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Hand-off and persistence phase essentials for Existing Building Commissioning (EBCx) projects

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Agenda

- EBCx process and cost allocation
- Hand-off phase
  - Documentation update and delivery
  - Staff and end-user training
  - Plan for persistence
  - Hand-off meeting
- Persistence phase
- Ongoing commissioning (OCx) plan
- Q&A

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Save on Energy Capability Building – EBCx Resources

- Designed to enhance knowledge and develop skills in organizations and communities to increase awareness and participation in energy-efficiency opportunities across Ontario, including Save on Energy programs
- Our dedicated EBCx resources include:
  - webinars (*EBCx in a Nutshell*, *Key Measures*)
  - practical guide for building owners and managers
  - information sheets: condos, medical buildings, office buildings and warehouses
  - incentives for ~20 training courses

See the EBCx resources on the Save on Energy website

Save on Energy - EBCx Program

HOW DOES THE PROGRAM WORK?

The EBCx program has three phases with incentives for participants who complete each one.

1. INVESTIGATION PHASE

Hire a CP to investigate your facility and prepare a report setting out a commissioning plan.

INCENTIVE

Up to $0.06/sq. ft., up to $50,000 per facility and/or 75% of the cost of working with a CP

2. IMPLEMENTATION PHASE

Implement the energy-efficiency measures identified in the commissioning plan.

INCENTIVE

$0.03/KWh of confirmed energy savings, up to the lesser of 30% of facility annual electricity consumption or $50,000

3. PERSISTENCE PHASE

Receive training from your CP to maintain savings and monitor your systems for one year after implementation.

INCENTIVE

$0.03/KWh of confirmed persisting energy savings, up to the lesser of 30% of facility annual electricity consumption or $50,000

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Energy Workforce Development: Northern Ontario

Save on Energy is offering no cost training and certification courses for people **living or working in Northern Ontario**.

Training in the following careers:

- Energy advisor
- HVAC designer (geothermal)
- Energy manager (intro or advanced)
- Energy consultant
- Building commissioning expert

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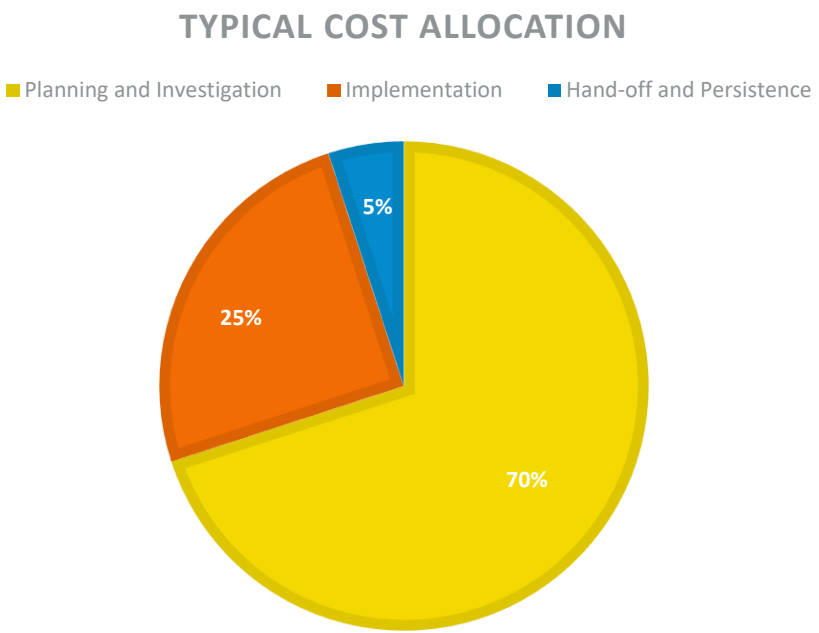
EBCx Cost Allocation per Phase



Source: Crowe, et al., 2020, *Building Commissioning Costs and Savings Across Three Decades and 1,500 North American Buildings*, Lawrence Berkeley National Laboratory

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The Hand-off Phase

Ensures that the facility staff and occupants have the understanding and documentation necessary to properly operate, and maintain the changes and improvements made during the EBCx process.

EBCx Provider Responsibilities

- Facilitate training of building staff
- Update operations sequences
- Update systems manual
- Update preventative maintenance procedures
- Implement performance tracking
- Develop ongoing commissioning recommendations

Owner Activities

- Support facility staff training
- Support ongoing commissioning plan execution

Reference: Building Commissioning Association, Ongoing Building Commissioning Best Practices

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Documentation Update and Delivery

Clear, accurate, and easily accessible documentation is **key** to ensuring the persistence of EBCx improvements.

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Final EBCx Report

Includes:

- Planning phase report and documentation
- Initial assessment phase report and documentation
- Investigation phase report and documentation
- Implementation phase report and documentation

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Final EBCx Report Continued

Includes (continued):

- As-built and updated building automation system (BAS) sequence of operations
- Updated operations and maintenance (O&M) documentation
- Single-line system diagrams of major systems
- Systems manual
- List of additional measures, if applicable

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Controls and Sequences of Operation

Update or rewrite sequences that were impacted by the EBCx process for all key systems and equipment, including:

- Set-points
- Reset schedules

For every new control point, include:

- Name of point
- Type of point
- Type of sensor or actuator and precision limits
- Name and type of the associated component
- Panel in which it is located

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O&M Manuals and As-Built Documentation

If the owner **has up-to-date** O&M manuals and as-built documentation:

- Modify them to reflect the changes to the equipment or operations from the EBCx project

If the owner **does not have** effective documentation of the existing equipment:

- The owner should consider adding a task to the EBCx scope to create or improve them (for all site data):
  - Digitize all O&M and site documentation into one file or folder structure
  - Drawings, specifications, submittals, testing adjusting and balancing (TAB) reports, control drawings, sequences, energy studies, warranties, preventive maintenance plans, etc.

