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1. GENERAL
	1. DESCRIPTION

#### This document summarizes the minimum owner requirements to support the planning and implementation of monitoring based commissioning (MBCx) for new or renovated construction projects that exceed 2,500 m2 or 250,000 ekWh total annual energy consumption at UBC.

.2 The MBCx plan is to be approved by UBCO operations and energy team before implementation.

* 1. PURPOSE

#### Monitor and verify system performance over time and identify opportunities for improving system performance.

#### Confirm if system performance is as per the Owners Project Requirements and Basis of Design.

#### Determine why systems are not performing as per design.

* 1. SCOPE

Monitoring based commissioning is the responsibility of the MBCx consultant. MBCx activities include preparation of MBCx plan, review design drawings and control schematics for appropriate meters and trends, MBCx related construction administration, MBCx related commissioning, and MBCx reporting. Throughout the project, the MBCx consultant will lead the integration and coordination of MBCx related matters with the Design Team, Construction team, Controls team, UBCO operations and energy team. The MBCx consultant shall be independent of the work of design and construction. It is recommended that the MBCx and the independent project commissioning provider (CxP) services are provided by the same consultant.

* 1. DEFINITIONS

**Monitoring Based Commissioning** - (MBCx) means utilizing energy performance metering and DDC trending for diagnosis of under-performing systems, for optimizing system performance and for on-going performance monitoring.

**MBCx Plan** -is a document which describes how energy and water consumption data and system performance data will be collected and analyzed for the purpose of evaluating short and long-term system performance, system efficiency, energy consumption, water consumption, and opportunities for optimization of system operation and efficiency. It includes details of who is responsible for each aspect of the MBCx process.

**Owners Project Requirements** - (OPR) is a written document that details the ideas, concepts, and criteria determined by the owner to be important to the success of the project.

**Basis of Design** - (BOD) is a description of the proposed design and how it will accomplish the owner’s project requirements. It should include system descriptions, indoor environmental quality criteria, design assumptions, and references to applicable codes, standards, regulations, and guidelines.

**Monitor** - The term “monitor” or “monitoring” herein implies inclusion of configuring trend logs in the BMS to support MBCx activities.

* 1. ORGANISATIONAL CHART

Owner

Project Manager

Integrated Design Team

Cx Provider

MBXc provider

Construction Manager

General Contractors

Mechanical Contractor

Controls Contractor

Electrical Contractor

M&E Coord

Cx Manager

Documented Deliverables

Design

Document Flow

Cx Meeting/Coordination Flow

* 1. RELATED DOCUMENTS

#### UBC Technical Guidelines Section 01 91 00 – COMMISSIONING

#### UBC Technical Guidelines Section 20 00 06 – MECHANICAL METERS

#### UBC Technical Guidelines Section 26 27 13 – ELECTRICAL METERS

#### UBC Technical Guidelines Section 25 05 00 – BUILDING MANAGEMENT SYSTEMS

#### ASHRAE Guideline 0-2005, “The Commissioning Process”, or the latest version.

#### LEED V4 Canada Commissioning requirements.

#### LEED v4 Water Efficiency (WE) Prerequisite: Building-Level Water Metering

#### LEED v4 WE Credit: Water Metering

#### LEED v4 EA Prerequisite: Fundamental Commissioning and Verification

#### LEED v4 EA Prerequisite: Building-Level Energy Metering

#### LEED v4 EA Credit: Enhanced Commissioning (Monitoring-based commissioning option)

#### LEED v4 EA Credit: Advanced Energy Metering

1. MINIMUM METERING REQUIREMENTS

#### Energy and water systems must be designed in such a way as to enable energy and water monitoring for the purpose of determining overall system performance.

* 1. PRIMARY SIDE UTILITY METERS

#### All new construction projects require primary metering for monitoring of the following energy and water sources:

##### Total building electricity consumption and demand (real and apparent power).

##### Total building natural gas consumption and demand.

##### Total building district energy consumption and demand.

##### Total building water consumption and demand.

#### Refer to Appendix 1 and 2 of this document and UBC Technical Guidelines sections 20 00 06 & 26 16 00 for specific guidance on metering equipment requirements and cross-discipline coordination.

