



BOC Level II Project Workbook

Edition 2.20

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About Building Operator Certification

Building Operator Certification (BOC®) is a national workforce training and credentialing program offering job skills in energy efficient building and operation maintenance practices. BOC leverages the U.S. Department of Energy's occupational skills standards for operating engineers/building technicians in a curriculum that covers energy efficient building operation and maintenance practices, energy management, sustainability, water efficiency, general and electrical safety, and building performance measures.

Training is offered at three levels: Fundamentals of Energy Efficient Building Operations provides the basic principles of energy efficiency awareness and practices in commercial buildings. BOC Level I addresses energy efficient building maintenance practices, while BOC Level II emphasizes equipment troubleshooting, maintenance, and optimization. There are two versions of BOC Level I: one specific to multifamily buildings and the other focusing on commercial/industrial buildings in general. BOC credentials are recognized by employers nationally as a standard of expertise in energy efficient building management.

To earn a BOC Training Certificate of Completion, participants must meet eligibility requirements, attend BOC classes, and complete written tests and on-the-job application projects. Successful completion of Fundamentals of Energy Efficient Building Operations can be paired with one-year of experience to meet eligibility requirements for BOC Level I. Classes consist of lecture, discussion, and small group exercises. Application projects in BOC Level I and Level II courses require participants to demonstrate knowledge of their own building by locating major equipment, distribution pathways, and control points for HVAC, electrical and lighting systems; benchmarking the building's energy performance in ENERGY STAR; completing occupancy profiles; conducting operational reviews of HVAC equipment and controls; and mapping facility electrical distribution. After earning a BOC Level I Training Certificate of Completion, graduates may use the designation *BOC Level I Certificate*. Graduates who earn a training certificate are eligible to sit for the BOC Certification Exam. Those passing the exam earn the BOC Certification and designation of *Certified Building Operator (CBO)*.

Fundamentals of Energy Efficient Building Operations

This course includes seven parts that are delivered over three full days or over six half-days via a virtual platform. The total time commitment is 18 hours.

PART 1 – ENERGY EFFICIENCY AND SUSTAINABILITY OVERVIEW

PART 2 – HVAC FUNDAMENTALS

PART 3 – LIGHTING FUNDAMENTALS

PART 4 – ENERGY MANAGEMENT

PART 5 – ENERGY CONSERVATION OPPORTUNITIES

PART 6 – INDOOR ENVIRONMENTAL QUALITY

PART 7 – PUTTING IT ALL TOGETHER

Multifamily Level I

The Multifamily Level I course series consists of seven core classes specific to multifamily buildings. Completion of Level I requires a time commitment of 74 hours. Class topics include the following:

CORE

BOC MF1001 – ENERGY EFFICIENT OPERATION OF MULTIFAMILY BUILDING HVAC SYSTEMS

BOC MF1002 – MEASURING AND BENCHMARKING ENERGY PERFORMANCE IN MULTIFAMILY BUILDINGS

- BOC MF1003 – EFFICIENT LIGHTING FUNDAMENTALS IN MULTIFAMILY BUILDINGS**
- BOC MF1004 – MULTIFAMILY FACILITY ELECTRICAL SYSTEMS, HVAC CONTROLS, AND SMART BUILDINGS FUNDAMENTALS**
- BOC MF1005 – INDOOR ENVIRONMENTAL QUALITY IN MULTIFAMILY BUILDINGS**
- BOC MF1006 – COMMON OPPORTUNITIES FOR LOW-COST OPERATIONAL IMPROVEMENT IN MULTIFAMILY BUILDINGS**
- BOC MF1008 – OPERATIONS & MAINTENANCE PRACTICES FOR SUSTAINABLE MULTIFAMILY BUILDINGS**

BOC Level I

The BOC Level I course series focuses on commercial and industrial buildings and consists of six core classes and one supplemental class. Completion of Level I requires a time commitment of 74 hours. Class topics include the following:

- CORE**
- BOC 1001 – ENERGY EFFICIENT OPERATION OF BUILDING HVAC SYSTEMS**
 - BOC 1002 – MEASURING AND BENCHMARKING ENERGY PERFORMANCE**
 - BOC 1003 – EFFICIENT LIGHTING FUNDAMENTALS**
 - BOC 1004 – HVAC CONTROLS FUNDAMENTALS**
 - BOC 1005 – INDOOR ENVIRONMENTAL QUALITY**
 - BOC 1006 – COMMON OPPORTUNITIES FOR LOW-COST OPERATIONAL IMPROVEMENT**

SUPPLEMENTS

- BOC 1007 – FACILITY ELECTRICAL SYSTEMS**
- BOC 1008 – OPERATIONS & MAINTENANCE PRACTICES FOR SUSTAINABLE BUILDINGS**
- BOC 1010 – ENERGY EFFICIENT VENTILATION STRATEGIES AND HIGH PERFORMANCE HEATING AND COOLING EQUIPMENT**
- BOC 1011 – ENERGY EFFICIENT VENTILATION STRATEGIES AND ENERGY SAVINGS THROUGH ENERGY RECOVERY**
- BOC 1012 – HIGH PERFORMANCE HEATING AND COOLING EQUIPMENT AND ENERGY SAVINGS THROUGH ENERGY RECOVERY**
- BOC 1013 – SMART BUILDINGS FUNDAMENTALS**
- BOC 1014 – ELECTRIFICATION AND BUILDING OPERATIONS**

BOC Level II

The BOC Level II course series focuses on commercial and industrial buildings and consists of five core classes and one supplemental class, culminating with a day of peer exchange preparing students to take their building walk-through plans, identifying performance improvement opportunities, back to their facilities and managers. Completion of Level II requires 61 hours. Class topics include the following:

- CORE**
- BOC 2001 – SCOPING YOUR BUILDING FOR OPERATIONAL IMPROVEMENT**
 - BOC 2002 – OPTIMIZING HVAC CONTROLS FOR ENERGY EFFICIENCY**
 - BOC 2003 – INTRODUCTION TO BUILDING COMMISSIONING**
 - BOC 2004 – WATER EFFICIENCY FOR BUILDING OPERATORS**
 - BOC 2005 – PROJECT PEER EXCHANGE DAY**

SUPPLEMENTS

- BOC 2010 – PREVENTIVE MAINTENANCE AND TROUBLESHOOTING PRINCIPLES**
- BOC 2012 – ADVANCED ELECTRICAL SYSTEMS DIAGNOSTICS**
- BOC 2014 – ENHANCED AUTOMATION & DEMAND REDUCTION**

BOC Administrators

Building Operator Certification training is provided by a national network of local administrators in states across the country. For the most current list of states and local administrators, visit:

<https://www.theboc.info/about/locations>

Competency

BOC graduates have the opportunity to apply elements of their BOC education to other industry credentials and licenses. For example, classes have been approved for continuing education units (CEU's) by the International Association for Continuing Education and Training (IACET) and by the U.S. Green Building Council® for continuing education for LEED AP® and Green Associate. Many professional associations also recognize BOC training. BOC and BOMI award competency credit between BOC Level I and II and BOMI International's Systems Maintenance Technician (SMT®) and Systems Maintenance Administrator (SMA®) Programs.

If you have questions, please call us at 877-850-4793 or email: BOCinfo@theBOC.info

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BOC Level II

Project Workbook

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Company: _____

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BOC Level II Project

Purpose. The purpose of the BOC Level II project is to enable you to demonstrate your ability to apply skills developed in the BOC classes. The assignments require you to gather information about your facility, provide documentation, and make recommendations for operational improvements. As a whole, the project should provide you with a useful overview of the facility’s operational characteristics, energy consumption, and maintenance status.

Requirements. Completion of the Level II Project Workbook is REQUIRED for the BOC Level II training certificate of completion (BOC II designation).

Organization and Instructions. The project consists of five assignments given during the course and each should be completed and returned to your training coordinator for review at the start of the following class. If you have any questions, ask your training coordinator or call the NEEC office at (877) 850-4793.

Score Card. This page is completed by the BOC Training Coordinator following review of each assignment. Be sure to complete your name and company name and include it when you hand in each assignment. The training coordinator will assign you a participant ID #, review your assignments, and note the score as you progress through the course series. At the end of the series, the training coordinator will submit this assignment record to NEEC.

Project Assignment Description

| By Class | Due |
|--|---------------------|
| Assignment 1: BOC 2001-A, Assemble Utility Data for Building Scoping Benchmark the building’s energy performance, set a performance goal, and evaluate seasonal trends. | the following class |
| Assignment 2: BOC 2001-B, Assemble Building Operation Data for Scoping Complete a scoping interview guide and a building operations map. | the following class |
| Assignment 3: BOC 2002, HVAC Control System Sequence of Operation and Functional Test Procedure Write a sequence of operation for an air handler in your building. Write a functional test procedure for verifying proper operation of the SoO. Create a checklist for maintenance of the system. | the following class |
| Assignment 4: BOC 2003, Building Walkthrough Plan Complete a building walkthrough plan for your facility. | the following class |
| Assignment 5: BOC 2004, Building Scoping Report Complete a building walkthrough; summarize/present your findings. | the following class |

Project Assignment Score Card

Name: _____ Company: _____

Participant ID #:

***** OFFICE USE ONLY *****

| Date | Assignment | Score | Comments (and Reviewer's Initials) |
|------|--|-------|---------------------------------------|
| | Assignment 1: BOC 2001-A, Assemble Utility Data for Scoping | | |
| | Assignment 2: BOC 2001-B, Assemble Building Operation Data | | |
| | Assignment 3: BOC 2002, HVAC Control System Sequence of Operation and Functional Test Procedure | | |
| | Assignment 4: BOC 2003, Building Walkthrough Plan | | |
| | Assignment 5: BOC 2004, Building Scoping Report | | |
| | | | |

Assignment 1: BOC 2001-A, Assemble Utility Data for Scoping

Introduction

In the 2001-A & B classes, you learned about the four steps involved in developing a Building Scoping Action Plan:

- Step 1 – Gather & analyze building data
- Step 2 – Interview building operators
- Step 3 – Document building systems operation
- Step 4 – Plan a building walkthrough

In this assignment, you will complete Step 1 by gathering and analyzing energy consumption data for your building. In later assignments, you will complete Steps 2-4.

Instructions

For this assignment, begin by identifying a single building you wish to use to complete all assignments in the Level II Project Workbook. If you are responsible for only one building, you will use it for the assignments. If you are responsible for a campus with multiple buildings, it is best to select a building with energy consumption meters that are not shared with another building. Use this building for all of the assignments.

Get Started

1. **Review the Assignment-A Utility Data Rubric.**

You will use the free, online tool ENERGY STAR Portfolio Manager to benchmark the energy performance of your building. This tool was introduced in the Level I course and the Level I project assignment. This assignment builds on the work you did in Level I. If you benchmarked your building in Level I, you may update the data for the current year, then print the Statement of Energy Performance. See step 3 below.

