Appendix P-6
Operations Commissioning Supporting Information

Introduction
Operations Commissioning shall be planned for during design, but focuses on the operations of the facility after construction through the next use of the facility. The Operations Commissioning process is the means to verify and document that the systems of a facility and the facility as a whole continue to operate in accordance with their design intent overtime. This includes planning, implementation, and documentation for regular preventative maintenance, Measurement and Verification of system and whole building performance, and improvement and correction of that performance. The Operations Commissioning process is coordinated by the Operations Commissioning Leader and executed by the Operations Commissioning Team. Initial operations input is provided by the participation of the Facility Operations Manager on the Design and Construction Commissioning Team. Later in design, the Operations Commissioning Team is formed and leads the planning for Operations Commissioning after occupancy.

The following are narrative descriptions of the activities (rows) in the Operations Commissioning Matrix.

1. GENERAL

1.01 Evaluate Existing Facility Operations
Evaluate existing facility operations to provide a reference point of operating issues for use in planning operation of the future facility.

1.02 Participate on Design & Construction Commissioning Team
Identify a Facility Operations Manager (FOM) who will manage maintenance and operations of the facility, be responsible for understanding Operations and Maintenance manuals, and monitor and report ongoing performance of the facility. The FOM should participate throughout the design process for continuity into final operation.

This person shall be part of the Design and Construction Commissioning Team and work closely with the Guideline Leader during design phases. The FOM shall represent operations issues from the beginning of the Design and Construction Commissioning Process and shall also be part of the Operations Commissioning Team once it is formed.

1.03 Engage Operations Commissioning Team
Identify Leader and Members of the Operations Commissioning Team during the Design Development phase of the design and construction project. The team shall be comprised of the following individuals, plus any added expertise needed for specific building systems.

- Facilities Operations Manager (FOM) is accountable for facility performance and manages or performs ongoing operational practices, maintenance and corrective actions. FOM may also fill the role of Guideline Leader during ongoing occupancy phases.
- The person from the Operations Work Team who will be in charge of compliance with the Guidelines during Ongoing Occupancy (Guideline Leader if applicable to Agency Process). This person will document ongoing management, maintenance and correction actions, and complete annual and interim reporting as per the Outcome Documentation Forms.

1.04 Operations Commissioning Plan
The Operations Commissioning Plan shall include directly or by reference provision for all items required in the Commissioning Guideline P.5 for planning, implementing, or documenting activities from
Correction Period through the life of the project. The Operations Commissioning Plan includes by reference the following documents that may be packaged separately but shall be coordinated with all other parts of the Operations Commissioning Plan.

- Systems Turnover Process (from Construction to Operations)
- Operations and Maintenance Manuals (O&M Manuals as per conventional contracts)
- Problem Response Plan
- Maintenance Plan
- Measurement and Verification Plan
- Systems Recommissioning Manual

The Operations Commissioning Plan shall evolve as follows:

- Design Development Phase
  - Operations Commissioning Plan shall be outlined during a project’s Design Development Phase; a time when operations issues shall be coordinated with design and construction issues.
  - Review and participate in coordination of the Operations Commissioning Plan and the Design and Construction Commissioning Plan
- Construction Documents Phase
  - A complete Operations Commissioning Plan shall be developed during the Construction Documents phase of the design and construction project in cooperation with the Design and Construction Commissioning Team.
- Correction Phase
  - The Operations Commissioning Plan shall be finalized during the Correction Period when all technical details of the building systems are known.

1.05 Annual Operations Commissioning Review & Plan Update
During On-going Operations, review all aspects of the Operations Commissioning Plan at least annually. Update the Plan as needed to reflect changes in equipment or practices.

1.06 Annual Operations Commissioning Report
The Operations Commissioning Report is an evaluation of work at a particular point in time in comparison with a particular version of the Commissioning Plan. After the correction period, complete an Operations Commissioning Report that documents monitored usage and other data, and includes a log of actions taken to address aberrations or problems.