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Systems Manual

Created by the EBCx provider, the goal of the systems manual is to enhance the ability of the building staff to operate the building effectively. It ensures that all of the relevant information about the systems and equipment within the scope of the EBCx project is in one place.

- Basic building systems description, operating conditions, setpoints, schedules and operating procedures
- Focuses on how systems and equipment interface
- Particularly useful for complex systems or where O&M staff turnover is common

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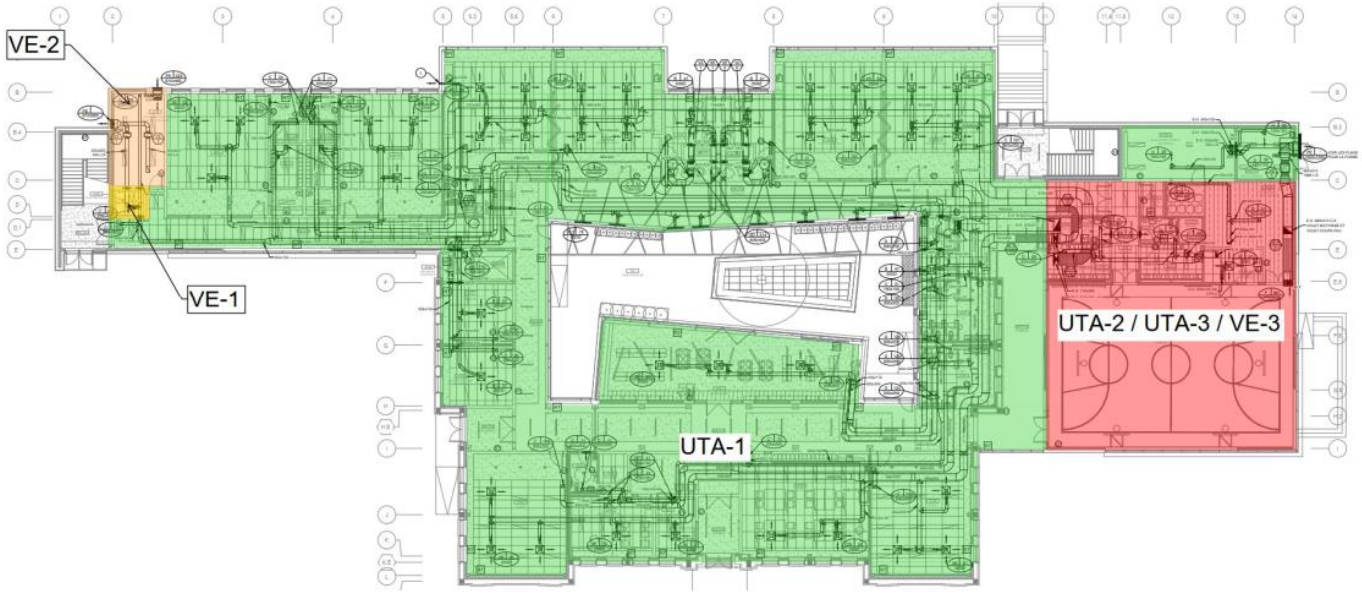
Systems Manual - Example

Floor plan for ventilation (zones)



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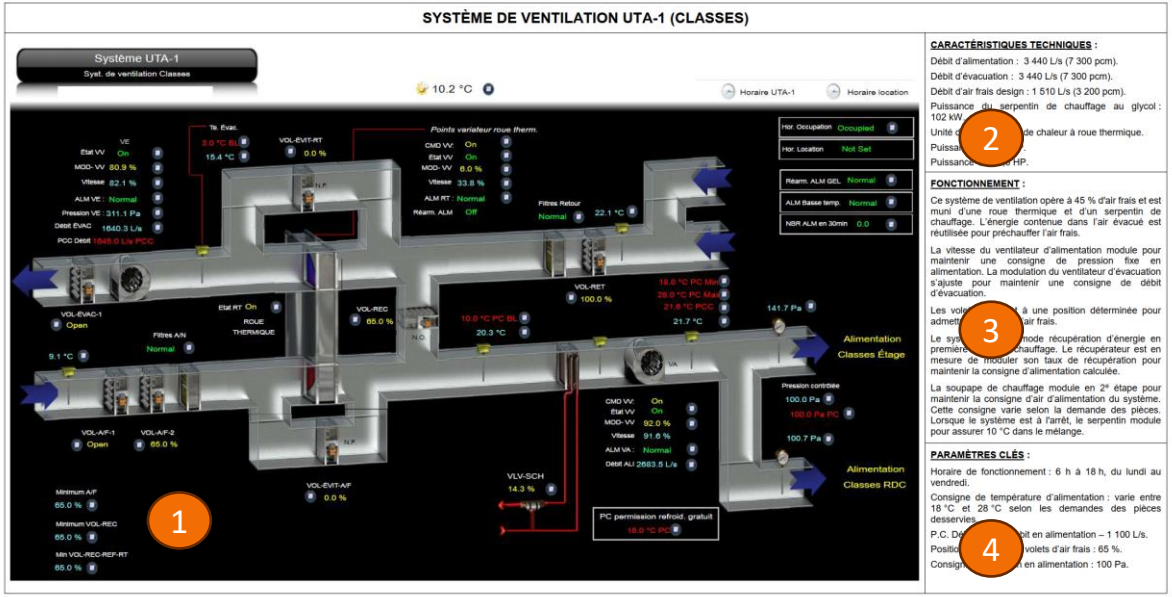
Systems Manual - Example

