configurable IP network.
		4. Support a configurable IP and MSTP network number
		5. Use on board diagnostic tools for setup and troubleshooting.
	3. The system shall support Modbus TCP/IP & RTU:
		1. Enabled or disabled in software.
		2. Operate in accordance with Modbus RTU.
		3. Can have adjustable baud rates (9.6k, 19.2k, 38.4k, 76.8k, 115k, 230k).
		4. Use on board diagnostic tools for setup and troubleshooting.
2. 8.2. Utility Billing
	1. software shall provide ability to produce bills (invoices) for payment by tenants for utilities usage.
	2. The software shall record and show a summary of previously produced bills (invoices) and allow users to download for viewing or re-distribution at a later date.
	3. The software shall provide the ability to produce bills (invoices) for the following utility types:
		1. Electricity
		2. Gas
		3. Water
		4. Thermal Energy
		5. Chilled Water
		6. Heating Hot Water
	4. Each tenancy afterhours bill (invoice) shall contain at a minimum the following information:
		1. Ability for biller to insert company logo
		2. Tenant name and address details
		3. Tax invoice number
		4. Date of issue
		5. Total amount payable
		6. Payment due date
		7. Total amount payable after due date
		8. Meter Summary
		9. Meter Description
		10. Days covered by bill (invoice)
		11. Previous reading
		12. Current reading
		13. Usage between previous and current reading
		14. Summary bar chart showing previous 12months consumption
		15. Average usage per day
		16. Average usage for same time last year
		17. Time of use charge details including:
			1. On and Off-peak
			2. Shoulder
			3. Peak demand
			4. Time on/off
			5. Rate applicable
			6. Usage during period
		18. Additional fees, charges and instructions:
			* 1. Service charge
				2. Processing charge
				3. Total usage and supply charges
				4. Instructions on how to pay bill (invoice)

PART 2 - PRODUCTS

* 1. CUSTOMER-OWNED METERS
	(SUBMETERING, CHECK-METERING, LOAD PROFILING, LOAD SEGREGATION AND/OR COST ALLOCATION)
1. Where applicable, all Meters and Electrical Components, Devices, and Accessories shall be Listed and labeled in accordance with UL 61010-1 or UL recognized, marked for intended location and application.
2. Electrical Meter Power Inputs and Measurement
	1. Meter measurement must be true RMS using high-speed digital signal processing (DSP) with continuous waveform sampling at minimum 1.8 kHz with parameter updates every 1 second
	2. Meters shall be Revenue Grade 0.2% accurate per ANSI C12.20-2015 Class 0.2 Resolution values per IEEE-754 single precision floating point format (32 bit)
	3. Meters shall be configurable for the following load monitoring of electrical service types:
		1. Single and Split Phase, (One and Two-Pole)
		2. Three Phase-Four Wire (WYE),
		3. Three Phase-Three Wire (Delta)
	4. Line frequency metered must be 50 or 60 Hz (45 - 70 Hz measurable range)
	5. Meter shall be capable of accepting one or two voltage reference inputs
		1. Line to Line: 90-600VAC RMS CAT III 500mA AC Max
		2. Line-to-Neutral: 90-346 VAC 500mA AC Max
	6. Meter shall have integral AC fuse protection at 0.5A, 200kA interrupt capacity
	7. Meters shall have an integral interval data recorder to kWh consumption:
		1. 15-minute interval data shall be stored for minimum of 63 days
		2. 5-minute interval data shall be stored for minimum of 21 days
		3. Each interval data recorded shall be time stamped
	8. Meter parameters measured for each phase and system total shall include:
		1. Volts
		2. Amps
		3. kW
		4. Kvar
		5. kVA
		6. PF Power Factor: both Apparent and Displacement
		7. kW demand
		8. kVA demand
		9. Import (Received) kWh
		10. Export (Delivered) kWh
		11. Net kWh
		12. Import (Received) kVAh
		13. Export (Delivered) kVAh
		14. Net kVAh
		15. Import (Received) kVARh
		16. Export (Delivered) kVARh
		17. Net kVARh
		18. THD – Total Harmonic Distortion
		19. Frequency.
	9. Meter Display Indicators
		1. Meter shall have a user scrollable tri-color backlit display
		2. Meter shall offer an user-configurable alarm Form C dry contact relay output
	10. Meter Pulse Input Option
		1. Meters may offer the ability to accept inputs from pulse output meters and devices:
			1. Sourcing voltage 3.3V (current limited) to user dry contact pulse output
			2. Maximum Pulse Rate 10 HZ (50 msec minimum transition time)
3. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
	1. Dent Instruments
	2. E-Mon D-Mon / Honeywell
	3. Eaton Corporation
	4. Optergy div. of Oberix

