23M – Energy & Utilities Metering

1. Summary

HMS's Energy and Utility metering system provide real time monitoring of electricity, steam, hot and chilled water, potable water, and compressed air demand and consumption on campus made accessible via web-based interfaces and various dashboards.

About 200 meters (~ 30 steam, ~ 35 chilled water, ~20 various hot water meters, ~20 compressed air meters, ~20 potable water meters, and ~80 electric) with the associated hardware and software licenses are currently installed. These meters are divided into the "main building meter" and "sub-meter" categories. Data networks employed to receive the data from the meters and send the results to the OSI PI Database/Historian.

HMS owns and maintains various data visualization and analytics software solutions residing on the internal servers. These include OSI PI Data Historian from OSI Soft, Retina from BCT, and Clockworks Fault Detections and Diagnostics platform from KGS Buildings.

2. Related Sections

a. Division 22 – Plumbing

b. Division 23 – HVAC

c. Division 25 – Building Automation System (BAS)

d. Division 26 – Electrical

3. Electric Meter Requirements

Technology:

a. Substation and campus primary switchgear shall have digital power quality meters which have ability to measure and communicate a range of electrical parameters required for proper system operation, calibration, and troubleshooting.

b. Building energy meters and sub- meters shall mostly have digital Revenue Type Meters which have ability to measure and communicate a limited range of electrical parameters including Voltages, Currents, Active and Reactive Power, Energy, and Power Factor. All meters shall have local displays configured for instantaneous electric demand and totalized consumption.

Connectivity

a. All installations shall be connected to OSI PI (Data Historian) or BAS (when required for proper operation of BAS) using ASHRAE BACnet/IP protocol. At a minimum, active power in kW, reactive power in kVAR, Totalizer for energy in kWh, as well as meter Error Diagnostics data shall be mapped into OSI PI. All readings in OSI PI shall match with the data shown on the local displays.

b. HMS IT department will provide one (1) Ethernet data drop to each meter with a static IP address.

c. The contractor shall be responsible for proper installation of the meter and for enabling energy consumption calculations before the project is turned over to HMS Facilities.

d. If requested by HMS Facilities, the GC may need to furnish and install temporary electric meters at the construction site to collect energy consumption information during the construction project.

Approved Meters

a. Power Quality Meters:
   i. Square D CM4000, PM870, or equivalent
   ii. ION 7650/7550 series
   iii. Eaton PXM 4000/6000/8000

b. Energy Meters:
   iv. Schneider Electric Square D PM820 or equivalent
   v. ION 6200 series or equivalent
   vi. Eaton PXM 1000
   vii. Siemens PAC4200 advanced meter or equivalent
   viii. Shark 2000 Power and Energy Meter

Meter Calibration and Maintenance Requirements

a. None

4. Chilled and Hot Water Meters

Technology:

a. The Clamp-on Ultrasonic flow meters may be used on all pipe types and shall be used for services 2” and greater in diameter. Services below 2” may use Teflon-lined Magnetic (MAG) flow meters or in-line Ultrasonic meters.

b. A calibrated pair of temperature sensors for CHW tonnage calculation shall be installed in thermo-wells on the chilled water supply and return lines.

c. If meters are installed in the mechanical rooms, they shall have flow computers and other electronics and displays mounted in the same room. When meters are installed in the tunnels or crawl spaces which are not easily accessible or when the environment in such locations may adversely affect the operation of electronic devices, a remote electronics option shall be used. Manufacturer specifications for maximum allowable distance between the flow sensing device (flow-cell) and its transmitter/electronics should be followed.

d. The Ultrasonic flow meters shall have 15 unobstructed pipe diameters of straight pipe upstream and 5 pipe diameters downstream unless specified otherwise by the manufacturer.

e. Straight run requirements for MAG meters should be verified with the manufacturer

f. Meter size selection shall be based upon the actual volumetric flow rate of fluid in the pipe and not the pipe diameter. If historical flow trends are not available, flows in the pipes should be verified by portable clamp-on meters. In case if installation of portable meter is not practical, the best attempt should be made to estimate the flow using design cooling and heating load data, pump curves, or other field verification techniques.