For each system included in EBCx scope of work:

1. **BAS graphic**
2. **Technical data** (airflow rate, heating/cooling capacities, etc.)
3. **Operation** (speed fan modulation, heating valve modulation, heat recovery, etc.)
4. **Operational parameters** (schedules, setpoints, etc.)



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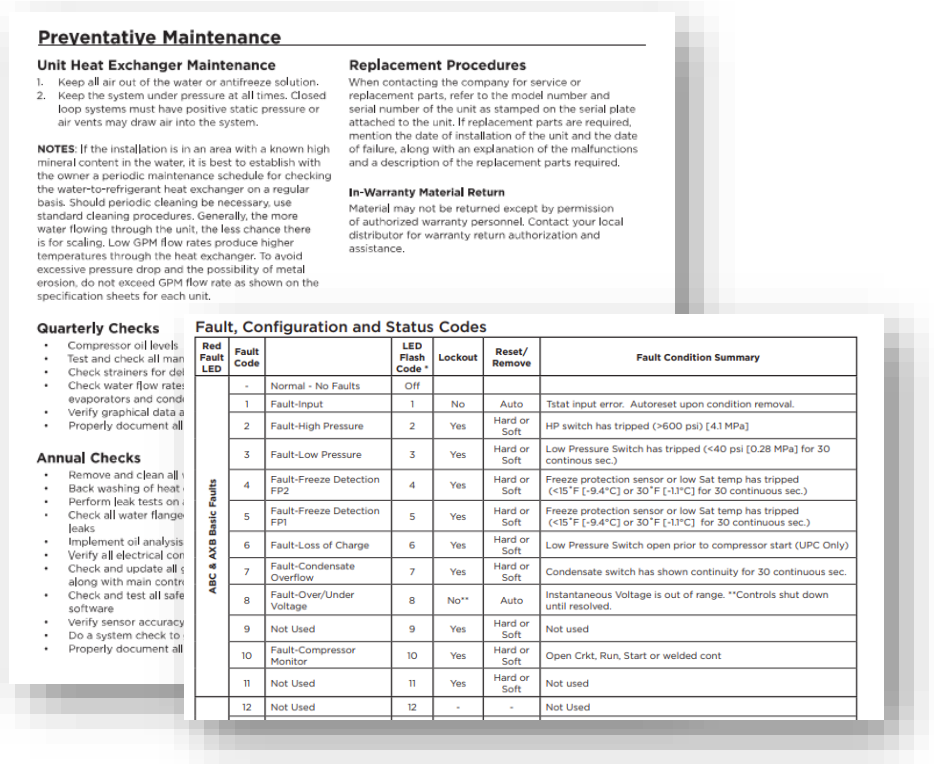
Systems Manual

Includes all relevant information:

- Ongoing maintenance requirements
- Calibration procedures
- Contact information for vendors or potential mechanical servicing
- Equipment vendor hotlines for operational support
- Troubleshooting guidelines



Preventative Maintenance

Unit Heat Exchanger Maintenance

1. Keep all air out of the water or antifreeze solution.
2. Keep the system under pressure at all times. Closed loop systems must have positive static pressure or air vents may draw air into the system.

NOTES: If the installation is in an area with a known high mineral content in the water, it is best to establish with the owner a periodic maintenance schedule for checking the water-to-refrigerant heat exchanger on a regular basis. Should periodic cleaning be necessary, use standard cleaning procedures. Generally, the more water flowing through the unit, the less chance there is for scaling. Low GPM flow rates produce higher temperatures through the heat exchanger. To avoid excessive pressure drop and the possibility of metal erosion, do not exceed GPM flow rate as shown on the specification sheets for each unit.

Replacement Procedures

When contacting the company for service or replacement parts, refer to the model number and serial number of the unit as stamped on the serial plate attached to the unit. If replacement parts are required, mention the date of installation of the unit and the date of failure, along with an explanation of the malfunctions and a description of the replacement parts required.

In-Warranty Material Return

Material may not be returned except by permission of authorized warranty personnel. Contact your local distributor for warranty return authorization and assistance.