1. Current Transformer (CT) Specification
	1. CTs shall be low voltage:
		1. Voltage output from 0 (zero) to 0.333 mV at full range
		2. CT input current shall not exceed 500 mA
	2. Measure zero to 5,000 Amps (current transducer dependent)
		1. The maximum current Input shall be no greater than 150% of the current transducer
		CT rating (mV CTs) to maintain accuracy
	3. Meter shall accept Solid, Split-Core and Flexible Rope CTs without a shorting block or integrator
		1. Solid and Split-Core CT conductor leads:
			1. Must be a twisted pair, 18AWG, 600VAC rated
		2. Flexible Rope CTs:
			1. Must be a 2-conductor shielded, 26 AWG, 1000V Rated, UL94V-0
	4. Meter and accuracy shall be maintained with CT lead lengths extended up to 500ft
2. Communications
	1. Meter shall Include ports for RS-485, Ethernet, and USB Hardware
	2. Meter shall support Modbus RTU or BACnet Master Slave Token Passing protocols (MS/TP)
		1. Modbus per SunSpec IEEE-754 single precision floating point model
			1. Maximum Meter Network Communication Length of 1200 meters (4000 ft.)
			2. Data Range of 100K bits/second or less
			3. RS-485 Loading 1/8 unit
			4. Modbus Communication Rate (baud): 9600, 19200, 38400, 57600, 76800, 115200
		2. BACnet per ANSI/ASHRAE 135. (ISO 16484-5) standard
3. Maximum Meter Network Communication Length of 1200 meters (4000 ft.)
4. Data Range of 100K bits/second or less
5. RS-485 Loading 1/8 unit
6. BACnet Communication Rate (baud): 9600, 19200, 38400, 76800
7. Mechanical / Environment
	1. Meter voltage power connection
		1. Must be 600VAC rated, #14 AWG or less.
	2. Mounting:
		1. Meter must be UL listed for wall or panel mount applications
			1. Enclosure ABS Plastic, 94-V0 flammability rating or greater
			2. Must accept either ½”, ¾” and/or 1” conduit connections
		2. Shall have a high-voltage cover per NEC safety compliance
	3. Environmental Ratings
		1. Meter shall be NEMA 1 rated (minimum IP 30 or better) as a minimum standard
			1. Must have options for outdoor applications, i.e., NEMA 3, 3R, 4, 4X, 12 & 13
		2. Operating Temperature: Meter shall be rated -20 to + 60⁰ C (-4 to 140⁰ F)
		3. Humidity: Meter shall be for use or storage in 5% to 95% non-condensing environments

2.2 PERFORMANCE REQUIREMENTS

1. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
	1. Minimum Protection for Power Lines 120 V and More: SPDs complying with UL 1449, listed and labeled for intended use by an NRTL acceptable to authorities having jurisdiction.
	2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines:
	Comply with requirements as recommended by manufacturer for type of line being protected.
2. Addressable Devices: Transmitters and receivers must communicate unique device identification and status reports to monitoring and control clients.
3. Backup Power Source:
	1. Electrical power distribution equipment served by a backup power source for controls must have associated power monitoring and control system products that monitor and control such systems and equipment also served from a backup power source.

2.3 RACEWAYS AND BOXES

* 1. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
	2. Comply with requirements in Section 270528 "Pathways for Communications Systems" for control wiring, and NFPA 70 Class 2 remote-control and signaling circuits.