* 1. SECONDARY SIDE BMS METERS

#### New construction projects that exceed 2,500 m2 or 250,000 ekWh total annual energy consumption require dedicated metering and monitoring of the following energy and water end-uses. *Renovation or tenant improvement project within a building that meets these requirements shall also include the following:*

##### Interior lighting.

##### Exterior lighting.

##### Space heating: electricity and/or natural gas consumed by heat pumps, electric boilers, natural gas boilers, and/or thermal energy from UBC’s District Energy System (DES).

##### Space cooling: electricity consumed by heat pumps, chillers, and/or cooling towers.

##### Domestic hot water heating: electricity and/or natural gas consumed by heat pumps, electric boilers, natural gas boilers, and/or thermal energy from UBC’s DES.

##### Thermal energy distributed by the building’s hydronic heating loop.

##### Thermal energy distributed by the building’s hydronic cooling loop.

##### Fans and pumps: no meter required, refer to monitoring requirements in section 2.3.

##### Receptacle loads: can be excluded from the sub metered list if it is possible to calculate their energy consumption through subtraction of all other sub-metered electrical loads from the electrical Primary Side Utility Meter.

##### Water for irrigation and hose bibs.

##### Data centres >50 kW’s (data centres electrical load only, excludes associated cooling load).

##### Energy end-uses can be excluded from the sub metered list if the end-use represents less than 10% of total annual energy consumption, as determined from detailed design-phase energy modeling. Where multiple sources of energy make up an end-use, this criterion refers to the total end-use.

##### For (3), (4), and (5) above, excludes electricity used for circulation pumps.

##### Where more than one meter is required to measure a given end-use type, include a virtual meter point to represent the aggregate load. For heat pumps, include virtual meter points for energy consumption for space heating and for space cooling.

#### Refer to Appendix 1 and 2 for specific guidance on metering equipment requirements and cross-discipline coordination.

* 1. SYSTEMS OPERATION AND PERFORMANCE VERIFICATION

#### For the following systems, monitoring is required through Secondary Side BMS Meters and systems level BMS trend-logs. Refer to section 2.4 for meter communications protocol and trend log configuration requirements.

#### In addition to the Secondary Side BMS Meters required, include provisions for monitoring as follows:

##### Environmental parameters: monitor outdoor air temperature.

##### On-site renewable energy systems:

###### For Solar PV or Wind Turbine: Monitor cumulative power production (kWh).

###### For Solar Thermal or Biomass: Monitor cumulative thermal production (kWh).

##### On-site reclaimed water systems: monitor volume of water supplied by the system.

##### Gas-fired hydronic systems that exceed 200 KW capacity: monitor thermal output (kWh) via thermal energy meter, natural gas consumption (kWh), calculated system efficiency, supply and return water temperatures.

##### Heat pumps and chillers that exceed 100 tons of capacity: monitor thermal energy output (kWh) from both condenser and evaporator systems, system mode (heating/cooling), calculated coefficient of performance in each mode of operation (heating/cooling).

##### Active Ventilation heat recovery (i.e. exhaust coils for chilled water heat recovery) on air systems greater than 2000 liters per second (LPS): Monitor thermal load reclaimed via thermal energy meter (kWh).

##### Passive Ventilation heat recovery (i.e. glycol run around or heat wheel) on air systems greater than 2000 liters per second (LPS): monitor incoming and leaving air temperatures on both sides of heat exchanger. Calculate and monitor heat exchanger effectiveness value. Monitor humidity for enthalpy recovery systems.

##### All individual electric loads that are greater than 20kW. Panel level metering is acceptable.

##### Variable frequency drive (VFD) pumps and fans 5 HP or more: monitor via BACnet integration motor speed and average kW demand over *5 minute* intervals and all corresponding control point values, e.g., duct static pressure or water differential pressure.

##### Air handling systems: monitor outdoor and mixed air damper positions, mixed and supply air temperatures, duct static pressure, and return air CO2 levels (when demand control ventilation strategy is implemented). Monitor outdoor air supply volumes greater than 2000 liters per second (LPS).

##### Variable Air Volume (VAV): monitor supply air temperatures, volumes, and valve positioning

#### Internal metering systems on equipment may be used as an alternative to installing external meters. Connection to BMS is required in either case.

#### For all systems identified above, include additional monitoring of relevant DDC points to further characterize system performances as deemed appropriate.

* 1. METERING AND TRENDING

#### All BMS Metering and system performance verification monitoring points must be configured to store trend log data in *5 minute* intervals for a minimum of three years on UBC BMS archiver. Ensure compatibility with UBC BMS virtualized servers.