g. The minimum velocity requirements specified by the meter manufacturers shall be verified and followed. The pipe reducers may be used in those instances where there is a need to increase velocity of the fluid passing through the meters.

h. All meters shall provide a Turndown Ratio of 50:1 or more

i. All meters shall provide 2.0% accuracy or less for the whole range of volumetric flows supported by the meter

j. All CHW meters shall have the ability to measure volumetric flow rate and calculate instantaneous cooling demand in Tons and totalized usage in Ton-Hrs

k. All Hot Water meters shall have the ability to measure volumetric flow rate and calculate instantaneous heating demand in kBtu/Hr and totalized usage in kBtu

Connectivity

a. All installations shall be integrated into OSI PI (Data Historian) and Siemens BAS (if required for proper operation of BAS) using BACnet/IP protocol. The flow rate of fluid in GPM, the Energy Rate in BTU/Hr, and the energy Totalizer in BTU as well as meter Error diagnostics data shall be mapped into OSI PI.

l. HMS IT department will provide one (1) Ethernet data drop to each meter with a static IP address.

m. Meters shall have ability to calculate and display energy consumption data without BAS/OSI PI support. All readings in OSI PI shall match with the data shown on the local displays.

n. The contractor shall be responsible for proper installation of the meters and for enabling network connections and data mapping before the service is turned over to HMS Facilities.

Approved Meters

a. Clamp on/Inline Ultrasonic flow meters:

   ix. FLEXSUS series flow meters from Flexim
   x. SITRANS FUS series from Siemens
   xi. Spire TP series

b. Magnetic flow meters:

   i. Toshiba LF-series
   ii. Johnson-Yokogawa ADMAG series
   iii. Siemens SITRANS FM series

Meter Maintenance Requirements

a. All chilled and hot water meters shall be inspected every year and records captured by work orders in Maximo

b. Annual inspections shall include examination of all components of metering assembly including meter body, flow cells, transmitters, signal tubing, condition of coax and other cabling, electronic panels and flow computers. Any evidence of mechanical or electric damages should be reported to HMS Facilities personnel.

c. For ultrasonic meters, it is required to verify that the signal strength from the transducers is above 55%. If signal strength is below 55%, the conditions of the strap and the coupling agent should be checked and re-adjusted.

d. Evidence of any error codes present on the local meter screens, meter panels, and flow computers shall be recorded in the inspection log and reported to the Facilities personnel. Inspection shall verify that the readings on the local displays match with the reading shown in BAS or OSI PI. Any significant deviations should be investigated and a proper calibration procedure performed to reduce the magnitude of these deviations.

e. In addition to the items described above, it is required to calibrate the readings from the temperature probes (RTDs) paired with the flow meters. This is done by removing the sensors from thermo-wells and testing them using a controlled temperature source.
    i. For chilled water meters which calculate the cooling tonnage, this calibration shall be performed at the temperature values of 40F and 50F. If the readings are off by more than 0.25F, then an adjustment procedure is required.
    ii. For hot water meters which calculate the Btu content, calibration process shall be performed at 100F and 150F. If the readings are off by more than 0.5F, then an adjustment procedure is required.

5. Saturated Steam Meters

Technology:

a. A few metering technologies are accepted for Medium/High Pressure steam applications including Veris' Averaging Pitot-Tube Accelabar meters and SpiraxSarco's Spring-loaded Variable Area (V-cone) meters.

b. Except for the Veris Accelabar meters, other meter types shall have 15 unobstructed pipe diameters upstream and 5 pipe diameters downstream of the meter (unless recommended otherwise by the manufacturer). When the minimum straight pipe run requirements are not met, an upstream flow straightener may be utilized.

c. If meters are installed in mechanical rooms, they shall have flow computers and other electronics and displays mounted in the same room. When meters are installed in tunnels or crawl spaces and not easily accessible, or if the environment in these locations may adversely affect the operation of electronic devices, a remote electronics option shall be used. Manufacturer specifications for maximum allowable distance between the flow sensing device (flow-cell) and its transmitter/electronics should be followed.