2. **Gather Building Data.**

Go to: <https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet> and select your Country and Property Type and look up the required data before logging in to Portfolio Manager. Print your data collection worksheet and submit it as part of your assignment (see rubric). Fill out as much of the data collection worksheet as you can, as some information may be difficult to obtain.

3. **Enter Data and Generate a Report.**

Refer to the Portfolio Manager Quick Start Guide in the appendix. Once you complete the data entry, generate and print the Statement of Energy Performance (SEP). See sample Statement of Energy Performance (SEP) in the appendix.

4. **Analyze Data and Benchmark.** Using the ENERGY STAR SEP from #3 above, complete the *Benchmark Analysis Worksheet*.

5. **Submit your work for review.** To receive full credit for the assignment, complete, print, and submit the three documents below to your course coordinator:

- (1) Your Portfolio Manager Data Collection Worksheet
- (2) Your building's Statement of Energy Performance (SEP)
- (3) Benchmark Analysis Worksheet

Assignment 1: BOC 2001-A, Utility Data Rubric

| Worksheet Data | Points |
|---|--|
| Portfolio Manager Data Collection Worksheet | |
| Worksheet includes the building name, address and zip code; Year built; Building type (e.g., school, office); Square footage; All data fields specific to the building type; and, Source of utility data: ___ Actual or ___ Sample | _____ 6 points |
| Report Generation & Analysis | |
| Entered utility data; Generated and printed the Statement of Energy Performance (SEP) | _____ 4 points |
| Benchmark Analysis Worksheet | |
| Accurately stated the site EUI; Compared EUI to national average; Accurately calculated EUI difference; Identified at least 2 reasons that may cause the building EUI to be higher or lower than the national average for same building type. | _____ 5 points |
| Calculated energy and cost savings for the “scenario” question (Q5); Estimated electricity baseload and evaluated consumption changes; Described source of utility consumption data. | _____ 5 points |
| Office Use | PARTICIPANT NAME: _____ <div style="text-align: right;">TOTAL _____ /20</div> Reviewer Initials: _____ Date: _____ Score: _____ |

ENERGY STAR® Portfolio Manager Data Collection Tool

You can benchmark almost any type of property in Portfolio Manager. The information required varies depending on the type of property and whether or not the property is eligible for an ENERGY STAR Score. Go to:

<https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet> and select your Country and Property Type and lookup the required data.

Portfolio Manager: What data is required to benchmark your property?

You can benchmark almost any type of property in Portfolio Manager! The information required varies depending on the type of property and whether or not the property is eligible for an [ENERGY STAR Score](#).

Pick your country and property type to get started.

Country: * [Why is this needed?](#)

Property Type: *

[+ Add Another Use Type](#)

You can look up more than one use type if needed. [Learn more about when to use different use types when setting up your property.](#)

[Lookup Required Data](#)

What Metrics Are Available?

All properties are eligible to receive metrics such as [Source EUI](#) by providing [Gross Floor Area](#) and 12 months of energy usage. The [ENERGY STAR Score](#) is available for specific property types and requires additional information. [Learn more about eligibility for the ENERGY STAR Score.](#)

This tool will present you with the Basic Data required for all properties as well as Additional Data required for your specific property type (see screen shots below). You can use this tool to create a “worksheet” (in Word or PDF) to send to others electronically or in hard copy. It will be especially helpful to users who need to gather this data from multiple sources.

Once you’ve filled in your Data Collection Worksheet, you will need to manually enter this data into Portfolio Manager. Continue to the next step of creating a Portfolio Manager account to enter your building data at www.energystar.gov/portfoliomanager.

Data Collected for All Properties

- Property Name
- Property Address
- Total [Gross Floor Area](#)
- Total [Gross Floor Area](#) of Property
- [Irrigated Area](#)
- [Year Built/Planned for Construction Completion](#)
- [Occupancy](#)
- Number of Buildings
- 12 consecutive months of energy data

Additional Data Collected for [Office](#)

The following information is **required** to get an ENERGY STAR score ([if eligible](#)):

- [Gross Floor Area](#)
- [Weekly Operating Hours](#)
- [Number of Workers on Main Shift](#)
- [Number of Computers](#)
- [Percent That Can Be Heated](#)
- [Percent That Can Be Cooled](#)

Start Collecting Data

Create a document with the information above.

[Create Word](#)

[Create PDF](#)



Portfolio Manager - What data is required?

In order for Portfolio Manager to calculate metrics about your property, you must provide several key pieces of information about your property's operation, in addition to your energy, water or waste data. The information required varies by the type of property and whether or not your property is eligible for an [ENERGY STAR Score](#).

Data Required for All Properties

| | |
|---|----------------------|
| Property Name _____ | |
| Property Address _____ | |
| Total Gross Floor Area of Property _____ | sq ft/sq M |
| Irrigated Area _____ | sq ft/sq M/ Acres |
| Year Built/Planned for Construction Completion _____ | |
| Occupancy _____ | % |
| Number of Buildings _____ | |

Helpful Hints for All Properties

- Definitions for Property Use Details are available in the [Portfolio Manager Glossary](#) (in the Help section, or <https://portfoliomanager.energystar.gov/pm/glossary>).
- Some properties may contain multiple Property Uses within a single building (e.g. office, data center, and parking; OR K-12 School and Swimming Pool). In most cases, EPA recommends you enter as few Property Uses as possible. More information about when to enter a separate Property Use is in this FAQ.
- For properties with multiple tenants within the same property use (e.g. Office), these tenants should be entered separately only when the number of Weekly Operating Hours differs by more than 10 hours. For example, say an Office Building has a Gross Floor Area of 100,000 square foot (SF) where 75,000 SF operates 60 hours a week and 25,000 SF operates 80 hours a week. Enter these as two separate Property Uses (one 75,000 SF property and one 25,000 SF property).

Office Uses

Data Collected for Office Uses

The following information is required to get an ENERGY STAR Score ([if eligible](#)):

[Gross Floor Area](#) _____

[Weekly Operating Hours](#) _____

[Number of Workers on Main Shift](#) _____

[Number of Computers](#) _____

[Percent That Can Be Cooled](#) _____

The following information is optional and not used to calculate a score; it may inform future analysis and score revisions by EPA and/or may help you manage and compare your properties:

[Percent That Can Be Heated](#) _____

Definition for Office

Office refers to buildings used to conduct commercial or governmental business activities. This includes administrative and professional offices.

Gross Floor Area (GFA) should include all space within the building(s), including but not limited to offices, conference rooms and auditoriums, break rooms, restrooms, kitchens, lobbies, fitness areas, basements, storage areas, stairways, and elevator shafts.

If you have restaurants, retail, or services (dry cleaners) within the Office, you should most likely include this square footage and energy in the Office Property Use. There are 4 exceptions to this rule when you should create a separate Property Use:

- If it is a [Property Use Type that can get an ENERGY STAR Score](#) (note: Retail can only get a score if it is greater than 5,000 square feet)
- If it accounts for more than 25% of the property's GFA

- If it is a vacant/unoccupied Office, Financial Office, Bank, Courthouse, or Medical Office (and the vacancy is greater than 10% of the property's GFA)
- If the Weekly Hours differ by more than 10% for the same Property Type AND that Property Type can get a score (ex: you have two Office tenants, and their hours differ by more than 10%)

[More on this rule.](#)

Helpful Hints for Office

- If more than 10 percent of the office's gross floor area on average was vacant through the last 12 months, enter the vacant space as a separate Property Use with zero for Weekly Operating Hours, Number of Workers on Main Shift and Number of Computers.
- The Weekly Operating Hours value is the number of hours per week that the office is occupied by the majority of its occupants. It should not include hours when the building is occupied solely by maintenance/security personnel or HVAC run times when the building is not occupied by the majority of occupants.
- The Number of Workers on Main Shift should be entered as the number of workers present on a site at the same time, not the total number of workers added up across all shifts during a day.
- When determining the Number of Computers, do not count extra monitors or tablets. For example, a desktop computer with 3 monitors would count as 1. Similarly, a laptop computer with an external monitor would count as 1.

Meter Information

What's required to see metrics:

- 12 consecutive, complete months of bills if your energy or water is metered continuously.
- At least one delivery if your energy is delivered in bulk quantities (e.g. filling a propane tank.)

Please copy this sheet as needed to account for all meters at your property.

| Basic Meter Information | |
|--|-------|
| Meter Name or ID | _____ |
| Meter Type (e.g. Electricity) | _____ |
| Units (e.g. kWh) | _____ |
| Date Meter Became Active | _____ |
| Date Meter Became Inactive | _____ |

You can use the form below to get ready to enter your data so you can see metrics, however you can create your property and set up your meters without entering your meter data. You can add bills later.

| Meter Bills | | | |
|--------------------------|---------------------------------------|----------------|-----------------|
| Start Date/Delivery Date | End Date (leave blank for deliveries) | Usage/Quantity | Cost (optional) |
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Benchmark Analysis Worksheet

1. What is the site energy use intensity (EUI) of your building? _____
2. Find your building type in the chart below and CIRCLE it. If the building type is not listed, CIRCLE the “Other” line.

Table 1. U.S. National Averages for Site Energy Use Intensity (EUI) *Source: ENERGY STAR 2024*

| Building Type | Average Site Energy Use Intensity (EUI) - kBtu/sf/year | Building Type | Average Site Energy Use Intensity (EUI) - kBtu/sf/year |
|-----------------------|--|-------------------------------|--|
| Education | | Public Assembly | |
| <i>College</i> | 84.3 | <i>Entertainment/Culture</i> | 56.2 |
| <i>K-12</i> | 48.5 | <i>Library</i> | 71.6 |
| Dormitory | 57.9 | <i>Recreation</i> | 50.8 |
| Fast food service | 402.7 | <i>Social/Meeting</i> | 56.1 |
| Restaurant | 325.6 | Public Order | |
| Health Care | | <i>Fire/Police Station</i> | 63.5 |
| <i>Hospital</i> | 234.3 | Service (repair, personal) | 47.9 |
| <i>Senior Living</i> | 99.0 | Storage/Warehouse | 22.7 |
| <i>Medical Office</i> | 97.7 | <i>Refrigerated warehouse</i> | 84.1 |
| Lodging | 63.0 | Religious Worship | 30.5 |
| Office | 52.9 | Laboratory/Technology | 115.3 |
| Retail (non-mall) | 51.4 | Multifamily | 59.6 |
| Retail (mall) | 101.6 | Other (mixed use) | 40.1 |

3. Compare your building’s site EUI to the average for your building type. My building is: (check one, and fill in the kBtu/sf/year difference between your building and the average)

___ Above the national average by _____ kBtu/sf/year.

___ Below the national average by _____ kBtu/sf/year.

___ Same as the national average.

4. List two or more reasons your building may use more or less energy than the average building of the same type? (e.g., inefficient lighting fixtures, no energy management control system, inefficient HVAC, etc.)