#### All BMS Metering (electric, natural gas, thermal energy, and water) and DDC monitoring points must be BACnet compliant for communications with UBC BMS.

#### Use packaged and calibrated thermal energy meters for thermal output monitoring.

#### For on-site renewable energy systems and reclaimed water systems, metering must be configured for real demand (not absolute value) to enable determination of direction of flow. If bi-directional flow is anticipated, set up trends for both directions.

#### All inputs and outputs to energy systems are to be in SI units.

#### For electric metering, monitor average demand (W or kW) for given trend log interval and energy consumption (Wh or kWh). Primary side electrical meter shall include trending of apparent power and power factor*. BMS graphic for primary meter shall include integration of line voltage and current for all 3 phases.*

#### Date and time stamps must be recognizable in Microsoft Excel. Use the following date/time format: dd/mm/yyyy h:mm:ss AM/PM

* 1. DATA COLLECTION

#### The MBCx monitoring system must be configured for collection of trend log data for all measured and calculated monitoring points (CSV or XLS file).

* 1. METER AND SENSOR CALIBRATION

#### Meters and sensors must be factory calibrated. Calibration records must be included in O&M manual.

#### Meters and sensors must be installed in such a way as to facilitate periodic calibration without interruption of system operations. Frequency of calibration is per manufacturer requirement, or in the absence of manufacturer requirements, every two years. On-going calibration is the responsibility of UBC.

* 1. BMS TREND LABELLING
1. Point The naming conventions for BMS are outlines in Appendix A of the BMS Technical guideline for UBCO. Trend objects within the BMS shall follow the same naming convention of the point being trended, with the following suffix applied:
	1. \_TL\_### where ### is the number indicating the sample time for the trend object (ex. *5 minutes*), or COV to indicate a change of value trend.

* 1. MBCX SYSTEM COMMISSIONING

#### Verification of the MBCx system shall be included in the project commissioning plan. Each monitoring point must be verified for correct units of measurement, reading over full operational range, correct calculated value, and adherence to monitoring point labelling convention. Includes Primary Side Utility Meters, Secondary Side BMS Meters and system performance verification monitoring points. BMS data and trending functionality must be demonstrated for each MBCx monitoring point.

#### Provide records of installation for Primary Side Utility Meters, Secondary Side BMS Meters, and thermal energy meters of the MBCx monitoring system. Record of installation must include the following information at a minimum: device make and model number, configuration for units of measurement, configuration of multipliers, confirmation that meter is recording and trend is set up, cross-reference with monitoring point name. Specifically, required for Primary and Secondary Side metering, and metering required for system performance verification.

#### Provide records of configuration for each system performance verification monitoring point. Record of configuration must include the following information at a minimum: configuration for units of measurement, equation for calculated values, confirmation that monitoring point is recording and trend is set up, cross-reference with monitoring point name.

1. MINIMUM INFORMATION REQUIREMENTS

#### MBCx system will be used to verify system performance against owner project requirements and over systems’ operational range during steady state operation.

* 1. DESIGN PERFORMANCE TARGETS

Provide the following documentation at project handoff:

#### UBC energy performance target, provided by UBC and as stated in OPR.

#### Summary of design system performance expectations (referenced baseline and proposed design system efficiencies) (PDF file), provided by Design Team and as stated in BOD.

#### LEED EA Credit: Optimize Energy Performance annual and monthly energy consumption by end-use and by source (LEED letter template for annual consumption and XLS file for monthly consumption), average daily outdoor air temperatures for simulation year (XLS or CSV file, including time/date field and temperature field), and energy simulation files including executable and auto-generated model output files (or similar for non LEED projects), provided by LEED consultant or Design Team for non LEED projects.

* 1. MONITORING PERIOD PERFORMANCE

The MBCx monitoring system must enable collection and calculation of the following:

#### Monthly and annual total energy consumption by source (electricity, natural gas, district energy) and peak electricity demand.

#### Monthly and annual total water consumption.

#### *5 minute* interval data by end-use (interior lights, space heating electricity, space heating natural gas, space heating district energy, space cooling, domestic hot water heating electricity, domestic hot water heating natural gas, domestic hot water heating district energy, aggregate of VFD electricity, irrigation and hose bib water).