2.4 WIRES AND CABLES

* 1. Electrical Power Wiring: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
		1. Copper conductors are Type THHN/THWN-2.
	2. Control Wiring:
		1. Copper: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
		2. Optical Fiber: Comply with requirements in Section 271323 "Communications Optical Fiber Backbone Cabling" and 271523 "Communications Optical Fiber Horizontal Cabling."
1. Optical-Fiber Cable: Multimode, 50/125-micrometer OM3, six-fiber, nonconductive, tight-buffer, optical-fiber cable, with aqua jacket.
2. Balanced Twisted-Pair Cable: 100 ohm, four-pair balanced twisted-pair cable, Category 5e.
3. Control-Voltage Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
	1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
	2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
	3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.1 POWER MONITORING AND CONTROL SYSTEM INSTALLATION

* 1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
	2. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
	3. Wiring and Cabling Installation:
		+ 1. Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
			2. Comply with Section 26 0523 "Control-Voltage Electrical Power Cables" for control wiring.
1. Raceways Installation:
	1. Comply with Section 26 0533.13 "Conduits for Electrical Systems" for electrical power wiring and NFPA 70 Class 1 remote-control and signaling circuits.
	2. Comply with Section 27 0528 "Pathways for Communications Systems" for control wiring, and NFPA 70 Class 2 remote-control and signaling circuits.
2. Identification Installation:
	1. Comply with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables" for electrical power wiring.
	2. Comply with Section 27 1513 "Communications Copper Horizontal Cabling" for identification products and cable management system requirements for UTP and control voltage cable.
	3. Comply with Section 27 1523 "Communications Optical Fiber Horizontal Cabling" for identification products and cable management system requirements for optical-fiber cable.

3.2 INSTALLATION OF WEBSERVER APPLIANCE OR SERVER

* 1. Webserver Appliance Installation:
		1. Install Webserver Appliance at location(s) directed by Owner.
		2. Provide each a dedicated UPS unit. Locate UPS adjacent to the Webserver Appliance.
		3. Test webserver to verify the appliance and software function properly.
	2. Server Based Application Installation:
		1. Install Server at location(s) directed by Owner.
		2. Provide a dedicated UPS unit. Locate UPS adjacent to the Server.
		3. Test Server to verify software functions properly.

3.3 NETWORK NAMING AND NUMBERING

* 1. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.4 GROUNDING

1. For data communication wiring, comply with BICSI N1.
2. For control-voltage wiring and cabling, comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."

3.5 FIELD QUALITY CONTROL

* 1. Field tests and inspections must be witnessed by Architect.
	2. Tests and Inspections:
		1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
		2. Visually inspect balanced twisted-pair cabling and optical-fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments and inspect cabling connections to confirm compliance with TIA-568-C.1.
		3. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and patch cords, and labeling of components.
		4. Test balanced twisted-pair cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
			1. Test instruments must meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
			2. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.
1. Optical-Fiber Cable Tests:
	* + - 1. Test instruments must meet or exceed applicable requirements in TIA-568-C.0. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
				2. Link End-to-End Attenuation Tests:

Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to IEC 61280-4-1.

Attenuation test results for links must be less than 2.0 dB that calculated according to equation in TIA-568-C.0.

1. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.
2. Power Monitoring and Control System Tests.
	* 1. Test Analog Signals:
			1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100%
			2. Check analog current signals using a precision current meter at zero, 50, and 100%
			3. Check resistance signals for temperature sensors at zero, 50, and 100% of operating span using a precision-resistant source.
3. Test Digital Signals:
	* + 1. Check digital signals using a jumper wire.
			2. Check digital signals using an ohmmeter to test for contact making or breaking.
4. I/O Control Loop Tests:
	1. Test every I/O point to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
	2. Test every I/O point throughout its full operating range.
	3. Test every control loop to verify that operation is stable and accurate.
	4. Adjust control loop proportional, integral, and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
	5. Test and adjust every control loop for proper operation according to sequence of operation.
	6. Test software and hardware interlocks for proper operation.
	7. Operate each analog point at the following:
		* 1. Upper quarter of range.
			2. Lower quarter of range.
			3. At midpoint of range.
	8. Exercise each binary point.
	9. For every I/O point in the system, read and record each value at operator workstation, at controller, and at field instrument simultaneously. Value displayed at operator workstation and at field instrument must match.
	10. Prepare and submit a report documenting results for each I/O point in the system, and include in each I/O point a description of corrective measures and adjustments made to achieve desire results.
5. Nonconforming Work:
	1. Wiring and cabling will be considered defective if they do not pass tests and inspections.
6. Prepare test and inspection reports.