A. _____

B. _____

Benchmark Analysis Worksheet (continued)

5. SCENARIO: Your management has set a target goal of reducing the building's EUI by 10% next year. Your management asks you to review the SEP and answer these questions. With a 10% reduction in the site EUI:

What is the potential annual energy savings in kBtu/year? _____ kBtu/YR

What is the potential annual cost savings in \$/year? _____ \$/YR

6. Take a close look at the monthly consumption data for electricity over a 12-month period – January to December. Answer these questions.

Estimate the monthly baseload for electricity:

Electric Baseload _____ kWh/Month

Determine if consumption changes with the four seasons of the year (check one):

- Electricity consumption is about the same each month over the year
- Electricity consumption is higher in winter than summer
- Electricity consumption is lower in winter than summer

7. How did you get access to your building's utility consumption data to complete this assignment? (check one)

- I have direct access to the data.
- I asked my boss.
- I asked my utility account representative.
- I asked someone in the company (describe job title/department):

- Other (describe):

Assignment 2: BOC 2001-B, Assemble Building Data for Scoping

Instructions

In the 2001-A & B classes, you learned about the four steps involved in developing a Building Scoping Action Plan:

- Step 1 – Gather & analyze building data
- Step 2 – Interview building operators
- Step 3 – Document building systems operation
- Step 4 – Plan a building walkthrough

In Assignment 1, you completed Step 1. In this assignment, you will complete Steps 2 & 3 by interviewing a building operator and documenting building systems operation. In a later assignment, you will complete Step 4.

At the completion of this assignment, you will have information from the building operator interview about the building's current operating condition, and opportunities for improvement. You will also have a building systems operations map documenting building uses and operational requirements.

Get Started

1. **Review the Assignment 2 Building Data Rubric**
2. **Complete Step 2: Scoping Interview Guide**
 - Start by reviewing the Guide to determine the best person(s) to interview. You will want to find someone with the knowledge to answer questions about staffing, vendors, energy management practices, performance goals, occupant complaints, issues, known problems, and the status of mechanical drawings, control sequences, equipment repair records, and T&B reports. A facility manager, chief engineer or maintenance manager is often a good resource. It may also be useful to interview a building occupant.
 - Arrange a date and time to conduct the interview.
 - Complete the Guide using the answers provided in the interview.
3. **Complete Step 3: Building Systems Operations Map (Map)**
 - Start by reviewing the Operations Map. The Map asks you to document the type of equipment, size, operating hours, and control systems for the building plant, air systems, pumps, lighting and general equipment.
 - Determine where you can find the information to complete the Map. Who will need to provide assistance?
 - Arrange a schedule to gather the information.
 - Complete the Map to the best of your ability.
4. **Submit Steps 2 & 3 for review.** To receive full credit for the assignment, complete the two documents below and submit them to your course coordinator at the next class:
 - A. Scoping Interview Guide
 - B. Building Systems Operations Map

Assignment 2: BOC 2001- B, Building Data Rubric

| Scoping Interview Guide | Points |
|--|---------------|
| 1 - Building name, date, interviewee, title are provided | ___ 1 point |
| 2 - Questions 1-9 are completed - 1 point/question | ___ 9 points |
| 3 - Questions 10-19 are completed - 1 point/question | ___ 10 points |
| Building Systems Operation Map | |
| 1 - Building name, date, year constructed, size and HVAC system information is provided. | ___ 1 point |
| 2 - Occupancy schedule, Lighting, Office equipment & Other are completed. | ___ 4 points |
| 3 - Cooling system equipment is completed for chillers & cooling tower. If the building doesn't have this equipment, was noted in comments. | ___ 4 points |
| 4 - Heating system equipment is completed for boilers and furnaces. If the building doesn't have this equipment, was noted in comments. | ___ 4 points |
| 5 - Air handling system equipment is completed for package units, terminal units and other air system equipment. If the building doesn't have this equipment, was noted in comments. | ___ 4 points |
| 6 - Water system documentation is completed for chiller, condenser, hot and domestic water. If the building doesn't have this equipment, was noted in comments. | ___ 3 points |
| OFFICE USE | |
| TOTAL POINTS: _____/40 | |
| REVIEWER INITIALS: _____ | |
| DATE: _____ | |
| SCORE: _____ | |

STEP 2: Scoping Interview Guide

Building Name: _____ Date: _____

Interviewee: _____ Title: _____

- 1. Have there been any energy systems modifications, replacements or additions in the last few years? YES NO

If yes, describe each action and implementation date.

- 2. Are you aware of any barriers to successful implementation of services in this facility, such as environmental dangers or tenant agreements? YES NO

If yes, please specify.

- 3. Who has overall responsibility for your O&M program?

- 4. How many members of your staff are permanently assigned to building operations and maintenance activities, and what are their duties?

Is ongoing training currently provided to upgrade facility staff skills? YES NO

- 5. Do you contract with outside vendors for building operations or maintenance services? YES NO

If yes, for which systems, equipment or roles? *(Check all that apply)*

| | | | |
|---------------|-----|----------------------|-----|
| Package Units | ___ | Chiller | ___ |
| Boiler | ___ | Entire Central Plant | ___ |
| DDC Controls | ___ | Entire HVAC | ___ |
| Refrigeration | ___ | Operating Engineer | ___ |
| Other | ___ | Describe _____ | |

BOC® Level II Project Workbook

Are you satisfied with the contracted services? YES NO

If no, describe areas that you are not satisfied with:

6. Are maintenance reports submitted to management? YES NO

7. Is there a unified equipment inventory? YES NO

8. Can the occupants control the temperature setpoints? YES NO

9. Can the occupants control the temperature schedules? YES NO

10. Have there been any recent occupant complaints relevant to the performance of the building systems? YES NO

If yes, describe:

11. Who is responsible for day-to-day operation of the EMCS?

Do they set up or modify:

Setpoints? Operating Schedules
 Trendlogs Control Algorithms
 Other _____

Maintenance and technical assistance performed by:

12. How often are thermostats checked and calibrated?

13. How often are the critical control sensors (OSA, SAT, and RAT) checked and calibrated?

14. Will building facility personnel be available to assist? YES NO

If no operator, is HVAC maintenance contractor available to assist? YES NO

15. Are there known problems with the following energy system equipment?

| EQUIPMENT TYPE | KNOWN PROBLEM/PLAN FOR CORRECTION | |
|---------------------|-----------------------------------|----|
| Chillers: | YES | NO |
| Cooling Towers: | YES | NO |
| Boilers: | YES | NO |
| Pumps: | YES | NO |
| Air Handling Units: | YES | NO |
| Other Fans: | YES | NO |
| Lighting Control: | YES | NO |
| Electrical Systems: | YES | NO |
| Other: | YES | NO |

16. Are the following items available? *(List only if correct and current)*

| ITEM | YES | NO | LOCATION |
|--|-------|-------|----------|
| Division 15 and 16 Specifications | _____ | _____ | _____ |
| Mechanical Drawings | _____ | _____ | _____ |
| Control Sequence Description | _____ | _____ | _____ |
| Control Drawings | _____ | _____ | _____ |
| EMCS Points List | _____ | _____ | _____ |
| EMCS Program Print Out | _____ | _____ | _____ |
| Electrical Drawings | _____ | _____ | _____ |
| Equipment Repair History | _____ | _____ | _____ |
| Test & Balance Report | _____ | _____ | _____ |
| Manufacturer Startup Documentation | _____ | _____ | _____ |
| O&M Manuals (For Controls and Major Equipment) | _____ | _____ | _____ |

17. Describe generally any lighting controls such as daylighting, occupancy or sweep controls.

18. Describe the trending capability of your control system(s).

19. How do you financially evaluate operations and maintenance “projects”?

STEP 3: Building Systems Operation Map

Building Name: _____

Date: _____

Year Constructed _____

Building Size: _____

Age of Chiller _____

Age of HVAC System _____

Number of Stories: _____

Age of Boiler _____

Describe HVAC System Type _____

| Occupancy Schedules | | | | | | |
|--------------------------------------|-------------------------------|---------------|---------------------|------------------------|--------|--------|
| Area | % of Building | Total Hours | | Wks Per Year | # Occ | Notes: |
| | | Wkdy | Wknd | | | |
| | | | | | | |
| | | | | | | |
| Lighting System | | | | | | |
| Area | System Type | Est. W/Sq.Ft. | % of Bldg | Notes: | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Misc. Office Equipment | | | | | | |
| Area | Load Density (High, Med, Low) | Notes: | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Other (e.g. Cafeteria, Data Centers) | | | | | | |
| Area | Description | HVAC Service | Est. Elec. W/Sq.ft. | Est. Other kBtu/sq.ft. | Notes: | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Comments:

Building Name: _____

Date: _____

| Service ID | No. Units | Est. Size Tons | Est. Motor HP | Est. Annual Oper Hours | Control System | | | | | Control Sequence Parameters/Notes |
|------------|-----------|----------------|---------------|------------------------|--|------------|--------------|------------|--|-----------------------------------|
| | | | | | "M" Manual "S" Self Contained "X" Control System | | | | | |
| | | | | | Start /Stop | Temp Reset | Temp Lockout | Stage Comp | | |
| Chillers | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| Service ID | No. Units | Capacity Control (Pony / Damper/ VFD) | Est. Motor HP / Cell | Est. Annual Oper Hours | Control System | | | | | Control Sequence Parameters/Notes |
|---------------|-----------|---------------------------------------|----------------------|------------------------|--|--------------------|-------------|-------|--|-----------------------------------|
| | | | | | "M" Manual "S" Self Contained "X" Control System | | | | | |
| | | | | | Temp Reset | O.S.A Temp Lockout | Cap Control | Other | | |
| Cooling Tower | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| Service ID | No. Units | Est. Size Mmbtu | Est. Annual Oper Hours | Availability Stand-by or On-Demand | Control System | | | | | Control Sequence Parameters/Notes |
|------------|-----------|-----------------|------------------------|------------------------------------|-------------------------------|------------|--------------|---------|--|-----------------------------------|
| | | | | | "M" Manual "X" Control System | | | | | |
| | | | | | Start /Stop | Temp Reset | Temp Lockout | Staging | | |
| Boilers | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

Building Name: _____

Date: _____

| | Service ID | No. Units | Capacity Control (Pony / Damper/ VFD) | Est. Motor HP | Est. Annual Oper Hours | Condition Comments |
|-----------------|------------|-----------|---------------------------------------|---------------|------------------------|--------------------|
| Chilled Water | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Condenser Water | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Hot Water | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Domestic | | | | | | |
| | | | | | | |
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Assignment 3: BOC 2002, HVAC Controls Sequence of Operation & Functional Test Procedure

Introduction

In the 2002 class, you learned how to write the sequence of operation (SoO) for typical HVAC system components. You also learned how to write a procedure for functionally testing the control system to verify proper operation. In this assignment, you will apply these lessons to equipment in your own building. The assignment has three parts which involve writing an SoO, writing a Function Test Procedure for the SoO, and creating a list of Maintenance Actions for the control system. Please complete each part to earn full credit for the assignment.