Quarterly Checks

- Compressor oil levels
- Test and check all man
- Check strainers for del
- Check water flow rate evaporators and condi
- Verify graphical data a
- Properly document all

Annual Checks

- Remove and clean all
- Back washing of heat
- Perform leak tests on
- Check all water flange leaks
- Implement oil analysis
- Verify all electrical con
- Check and update all along with main contr
- Check and test all safe software
- Verify sensor accuracy
- Do a system check to
- Properly document all

Fault, Configuration and Status Codes

Red Fault LED	Fault Code		LED Flash Code *	Lockout	Reset/ Remove	Fault Condition Summary
ABC & AXB Basic Faults	-	Normal - No Faults	Off			
	1	Fault-Input	1	No	Auto	Tstat input error. Autoreset upon condition removal.
	2	Fault-High Pressure	2	Yes	Hard or Soft	HP switch has tripped (>600 psi) [4.1 MPa]
	3	Fault-Low Pressure	3	Yes	Hard or Soft	Low Pressure Switch has tripped (<40 psi [0.28 MPa] for 30 continous sec.)
	4	Fault-Freeze Detection FP2	4	Yes	Hard or Soft	Freeze protection sensor or low Sat temp has tripped (<15°F [-9.4°C] or 30°F [-1.1°C] for 30 continuous sec.)
	5	Fault-Freeze Detection FP1	5	Yes	Hard or Soft	Freeze protection sensor or low Sat temp has tripped (<15°F [-9.4°C] or 30°F [-1.1°C] for 30 continuous sec.)
	6	Fault-Loss of Charge	6	Yes	Hard or Soft	Low Pressure Switch open prior to compressor start (UPC Only)
	7	Fault-Condensate Overflow	7	Yes	Hard or Soft	Condensate switch has shown continuity for 30 continuous sec.
	8	Fault-Over/Under Voltage	8	No**	Auto	Instantaneous Voltage is out of range. **Controls shut down until resolved.
	9	Not Used	9	Yes	Hard or Soft	Not used
	10	Fault-Compressor Monitor	10	Yes	Hard or Soft	Open Crkt, Run, Start or welded cont
	11	Not Used	11	Yes	Hard or Soft	Not used
	12	Not Used	12	-	-	Not Used

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Staff and End-user Training

Training objectives:

- Promote efficient building operations
- Facilitate the hand-off process
- Ensure the persistence of results
- Enhance knowledge and skills of in-house staff

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Staff and End-user Training

To ensure the **right staff** are present, the EBCx provider needs to review who receives the calls to:

- Adjust the setpoints
- Respond to comfort issues
- Respond to HVAC issues
- Respond to controls issues
- Respond to warranty issues versus repair

Training checklist

- ✓Ensure the right staff attend
- ✓Create agendas
- ✓Provide a sign-in/sign-out sheet
- ✓Record training sessions for future reference (new employees)
- ✓Include on-site visit and time for Q&A
- ✓Involve management staff

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Staff and End-user Training

Conduct training workshop for building **O&M staff**:

- Ideally, facility staff who have been involved since the planning or investigation phase
- Explain the issues observed during investigation and review the changes made, expected benefits and lessons learned

Conduct training workshop for **management staff**:

- Introduce to energy management best practices

Conduct **end-user** training (if applicable):

- Prepare a user-specific training document (lighting controls, thermostats, energy-efficiency awareness program)

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Suggested Training Topics

- **Improve O&M staff understanding of how systems should now operate**:
  - Training on the system from start to finish, in different modes (cooling, heating, free-cooling, heat recovery)
  - Specific training on the operation of more complex systems/new equipment implemented
- **Train staff on their role in maintaining persistence of savings**:
  - Visit top five or 10 things to check on the equipment and/or the BAS on a regular basis (e.g., weekly check for schedules)
  - Importance of performing routine maintenance (e.g., sensor calibration)

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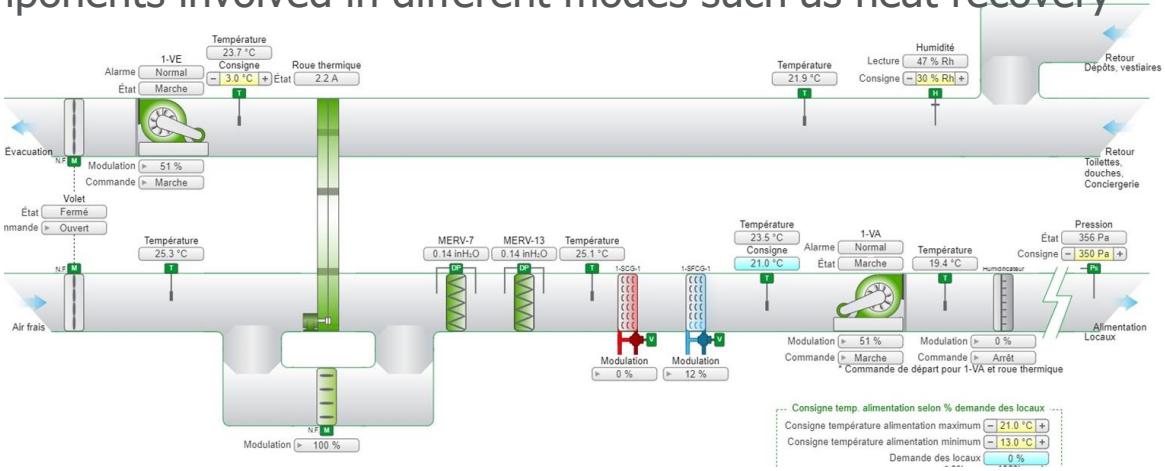
Examples of O&M Training Content

Training on the system from start to finish:

- Methodically follow air in the building to know how it enters the space,
- Review each damper, coil, filter and other components
- Review components involved in different modes such as heat recovery