d. Since the HP/MP steam provided to the campus buildings is saturated, the meters need

only one process parameter (temperature or pressure) to accurately calculate the Mass Flow Rate and Btu rate of steam in the flow computer.

e. For existing buildings, meter technology and size selection shall be based upon the actual mass flow rate of steam and not the utility service pipe diameter. If historical flow trends are not available, the best attempt should be made to estimate the flow using design cooling and heating load data, pump curves, or other field verification techniques.

f. For each application, the following parameters have to be verified prior to meter selection:

   i. Steam pressure (psig)
   ii. Steam temperature (°F)
   iii. Min and Max mass flow rate in Lb/Hr
   iv. Min and Max volumetric flow rate (ft^3/sec)
   v. Min and Max velocity (ft/sec)
   vi. Turndown Ratio = Vmax / Vmin

g. Meter specification package shall include a flow analysis with the tabulated values of the above parameters as well as the value for the permanent pressure loss through the meter at maximum flow.

h. The minimum velocity requirements specified by the meter manufacturers shall be verified and followed. The pipe reducers may be used in those instances where there is a need to increase velocity of the steam passing through the meters. For these instances, the section of the pipe of a required length shall be downsized using two eccentric reducers to avoid accumulation of condensate in the pipe.

i. Care shall be exercised while selecting meters for Low Pressure steam applications (<10psig). The choice of steam flow meter should avoid excessive permanent pressure loss through the flow meter. This is achieved by selecting a flow meter with a lower minimum velocity requirement. The permanent pressure drop across LP steam meter shall not exceed 1 psi at the design flow conditions.

j. All meters shall have the ability to communicate multiple process parameters, including steam Pressure (PSIG), Temperature (°F), Volumetric Flow Rate (ft3/sec), Mass Flow Rate (Lb/Hr), and Energy Rate (Btu/Hr)

k. All meters shall have ability to calculate instantaneous and totalized Mass and Energy Rates of steam.

l. All meters shall provide a Turndown Ratio of 50:1 or more. If this turndown ration for Averaging Pitot Tube and V-Cone style meters is not achievable, then stacked diff pressure transmitters should be used to provide reliable winter and summer readings

m. All meters shall provide 2.0% accuracy or less for the whole range of volumetric flows supported by the meter

Connectivity

a. All installations shall be integrated into OSI PI (Data Historian) and Siemens BAS (if required for proper operation of BAS) using BACnet/IP protocol. The Mass Flow Rate of

steam in Lb/Hr, the Energy Rate in kBTU/Hr, and the energy Totalizer in kBTU as well as meter Error diagnostics data shall be mapped into OSI PI.

b. HMS will provide one (1) Ethernet data drop to each meter with a static IP address.

a. Meters shall have the ability to calculate and display energy consumption data without BAS/OSI PI support. All readings in OSI PI shall match with the data shown on the local displays.

b. The contractor shall be responsible for proper installation of the meters and for enabling network connections and data mapping before the service is turned over to HMS Facilities.

Approved Meters

a. Spring-loaded variable area (V-cone) meters:

iii. Spirax-Sarco Gilflo, ILVA, or DIVA series

b. Averaging Pito-tube meters:

iv. Veris Accelabar, AFS series

c. Flow Computers:

v. Spirax-Sarco M800 series
vi. KEP ES749 series
vii. KEP SuperTROL series

Meter Maintenance Requirements

a. Steam meters shall be inspected annually and records captured by work orders in Maximo The annual inspections shall include examination of all metering assembly components including the body, transmitters, condition of cabling, electronic panels, and flow computers. Any evidence of mechanical or electric damages should be reported to HMS Facilities.

a. Evidence of any error codes present on the local meter screens, meter panels, and flow computers shall be recorded in the inspection log and reported to HMS Facilities.

b. Inspection shall verify that the readings on the local displays match with the reading shown in BAS or OSI PI. Any significant deviations should be investigated and a proper calibration procedure performed to reduce the magnitude of these deviations

viii. For V-cone meters, isolation valves on the transmitter manifolds should be exercised to perform “Zero”-calibration procedure.

c. For annual inspections, in addition to the items described above, it is required to check the readings from the temperature and pressure transmitters paired with the flow meters. This is done by removing the sensors from the lines and testing them using a calibrated pressure/temperature sources at 5 different values of these parameters.