Part 1 – Write a sequence of operation for an air handling unit in your building.

Part 2 – Write a functional test procedure to verify operation.

Part 3 – Create a checklist of maintenance actions for the control system.

Instructions

For this assignment, begin by identifying an air handling system in your building that provides heating and/or cooling. The system can be a single zone system or a multi-zone system. If using a multi-zone system identify whether you are writing the SoO for the central air handling unit or a terminal unit.

Get Started

1. **Review the SoO and Functional Test Rubrics on the next few pages following these instructions.** The rubrics identify the point system for grading your assignment.
2. Refresh your knowledge of SoO's and functional tests by referencing your BOC 2002 Student Handbook. Reference the two examples of an SoO and a functional test procedure in the Appendix.
3. **Complete Parts 1-3 on the following pages.**

Assignment 3: BOC 2002, SoO, Functional Test Procedure & Maintenance List Rubric

| Part I: Sequence of Operation | POINTS |
|--|---------------|
| 1 - System type, name, and area served are provided. | ___ 1 point |
| 2 - Operating schedules are provided for the occupied and unoccupied modes. | ___ 4 points |
| 3 - Set points are provided for heating and cooling for occupied and unoccupied modes. | ___ 4 points |
| Parts 2 & 3: Functional Test Procedure & Maintenance | POINTS |
| 1 - A procedure for testing the heating mode of operation is provided. Checks for fan operation, damper position, and heat enabling are noted in comments. | ___ 4 points |
| 2 - A procedure for testing the cooling mode of operation is provided. Checks for fan operation, damper position, and cooling enabling are noted in comments. | ___ 4 points |
| 3 - A procedure for testing the unoccupied mode of operation is provided. Checks for fan operation, and damper position are noted in comments. | ___ 4 points |
| 4 - Five or more maintenance actions for the control system are listed. | ___ 4 points |
| OFFICE USE | |
| TOTAL POINTS: _____/25 | |
| REVIEWER INITIALS: _____ | |
| DATE: _____ | |
| SCORE: _____ | |

Assignment 4: BOC 2003, Building Walkthrough Plan

Introduction

In the BOC 2001-B class, we learned about a building walkthrough. A building walkthrough is one means for assessing a building's general characteristics and operating condition. We reviewed and discussed a building walkthrough checklist (see the following pages) and watched a video series on conducting building walkthroughs. In this assignment, you will apply these lessons to completing a building walkthrough plan for your building. The assignment instructions are below. As you work on the assignment, keep in mind that the plan you develop will serve as the roadmap for PW Assignment 5, which is a Building Scoping Report summarizing the building walkthrough you will conduct in your facility.

Instructions

For this assignment, you will use the building you used in PW Assignments 1-3 to complete the building walkthrough plan.

Get Started

1. Select the building area for the walkthrough. This can be the entire building, or if the building is large (e.g., greater than 75K sf), you may pick a smaller space between 30K-50K sf to plan and conduct the walkthrough.
2. Refresh your knowledge of a building walkthrough by watching the Building Walkthrough Video Series at the links below:

Option 1: <https://www.theboc.info/student-partner-login/>

Click on "Access Materials" under "BOC Supplemental Class Materials"

Password: BOCstudent

Scroll to "BOC 2001" and download the "Building Walkthrough Video Series" Powerpoint file to view the embedded videos.

Option 2:

Video series #1 - <https://www.youtube.com/playlist?list=PL6B04186FC605C883>

(Or go to youtube.com and search for "betterbricks night walks")

Video series #2 -

<https://www.youtube.com/playlist?list=PLnLeZbPFNXBhuhwC3D1gZyYPXsnB0Ylap>

3. Reference the walkthrough plan checklists at the end of the Walkthrough Plan Form on the following pages.
4. Complete the Building Walkthrough Plan Form on the following pages.

Assignment 4: Building Walkthrough Plan Rubric

| Walkthrough Plan Elements | Points |
|---|--|
| | |
| 1. Characteristics – General Sections a. through g. are complete with responses. | .25 points per section (1.75 total) ____ points |
| 2. Characteristics – HVAC, Interior Loads, Utility Usage Sections a. through k. are complete with responses. | 1 point per section (11 points total) ____ points |
| 3. Issues for Investigation Sections a. through f. are complete with responses. | 2 points per section (12 points total) ____ points |
| 4. Personnel and Tools Sections a. through h. are complete with responses. | .25 points per section (2 points total) ____ points |
| 5. Locations Sections a. through h. are complete with responses. | 2 points per section (16 points total) ____ points |
| Office Use | |
| <p>Total Points: _____ <u>/42.75</u></p> <p>Reviewer Initials: _____</p> <p>Date: _____</p> <p>Score: _____</p> | |
| | |

Walkthrough Plan Form

Building Name: _____ City/State: _____

1. Building Characteristics - General

| Characteristic | Description |
|--|---|
| a. Year constructed | _____ |
| b. Square feet – whole building | _____ square feet |
| c. Will the walkthrough comprise the whole building? Yes/No | <input type="checkbox"/> Yes <input type="checkbox"/> No |
| d. If no, provide approximate square feet of space for walkthrough. | _____ square feet |
| e. Space types (check all that apply) | <input type="checkbox"/> Office <input type="checkbox"/> Parking <input type="checkbox"/> Data center/Server room <input type="checkbox"/> Kitchen/Cafeteria <input type="checkbox"/> Retail <input type="checkbox"/> Lodging <input type="checkbox"/> Warehouse <input type="checkbox"/> Healthcare <input type="checkbox"/> Public assembly <input type="checkbox"/> Laboratory <input type="checkbox"/> Other: _____ |
| f. Occupancy | Number of people: _____ Schedule M_F (AM/PM): _____ Schedule Sat (AM/PM): _____ Schedule Sun (AM/PM): _____ |
| g. Additional information (e.g., number of stories, major remodels, additions) | |

2. Building Characteristics – HVAC, Interior Loads, Utility Usage

| HVAC | Description |
|---|---|
| a. Type of system (check all that apply) | <input type="checkbox"/> Package Units <input type="checkbox"/> Chiller <input type="checkbox"/> Boiler <input type="checkbox"/> Heat pumps <input type="checkbox"/> Central Plant <input type="checkbox"/> DDC Controls <input type="checkbox"/> Refrigeration <input type="checkbox"/> Other (describe): _____ |
| b. Control system – what is controlled on HVAC? | |
| c. Operating hours for HVAC | M-F, AM/PM _____ Sat, AM/PM _____ Sun, AM/PM _____ |
| Interior & Exterior Loads | Description |
| d. Type of equipment (check all that apply) | <input type="checkbox"/> Server rooms <input type="checkbox"/> Lighting <input type="checkbox"/> Kitchen <input type="checkbox"/> Plug loads (describe): _____ <input type="checkbox"/> Appliances (describe): _____ |
| e. Control system – what is controlled on lighting and appliances? | |
| f. Exterior loads (check all that apply) | <input type="checkbox"/> Garage Exhaust <input type="checkbox"/> Lighting |
| Utility Usage (see PW Assignment 1) | Description |
| g. Types of fuels (e.g., electricity, natural gas, solar, other) | |
| h. Total electricity kWh consumed for the most recent 12-month period | _____ |

| Utility Usage, continued | Description |
|--|--------------------|
| i. Total natural gas therms consumed for the most recent 12-month period (if applicable) | _____ |
| j. Total energy use intensity (EUI) in Kbtu/sf/year ENERGY STAR Score (if applicable) | _____ _____ |
| k. Is on-site solar or combined heat and power (CHP) used? | |

3. Building Walkthrough - Issues for Investigation

| Issues for Investigation during Building Walkthrough | Description |
|--|-------------|
| a. Known Problems <i>(e.g., equipment repairs needed, equipment operation problems, air leaks, noise) See Item 15 of the <u>Scoping Interview Guide</u> you completed in PW Assignment 2.</i> | |
| b. Opportunities <i>(e.g., repair broken economizer, adjust operating schedule for office lighting to match tenant hours, relocate OSA sensor for accurate readings, replace water fixtures with low-flow models and/or add aerators, etc.) (see Item 15 of the <u>Scoping Interview Guide</u> you completed in PW Assignment 2)</i> | |
| c. Occupant Complaints <i>(e.g., hot/cold call areas, noise, rattling/humming, glare, extremely dark or bright areas, odors, dripping water) See also Item 10 of the <u>Scoping Interview Guide</u> you completed in PW Assignment 2.</i> | |

| Issues for Investigation, continued | Description | | | | | | | | | |
|--|--|--|------|----------|-----|--|-----|--|-----|--|
| d. Equipment operating schedules | <table border="1"> <tr> <td data-bbox="711 258 1084 296">HVAC</td> <td data-bbox="1084 258 1455 296">Lighting</td> </tr> <tr> <td data-bbox="711 296 1084 333">M-F</td> <td data-bbox="1084 296 1455 333"></td> </tr> <tr> <td data-bbox="711 333 1084 371">Sat</td> <td data-bbox="1084 333 1455 371"></td> </tr> <tr> <td data-bbox="711 371 1084 409">Sun</td> <td data-bbox="1084 371 1455 409"></td> </tr> </table> | | HVAC | Lighting | M-F | | Sat | | Sun | |
| HVAC | Lighting | | | | | | | | | |
| M-F | | | | | | | | | | |
| Sat | | | | | | | | | | |
| Sun | | | | | | | | | | |
| <p>e. Documents for the Building Walkthrough <i>(check all that apply) See Item 16 from Scoping Interview Guide you completed for reference.</i></p> <p> <input type="checkbox"/> Division 15 and 16 Specifications <input type="checkbox"/> Mechanical Drawings <input type="checkbox"/> Control Sequence Description <input type="checkbox"/> Control Drawings <input type="checkbox"/> EMS Points List <input type="checkbox"/> EMS Program Print Out <input type="checkbox"/> Electrical Drawings <input type="checkbox"/> Equipment Repair History <input type="checkbox"/> Test & Balance Report <input type="checkbox"/> Manufacturer Start Up Documentation <input type="checkbox"/> O&M Manuals (For Controls and Major Equipment) </p> | | | | | | | | | | |
| <p>f. Additional Documents</p> <p> <input type="checkbox"/> BOC Operational Checklists (4) <input type="checkbox"/> Other checklists (e.g., in-house checklists) Provide examples, if available. <input type="checkbox"/> Other (describe): </p> | | | | | | | | | | |