#### *5 minute* interval data for power production by on-site renewable energy system.

#### *5 minute* interval data for water supply by on-site reclaimed water system.

#### *5 minute* interval data for systems performance verification monitoring points, including calculated values.

1. REPORTING REQUIREMENTS
	1. MBCX PLAN

#### An MBCx plan that has been approved by UBCO operations and energy team must be submitted at the time of the building permit application.

* 1. REPORTING SCHEDULE

#### A performance monitoring report shall be submitted to UBCO operations and energy team eighteen (18) months following building occupancy. The report shall include annual and monthly total building consumption by energy and water source and by end-use, as required in section 3. The report shall include a summary of system performance findings and summary of actions taken or recommended by MBCx consultant to optimize system performance.

#### Interim performance monitoring data for one month of system operation shall be compiled and submitted to UBCO operations and energy team within six (6) months of building occupancy. Specifically, one month of energy and water consumption data by source and by end-use, and calculated system performance parameters shall be submitted (trend log data, XLS file).

* 1. REPORTING FORMAT

#### MBCx report must provide a collated summary of system performance trends and energy and water consumption based on data collected over the monitoring period (e.g., 1 year timeframe). It is the responsibility of the MBCx consultant to compile and interpret the data and present information in a manner that clearly summarizes trends in short- and long-term system performance and recommends opportunities for corrective action and system optimization to improve system efficiency where warranted.

1. RESPONSIBILTIY

In addition to the responsibilities set out in section 3, the following applies:

* 1. MBCX DESIGN SPECIFICATION

#### During design phase, the MBCx consultant must develop a project specific specification for the MBCx monitoring system (the “MBCx specification”), including a comprehensive MBCx monitoring points list. The MBCx specification is to be included in Div 1 of the project specifications. The MBCx specification is to be written in standard contractor language.

#### Primary Side Utility Meters, Secondary Side BMS Meters, and meters included for system performance verification must be shown in design drawings.

* 1. DESIGN REVIEW

The following design documents must be submitted to UBCO operations and energy team for review at schematic design, issued for tender, and 100% design stages (prior to submission of Issued for Construction (IFC) set):

#### MBCx specification.

#### Electrical single line diagram.

#### Electrical panel schedules.

#### Mechanical plumbing schematics, including hot water and district energy systems showing meters as required.

* 1. EVALUATION OF BUILDING PERFORMANCE

#### The building will be deemed to meet the owner project requirements and design performance target when actual performance at the end of the warranty period is within 20% of adjusted design performance target. The design performance target may be adjusted to account for weather normalization, changes in system operating schedules from design to operation, and loads that are not included in the design performance target.

1. *Energy Performance Targets*

*New construction projects shall meet energy performance-based targets. These targets are based on the amount of electricity and natural gas supplied to the building and the hot and chilled water delivered to the building from district energy systems (DES).*

*The following energy performance metrics have defined targets:*

* *Total Energy Use Intensity (EUI): The total of the electricity, DES hot water and DES cold water delivered to the building.*
* *Thermal Energy Demand Intensity (TEDI): The amount of energy delivered to the building that is used for heating the building, this does not include domestic hot water.*
* *Peak Heating Demand: The annual maximum rate of thermal heat required to be delivered to the building.*
* *Peak Cooling Demand: The annual maximum rate of thermal cooling required to be delivered to the building.*
* *Peak Electrical Demand: The annual maximum electrical load of the building.*

*In calculating building performance, the above metrics are to be calculated on an hourly basis. The assumed baseline system for UBCO buildings is connection to a 4-pipe hot and chilled water DES. Due to the ability of heat sharing within the district system, thermal energy delivered to the building is to be calculated on an hourly net-energy delivered basis. For example, during heating dominated periods, cooling energy delivered will be deemed to be zero and heating energy delivered will be calculated as the heat delivered minus the cooling delivered. The reverse applies during cooling dominated periods.*

*These targets were developed on a per space type basis for different building archetypes. In order to calculate the target for a building, choose the table below for the archetype that most closely matches the building and then use the proposed building’s space breakdown and the space type target to determine the overall building target.*

|  |
| --- |
| ***Student Residence Building*** |
| ***Metric*** | ***Whole bldg*** |
| *EUI kWhr/m2/yr* | *97* |
| *TEDI kWhr/m2/yr* | *12* |
| *Peak Heating Demand kW/m2* | *14* |
| *Peak Cooling Demand kW/m2* | *14* |
| *Peak Electrical Demand kW/m2* | *9* |