3.6 FINAL REVIEW

* 1. Submit written request to Architect when the power monitoring and control system is ready for final review. Written request must state the following:
		1. The system has been thoroughly inspected for compliance with Contract Documents and found to be in full compliance.
		2. The system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
		3. The system monitoring and control of electrical distribution systems results in operation according to sequences of operation indicated.
		4. The system is complete and ready for final review.
	2. Review by MEP will be made after receipt of written request. A field report must be issued to document observations and deficiencies.
	3. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when deficiencies have been corrected. Repeat process until no deficiencies are reported.
	4. Final review must include a demonstration to parties participating in final review.
	5. Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by manufacturer's authorized service representative. Include annual preventive maintenance, repair or replacement of defective components, cleaning, and adjusting as required for proper system operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.

3.7 SOFTWARE SERVICE AGREEMENT

* 1. Technical Support: Beginning at Substantial Completion, service agreement must include software support for two years.
	2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.
		1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.8 TRAINING

* 1. On-Site Training:
		1. Owner will provide conditioned classroom or workspace with ample desks or tables, chairs, power, and data connectivity for instructor and each attendee.
		2. Instructor must provide training materials, projector, and audiovisual equipment used in training.
		3. Provide as much of training located on-site as deemed feasible and practical by Owner.
		4. On-site training must include walk-through tours, as required, to observe each unique product type installed with hands-on review of operation, calibration, and service requirements.
		5. An operator workstation within the system must be used in training. If operator workstation is not indicated, provide a temporary workstation to convey training content.

END OF SECTION

APPENDIX

DEFINITIONS

1. - AMR Automated Meter Reading
- Appliance: A computing device with Energy Management operating system and software installed.
2. - BACnet MSTP: An open protocol for exchange of process data that allows 4000’ RS-485 twisted pair network cabling (straight-thru daisy-chain device terminations).

- BACnet IP: An open protocol for exchange of process data. Ethernet Category 5e or 6 network cabling is limited to 100-meter (328 feet) length runs to a port within a managed network switch.

BMS or BMCS: Building Management Systems (BMS) or Building Management Control Systems (BMCS) also known as Building Automation Systems (BAS), Building Management and Control System (BMCS), Direct Digital Controls (DDC) and Building Controls.

1. - Current Sensor: A pre-burdened Current Transformer (CT) with 0-2V low-voltage milliamp output sized according to the amperage of an electrical circuit being monitored. Capable of monitoring a load up to 2,000 feet away from a pulse output meter, and 500 feet from a “Smart Meter” without need for derating or loss of accuracy. Current Sensors are polarity sensitive and can be installed too monitor multiple circuits from the same source and provide additive (cumulative) or segregated (subtractive) readings of usage of multiple loads.
- Current Transformer: Also referred to as a “CT” is a full voltage output electric device placed around an alternating current (AC) conductor to measure electrical current. With a corresponding voltage input from a power source, a revenue-grade CT can accurately meter a single and three-phase electrical service.

- Communications Protocol: Are formal descriptions of digital message formats and rules. They are required to exchange messages in or between computing systems and cover authentication, error detection and correction and signaling. Common building and energy management Ethernet Internet Protocols include ModBus TCP/IP, BACnet IP, Internet IP, and/or RS-485 Serial communications which include ModBus RTU and BACnet MS/TP (twisted pair).