1.07 New Employee Training Program
Orient new members of the facility’s operations and maintenance management and staff to the building system documentation and the Operations Commissioning Plan. All staff shall be familiar, at a level appropriate with their responsibilities, with the history and upkeep of project records and their contents from review of prior phases of the Operations Commissioning Plan and its supporting documents.

1.08 Submit Outcome Documentation
Submit Outcome Documentation (Forms P-1 through P-6) as required by the MSBG at the end of each phase of the design and construction process and throughout the on-going operations phase.

1.09 Next Use
Provide transition data, history, requirements and Guideline plans and reports to new owner and facility manager. Encourage the new owner to proactively support the Guidelines.
2. SYSTEM TURNOVER PROCESS FROM CONSTRUCTION TO OPERATIONS

2.01 Define Turnover Prerequisites
Define the minimum level of completeness and/or performance required prior to the formal transfer of responsibility from the construction team (contractors) to the operations team (owner). These prerequisites must be objective and enforceable and communicated clearly to the Design and Construction team for inclusion in the bid documents.

2.02 Define Authority for Official Acceptance and Turnover
Define exactly who, typically someone representing the Owner, will have final approval authority for the transfer of the systems from the contractors to the owner.

2.03 Operations Team Familiarization with Project Documentation and Systems
Prepare and follow a schedule for preparing operations and maintenance individuals to take over the building systems. This familiarization should be complete prior to the official turnover:

- Identify the future operations team members and make them available for turnover preparation activities.
- Allow the future operations team members to walk through the construction site as frequently as practical, especially prior to wall and ceiling close-in.
- Introduce the future operations team members to the construction documents and operations & maintenance manuals.
- The future operations team members shall attend the formal equipment and systems training sessions provided by the installing contractors.
- Conduct formal question and answer sessions with the future operations team and the designers and contractors to address remaining questions and concerns prior to turnover.

2.04 Complete Systems Transfer from Contractors to Operators
Systems shall be turned over to the operations team either all at once or on a pre-defined piecemeal basis. However, once a system is turned over to the owner, the contractors shall obtain permission and provide full documentation for all work performed on any turned-over system.

3. PROBLEM RESPONSE PLAN
The Problem Response Plan is part of the Operation Commissioning Plan and shall cover the systems and materials commissioned under Operations Commissioning Scope. Key components of the Plan are clear assignments of responsibility to individuals and defined lines of communication. Incorporate a planned response to anticipated feedback or triggers indicating potential performance problems such as an increase in IEQ complaints or aberrations in monitored resource use.

3.01 Problem Documentation Process
Define a process by which problems are documented and passed on to the appropriate party for attention.

3.02 Problem Response Process
Predefine potential problem responses for use in timely and comprehensive management of each documented problem. Responses may include fixing or replacing broken components (including correction work by installing contractors), recalibrating control devices, performing functional performance tests to help identify the root cause of a problem, redesigning an system that no longer meets the changing needs of the occupants, etc.
3.03 Problem Resolution Documentation Process
The Problem Response Plan process shall include a feedback loop for positive closure.

3.04 Implementation
Implement the Problem Response Plan immediately upon turnover from the contractors to the operations team. Clearly define lines of communication with the installing contractors for correction phase activities. The operations team must be in control of and/or aware of all activities associated with the systems following turnover.

3.05 Annual Evaluation and Reporting
Each problem and its resolution shall be logged for incorporation into the annual Operations Commissioning Report.

4. MAINTENANCE PLAN
The Maintenance Plan is part of the Operations Commissioning Plan and shall apply to all systems and materials commissioned under the Operations Commissioning Scope.

4.01 Cleaning Products and Practices
Use ISO 14000 requirements for cleaning supplies in standard maintenance after building occupancy.

4.02 Cleaning Products Documentation
Document all cleaning products used and quantities of each for inclusion in the annual Operations Commissioning Report.

4.03 Moisture Prevention Practices
Establish maintenance procedures that will identify unintended water intrusion, leakage or accumulation quickly and provide drying or removal of building structure elements within 48 hours of the unintended event.

