SECTION 26 16 00

ELECTRIC METERING

PART 1 -DESIGN DIRECTIVES

1.1 CAMPUS ELECTRICAL METERING SYSTEM DESCRIPTION

A. GENERAL

1. The guidelines of this section define requirements for electrical metering of Dartmouth College properties.

2. Permanent Metering

a. These guidelines apply to all new electric meter installations. When modifying an existing meter, the contractor will attempt to follow these standards as closely as possible. If the existing meter cannot be made to fully adhere to these standards the contractor will come to an agreement with Dartmouth College Engineering about how to handle all discrepancies.

3. Temporary Metering During Construction

a. Any project that will be connected to Dartmouth's campus electric grid during construction must include temporary electric meters and budget for electricity costs. The project is responsible for the purchase, installation, network connection, and integration to Dartmouth College's Campus Energy Management System (CEMS) for temporary electric meters. Coordinate with Dartmouth College Engineering early in project coordination regarding temporary metering.

4. All electric meters that are used for utility billing must be installed and configured within 10 days of connecting to the Dartmouth College electric grid. Coordinate with Dartmouth College Engineering to identify utility meters during project design.

5. Metering coordination should occur early in the project design process. Meters should be shown starting at 100% design development (DD) drawings and design finalized by the time that the project is put out to bid and no later than 100% construction documents (CDs).

B. METERING APPLICATIONS

1. Substations – metering is required on all buses and feeders in campus substations.
2. Main distribution panels (MDPs)– metering is required on main breaker of MDP.
3. Whole-building metering – metering is required on each main building breaker/panel.
4. Other electrical source metering – metering is required on all other electrical sources fed into a building, including but not limited to:

a. Emergency and Standby Automatic Transfer Switches (ATSs)
b. Photovoltaic (PV) Arrays

5. Building sub-metering – metering required as noted below.

a. LEED projects – project design teams will clearly call out all metering requirements in project drawings and specifications, including any sub-meters required to comply with the requirements of LEED.
b. Electric Vehicle Chargers (EV) chargers – meters are required on all EV circuits fed by the building.
c. Additional Sub-metering - In some instances, additional electrical sub-metering may be required. Consult with Dartmouth College Engineering to identify any required sub-metering.

C. METER INTEGRATION

1. Electric meters to be integrated into the following Dartmouth College software systems:

   a. Dartmouth's Asset Management Software
   b. Dartmouth's Campus Energy Management System (CEMS) Software
   c. Dartmouth's Electrical Power Monitoring System Software
   d. Dartmouth's Building Automation System (BAS) (coordinate with Division 23 and 25 contractors)

2. The electrical contractor will include integration and commissioning of meters in their scope of services.

3. The electrical contractor will coordinate with Dartmouth College Engineering and the BAS contractor to ensure compliance with this section and Section 25 00 00 – Integrated Automation.

D. DESIGN CRITERIA

1. All Metering Systems will be provided with:

   a. Control module ("meter")
   b. Fused reference voltage disconnects
   c. Fused meter control power disconnect
   d. Split core current transformers (CTs) from Schweitzer Engineering Laboratories, Electro Industries, Schneider, or an approved equivalent. Split core CT's shall have a thermal rating factor between 1.0 and 2.0.
   e. CT shorting block with appropriate number of shorting block screws
   f. Integral ethernet gateway or dedicated external ethernet gateway
   g. Network jack for direct ethernet communication
   h. A factory-provided meter enclosure to house meter, shorting blocks, power supply, ethernet gateway, and other associated components of meter equipment.
   i. Provide blank filler plates as required to completely close any unused openings

2. Design team to include the following on design drawings:

   a. Meter locations shown on electrical floor plans and one-line drawings
   b. All data jacks required for connecting meters to campus ethernet. Show data jacks on telecom floor plans with label of "Mtr".
   c. Meter communications wiring architecture
   d. Note indicating panel/breaker that is the source of reference voltage for each meter
   e. Note indicating panelboard/switchgear where meter current transformers (CTs) will be installed

f. Note indicating CT size, type, CT accuracy class, and CT ratio (i.e. 300:5 or 100:0.333)