4. Building Walkthrough - Personnel and Tools

| Personnel and Tools | Notes | | | | | | | | | |
|---|---|---|------|------|--|--|--|--|--|--|
| a. Meet-up Location, Date and Time (Begin Walkthrough) | | | | | | | | | | |
| b. Finish Location and Time (End Walkthrough) | | | | | | | | | | |
| c. Length of time per floor (min/floor) | | | | | | | | | | |
| d. What special permissions are needed for access to building spaces? | | | | | | | | | | |
| e. Who will participate in Walkthrough? f. What is their responsibility? | <table border="1"> <thead> <tr> <th>Name</th> <th>Role</th> </tr> </thead> <tbody> <tr> <td></td> <td></td> </tr> <tr> <td></td> <td></td> </tr> <tr> <td></td> <td></td> </tr> </tbody> </table> | | Name | Role | | | | | | |
| | Name | Role | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| g. Who will document the findings during the Walkthrough? | | | | | | | | | | |
| | | | | | | | | | | |
| h. Tools | Check all that apply | | | | | | | | | |
| Flashlight with good batteries | Digital camera/Video camera | Infrared camera | | | | | | | | |
| Safety gear | Clothes for outdoor/roof time | Tape measure | | | | | | | | |
| Portable data logger with T and Rh sensors | Toolkit for accessing filters, mixing boxes, etc. | Hand-held radio, cell phone or walkie-talkies | | | | | | | | |
| Insertion thermometer | Multimeter | IR temperature sensor | | | | | | | | |
| Stethoscope | Rags to clean nameplates | CO ₂ sensor | | | | | | | | |
| Other (describe): | Other (describe): | Other (describe): | | | | | | | | |

5. Building Walkthrough – Locations

| Space | What will you investigate in the space? (See examples below. For additional examples refer to the BOC O&M Checklists on the following pages.) |
|------------------------------------|---|
| a. Lobby | <i>(e.g., Look, listen, feel for airflow; Check airflow at exhaust grills and joints; Verify backdraft dampers are properly installed & operating; Exterior door leakage)</i> |
| b. Mechanical and Electrical Rooms | <i>(e.g., check HVAC temps at AHU's – is the SAT above or consistent with building rest temp?; Hot electrical and mechanical equipment; Visible condensation; Ceiling stains)</i> |
| c. Building Control System | <i>(e.g., Review EMS programming for schedules; Verify working as programmed; Is the sequence of operation working as programmed?; Are manual mode or overrides enabled?)</i> |

5. Building Walkthrough – Locations, continued

| | |
|--|---|
| <p>d. Stairwells, Elevators, and Top Level</p> | <p><i>(e.g., Air losses from stack effect; Stairwell doors or roof hatches propped open; Air sealing at top of elevator shaft; Broken windows)</i></p> |
| <p>e. Roof</p> | <p><i>(e.g., Roof penetrations; Water damage; Visually inspect accessible ductwork; Uninsulated attic or insulation disturbed)</i></p> |
| <p>f. Tenant/Occupant Spaces (pick 2 representative spaces; include spaces where occupant complaints originated)</p> | <p><i>(e.g., Blocked air diffusers; Lights and appliances left on; Look, listen, feel for airflow; Vibration; Acoustics; Odors)</i></p> |
| <p>g. Exterior (lighting, parking, other)</p> | <p><i>(e.g., Exterior lighting operational and off during day; Brightly lit or very dark areas; Parking garage exhaust fan operation matches occupancy)</i></p> |
| <p>h. Water-using equipment (restrooms, kitchens, cooling towers, irrigation, etc.)</p> | <p><i>(e.g., leaking fixtures, older fixtures that could be upgraded to lower flow, operation schedules)</i></p> |
| <p>i. Other (specify):</p> | |

6. Building Walkthrough Checklists

(There are several checklists on the following pages. Check each item that you will include in your Building Walkthrough, then use each checklist during the walkthrough to verify operation of Schedules, Sensors, Outside Air, and Simultaneous Heating and Cooling.)

In addition to the four checklists, refer to the functional test procedure you prepared for the Project Workbook Assignment #3 - Functional Test Procedure. Review the procedure and check the box below if you plan to use it during the Walkthrough.

Yes, I plan to perform the functional test during my Walkthrough.

No, I don't plan to perform the test during the Walkthrough because (explain):

Equipment Operation Schedules

Notes

| | | |
|--------------------------|--|--|
| <input type="checkbox"/> | Clock matches actual time (TOD and Date) | |
| <input type="checkbox"/> | Timeclocks actually provide control | |
| <input type="checkbox"/> | Schedules match occupancy | |
| <input type="checkbox"/> | Optimum start enabled | |
| <input type="checkbox"/> | Opportunity to implement optimum stop reviewed | |
| <input type="checkbox"/> | Space temperature setpoints reflect standards of service and comfort | |
| <input type="checkbox"/> | DHW circulation pumps scheduled | |
| <input type="checkbox"/> | Opportunities for tenant equipment scheduling (coffee, vending, etc) | |
| <input type="checkbox"/> | Chiller lockouts appropriate | |
| <input type="checkbox"/> | VFDs in AUTO, fan speed/static appropriate | |
| <input type="checkbox"/> | Boiler lockouts appropriate | |
| <input type="checkbox"/> | Chilled water setpoints appropriate | |
| <input type="checkbox"/> | Chilled and condenser water pump operations – appropriate | |
| <input type="checkbox"/> | Cooling tower water setpoints appropriate | |

Lighting Operation Schedules

Notes

| | | |
|--------------------------|--|--|
| <input type="checkbox"/> | Control clock matches correct time/day | |
| <input type="checkbox"/> | Controller actually provides control | |
| <input type="checkbox"/> | Schedules match occupancy | |
| <input type="checkbox"/> | Night check – Lighting off | |
| <input type="checkbox"/> | Occupancy sensors operational | |
| <input type="checkbox"/> | Exterior lighting off during day | |
| <input type="checkbox"/> | Atrium lights off during day | |
| <input type="checkbox"/> | Light levels match IES recommendations | |
| <input type="checkbox"/> | Other | |

Sensor Calibration

Notes

| | | |
|--------------------------|--|--|
| <input type="checkbox"/> | OSA damper setting appropriate for temperature and time of day | |
| <input type="checkbox"/> | Do MAT, OAT, RAT, and DAT make sense? | |
| <input type="checkbox"/> | Boilers and chillers appropriately locked out | |
| <input type="checkbox"/> | OSA temperature reading reasonable | |
| <input type="checkbox"/> | OSA temperature sensor located well | |
| <input type="checkbox"/> | Lobby pressurization issues – (building static) | |
| <input type="checkbox"/> | Airflow through open or closed doors – (building static) | |
| <input type="checkbox"/> | Other (specify) | |

Outside Air Use

Notes

| | | |
|--------------------------|--|--|
| <input type="checkbox"/> | Minimum outside air percentage appropriate for occupancy type and # of people | |
| <input type="checkbox"/> | Lobby pressurization issues | |
| <input type="checkbox"/> | Check elevators for airflow through open or closed doors | |
| <input type="checkbox"/> | Check stairwell and elevator pressurization fans for damper positions (fire safety and others) | |
| <input type="checkbox"/> | Check elevator machine room for signs of exfiltration or infiltration | |
| <input type="checkbox"/> | Check exhaust fans for controlled dampers | |
| <input type="checkbox"/> | Check building perimeter for signs of leakage | |
| <input type="checkbox"/> | Economizers operating properly | |
| <input type="checkbox"/> | OSA lockout during morning startup as appropriate | |
| <input type="checkbox"/> | OSA lockout during afterhours as appropriate | |
| <input type="checkbox"/> | Demand Control Ventilation opportunity | |
| <input type="checkbox"/> | | |
| <input type="checkbox"/> | | |

Simultaneous Heating and Cooling

Notes

| | | |
|--------------------------|--|--|
| <input type="checkbox"/> | Chiller lockouts in place | |
| <input type="checkbox"/> | Boiler lockouts in place | |
| <input type="checkbox"/> | Chilled water setpoints appropriate | |
| <input type="checkbox"/> | Chilled and condenser water pump operations – appropriate | |
| <input type="checkbox"/> | Cooling tower water setpoints appropriate | |
| <input type="checkbox"/> | Discharge air temperature setpoints (resets) | |
| <input type="checkbox"/> | Heating water setpoints (resets) | |
| <input type="checkbox"/> | Insulation between unconditioned and conditioned spaces | |
| <input type="checkbox"/> | Valve leakage through coils | |
| <input type="checkbox"/> | Space temperature setpoints reasonably consistent in next-to zones | |
| <input type="checkbox"/> | VFDs operating and fan speed appropriate for anticipated loads | |
| <input type="checkbox"/> | Opportunity to reset duct static pressure evaluated | |
| <input type="checkbox"/> | Terminal units operating cooperatively | |
| <input type="checkbox"/> | Review potential to schedule terminal units | |
| <input type="checkbox"/> | | |

Assignment 5: BOC 2004, Building Scoping Report

Introduction

In the BOC 2001-A and 2001-B classes, we learned about a scoping process for improving the operational performance of our buildings. A building scoping involves a review of the building's operation and is focused on low-cost operation and maintenance improvements to energy-using systems and equipment. It is intended to provide only enough technical and financial detail to obtain a commitment from management for a deeper analysis such as an energy audit. In this assignment, you will apply these lessons to completing a building walkthrough of your facility. After completing the building walkthrough, you will prepare a written report of the findings from the walkthrough. The assignment instructions are below.

Instructions

There are three parts to this assignment. In part 1, you will conduct a building walkthrough of your facility. In part 2, you will summarize your findings from the walkthrough using a building scoping report form. In part 3, you will share the highlights of your findings in a short presentation to your peers.

Get Started

1. Part 1: Using the building walkthrough plan you prepared for PW Assignment 4, schedule a date for a building walkthrough of your facility. Conduct the walkthrough of your facility using the tools and personnel identified in your plan. Visit each location identified in your plan. Make note of your findings during the walkthrough. You will use these notes to complete the building scoping report form.
2. Part 2: Review the Building Scoping Report Form on the following pages to refresh your knowledge of the report contents and the information you will need to complete the report form. You will need three documents you completed for earlier project assignments to complete the report form. These include the Building Scoping Interview Guide for PW Assignment 2; Building Operations Map for PW Assignment 2; and Building Walkthrough Plan for PW Assignment 4. In addition to the documents above, you will need to reference the notes you take during the building walkthrough. Working from the three documents and your notes, complete the Building Scoping Report Form on the following pages. This can also be found in the Student Supplemental Materials section of the BOC website:

<https://www.theboc.info/student-partner-login/>

Click on "Access Materials" under "BOC Supplemental Class Materials"

Password: BOCstudent

3. Prepare a short presentation of your findings to share on your final day of class, BOC 2005 Project Peer Exchange.

Why an oral presentation of your building scoping report?