4.04 Moisture Response Practices
When exterior water intrusion, leakage from interior water sources, or other uncontrolled accumulation of water occurs, the intrusion, leakage or accumulation shall be corrected because of potential for these conditions to cause the growth of mold. (Title 8, Chapter 4, Section 3362(g) of California Occupational Safety and Health Standards, Sept. 2002.)

4.05 Moisture Control Documentation
Document all moisture intrusion events and their resolution for inclusion in the annual Operations Commissioning Report.

4.06 Preventive Maintenance Activities
Implement a preventive maintenance program for IAQ and other Indoor Environmental Quality factors in the building. The preventive maintenance plan shall include regularly scheduled checks to verify ongoing performance and to prevent failures of the facility and its systems. This can be modeled after EPA's Building Air Quality Program (1991) or their web-based system called I-BEAM (IAQ building education and assessment).
4.07 Preventive Maintenance Documentation
Document the preventive maintenance program, inventory of equipment, and scheduled work orders in the Operations Commissioning Plan. Log all completed preventive maintenance activities for inclusion in the annual Operations Commissioning Report.

4.08 Implementation
Implement the Preventive Maintenance Plan immediately upon turnover from the contractors to the operations team. During the correction phase of the project, it is critical that required preventive maintenance be performed in order to maintain the validity of equipment manufacturers’ warranties.

4.09 Annual Building IAQ Performance Evaluation
Perform an evaluation of building IAQ performance annually. Measure key factor that determines ventilation rate for the building (major pollutant or CO2) in the building occupied zones. Pollutant concentrations measured should be within the guideline range, and CO2 levels should be at or below 450 ppm over outdoor levels. If not, additional ventilation must be provided or sources eliminated until concentrations fall below action levels. Action values for each pollutant are given in Appendix I-1.\footnote{Consider (recommended, not required), annual monitoring of other pollutants on the IAQ guideline list which are not the pollutants that determine the ventilation rate. Concentrations should be in the guideline range and below the action value for each pollutant. Sample pollutant action levels are given in Appendix I-1.}

4.10 Occupant Comfort and Satisfaction Surveys
After the required surveys during the correction period, Guideline Leader shall perform or coordinate completion of occupant comfort and satisfaction surveys when organizational or productivity issues arise, or optionally at regular intervals as stated in the Measurement and Verification Plan.

4.11 Annual Evaluation and Reporting
Annually review the results of Indoor Environmental Quality management practices with Facilities Operations Manager and highlight any aberrations. If, in the judgment of the Facilities Operations Manager, a severe or repeated complaint occurs, the Facilities Operations Manager will arrange for an investigation of the situation, and recommend corrective action if appropriate.

Annually, evaluate the following Systems Operations and Maintenance Practices in comparison to the Maintenance Plan portion of the Operations Commissioning Plan. Document findings and correct maintenance and operations practices, or update the Plan to reflect changes in practices.

- Site Systems
- Water Systems
- Energy Systems
- IEQ Systems
- Materials and Waste Systems

5. MEASUREMENT & VERIFICATION PLAN
The Measurement and Verification Plan is part of the Operations Commissioning Plan. It is aimed at monitoring performance over time and measuring savings and benefits. The Measurement and Verification Plan shall monitor the following processes.

- Frequency of user comfort and satisfaction assessments (Maintenance Plan)
- Format and procedures for user complaint and work request logs (Problem Response Plan)
- Procedures for reporting potential problems to Facilities Operations Manager for possible corrective action (Problem Response Plan)

\footnote{Consider (recommended, not required), annual monitoring of other pollutants on the IAQ guideline list which are not the pollutants that determine the ventilation rate. Concentrations should be in the guideline range and below the action value for each pollutant. Sample pollutant action levels are given in Appendix I-1.}
• Schedule regular checks to verify ongoing performance, and prevention of failures of facility and its systems (Maintenance Plan)
• Procedures to compare to weather normalized expectations, track trends in usage, and identify aberrations in use patterns (Resource Management Plan)
• Method of quantifying savings