ix. For V-cone meters, “Zero” and “Span” adjustments should be performed at this time for all differential manometers

6. Steam Condensate Meters

   Technology:

   a. Ceramic lined electromagnetic flow meters maybe used for condensate flow measurements and must be approved by HMS Facilities when a steam flow meter cannot be installed.

   b. Condensate meters shall have ability to measure the volumetric flow of steam condensate in GPM in both directions and should be rugged enough to withstand high temperatures (250^{o}F) and steam hammer effects which are common on the condensate return lines

   Connectivity

   a. Same as for steam meters.

   Approved Meters

   a. Magnetic meters for condensate flow measurements:

      i. Toshiba LF-series
      ii. Johnson-Yokogawa ADMAG series
      iii. Siemens SITRANS FM series

7. Potable Water Meters

   Technology:

   a. A few water metering technologies are approved for measuring the flow of potable water on campus. This includes positive displacement meters, compound dual-register meters, and solid-state ultrasonic flow meters.

   b. The positive displacement meters based on the magnetically driven flat nutating disc have enhanced low flow accuracy and should be used for all water connections below 1 ½" in diameter. These meters should meet or exceed the latest AWWA C700 Standard.

   c. Compound meters shall consist of a combination of an AWWA Class II turbine meter for measuring high rates of flow and a nutating disc type positive displacement meter for measuring low rates of flow enclosed in a single main-case. An automatic valve shall direct flows through the disc meter at low flow rates and through the turbine meter at high flow rates. At high flow rates, the automatic valve shall also serve to restrict the flow through the disc meter to minimize wear. These meters should be used on all service connections with pipe diameters between 2" and 3".

   d. Potable water connection lines above 3" in diameter shall use solid state in-line ultrasonic meters. These meters provide enhanced low flow accuracy performance, high turndown ration, and extended accuracy over meter life.

   e. All meter types shall be made of "lead free" alloy as defined by NSF/ANSI 61, Annex G and Annex F.

   f. All meter types should have main-case screws bolts made of 300 series non-magnetic stainless steel to prevent corrosion.

g. All electronics and meter registers must feature fully-potted electronics and battery as well as carry an IP68 rating for submersion in flooded pits.

h. Registration accuracy for all meters over the normal operating range shall be 98.5% to 101.5%. Registration for compound meters at the crossover point shall not be less than 95% with direct reading registers.

i. Registration at the extended low flow rate shall not be less than 95%.

j. All meters of smaller sized (<1") should have built-in strainers

Connectivity

a. It is preferred to have BACnet connection capability for all new meter installations. If this is not practical, the following shall apply:

   I. All meters shall be equipped with encoder remote registers per AWWA C707 and shall meet all AWWA C702 performance standards

   II. All meters shall have the ability to communicate the encoder or pulse output for the totalized flow in Gallons or Cubic Feet

   III. When required (mostly on larger service lines), the meters will need to have additional 4-20mA output to provide instantaneous flow information in GPM.

   IV. When it is required to translate encoder signal into 4-20mA output, an external signal generator similar to SignalizerTM from SCADAmetrics could be used. The Signalizer utilizes the popular encoder signal from the water meter to generate both a 4-20mA rate-of-flow signal and a dry-contact pulse-per-volume signal.

b. All potable water meters shall be digitally integrated into OSI PI or BAS

c. The contractor shall be responsible for proper installation of the meters and for connections and data mapping before the service is turned over to HMS Facilities.

Approved Meters

a. Positive Displacement
   i. Neptune T-10 (5/8" to 1 ½")
b. Compound meters:
   ii. Neptune TRU/FLO (2" – 3")
c. Ultrasonic meters:
   iii. Neptune MACH-10 (>3")

Meter Maintenance Requirements

a. Potable water meters shall be inspected annually and records captured by work orders in Maximo.

b. Annual inspections shall include examination of metering assembly including meter body and electronics. Any evidence of mechanical or electric damages should be reported to HMS Facilities personnel.