The ability to create and deliver an effective presentation is an increasingly important skill for building operation professionals. Employers value the ability to deliver briefings and reports to colleagues, conduct in-house training sessions for co-workers, present information to tenants, building occupants, and contractors, and to perform any number of other tasks that involve speaking before an audience. Also, benefits of the work students do to identify energy-saving opportunities are maximized by effectively being able to communicate the value to financial decision-makers, so that recommended measures will be implemented and energy savings potential reached. This result in turn reflects well on the operations staff. Building this skill can help facility professionals advance their careers.

This assignment involves preparing and delivering a short presentation to your classmates on the Building Scoping Report you will complete for your facility. Your presentation should be about 7-10 minutes in length and should highlight your findings. The presentation can take any form you choose (e.g., speech only, poster presentation, illustration using a whiteboard, and/or slides).

A customizable PowerPoint slide deck template is provided in the Student Supplemental Materials section of the BOC website. A slide presentation is not required for the assignment, but it can be a good way to keep things organized and interesting. Keep in mind that visual resources (pictures, graphs, etc.) make a presentation more compelling. It is best to avoid large blocks of text and instead use short bullet points summarizing the main ideas.

Each Level II core class includes a short module on presentation skills, preparing you to successfully complete your presentation in the final class. This is an opportunity for you to practice your communication skills, gain/share feedback, and network with your peers. The 2005 class, including your presentation, will be graded as pass or fail, based on participation only.

Your classmates will provide feedback on your presentation using the following criteria. Keep these criteria in mind as you prepare your presentation:

- Attention getter - What did the presenter do to get your attention?
- Credibility - What made the presenter credible?
- Thesis statement - Did the presenter explain the main points? What was the action to take?
- Presentation body - What were the main points?
- Conclusion - Did they provide a summary? Ask for questions?

Building Scoping Report:

Recommendations for Management Decision

[building name]

[building image]

Prepared for

[manager/boss name, title and company]

Prepared by

[your name, title and company]

Date

1.0 Executive Summary

Introduction

The (company name) Facilities Management Team is pleased to present the findings from a Building Walkthrough assessment of (name of building) on (date). The purpose of the walkthrough was to investigate operational problems with equipment and systems in the building. Our findings identified XX opportunities for improving performance. Addressing these opportunities will (list examples: improve safety, reduce waste and save money for the company). This report summarizes the opportunities and the benefits.

Decision: We would like a decision from management to authorize the team to develop a budget and timetable for implementation of these opportunities. We will prepare a budget and timetable for management review (provide a date).

Problem and Opportunity

The Building Walkthrough assessment combined with a utility bill analysis indicates that (name of building) is not operating optimally.

- Give examples of suboptimal performance. (e.g., does the building consume more energy than expected, are there safety/IEQ concerns, occupant complaints, burdens on facility staff time, etc.)
- Describe the cost of the problem, if possible.
- Describe the potential cost savings.

Recommended Plan of Action

- What actions will you recommend based on the opportunities identified during the BWT? (See your notes from the BWT and any notes made on the O&M Checklists on pages 8-11 of BWT plan.)
- List a minimum of 5 opportunities here.

2.0 Building Characteristics

[Refer to page 1 of your Building Walkthrough Plan for information to include in this section]

Describe: Building name, age or year constructed, square feet, number of floors, location, function (e.g., office, school, healthcare, etc.) and occupancy.

2.1 HEATING VENTILATING & AIR CONDITIONING (HVAC)

[Refer to the following documents you completed for earlier project assignments to complete this section:

Building Scoping Interview Guide for PW Assignment 2;

Building Operations Map for PW Assignment 2;

Building Walkthrough Plan for PW Assignment 4]

- Briefly describe HVAC system equipment including heating and cooling. [e.g., What areas of the building does the equipment serve? Are there dedicated systems? Is the equipment in good repair? Functioning effectively?]
- Describe the HVAC control equipment. [e.g., What do the functions do the controls provide? Are they fully utilized? Are there improvements needed?]
- Describe the operating schedule for the HVAC equipment. Does it match occupied hours?
- List operational problems identified by facilities staff (see the Building Scoping Interview Guide for PW2).
- List occupant complaints (if any) associated with HVAC (see the Building Scoping Interview Guide for PW2).

2.2 Interior Loads

- Describe internal equipment loads (e.g., server rooms, commercial kitchen, lighting, specialized equipment such as MRI machines, manufacturing, etc.)
- Describe the control system (if any) for this equipment, in particular lighting system controls.

2.3 Utility Usage

Describe the energy performance of the building using the data from your PW Assignment 1. Provide the following:

- Annual cost of overall utility consumption (\$).
- Annual electricity, natural gas, and other fuel consumption figures.
- Peak demand figure.
- Energy Use Intensity (EUI) in Btu/sf/year.
- ENERGY STAR score on 1-100 scale.
- How does the EUI compare to the national average for similar buildings? (higher, lower, same)

2.4 Water Usage (optional)

Describe areas of possible water waste (domestic fixtures, HVAC systems, irrigation, etc.)

2.5 Potential Opportunities

- List the date of your building walkthrough.
- List a minimum of 5 potential opportunities for improvement found.
- For each opportunity, describe the benefit of addressing it (e.g., saves money, saves facility staff time, improves safety, reduces occupant complaints, etc.).

2.6 Savings Potential

- Is there potential to reduce utility costs by pursuing the opportunities in 2.2 above? If yes, describe the overall savings in dollars (e.g., \$50,000 annually).
- List and rank the potential opportunities in a table. See template below.

TABLE XX – Opportunities for Improvement

| Number | Priority (immediate, high, medium, low) | Opportunity |
|--------|---|---|
| 1 | I | Immediate Need (e.g., safety issue, essential equipment broken, etc.) |
| 2 | H | Schedule Exhaust Air |

3.0 Recommendation for Management Decision

The Facilities Management Team proposes the following actions be taken to address the opportunities identified during the BTW. These actions will ...*(list the benefits noted in the Introduction on page 2 – e.g., improve safety, reduce operating costs, etc.)*

- List the actions (e.g., repairs, building tune-up, energy audit, RCx)

We request management approval to develop a detailed budget for implementing these actions and a schedule for completion. If approved, we will prepare the budget and schedule for management review and decision *(provide a future date)*.

4.0 Appendices

[Optional]

- ENERGY STAR Statement of Energy Performance
- Photo of Facility Management Team
- Selected images from BWT
- Other images that augment the points in the report

Appendix

| | |
|--|--------------|
| Assignment 1: ENERGY STAR Portfolio Manager Quick Start Guide | A1-A5 |
| Assignment 2: Sample of completed Scoping Interview Guide | B1-B4 |
| Assignment 2: Sample of completed Building Systems Operations Map | C1-C4 |
| Assignment 4: Example Sequence of Operation | D1 |
| Assignment 4: Example Functional Test Procedure | D2-D3 |
| Assignment 5: Sample Scoping Report | E1-E8 |



Portfolio Manager Quick Start Guide

EPA’s ENERGY STAR Portfolio Manager tool helps you measure and track the energy and water use, waste and materials, and greenhouse gas emissions of your buildings, all in a secure online environment. You can use the results to identify underperforming buildings, set investment priorities, verify efficiency improvements, and receive EPA recognition for superior energy performance. Follow the steps in this guide to get started using the new Portfolio Manager to benchmark your properties, assess performance, and view results.

Getting Started

- Step 1: Add a Property
- Step 2: Enter Energy, Water, Waste & Materials Data
- Step 3: View Results & Progress

1 Add a Property

To get started, log in to Portfolio Manager at <https://portfoliomanager.energystar.gov/pm/>. Then, follow these instructions to create a property and enter property information.

- Click **Add a Property** on the **MyPortfolio** tab.
- Answer the questions about your property and click **Get Started!**
- Enter basic property information and select the boxes next to the statements that apply to your property. Then click **Continue.**
- Enter Use Details such as Gross Floor Area (GFA), operating hours, and number of workers for each type of use. You can use default or temporary values at this time and enter more accurate data later. **NOTE:** Hover the mouse over or click the Use Detail to see a definition.
- Click **Add Property.** When you have successfully added your property, you will see the property’s **Summary** tab.

If you have additional types of uses on the property, you can add them at any time.

- Click the property’s **Details** tab, and then click the **Add Another Type of Use** drop-down menu. Select a property use, then click **Add.**
- Enter the Property Use Details and then click **Save Use.**

Property Types

All property types can be benchmarked. For properties with multiple buildings, only hospitals, hotels, K-12 schools, multifamily, and senior living communities are eligible to receive the 1-100 ENERGY Score.

Properties with Multiple Use Types

Some properties include multiple-use types, such as restaurants in hotels, salons in senior living communities, and cafeterias in hospitals. As a general rule, if a certain use commonly occurs in the type of property being benchmarked, do not break it out as a separate Property Use Type. Simply include its square footage with the building's primary use.

2 Enter Energy, Water, and Waste & Materials Data

To receive the most accurate picture of your building's performance, tell Portfolio Manager how much energy and water your building consumes, and the volume of waste and materials that you generate. Follow these steps to enter energy, water, and waste data for your property.

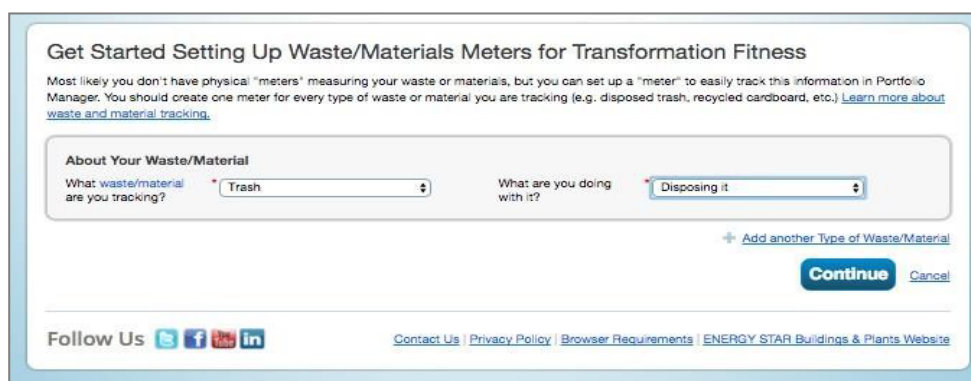


Figure 1: Setting up property meters

- Click on your property from the **MyPortfolio** tab, then select either the **Energy, Water, or Waste & Materials** tab.
- Click **Add a Meter**
- If you create an energy or water meter:
 - Select the type of energy or water you want to track. Enter the number of meters used and click **Get Started!**
 - Click on a meter to enter the units your water or energy data is measured in and the first bill date. If this meter reflects a bulk fuel purchase for an energy meter, select the **Enter as Delivery?** Checkbox.
 - If you would like to add Custom Meter IDs, enter them in the text box. Then click **Create Meters**.
 - Click the blue arrow next to each meter to expand the section. You will be brought to the **Your Meter Entries** page where you can click the blue arrow next to each meter to expand the selection and view details. Click **Add Another** Entry under the meter and enter data. Check Estimation if you are not including measured data for the entry. You may also choose to record the cost here. Once you're finished adding entries, click **Continue**.