For details on Measurement and Verification based on US DOE's International Performance Measurement and Verification Protocol (IPMVP) see web site: www.ipmvp.org

For each system included in the Measurement and Verification Plan, include the following components excerpted from USGBC LEED page 158 of reference package Version 2.0, June 2001.
• IPMVP standard language and terminology should be employed (recommended).
• State which options and method from the IPMVP document will be used.
• Create an accurate baseline using techniques appropriate to the project.
• Indicate who will conduct the Measurement and Verification.
• State key assumptions about significant variables or unknowns.
• Describe the method of ensuring accurate savings determination.
• Specify criteria for equipment metering, calibration, and measurement period.
• Define level of accuracy to be achieved for all key components.
• Indicate quality assurance measures.
• Describe contents of reports to be prepared, along with a schedule.

5.01 Determine which Option and Methods from IPMVP will be Used for Each System
The following summarizes several of the types of Measurement and Verification defined by the IPMVP standard that are used below.
• **Option B:** After project completion, savings are determined by short term or continuous measurements taken throughout term of the contract at device or system level. Both performance and operations factors are monitored. Savings calculations are based on engineering calculations using metered data.
• **Option C:** After project completion, savings are determined at "whole building" or facility level using current year and historical utility meter (gas or electricity or other) or sub-meter data. Savings are based on analysis of meter or sub meter data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis.
• **Option D:** Savings are determined through simulation of facility components and/or the whole facility. Savings are based on calibrated energy simulation and modeling; calibrated with hourly or monthly utility billing data and/or end use metering.

For each major system to be included in the Measurement & Verification Plan, define which option is to be applied, as follows:

• **Water Device and System Level Measurement and Verification:** Comply with a long-term continuous measurement of performance as stated in Option B: Methods by Technology of the U.S. DOE's International Performance Measurement and Verification Protocol (IPMVP) for the following:
  - Indoor water risers
  - Outdoor irrigation systems

• **Water Whole Building Measurement and Verification:** Comply with a long-term continuous measurement of performance as stated in Option C: Methods by Technology of
the U.S. DOE’s International Performance Measurement and Verification Protocol (IPMVP) for the following:
  o Indoor water usage
  o Outdoor irrigation usage
  o Every 5 years- Testing of water infiltration rate and quantity
  o (Recommended) Biannual (Spring/Fall) testing of water quality (TSS measurements)
  o (Recommended) Biannual (Spring/Fall) testing of water quality (Phosphorus measurements)

• **Energy Device and System Level Measurement and Verification:** Comply with a long-term continuous measurement of performance as stated in Option B: Methods by Technology of the U.S. DOE’s International Performance Measurement and Verification Protocol (IPMVP) for the following:
  o Lighting systems and controls
  o Constant and variable motor loads
  o Variable frequency drive (VFD) operation
  o Chiller efficiency at variable loads (kW/ton)
  o Cooling load
  o Air and water economizer and heat recovery cycles
  o Air distribution static pressures and ventilation air volumes
  o Boiler efficiencies
  o Buildings specific process energy-efficiency systems and equipment

• **Energy Whole Building Measurement and Verification based on Metering and Calibrated Energy Simulation:** Depending on size of project, comply with additional long-term continuous measurement of performance as stated in Options C and D: Methods by Technology of the U.S. DOE’s International Performance Measurement and Verification Protocol (IPMVP) for the following:

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<th>Size (sq.ft.)</th>
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<tr>
<td></td>
<td>Metering with Submetering</td>
<td>Calibrated Simulation (annual Energy Use)</td>
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<tr>
<td>&gt;10,000</td>
<td>Required</td>
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<td>10-50,000</td>
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<td>&gt;50,000</td>
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• **Indoor Environmental Quality (IEQ) Measurement and Verification:** Comply with a long-term continuous measurement of performance as stated in Volume II of the U.S. DOE’s International Performance Measurement and Verification Protocol (IPMVP).
  o Annual indoor air quality assessments shall be executed under the Maintenance Plan.
  o Moisture control procedures shall be executed under the Maintenance Plan.
  o User complaint logs shall be maintained under the Problem Resolution Plan.
  o Thermal Comfort (I.7) For details on Measurement and Verification based on US DOE’s International Performance Measurement and Verification Protocol (IPMVP) see web site: www.ipmvp.org
  o Quality of Lighting, (I.9) For details on Measurement and Verification based on US DOE’s International Performance Measurement and Verification Protocol (IPMVP) see web site: www.ipmvp.org
- Other Recommended IEQ Measurement and Verification
  - Access to Daylight, (I.8)
  - View space and window access (I.10)
  - Vibrations, Acoustics and Noise (I.11, I.12)
  - Personal Control of IEQ conditions and impacts (I.13)
  - Opportunities and encouragement for healthful physical activity (I.14)

- Waste Measurement and Verification: Annually evaluate waste and recycling generated compared to expectations and baseline.

- (Recommended) Materials Measurement and Verification: Annually evaluate the wear and durability of materials compared to expectations.

5.02 Create an Accurate Baseline
Create an accurate baseline for each element being measured using techniques appropriate to the project.

5.03 Define Key Assumptions about Significant Variables or Unknowns
For each measurement and/or calculation, define unknowns or assumptions used to arrive at results.

5.04 Define Level of Accuracy to be Achieved for All Key Components
Define the level of accuracy required of each key component and coordinate with the design and construction team to incorporate those requirements into the bid documents.

5.05 Assign Roles and Responsibilities
Clearly define responsibilities for system set up, data collection, calculations, analysis, and documentation to appropriate internal and/or outsourced individuals.

5.06 Define Criteria for Equipment Metering, Calibration, and Measurement Period
Work with the Design and Construction Team to incorporate required meters into the bid documents. Document intended Measurement and Verification Plan use for each meter, including measurement frequency, data collection method, data reporting method, and calibration frequency.

5.07 Procedures to Compare Weather-Normalized Expectations, Track Trends, and Identify Aberrations
Define procedures for analyzing the data collected through the Measurement and Verification process.

5.08 Method to Quantify Savings
Define an objective method of quantifying savings in energy, water, and other resources, based on the data collected in the Measurement and Verification process.

5.09 Problem Reporting Process
Define a process by which aberrations in the data collected and analyzed through the Measurement and Verification process are reported to individuals with the authority to effect change. This may be part of the Problem Resolution Plan.

5.10 Measurement and Verification Process Quality Assurance Measures
Define Quality Assurance oversight responsibilities and tools to ensure continued reliability of the Measurement and Verification process throughout the life of the facility.
5.11 Measurement and Verification Documentation Processes
Define processes, forms, templates, and reporting communication channels for the results of the Measurement and Verification process. Documentation should be standardized to the greatest extent possible to allow for maximum analysis time and minimum documentation time without sacrificing the quantity and quality of the reported information.

5.12 Incorporate Measurement and Verification Elements into the Construction Documents
Work with the Design and Construction Team to incorporate hardware and software components required for implementation of the Measurement and Verification Plan into the project bid documents. Such requirements shall include, but not be limited to, the following:

- Separate circuits and panels for power, lighting, HVAC and plumbing systems and equipment with high power and/or water use to facilitate monitoring.
- Separate energy (electric, gas, other) meters for each building and sub-meters depending on project size to meet requirements of P.5 Operations Commissioning.
- Separate water meters for each building, and separately meter building water use for irrigation and process water uses.
- Design elements needed to enable measurement and verification for site, water, energy, IEQ, materials, and waste sections of P.5.
- Summary schedule of instrumentation and controls for required monitoring categories, highlighting I/O data points to be collected.

5.13 Implementation
Implement the Measurement and Verification Plan immediately upon turnover from the contractors to the operations team. During the correction phase of the project, the Measurement and Verification process and data will help identify any previously un-discovered aberrations in the system design, installation, and/or startup.