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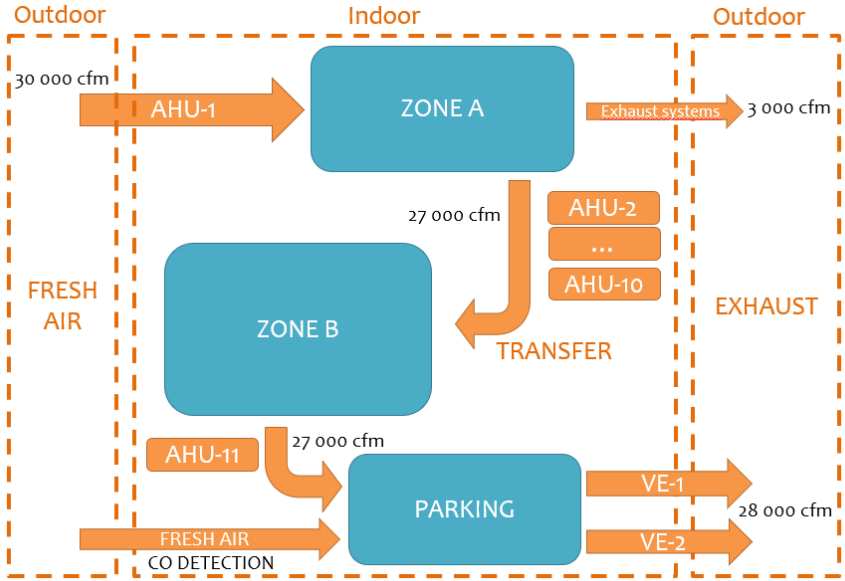
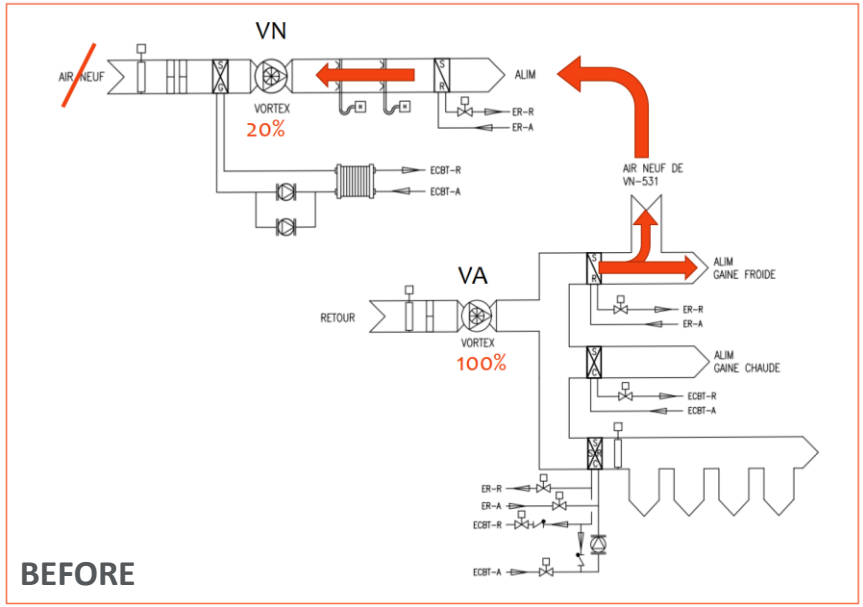
Examples of O&M Training Content

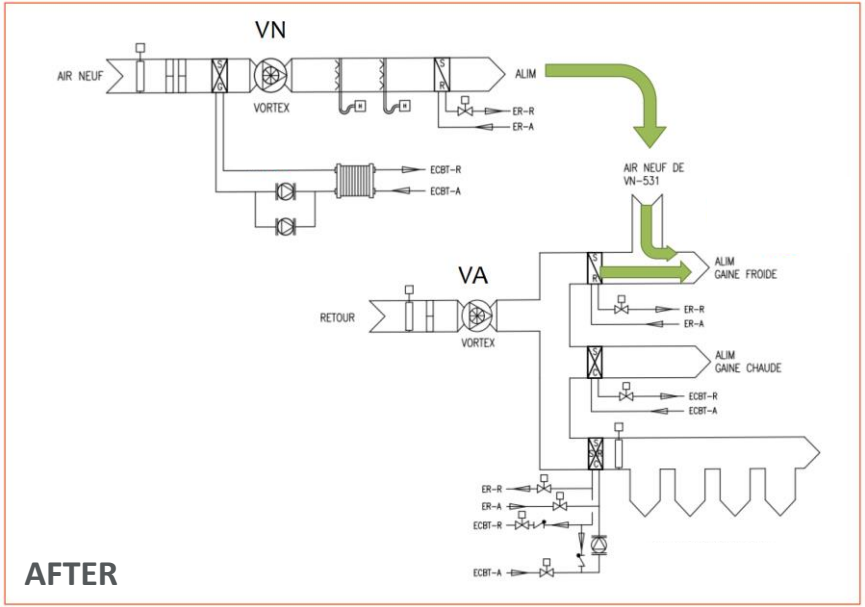
Provide a global perspective of air entering and leaving the building (air balancing).



Examples of O&M Training Content

Implemented measures: description of improved performance and before/after operation.





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Plan for Persistence

To ensure the benefits of recommissioning are enduring, the owner and recommissioning provider determine effective **persistence strategies** by:

- Developing policies and procedures for updating building documentation
- Providing ongoing training for building staff
- Ensuring efficient operational performance
- Tracking energy and system performance
- Plan for periodic EBCx

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Plan for Persistence

The **biggest challenge** for facility staff is to redefine their preventive maintenance program to include activities that maintain the recommissioning operational improvements.