c. Inspection shall verify that the readings on the local displays match with the reading shown in BAS or OSI PI. Any significant deviations should be investigated and a proper

calibration procedure performed to reduce the magnitude of these deviations

8. Compressed Air Meters

Technology:

a. Thermal mass flow meters are approved for measuring production, flow, and consumption of compressed air on campus. These meters work by sensing the amount of heat required to deliver to the probes located in the stream to maintain a fixed temperature difference between them. The faster the air flows, the more heat is required to be delivered to the probes.

b. Clamp-on insertion style meters could be used on all steel or copper compressed air lines with pipe diameters of 3/4" and above. These meters connect onto a pipe with a metal clamp of the same material and two flow-sensing probes projecting into the pipe through 3/16-in pre-drilled holes. They attach directly to the pipe with no cutting or welding required which simplifies the installation process.

c. In-line meters shall be used on pipe diameters of ½" and below and require full-pipe NPT or flanged connection.

d. Meters shall be installed where the air is free of oil and water droplets, i.e. downstream of the air dryer and filter.

e. A length equal to 20 pipe diameters is normally sufficient in most cases. More is recommended after long-radius elbows and other items that could distort or concentrate the flow.

f. All meters shall have the ability to calculate instantaneous flow in SCFM and the totalized flow in SCF.

g. For some applications, it may be required to use meters which can provide additional process parameters including compressed air pressure and temperature.

h. All meters shall provide 5.0% accuracy or less for the whole range of volumetric flows supported by the meter

i. The meters shall be designed to sustain maximum pressures of 220 psig and temperatures of 250F (120C).

Connectivity

a. It is preferred to have BACnet connection capability for all new meter installations. If this is not practical, then a 4-20mA or Modbus integration into the BAS will be required.

b. All meters shall have the ability to communicate the instantaneous flow in SCFM (or SCFH) and a pulse output for the totalized flow in SCF (or kSCF).

c. All compressed air meters shall be digitally integrated into BAS (Siemens) permitting remote display and data collection.

d. A BACnet communication option capable of transmitting multiple process parameters to is preferred

e. The contractor shall be responsible for proper installation of the meters and for BAS connections and data mapping before the service is turned over to HMS Facilities

Approved Meters

a. 5000 series compressed air/nitrogen meters from CDI
b. SD-6000/8000/9000 series from IFM

Meter Maintenance Requirements

a. CA meters shall be inspected annually and records captured by work orders in Maximo. Annual inspections shall include examination of metering assembly including meter body and electronics. Any evidence of mechanical or electric damages should be reported to HMS Facilities personnel.

b. Inspection shall verify that the readings on the local displays match with the reading shown in BAS or OSI PI. Any significant deviations should be investigated and a proper calibration procedure performed to reduce the magnitude of these deviations

9. Naming Conventions for BAS Metering Points

HMS Facilities shall have control over the naming of new points so there is consistency and clarity across all meters. The front-end point names of OSI PI or BAS integrated metering points shall be standardized in such a way that their (if applicable) building, utility, location, sub-location, system, parameter, and descriptor are easily identified while accessing associated metering data.

There are grandfathered exceptions to the rules (*), but the general naming convention is as follows:

General

a. This naming system shall be applied to the OSI PI/BAS system.
b. The convention's design and any subsequent changes to it are directed and owned by HMS.
c. The naming shall be consistent in project documents, drawings, specs, equipment labeling, and graphics.

Naming Convention

a. Only the period (.) character shall be used to delimit the segments of the point name.
b. Points' AKA Tags shall be named with the following convention, with segments in this order:
    i. Building Letter
    ii. Utility
    iii. Location
    iv. Sub-Location OR System*
    v. Parameter
    vi. Calculated Point Descriptor**
    vii. Error***

    EX: Building Letter. Utility. Location. Sub-Location/System. Parameter. CalcPointDescriptor. Error

c. When creating new points in the OSI Pi system, Tag, Descriptor, ExDesc****, Pointsource, EngUnit, Pointtype, source are required fields.

d. Tag shall follow the naming convention detailed in this section.
e. Descriptor shall write out the Tag's fields without abbreviation and include any necessary details of the meter/equipment monitored