1) Design team to size CTs based on anticipated loads and not on panel rating. Consult with Dartmouth College Engineering regarding CT sizing.
2) All CTs to be provided with CT shorting blocks unless otherwise approved by Dartmouth College Engineering.
3) Wire all taps directly to shorting terminal blocks. All wires connecting to terminal blocks for multi-ratio CT's shall be long enough to reach all possible tap positions.

g. Note indicating make and model of metering package. Package includes meter and factory-provided enclosure.
h. Remote displays, when utilized, indicated on one-line, schematics, front-views and wiring.

3. Current Transformer and Potential Transformer Testing

a. Metering Current Transformers

1) Test each Metering Current Transformer in accordance with ANSI C57.13. Metering CTs are identified as Meter Accuracy on the one-line diagram.
2) Ratio correction factor and phase angle tests for each CT ratio, standard burdens B=0.3 through B=2.0, 0.5 and 5.0 secondary amperes.
3) Resistance of current transformer secondary and connecting leads for each ratio.
4) Excitation and actual current ratio and turn ratio for each tap.
5) Note the individual CT serial number and the location it is installed within the switchgear on each test report.

b. Voltage Transformers

1) Test each Voltage Transformer in accordance with the requirements of ANSI C57.13. Voltage transformers shall be utilized for revenue metering and/or relay duty.
2) Note the individual VT serial number and the location it is installed within the switchgear on each test report.

4. Meter Mounting Location

a. Install meters on secondary side of building transformers.
b. To the extent possible, locate meters in the building where the metered loads are located.
c. Socket type meters are prohibited.
d. Meter enclosure to be remotely mounted outside of switchgear and panelboards.

1) Exception:

a) Mounting meters inside switchgear and panelboards is only acceptable when approved by Dartmouth College Engineering. In such cases, meters and meter components other than CTs must be installed in a separate cabinet section of switchgear isolated from active buses and breaker connections.

5. Communications:

    a. Proprietary communication protocols, mapping, data encoding, or socket types are prohibited. The metering system will be comprised of a network of stand-alone electric meters communicating via ModbusTCP and/or BACnetIP.
    b. If multiple disparate systems (BAS, CEMS, PME) require access to the meter data, the design team will include information in drawings and specifications showing what protocol will be used to connect to each system and a detail illustrating how connections will be made as well as any intermediary devices (i.e. Modbus to BACnet protocol converters) required to connect the meters to each system.

6. Wiring:

    a. Materials and installation of CT and voltage wiring will be in accordance with meter manufacturer requirements and Division 26. All reference voltage, control power, and CT wiring will be in conduits.
    b. Connect current and voltage transformer leads to accessible terminal blocks before wiring to metering devices.
    c. Use No. 14 AWG minimum stranded tinned copper conductor, 600 volt class, type SIS cross-linked polyethylene insulation for secondary and control circuits,
    d. Use No. 12 AWG minimum stranded tinned copper conductor, 600 volt class, type SIS cross-linked polyethylene insulation for current transformer secondary circuits.
    e. Use Multi-strand Class K hinge wire where door openings require bending in service.
    f. Where a moving object, such as a door will come into contact with a wire, suitable guards shall be provided to protect from chafing of the insulation.

7. Data Jacks & Communications Wiring

    a. Project to include one data jack per ethernet gateway device. Gateways may be integral to meter or a separate device.
    b. Electrical contractor to provide serial communication wiring between ethernet gateways and meters.
    c. Electrical contractor to provide patch cord between ethernet gateway device and data jack.
    d. Project to include at least one extra data jack in each room where meter gateway(s) are located.