|  |
| --- |
| ***Campus Housing Archetype: 83% res.suite/w kitchens & 13% commercial*** |
| ***Metric*** | ***Residential*** | ***Commercial*** |
| *EUI kWhr/m2/yr* | *138* | *132* |
| *TEDI kWhr/m2/yr* | *15* | *5* |
| *Peak Heating Demand kW/m2* | *8* | *20* |
| *Peak Cooling Demand kW/m2* | *18* | *32* |
| *Peak Electrical Demand kW/m2* | *11* | *19* |

|  |
| --- |
| ***Science Lab Archetype: 47% lab, 40% office & 13% class*** |
| ***Metric*** | ***Lab*** | ***Class*** | ***Office*** |
| *EUI kWhr/m2/yr* | *334* | *159* | *112* |
| *TEDI kWhr/m2/yr* | *66* | *44* | *35* |
| *Peak Heating Demand kW/m2* | *46* | *37* | *33* |
| *Peak Cooling Demand kW/m2* | *62* | *37* | *29* |
| *Peak Electrical Demand kW/m2* | *37* | *16* | *16* |

|  |
| --- |
| ***Lab Building Archetype: 68% lab, 14% office & 18% class*** |
| ***Metric*** | ***Lab*** | ***Class*** | ***Office*** |
| *EUI kWhr/m2/yr* | *381* | *177* | *138* |
| *TEDI kWhr/m2/yr* | *72* | *45* | *39* |
| *Peak Heating Demand kW/m2* | *49* | *38* | *33* |
| *Peak Cooling Demand kW/m2* | *68* | *41* | *29* |
| *Peak Electrical Demand kW/m2* | *39* | *19* | *19* |

|  |
| --- |
| ***Classroom Office Archetype: 70% class & 30% office*** |
| ***Metric*** | ***Class*** | ***Office*** |
| *EUI kWhr/m2/yr* | *138* | *98* |
| *TEDI kWhr/m2/yr* | *7* | *10* |
| *Peak Heating Demand kW/m2* | *26* | *33* |
| *Peak Cooling Demand kW/m2* | *42* | *33* |
| *Peak Electrical Demand kW/m2* | *19* | *19* |

#

1. APPENDIX 1

 

Figure 1 UBCO Metering Requirements

1. APPENDIX 2
	1. PRIMARY SIDE UTILITY METER SPECIFICATIONS

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Type of meter | Metric Output Units | Make/ Model  | Database  | Recording interval & duration  | Protocol  | Division of responsibility  | UBCO coordination  |
| Electrical  | KW, KWh, KVA | N/A  | BMS Archiver | *5 minute*Ongoing  | Bacnet /IP | *Division 25*  | IT, UBCO operations and energy team |
| District Energy  | MWh’s, L/h, °C supply & return  | N/A  | BMS Archiver | *5 minute*Ongoing  | Bacnet /IP | Division 20 install & Division 26 wiring  | IT, UBCO operations and energy team |
| Gas  | Standard Cubic Meters (SCM)  | N/A  | BMS Archiver | *5 minute*Ongoing | Pulse output/ Bacnet /IP | Division 20 install & Division 26 networking  | IT, UBCO operations and energy team |
| Water  | Cubic Meters (M^3)  | N/A | BMS Archiver | *5 minute*Ongoing | Pulse output/ Bacnet /IP | Division 20 install & Division 26 networking | IT, UBCO operations and energy team |

* 1. SECONDARY SIDE BMS METER SPECIFICATIONS

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| System Type  | Metric Output Units | Make/ Model  | Database  | Recording interval & duration | Protocol  | Division  | UBC coordination  |
| Electrical  | KWh’s  | N/A  | BMS Archiver | *5 minute*3 Year  | Bacnet /IP | *Division 25*  | IT, UBCO operations and energy team |
| Gas  | SCM  | N/A  | BMS Archiver | *5 minute*3 Year | Bacnet /IP | Division 20  | IT, UBCO operations and energy team |
| Thermal Energy  | MWh’s, L/S °C supply and return  | N/A  | BMS Archiver | *5 minute*3 Year | Bacnet /IP | Division 20 | IT, UBCO operations and energy team |
| Water  | Cubic Meters (M^3)  | N/A | BMS Archiver  | *5 minute*3 Year | Bacnet /IP | Division 20  | IT, UBCO operations and energy team |

Table 2 Secondary Side BMS Meter Specifications

**\*\*\*END OF SECTION\*\*\***