- Have temporary occupancy schedules been returned to original settings?
- Have altered equipment schedules or lockouts been returned to original settings?
- Is equipment short-cycling?
- Are time clocks checked monthly to ensure their proper operation?
- Are the building's sequences of operation performing as intended?

Reference: Natural Resources Canada, Recommissioning Guide For Building Owners and Managers

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Operational Parameter Checks

To ensure operational performance, the persistence plan should include:

- Frequencies for recalibrating sensors and actuators
- Description and frequencies for running override and in-alarm reports
- Verification of time-of-day schedules and setpoints
- Standard trend logs and their interpretations
- Description of functional tests and their periodic frequency

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Performance Tracking

Helps building operators detect and diagnose problems early, before they lead to tenant comfort complaints, high energy costs and unexpected equipment failures.

There are three key strategies:

- Benchmarking
- Utility bill analysis
- Trend analysis

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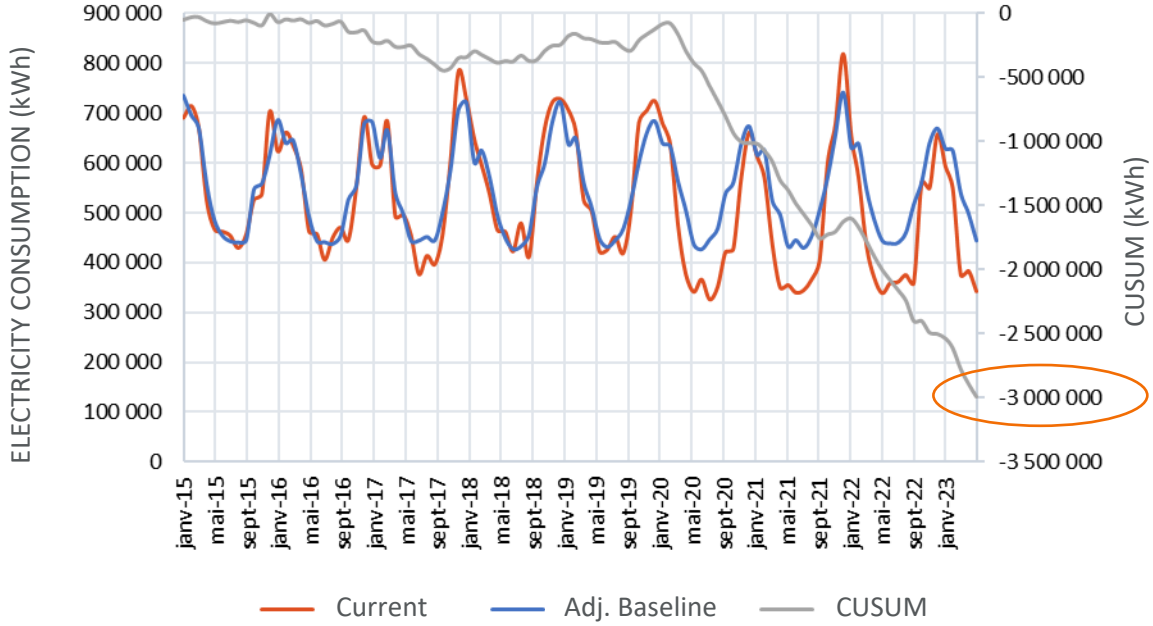
Performance Tracking

Performance tracking using a CUSUM (cumulative sum) chart:



CUMULATIVE SAVINGS

EBCx Provider Involvement

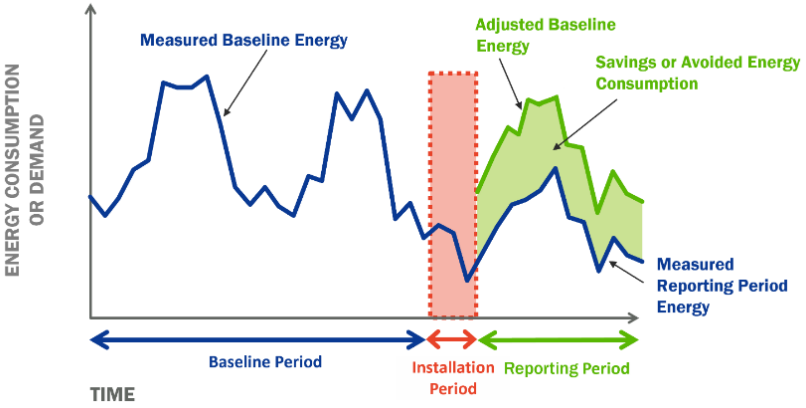
For complex systems or for buildings without specialized in-house staff (i.e., building controls adjustments are subcontracted), CxP should be involved during persistence phase to help with:

- Remote monitoring
- Periodic visits
- Performance tracking

Energy Performance Measurement and Verification

What is measurement and verification (M&V)?

- **Process** of planning, measuring, collecting and analyzing data for the purpose of verifying and reporting energy savings
- **Savings** are determined by comparing energy use before and after implementation of ECMs (energy conservation measures)
- **Adjustments** consider changes in conditions (weather, space use, occupancy rate, etc.)