8. Terminations

    a. Made using short-shank, uninsulated ring-tongue terminal connectors.
    b. Crimped using ratcheting type crimping tools designed to ensure a proper crimp by not releasing the connector until the crimp is fully complete.
    c. Made with no more than two conductors per terminal stud

9. Terminal Blocks:

    a. Rated 30 amperes, 600 volts minimum, or as required by circuit conductors
    b. Equipped with insulating barriers between poles and washer-head binding screws on each pole.
    c. Furnished with marking strips
    d. Short circuiting type for current transformer terminations.

E. PRODUCT SUBMITTALS

a. All metering submittals must be reviewed and approved by Dartmouth College Engineering prior to project team approval and equipment acquisition.

PART 2 - PRODUCTS

2.1 METERING SYSTEMS

A. Metering systems will be one of the Dartmouth College standard systems included in the tables below. Projects that use metering products other than those listed in these tables must first receive Dartmouth College Engineering approval for the proposed products and include the creation of new CEMS and PME device integration templates in their scope. If providing a non-standard meter utilizing the Modbus protocol, the project team must provide all protocol and register mapping to Dartmouth College Engineering for that specific meter make and model.

Table 1: Dartmouth College Standard Meter Make/Model by Application

Application Type	Application Description	Dartmouth College Standard Product	Dartmouth College Acceptable Alternative with DC Engineering Approval
Substation buses	Monitor loads and power quality on buses coming in from utility service to campus substations.	SE PM8000 in factory provided enclosure	**
Substation feeders	Monitor loads and power quality on feeders from campus substations to campus electric grid.	SE PM5563RD in factory provided enclosure	SE PM5560 in factory provided enclosure OR Electro Industries Shark 100 in factory provided enclosure
Substation capacitors	Monitor loads and power quality on capacitors in campus substations.	SE PM5563RD in factory provided enclosure	Electro Industries Shark 100 in factory provided enclosure
Main distribution panels (MDPs) serving multiple buildings	Monitor loads and power quality on main distribution panels (MDPs) that serve multiple buildings.	SE PM8000 in factory provided enclosure	**
Main Meters - Large or High Priority Buildings	Monitor loads and power quality on large and high priority buildings. Large and high priority buildings include Science Facilities Buildings, Medical School Lab Buildings, Thayer Engineering School Buildings.	SE PM8000 in factory provided enclosure	**
Main Building Meters - All other Buildings	Monitor loads and on all other buildings.	SE PM5563RD in factory provided enclosure	**
Automatic Transfer Switch (ATS)	Monitor the loads on standby and emergency ATSs.	Russ Electric Integral RTCS03 w/Panel Server Gateway OR ASCO Controller with PM8000 OR PM5560	**
Solar PV	Monitor loads and power quality to all other buildings.	SE PM5563RD in factory provided enclosure	SE PM5560 in factory provided enclosure
Electric Vehicle	Monitor loads on circuits serving electric vehicle chargers	SE EM3570 in factory provided enclosure	**
LEED End-Use Loads Submetering	Monitor loads on circuits serving end-use loads as required by LEED	SE EM3570 in factory provided enclosure OR SE HDPM6000 in factory provided enclosure with HDMI display *(applicable for metering*	**

		multiple circuits/loads in a single panel)	
Other End-Use Loads	Other End-Use Loads	**	**