1. - Dashboards: Web pages that display charts, reports, data and device management via a common language such as JAVA, XML and HTML.
2. - Ethernet: Local area network based on IEEE 802.3 standards.

Edge Controller: Appliance to operates building equipment autonomously with I/O modules controller hardware points. The Controller connectivity is via BACnet IP (PoE), MS/TP, and BACnet IP routing.

1. - Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.

- Front End: Legacy term used to refer to the BMS Operator Workstation

- FTP: File transfer protocol

1. HTML: Hypertext Markup Language.
2. I/O: Input/output.

Interval Data Recorder: Am electronic device that collects and store energy and pulse data from meters in time-stamped intervals for retrieval via Ethernet modem, ModBus RTU, TCP/IP; BACnet/MSTP allowing for profiling of meter data and more detailed comparative analysis or billing by E-Mon Energy Automatic Meter Reading, Optergy or Tritium/Niagara based Building/Energy Management System software.

1. JACE: A device that provides connectivity to building management and control systems via the Niagara framework via common network protocols such as BACnet, Modbus and proprietary networks.
2. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.
3. LAN: Local area network; sometimes plural as "LANs."

LCD: Liquid crystal display.

LED – Light Emitting Diode display.

Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.

1. MMU: Multiple Meter Unit Cabinets supplied preprogrammed with up to 96 high-density meters and/or Interval Data Recorders. Cabinets may contain meters of different voltage configurations. May contain any mixed combination of 8, 16 or 24 E-Mon D-Mon Class 1000, Class 2000 and Class 6200 Meters, IDR Interval Data Recorders, and Class 3200 or Class 6400 Smart Meters.

- Modbus RTU: An open protocol for exchange of process data that allows a communications cable run of up to 1219.2 Meters (4000 feet) RS-485 twisted pair serial network cable with devices wired in a straight-thru, daisy-chain configuration.

- Modbus TCP/IP: An open protocol for exchange of process data. Ethernet Category 5e or 6 network cabling is limited to 100 Meter (328 feet) runs.

Monitoring: Acquisition, processing, communication, and display of equipment status, metered electrical values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.

1. - Niagara AX: An open, Java-based framework to connect devices and systems, regardless of manufacturer or communication protocol allowing for integrated control, supervision, data-logging, scheduling and alarming, as well as support for internet communications and web services.
2. - Optergy Enterprise: Optergy Enterprise a software-based supervisor that combines energy and building management functions via an web interface accessible using a common browser.
3. - PC: Personal computer.

Proton: Software based building controller that combines energy and building management functions, with an intuitive web interface accessible through any PC, Server, IOS or Android smart device. Manages up to 100 BACnet, Modbus devices or meters, with built-in database, programming and tools that include Utility billing, After-hours Billing, Automated Reporting, Live Dashboards, Alarms and Foyer Displays.

- Pulse Input: Term used by the metering industry to describe the means of a devices ability to accept a input from a pulsing device.

- Pulse Output: Term used by the metering industry to describe a method of measuring consumption based on a relay opening and closing. Meters supplied with a Pulse Output can interface directly into a JACE, building or energy management system via a pulse input terminal.

1. - RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- RS-485: A TIA standard for multipoint communications using two twisted-pairs, i.e., for Modbus RTU, BACnet MS/TP, E-Mon Energy EZ-7.
2. - Smart Meter: An electronic device that records interval electric consumption and communicates information back to a private network or utility PC, Server, Building Automation or Energy Management System for the purpose of energy monitoring, cost allocation, load profiling and billing, i.e., E-Mon Class 3200, 3400, 5000 or 6400 Series meters.
3. - Tridium: A brand name for a product built upon the Niagara AX (or N4) framework comprised of open and proprietary protocols on a scalable platform building operators can design their automation systems.
4. - TCP/IP: Transport Control Protocol/Internet Protocol used to transfer data on the internet or computers.
5. - Web Server: User Interface via an IOT smart device, i.e BMS, EMS, PC or Server whose software enables data and subsystem

END OF SECTION 262713