Monitor and evaluate the consumption of energy and water. In addition, monitor indoor environmental quality (IEQ) parameters.

5.14 Annual Evaluation and Reporting
At least annually review the results of the Measurement and Verification process with Facilities Operations Manager and highlight any aberrations. If, in the judgment of the Facilities Operations Manager, a severe or repeated problem occurs, the Facilities Operations Manager will arrange for an investigation of the situation and recommend corrective action if appropriate.

Annually, evaluate the Measurement and Verification process itself in comparison to the Measurement and Verification Plan portion of the Operations Commissioning Plan. Document findings and correct or update the Plan to reflect changes in practices.

6. SYSTEMS RECOMMISSIONING MANUAL (Recommended)
The Systems Recommissioning Manual is part of the Operations Commissioning Plan and documents important reference information for operating or recommissioning building systems. The recommissioning process shall occur at regular intervals, or in response to other events or triggers at the discretion of the owner, to evaluate the following:

• Electrical Systems, including Lighting and Daylighting Controls: As needed to support performance of Guidelines: S.5, E.1, E.2, E.3, I.6, I.9
• Indoor Air Quality Elements and Systems: As needed to support performance of Guidelines: I.1, I.2, I.3, I.4, I.5
• Plumbing Systems: As needed to support operational achievement of guidelines: S.7, S.8, S.13
• Interior Materials (specification, installation as finishes and furnishings are replaced or reconfigured): As needed to support operational achievement of guidelines: I.2, M.1, M.2
• Envelope Integrity: As needed to support operational achievement of guidelines: I.3, M.1, M.2

The Systems Recommissioning Manual shall include the following elements, based on LEED Reference Manual Version 2.0, June 2001 (page 147).

6.01 System Descriptions
Owner’s performance requirements, design basis narratives, descriptions of each system, etc.

6.02 As Built Control Drawings and Sequences of Operation
As built control system documentation is typically obtained from the control system contractor following commissioning and acceptance of the systems at the end of project construction.

6.03 Time of Day Schedules and Plan for Assessing their Relevance
Document initial time of day schedules for each piece of controlled equipment. Based on building occupancy and usage, determine if and how often these schedules should be re-evaluated for minimum run times. Program those re-evaluations into the Preventive Maintenance system for automatic reminders.

6.04 Seasonal Considerations
Seasonal startup and shutdown, manual and restart operation procedures, and recommendations regarding seasonal issues that affect energy use. Program seasonal activities into the Preventive Maintenance system.

6.05 Recalibration Schedule
Recommended recalibration frequency for each sensor and device type. Program recalibration of each sensor and device into the Preventive Maintenance system.

6.06 Adjustable Setpoints and Plan for Assessing their Relevance
List of adjustable setpoints and reset schedules. Based on building requirements and performance under actual occupied loads, regularly evaluate the appropriateness of each setpoint for meeting with owner’s requirements while minimizing energy consumption. Program those re-evaluations into the Preventive Maintenance system for automatic reminders.

6.07 Diagnostic Tools
List of diagnostic tools associated with each building system, as applicable. Describe how these tools are to be used and when. Coordinate with the Measurement and Verification Plan to avoid duplication. As applicable, program their use into the Preventive Maintenance system.

6.08 Recommissioning Tests
Schedule for testing systems with procedures used in initial commissioning process. Program recommissioning tests into the Preventive Maintenance system.
6.09 Implementation
Implement the Recommissioning Plan immediately upon turnover from the contractors to the operations team. During the correction phase of the project, the Recommissioning process and data will help identify any previously un-discovered aberrations in the system design, installation, and/or startup. It will also help to identify equipment failures within their respective correction periods.

6.10 Annual Evaluation and Reporting
At least annually review the results of the Recommissioning process with Facilities Operations Manager and highlight any aberrations. If, in the judgment of the Facilities Operations Manager, a severe or repeated problem occurs, the Facilities Operations Manager will arrange for an investigation of the situation and recommend corrective action if appropriate.