***Discuss with Dartmouth College Engineering*

Table 2: Dartmouth College Standard Electric Metering System Products

	SE PM8000 in factory provided enclosure	**SE PM5563RD in factory provided enclosure**	**SE PM5560 in factory provided enclosure**	**Electro Industries Shark 100 in factory provided enclosure**	**Russ Electric Integral RTCS03 w/Panel Server Gateway**	**ASCO Controller with PM5560 (ASCO Option 113L)**	**ASCO Controller with PM8000 (ASCO Option 150A8)**	**SE EM3570 in factory provided enclosure**	**SE HDPM in factory provided enclosure**
Manufacturer	Schneider Electric	Schneider Electric	Schneider Electric	Electro Industries	Russ Electric	ASCO	ASCO	Schneider Electric	Schneider Electric
Meter model	PM8000	PM5563RD	PM5560	Shark 100	RPTCS03	ASCO ATS w/Option 113L	ASCO ATS w/Option 150A8	EM3570	HDPM6000
Enclosure model	9761C	9761C	FAEV	ENC	N/A – integral to ATS	N/A – integral to ATS	N/A – integral to ATS	ENC	To be coordinated with SE during submittals
CT Type	XXX:5A	XXX:5A	XXX:5A	XXX:5A	XXX:5A	XXX:5A	XXX:5A	XXX:0.333 V (LVCTs)	XXX:0.333 V (LVCTs)
Ethernet Gateway	Integral to Meter	Integral to Meter	Integral to Meter	Integral to Meter	External ethernet gateway	Integral to Meter	Integral to Meter	External ethernet gateway	Integral to meter

B. OTHER DEVICES

1. Other Devices include but are not limited to the following:

   a. Micrologic trip units in switchgear
   b. Transient voltage surge suppressor (TVSS) units
   c. Transformer fan controllers
   d. Switchgear temperature sensors

2. Projects team to discuss scope of integration and ethernet connectivity for "Other Devices" with Dartmouth Engineering during design process.

3. When integrating "Other Devices" into Dartmouth College software systems (i.e. CEMS, PME), design teams are permitted to utilize serial wiring with prior approval from Dartmouth Engineering. In such instances, serial daisy-chains will:

   a. Be limited to 5 devices or less whenever possible
   b. Not span between rooms
   c. Be wired to a dedicated ethernet gateway. Utilizing integral main meter ethernet gateways is not acceptable for "Other Device" daisy-chains

C. EXTERNAL ETHERNET GATEWAYS

1. Preferred external ethernet gateway manufacturer and model for connecting serial devices to campus ethernet:

   a. Schneider Electric Panel Server with POE power, model number: PAS600PWD

PART 3 - EXECUTION

3.1 METERING SYSTEM INSTALLATION

A. Metering system installations to be provided with manufacturer's start-up and training.

B. Metering system procurement and installation to be by project's electrical contractor

1. Install per manufacturer's instructions and Dartmouth College's Division 26 guidelines

2. Metering system installation includes:

a. Meters, CTs, shorting blocks, voltage reference, control power, interconnecting wires, pathway (conduit), enclosure, ethernet gateway, and ethernet patchcord as necessary
b. Reference voltage breakers, typically a dedicated 3pole 15 amp circuit breaker.
c. Meter control power either via a dedicated 1 pole 15 amp circuit breaker OR fed via reference voltage and step down transformer inside of factory-provided metering enclosure.
d. Dedicated current transformers (CTs) wired through a shorting block, unless otherwise reviewed and approved by Dartmouth Engineering. One side of each current transformer must be grounded at the CT shorting block.

3.2 DATA/ETHERNET INSTALLATION

A. Network jacks (demarcation point) for IP-based meters will be installed by the Division 27 contractor.

B. Pathway and patch cords from Division 27 demarcation point (network jack) to meter will be installed by project electrical contractor.

C. Metering installations utilizing RS485 wiring communicating data via BACnet MSTP or Modbus RTU will only be permitted with approval from Dartmouth College Engineering. Low voltage serial control and sensor wiring (e.g. twisted pair 18AWG) will not be bundled with Ethernet or Category 5-5e-6 cabling. Serial communication wiring to be run by and terminated at gateways by electrical contractor.

D. All network cabling will be properly labeled.

E. See Division 27 for patch cord pathway and cabling requirements.

3.3 LABELING

A. Electrical contractor to label all meter enclosures with panelboard and breakers from which reference voltage and control power are sourced and with CT ratio (i.e. XXXX:5A) and panelboard/switchgear where CTs are located.