The following tables show the allowable entries/acronyms used in the naming convention:

a. Building Letters	
A	Gordon Hall
B	Goldenson
C	Building C
D	Armenise
E	Toteston Medical Education Center (TMEC)
F	180 Longwood
J	641 Huntington Ave
K	Research Education Building (REB)
L	LHRRB
M	Seeley G Mudd
P	Harvard Institutes of Medicine (HIM)
Q	Warren Alpert (WAB)
S	New Research Building (NRB)
T	School of Dental Medicine
ETERRACE	
H	Harvard Medical School Campus Point

b. Utility Acronyms	
ELEC	Electric
STM	Steam
CHW	Chilled Water
NG	Natural Gas
POTWTR	Potable Water
NPWTR	Non-Potable Water
HHW	Heating Hot Water
DHW	Domestic Hot water
CA	Compressed Air
AIR	Comfort H&C Air

c. Location Acronyms	
Side of Building or Switchgear	
	A
	B
Building Wing or Electric Feed	
	1
	2

d. Examples of Sub-Locations	
FROG	Frog Room
JMIC	Modell
HCCM	Animal spaces
COLDRM	Cold Room
FRZRM	Freezer Room

e. Examples of Systems	
AHU	Air Handling Units
ATS	Transfer Switch Systems
CHP	Chilled water pump
CT	Cooling Tower
DHW	Domestic Hot Water
COND	Condensate
HRC	Heat Recovery System
HX	Heat Exchanger System
RH	Re-Heat
FCU	Fan Coil Unit
HHW	Heat Hot Water

f. Major Physical Parameters	
FLOW	Flow of fluid or steam in GPM or LB/hr
imp	Pulse count from pulse meters
KW	Kilowatt of power
kWH	Kilowatt-hour of energy
LBSHr	Pounds per hour (steam)
NETENERGY	
PF	Power Factor
Pressure	
Return	
Sound Speed	
SSDN	Downstream Signal Strength
SSUP	Upstream Signal Strength
Supply	
Tonhrs	Ton-hours of cooling CHW heat content
Tons	Tons of cooling – CHW load
Vavg	Average velocity
Velocity	
Xgal	Extra gallon of CHW flow

g. Calculated Point Descriptor
TOTAL
MAX
MED
Mode
MIN
15Avg
30Avg
60Avg
Avg

h. Error State Point
Error

Notes & Exceptions:

*If the meter is a building level meter, the system/equipment segment is omitted from the point name. If the equipment has a defined number or name (ex: AHU5), then the sub-location field is not required. If the equipment has no number or is not well defined, sub-location is required.

Example:	
Equipment level (name undefined)	A.CHW.FROG.AHU.RET.F
Equipment level (name defined)	A.CHW.AHU3.RET.F
Building Level	A.CHW.RET.F

**If the Point is a calculated point of the type referenced in Table f., this segment should be included.

Example:	
Parent Point	S.STM.FLOW
Calculated Point	S.STM.FLOW.15AVG

***Meter error points shall have the same name as their parent point, but with “ERROR” at the end.

Example:	
Parent Point	A.CHW.FLOW
Error Point	A.CHW.FLOW.ERROR

****EXDesc segment shall include the formula of any calculation taking place, applies to calculated points only.

Example:	
Point Name	LY.MATEP.CHW.TONS
Desc	Lying In TONS BASED ON MATEP
ExDesc	('LYGPM1_CV' * ('LYCWRT_CV' - 'H.CHW.SUPPLY') /23.954)

The Parameter segment, defined above in Table f., corresponds to the following Engineering Units, depending on utility.

Engineering Unit Parameters	
ELEC	**Electric**
	kW
	kWh

	PF
	Netenergy
STM	**Steam Flow/Energy Meter**
	lbshr
	lbs
	Btu/Hr or Btu
	psi
	fts
	SSDN
	SSUP
CHW	**Chilled Water**
	gpm
	tons
	tonhrs
	Xgal
	SSDN
	SSUP
	F
AIR	**Air Flow Meter**
	fts
	BTU
CA	**Compressed Air**
	CFM
	scFM
HW	**Hot Water Flow/Energy Meter**
	gpm
	Btu/Hr or Btu
	F

End of Section