Source: EVO – Efficiency Valuation Organization https://evo-world.org/

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Energy Performance Measurement and Verification

- The M&V process provides a way to state energy savings within the confidence limits
- These savings are based on energy measurements taken before and after improvements
- It **differs from savings estimates** that are based on data collected only during the reference period and on calculations and engineering hypotheses that vary greatly in term of quality and depth

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Energy Performance Measurement and Verification

PLANNING AND INVESTIGATION

IMPLEMENTATION

HAND-OFF

PERSISTENCE

BEFORE IMPLEMENTATION

- Design M&V process
- Collect baseline data (energy and operating conditions)
- Document **M&V plan**

AFTER IMPLEMENTATION

- Verify that appropriate equipment/systems are installed and operating according to specifications
- Calibrate meters as needed
- Collect energy and operation data
- Calculate savings as defined in the M&V plan

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Energy Performance Measurement and Verification

Savings may be determined for an entire facility or for a portion of a facility. IPMVP provides four different options for determining project savings:

Retrofit Isolation

- Option A - Measurement of key parameter(s)
- Option B - Measurement of all parameters

Whole Facility

- Option C - Whole facility
- Option D - Calibrated simulation

International
Performance
Measurement
&
Verification
Protocol

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Energy Performance Measurement and Verification

Option A: Modifications isolation – key parameter(s) measurement

- To verify the savings from one specific ECM
- This specific option allows for the estimation of a key parameter
- Example: lighting retrofit. The power drawn can be measured and the operational hours can be estimated

Option B: Modifications isolation – all parameters measurement

- All parameters associated with the energy conservation measure must be measured and cannot be estimated
- Example: installation of a variable speed drive. The power drawn as well as the hours of operation must be measured to determine the energy savings

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Energy Performance Measurement and Verification

Option C: Whole facility approach

- The facility to be measured is clearly outlined using key energy meters
- Verify savings from multiple (ECMs) with interactive effects
- Adjusted baseline: a number of independent variables may need to be considered, such as heating/cooling degree days or production data/occupancy rate
- **Preferred option for EBCx project: low-cost and easy to set up**
- If energy savings are not significant (less than 10-15% of total energy use), option A or B should be considered

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Energy performance M&V

Option D: Calibrated Simulation

- Apply energy data from a calibrated simulation model for either part or all of the facility
- When baseline or reporting period data is unreliable or unavailable (e.g., new construction)
- Rarely applicable for EBCx projects

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EBCx Program Measurement and Verification

M&V level	Estimated savings per year	M&V requirements
No M&V	<50 MWh	• Facility benchmark • **No formal M&V plan required** • Engineering calculations • Verification of ECMs by CxP
Basic M&V	≥50 & <500 MWh	• Facility benchmark • **Basic M&V plan** • Engineered calculation • Participant report • Equipment verification
Enhanced M&V	≥500 MWh	• Facility benchmark • **Enhanced M&V plan** • Participant report • Equipment verification

Source: IESO – Existing Building Commissioning Program – Measurement & Verification Guide

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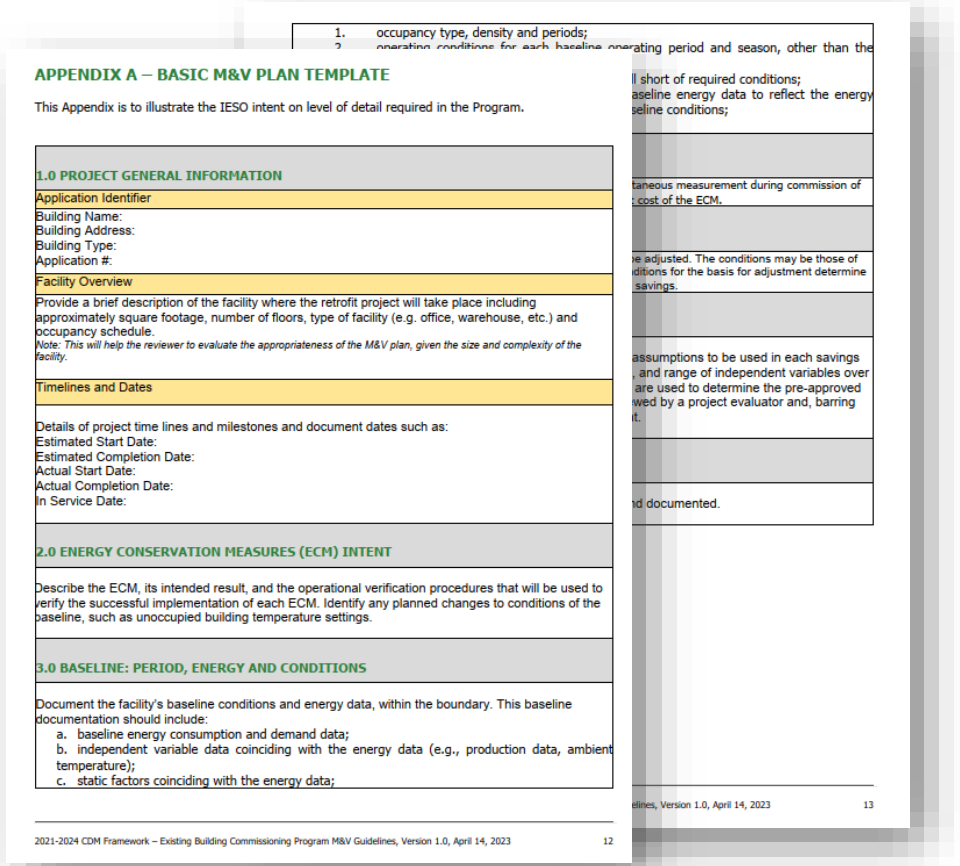
Measurement and Verification Plan Templates

Templates available on the EBCx program website

- M&V guide
- Basic M&V plan
- Enhanced M&V plan

https://saveonenergy.ca/For-Business-and-Industry/Programs-and-incentives/Existing-Building-Commissioning-Program



1. occupancy type, density and periods;

short of required conditions;
aseline energy data to reflect the energy
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taneous measurement during commission of
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elines, Version 1.0, April 14, 2023 13

APPENDIX A – BASIC M&V PLAN TEMPLATE

This Appendix is to illustrate the IESO intent on level of detail required in the Program.