B. Identify at each wire end using white tubular plastic wire markers with black markings in accordance with schematic and wiring diagrams. Wire labels shall indicate destination (other end) of each wire. Wire markers shall completely surround the wire, shall be oriented so as to be easily read when the wiring is installed, and shall not be removable once termination has been crimped on.

3.4 METERING START-UP

A. Electrical contractor to energize meters.

B. Electrical contractor to request IP addresses and BACnetID for each meter gateway from Campus Services Technology Services (CSTS).

C. Electrical contractor to coordinate with Division 27 contractor and Dartmouth College Network Services to confirm that data jacks are activated and configured for the correct Energy Management VLAN.

D. Electrical contractor to coordinate with Dartmouth College Metering Technician to input basic meter configuration data into meter, including:

1. CT/PT ratio
2. Wiring configuration (i.e. 4-wire WYE, 3-wire delta, etc.)

E. Electrical contractor to coordinate with Dartmouth College Metering Technician to input static IP, subnet mask, gateway address, and BACnetID into each meter gateway.

F. Metering start-up to be completed before Meter Commissioning.

3.5 METER COMMISSIONING

A. Meter commissioning to be coordinated by Electrical Contractor and performed on-site by Meter Manufacturer's Technician with Electrical Contractor and Dartmouth College Metering Technician Support.

B. Contractor will set up commissioning schedule with minimum 5 days notice to the following parties:

1. Members of the Project Team
2. Dartmouth College Engineering
3. Dartmouth College Metering Technician
4. Dartmouth College FOM Electrical Shop

C. Project teams should plan for 2 hours per meter for commissioning.

D. Meter commissioning to include:

1. Verifying that the meter is properly configured for the electrical system including: CT/PT ratio, system type, IP Address, BACnet ID and Modbus address if applicable, and phasor diagram for meter.
2. Electrical contractor to spot measure amps, voltage (L-N), power factor, and true power on each phase and average with a hand-held power meter and compare to data shown on each permanent meter. Results of spot measurements to be reported to Dartmouth College Engineering in format similar to example in Table 3 below.

Table 3. Example Meter Reading Validation Table

Reading Type	***Phase A***	***Phase B***	***Phase C***	***Notes***
Amps	*20.1/19.1*	*21.0/19.7*	*23.4/24.1*	*handheld/permanent meter*
Volts (L-N)	*278.1/279.7*	*279.0/278.7*	*280.1/280.3*	*handheld/permanent meter*
Power Factor	*99%/98%*	*97%/98%*	*96%/95%*	*handheld/permanent meter*

Real Power (kW)	*5.6/5.4*	*6.0/5.3*	*6.2/6.3*	*handheld/permanent meter*

E. METER DATA INTEGRATIONS

1. Project team is responsible for meter integration into Dartmouth's power quality monitoring (PME), asset management (Planon), campus energy management (CEMS) and building automation system (BAS) softwares.
2. Electrical contractor to include coordination of PME software integration in their scope of services.

    a. PME Software Integration: Schneider Electric Technician will connect and configure meter in the PME software and create graphics for each meter. This can be completed during commissioning or via a remote session after meter commissioning is complete.
    b. Dartmouth College Engineering will provide access to PME server via remote desktop and an online session with Schneider Electric Technician.

3. Electrical contractor to assist project Commissioning Agent in populating workbook with meter asset data for upload into Dartmouth's Asset Management software. If project does not have a Commissioning Agent, electrical contractor will work with Dartmouth College Metering Technician to populate this workbook.

4. Electrical contractor will notify Dartmouth College Metering Technician and Dartmouth College Engineering when meter commissioning is complete. Dartmouth College Metering Technician and Dartmouth College Engineering will coordinate with CEMS vendor to integrate meters into the CEMS and asset managment software.

    a. Project to cover cost of meter integration into the CEMS.

5. Building Automation System (BAS) Integration: See BAS integration requirements detailed in Division 25.