- Select the boxes of the meters that total your property's energy or water use on the **Select Meters to Include in the Metrics** page. Click **Apply Selections**.
- If you create a waste meter:
 - Select the waste you are tracking and indicate what you do with it. Click **Continue**.
 - Indicate how often the material is being collected (regular or intermittent), the units used for tracking, and if prompted, the date you first started tracking. Click **Create Meter(s)**.
 - Click the blue arrow next to each meter to expand the section on the **Waste/Material Meter Entries** page. Click **Add Another Entry** under the meter and enter the requested data. Check **Estimation** if you are not including measured data for the entry. You may also choose to record the cost and disposal destination here, too. Once you're finished adding entries, click **Continue**.
 - Select the boxes of the meters that total your property's waste and materials on the **Select Meters to Include in Metrics** page. Click **Apply Selections**.

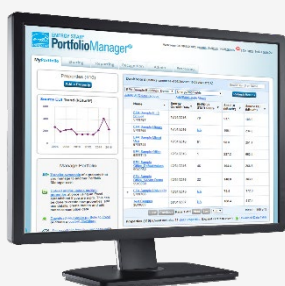
3 View Results & Progress

It is easy for you to see trends and to track improvement for your entire portfolio of buildings with a variety of standard graphs and reports in Portfolio Manager. Follow these steps to view reports about your properties and to assess progress.

- Click the **Reporting** tab to view graphs and reports for a property or portfolio.
- Click on the **Charts & Graphs** options to instantly see colorful graphs of how your portfolio or group of properties is performing. You can print graphs or download the images to incorporate into a presentation or document.
- View the **Reports & Templates** section to see a list of available standard reports, including Performance Highlights, Energy Performance, and Water Performance. Select **Generate New Report** from the **Action** drop-down menu to create a spreadsheet.



Figure 2: Reporting Dashboard



Learn More!

- About Portfolio Manager: energystar.gov/benchmark
- ENERGY STAR Guide for Licensed Professionals energystar.gov/LPGuide
- ENERGY STAR for Buildings: energystar.gov/buildings

PM Helpful Hints

- Enter **12 or more consecutive months** of energy data for all fuels covering the same time period.
- Be sure to **review energy data** you have entered for lapses in time. Where gaps occur, the tool may not be able to generate a rating. If no energy was used for a particular time period, enter a zero for that period.
- When entering quantitative data, **do not include commas or other punctuation** in either energy consumption or cost. The tool will do this for you.
- When **updating** a facility's energy use, enter the appropriate meter name and energy use data, while selecting the correct units of measurement.
- Be sure to **include the correct zip code**, as the tool normalizes for both climate and weather variations.
- **Coordinate with your energy service provider or utility** to help assess the performance of your building and implement improvements.

For **further assistance**, select "Help" on the Portfolio Manager top navigation bar or contact the Help Desk by submitting the Online Help Form:

<https://portfoliomanagerhelp.zendesk.com/hc/en-us/requests/new>

Statement of Energy Performance (SEP): What does it tell you?

ES (Energy Star) Score

The SEP generates an Energy Performance Rating Score of 1-100. A rating of 50 indicates that the building, from an energy consumption standpoint, performs better than 50% of all similar buildings nationwide (average energy performance), while a rating of 75 indicates that the building performs better than 75% of all similar buildings nationwide (top performance).

If you received an "N/A," it means your building is not ratable in the Energy Star tool. *Note: Review your input for errors. Some common mistakes that might result in an N/A are double entering a day, etc.*

Energy Use Index (EUI)

The SEP also generates an Energy Use Index (EUI) for energy intensity. Two different EUI's are generated: site energy intensity and source energy intensity. Each are reported in kBtu/sf/year (expressing how much energy is used each year per square foot of building). **Site Energy** is the amount of heat and electricity consumed by a building as reflected in utility bills. **Source Energy** is the total amount of raw fuel that is required to operate the building. It incorporates all transmission, delivery, and production losses, thereby enabling a complete assessment of energy efficiency in a building.



LEARN MORE AT
energystar.gov

ENERGY STAR[®] Statement of Energy Performance

77

ENERGY STAR[®]
Score¹

Sample Property

Primary Property Function: Office
Gross Floor Area (ft²): 50,419
Built: 1951

For Year Ending: July 31, 2014
Date Generated: October 01, 2014

1. The ENERGY STAR score is a 1-100 assessment of a building's energy efficiency as compared with similar buildings nationwide, adjusting for climate and business activity.

Property & Contact Information

Property Address

Sample Property
123 Main St
Boston, Massachusetts 02134

Property Owner

Property Inc.
123 Early Bird St.
Washington, DC 20460
202-999-9876

Primary Contact

Jane Doe
123 Early Bird St.
Washington, DC 20460
555-123-4567
jane_doe@propertyinc.com

Property ID: 3681885

Energy Consumption and Energy Use Intensity (EUI)

| Site EUI | Annual Energy by Fuel | National Median Comparison | |
|----------------------------|---|--|-------|
| 75.7 kBtu/ft ² | Electric - Grid (kBtu) 2,453,824 (64%) | National Median Site EUI (kBtu/ft ²) | 103.5 |
| | Natural Gas (kBtu) 1,273,766 (33%) | National Median Source EUI (kBtu/ft ²) | 247.6 |
| | Propane (kBtu) 91,000 (2%) | % Diff from National Median Source EUI | -27% |
| Source EUI | Annual Emissions | | |
| 181.2 kBtu/ft ² | Greenhouse Gas Emissions (Metric Tons CO ₂ e/year) | 311 | |

Signature & Stamp of Verifying Professional

I _____ (Name) verify that the above information is true and correct to the best of my knowledge.

Signature: _____ Date: _____

Licensed Professional

John Smith
4 Privet Dr
Arlington, VA 22201
703-111-1234
john_smith@energyinspectors.com



Professional Engineer Stamp
(if applicable)

Scoping Interview Guide

Building Name: ACME Office Date: Today

Interviewee: B. Smith Title: Manager, Plant Services

1. Have there been any energy systems modifications, replacements or additions in the last few years? YES NO

If yes, describe each action and implementation date.

complete system upgrade 8 yrs ago - new chiller, boiler, DDC

2. Are you aware of any barriers to successful implementation of services in this facility, such as environmental dangers or tenant agreements? YES NO

If yes, please specify.

Sublease requires weekend (Sat.) 9-1 conditioning

3. Who has overall responsibility for your O&M program? B. Smith

4. How many members of your staff are permanently assigned to building operations and maintenance activities, and what are their duties?

2 - perform PM, respond to complaints

Is ongoing training currently provided to upgrade facility staff skills? YES NO

Plan to next year

5. Do you contract with outside vendors for building operations or maintenance services? YES NO



If yes, for which systems, equipment or roles? (Check all that apply)

| | | | |
|---------------|-------------------------------------|----------------------|-------------------------------------|
| Package Units | ___ | Chiller | <input checked="" type="checkbox"/> |
| Boiler | <input checked="" type="checkbox"/> | Entire Central Plant | ___ |
| DDC Controls | <input checked="" type="checkbox"/> | Entire HVAC | ___ |
| Refrigeration | ___ | Operating Engineer | ___ |
| Other | ___ | Describe | _____ |

Are you satisfied with the contracted services?

YES NO

If no, describe areas that you are not satisfied with:

Only do the minimum, not responsive

6. Are maintenance reports submitted to management?

YES NO

7. Is there a unified equipment inventory?

YES NO

8. Can the occupants control the temperature setpoints?

YES NO

3 degree band

9. Can the occupants control the temperature schedules?

YES NO

10. Have there been any recent occupant complaints relevant to the performance of the building systems?

YES NO

If yes, describe:

Frequent cold calls

11. Who is responsible for day-to-day operation of the EMCS?

C. Jones



Do they set up or modify:

- Setpoints? Operating Schedules
- Trendlogs Control Algorithms
- Other _____

Maintenance and technical assistance performed by:

_____ xyz Controls for programming and controls changes _____

12. How often are thermostats checked and calibrated?
 _____ when there is a complaint in that zone _____

13. How often are the critical control sensors (OSA, SAT, and RAT) checked and calibrated?
 _____ Not sure, should be done by XYZ _____

14. Will building facility personnel be available to assist? YES NO
 If no operator, is HVAC maintenance contractor available to assist? YES NO

15. Are there known problems with the following energy system equipment?

| EQUIPMENT TYPE | KNOWN PROBLEM/PLAN FOR CORRECTION | |
|---------------------|---|-----------------------------------|
| Chillers: | YES <input type="radio"/> NO <input checked="" type="radio"/> | <u>- seems like it runs a lot</u> |
| Cooling Towers: | YES <input type="radio"/> NO <input type="radio"/> | <u>NA - air cooled</u> |
| Boilers: | YES <input type="radio"/> NO <input checked="" type="radio"/> | _____ |
| Pumps: | YES <input type="radio"/> NO <input checked="" type="radio"/> | _____ |
| Air Handling Units: | YES <input type="radio"/> NO <input checked="" type="radio"/> | _____ |
| Other Fans: | YES <input type="radio"/> NO <input checked="" type="radio"/> | _____ |
| Lighting Control: | <input checked="" type="radio"/> YES <input type="radio"/> NO | <u>hard to schedule</u> |
| Electrical Systems: | YES <input type="radio"/> NO <input checked="" type="radio"/> | _____ |
| Other: | YES <input type="radio"/> NO <input type="radio"/> | _____ |



16. Are the following items available? (List only if correct and current)

| ITEM | YES | NO | LOCATION |
|--|-----|----|------------------|
| Division 15 and 16 Specifications | ✓ | | Fac. etc. |
| Mechanical Drawings | ✓ | | Fac. etc. |
| Control Sequence Description | | ✓ | (in programming) |
| Control Drawings | ✓ | | Fac. etc. |
| EMCS Points List | ✓ | | Fac. etc. |
| EMCS Program Print Out | | ✓ | comp print out |
| Electrical Drawings | ✓ | | Fac. etc. |
| Equipment Repair History | ✓ | | " |
| Test And Balance Report | ✓ | | " |
| Manufacturer Startup Documentation | ✓ | | " |
| O&M Manuals (For Controls and Major Equipment) | ✓ | | " |

17. Describe generally any lighting controls such as daylighting, occupancy or sweep controls.

Have sweep controls, but not sure if they are working
 No daylighting - some occupancy sensors in conference rooms

18. Describe the trending capability of your control system(s).

Can trend - limited data storage

21. How do you financially evaluate operations and maintenance "projects"?

Management wants < 3 yr. p.b.
 Anything over \$10k needs CFO approval



Building Name: ACME Office

Date: _____

Year Constructed 1985

Building Size: 100,000sq.ft.