1.0 PROJECT GENERAL INFORMATION

Application Identifier

Building Name:
Building Address:
Building Type:
Application #:

Facility Overview

Provide a brief description of the facility where the retrofit project will take place including approximately square footage, number of floors, type of facility (e.g. office, warehouse, etc.) and occupancy schedule.
Note: This will help the reviewer to evaluate the appropriateness of the M&V plan, given the size and complexity of the facility.

Timelines and Dates

Details of project time lines and milestones and document dates such as:
Estimated Start Date:
Estimated Completion Date:
Actual Start Date:
Actual Completion Date:
In Service Date:

2.0 ENERGY CONSERVATION MEASURES (ECM) INTENT

Describe the ECM, its intended result, and the operational verification procedures that will be used to verify the successful implementation of each ECM. Identify any planned changes to conditions of the baseline, such as unoccupied building temperature settings.

3.0 BASELINE: PERIOD, ENERGY AND CONDITIONS

Document the facility's baseline conditions and energy data, within the boundary. This baseline documentation should include:
a. baseline energy consumption and demand data;
b. independent variable data coinciding with the energy data (e.g., production data, ambient temperature);
c. static factors coinciding with the energy data;

2021-2024 CDM Framework – Existing Building Commissioning Program M&V Guidelines, Version 1.0, April 14, 2023 12

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Hand-off Meeting

Hold a lessons learned meeting with the building staff to help sustain the EBCx performance benefits, increase their knowledge, and enhance their ability to identify and address improvement measures

- Present the final EBCx report
- Address questions from O&M staff and management
- Discuss remaining issues and review next steps
- Celebrate project successes!

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Persistence Phase

During this phase, the facility staff receive training and support from the EBCx provider to maintain savings and monitor the systems for **one or two years** after implementation

Persistence report, required by IESO after one year, includes:

- Baseline conditions and final conditions following implementation
- Data collected, including method of data collection/time periods
- Clear description of how energy savings will be verified
- Measurement and calculation methods and details

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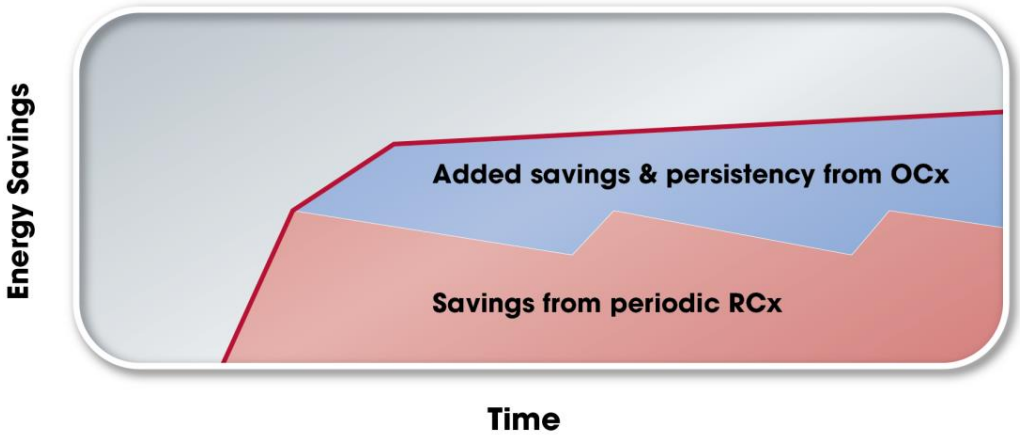
Energy Use Over Time

An IEA (International Energy Agency) study revealed that energy savings **dropped by 25% four years** after Cx or EBCx was completed.

- Periodic EBCx (every three to five years)
- EBCx + Ongoing commissioning



Source: IEA-ECBCS Annex 47 Cost-Effective Commissioning of Existing and Low Energy Buildings, Final Report, 2009.

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Ongoing Commissioning

OCx is the means and process of investigating, evaluating, monitoring and implementing improvement measures related to facility performance on an **ongoing basis** to maintain the built infrastructure at current facility requirements (CFR) performance standards

The objective is to **create a bridge** between EBCx project conclusion and ongoing building and systems performance

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Purpose of On-going Commissioning

1. Evolving CFRs due to changes in facility use, system changes and/or building renovations
2. Reduce/control energy use while maintaining environmental condition requirements
3. Proactively identify degradation in system performance for correction prior to occupant impact
4. Proactively identify degradation in system performance for correction prior to operational (maintenance) or efficiency impact.

For further details see Building Commissioning Association Ongoing Commissioning Best Practices

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Discussion

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Thank you for participating!

Questions: trainingandsupport@ieso.ca

Information, events, courses: https://saveonenergy.ca/For-Business-and-Industry/Training-and-support

EBCx program: https://saveonenergy.ca/For-Business-and-Industry/Programs-and-incentives/Existing-Building-Commissioning-Program

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