Age of Chiller 8 Yrs

Age of HVAC System 8 Years

Number of Stories: 8

Age of Boiler 8 Yrs

Describe HVAC System Type: HVAC system is VAV with fan powered VAV perimeter boxes and electric reheat.

4 Airhandlers with inlet vanes provide system air.

| Occupancy Schedules | | | | | | |
|---------------------|---------------|-------------|------|--------------|--------|--------|
| Area | % of Building | Total Hours | | Wks Per Year | # Occ. | Notes: |
| | | Wkdy | Wknd | | | |
| Offices | 100 | 52.5 | 4 | 52 | 400 | |
| | | | | | | |
| | | | | | | |

| Lighting System | | | | |
|-----------------|--------------------------|---------------|-----------|--|
| Area | System Type | Est. W/Sq.Ft. | % of Bldg | Notes: |
| Offices | T8 Electronic with 3 lps | 1.1 | 100 | manual control, some occupancy sensors in conference rooms |
| | | | | |
| | | | | |

| Misc. Equipment | | |
|-----------------|-------------------------------|------------------------------------|
| Area | Load Density (High, Med, Low) | Notes: |
| Data Center | Med | |
| Office Areas | Med | Med occupancy with computer / occ. |
| Elevators | 4 Hydraulic Elevators | |

| Other (e.g. Cafeteria, Data Centers) | | | | | |
|--------------------------------------|-------------|--------------|---------------------|------------------------|--------|
| Area | Description | HVAC Service | Est. Elec. W/Sq.ft. | Est. Other kBtu/sq.ft. | Notes: |
| Data Center | 250 sqft | | | | |
| | | | | | |
| | | | | | |

Comments:

Data center is served by dedicated SF-4 with constant volume, requires 24 hours per day HVAC

Control System Manufacturer & Model#: Sample System Model # A

Building Name: ACME Office

Date: _____

| Service ID | No. Units | Est. Size Tons | Est. Motor HP | Est. Annual Oper Hours | Control System | | | | Condition Comments |
|-----------------|-----------|----------------|---------------|------------------------|-------------------------------|---------------------------|---------------------------------------|-------------------------------|---|
| | | | | | M ^m Manual /S/Stop | S ^s Self Reset | X ^x Contained Temp Lockout | "X" Control System Stage Comp | |
| Split System | 1 | 5 | unk | 8760 | X | X | None | X | Tenant server room |
| 4 Stage Recip | 2 | 200 | unk | 4000 | X | X | None | X | Reset is return chilled water temp. 44/55 48/52, available 24/7 for small data center |
| Chillers | | | | | | | | | |

| Service ID | No. Units | Capacity Control (Pony / Damper/ VFD) | Est. Motor HP / Cell | Est. Annual Oper Hours | Control System | | | | Condition Comments |
|----------------------|-----------|---------------------------------------|----------------------|------------------------|-------------------------------|---------------------------|---------------------------------------|--|--|
| | | | | | M ^m Manual /S/Stop | S ^s Self Reset | X ^x Contained Temp Lockout | "X" Control System O.S.A Cap Control Other | |
| 2 Cell Tower | 1 | Damper | 5 | 4000 | None | None | X | | Tower hasn't been shut down for maintenance in 3 years |
| Cooling Tower | | | | | | | | | |

| Service ID | No. Units | Est. Size Mbtu | Est. Annual Oper Hours | Availability Stand-by or On-Demand | Control System | | | | Condition Comments |
|------------------|-----------|----------------|------------------------|------------------------------------|-------------------------------|---------------------------|---------------------------------------|----------------------------|--------------------------------|
| | | | | | M ^m Manual /S/Stop | S ^s Self Reset | X ^x Contained Temp Lockout | "X" Control System Staging | |
| Hot Water Boiler | 1 | 275 | 4000 | On-demand | X | X | None | X | Only used for morning warm-up. |
| Boilers | | | | | | | | | |

Building Name: ACME Office

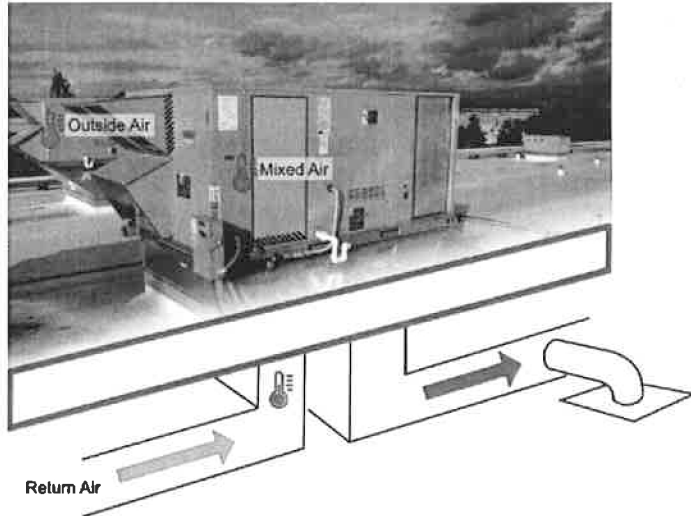
Date: _____

| | Service ID | No. Units | Capacity Control (Pony / Damper/ VFD) | Est. Motor HP | Est. Annual Oper Hours | Condition Comments |
|-----------------|----------------|-----------|---------------------------------------|---------------|------------------------|--|
| Chilled Water | C-1 | 1 | None | 20 | 3350 | Good maintenance condition. Hours of operations high due to chiller availability. 1 Dedicated per chiller. Just primary pump |
| | C-2 | 1 | None | 20 | 3350 | Good maintenance condition. Hours of operations high due to chiller availability. 1 Dedicated per chiller. Just primary pump |
| | | | | | | |
| | | | | | | |
| Condenser Water | CD-1 | 1 | None | 20 | 3350 | Chillers available 8760 operate most of year / maintenance good |
| | CD-2 | 1 | None | 20 | 3350 | Chillers available 8760 operate most of year / maintenance good |
| | | | | | | |
| | | | | | | |
| Hot Water | Main Circ Pump | 1 | None | 10 | 8760 | Boiler available 8760 hours / leak in boiler pump no. 1 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Domestic | | | | | | |
| | | | | | | |
| | | | | | | |

APPENDIX – Assignment 3

Example Sequence of Operation (SoO): Single Zone Package Rooftop Unit

Disclaimer: This example of an SoO is intended for instructional purposes. It is not written or recommended for application in a real world setting.



Here is a single-zone constant volume package rooftop AC unit with gas heating, compressor cooling, economizer cooling and a single supply fan. The economizer has integral barometric relief. Temperature and scheduling control is by a programmable thermostat with optimum start capability.

Operating Schedule and Setpoints

| | |
|-----------------------------------|--|
| Occupied mode: | Monday thru Friday 7am to 6pm |
| Unoccupied mode: | Weekday evenings, Saturday & Sunday |
| Occupied heating setpoint | 70°F. |
| Occupied cooling setpoint | 75°F. |
| Unoccupied heating setpoint | 55°F. |
| Unoccupied cooling setpoint | 85°F. |
| Economizer control type | Integrated economizer with fixed dry bulb temperature setpoint |
| Economizer changeover temperature | 70°F |

SEQUENCE OF OPERATION

Occupied Mode: Supply fan is on and runs continuous. Outside air damper is open to minimum position for ventilation. On a drop in space temperature below the heating setpoint of 70°F (adj.) the gas furnace cycles as required to maintain heating setpoint temperature. On a rise in temperature above the cooling setpoint of 75°F. (adj.) cooling is enabled. If the outside air temperature is below the economizer changeover setpoint temperature of 75°F, the economizer shall be the first stage of cooling and shall cycle as required to maintain cooling setpoint temperature. If economizer cooling is unable to maintain the cooling setpoint the AC compressor(s) shall cycle as required to maintain setpoint. If the outside air temperature is above the economizer changeover temperature the economizer damper shall close to minimum position for ventilation.

Unoccupied Mode: The supply fan is off and the outside air damper is closed. On a drop in space temperature below the unoccupied heating setpoint temperature of 55°F(adj.) the supply fan and gas furnace shall cycle as required to maintain the unoccupied temperature setpoint. The outside air damper shall remain closed. On a rise in temperature above the unoccupied temperature setpoint of 85°F (adj.) the cooling shall be enabled. The supply fan, economizer and AC compressor shall cycle as required to maintain the unoccupied temperature setpoint. The outside air damper shall remain closed.

Warmup Mode: System start time shall be determined by the programmable thermostat. During the building warmup period, the supply fan shall run continuous. The outside air damper shall be closed. The gas furnace shall operate as required to meet the occupied temperature setpoint of 70°F. (adj.). When the space temperature setpoint is met the system shall change to the occupied mode of operation.

APPENDIX – Assignment 3

Example Functional Test Procedure: Single Zone Package Rooftop Unit

Disclaimer: This example of a test procedure is intended for instructional purposes. It is not written or recommended for application in a real world setting.

Equipment ID: _____ Date of Testing _____
Person(s) Performing Testing _____
Outside air temperature at time of testing _____

OCCUPIED MODE

1. Verify setpoints and schedules match sequence of operation Yes No
If no, how do the settings deviate from the SoO?

2. Set thermostat to occupied mode heating. Does the fan run continuously? Yes No
Is the outside air damper open to minimum position? Yes No
Notes: _____

3. In the occupied mode, set heating setpoint to 5°F. higher than room temperature.
Is the heating enabled? Yes No
Record supply air temperature _____
Notes: _____

4. In the occupied mode, set the cooling setpoint to 5°F cooler that the space temperature.
Is cooling enabled? Yes No
If the outside air temperature is less than the economizer setpoint is economizer enabled? .. Yes No
If the outside air temperature is greater that the econo. setpoint is economizer disabled? Yes No
Record supply air Temperature _____

UNOCCUPIED MODE

1. Set thermostat to unoccupied mode.
Is the outside air damper 100% closed? Yes No
Is the supply fan off? Yes No
Notes: _____

2. Set unoccupied heating setpoint to 5°F warmer than the space temperature.
Is the heating enabled? Yes No
Is the outside air damper 100% closed Yes No
Notes: _____

3. Set unoccupied cooling setpoint to 5°F cooler than the space temperature.
Is the cooling enabled? Yes No
If the outside air temperature is less than the economizer setpoint is economizer enabled? .. Yes No
If the outside air temperature is greater that the econo. setpoint is the damper closed? Yes No
Notes: _____

Scoping Report

ACME Office Building



Prepared for

ACME Explosives Inc.

Prepared by

ACME Facilities Group

Date

1.0 Executive Summary

The ACME Facilities Group is pleased to present findings from a Scoping Study for ACME Office Building. The study was done to reduce operating costs through optimizing building systems performance.

This Scoping Report presents a broad assessment of the major energy-consuming equipment within ACME Office Building. It identifies the estimated potential savings for ACME Office Building and proposes a plan of action designed to identify and implement specific cost saving opportunities.

Energy Savings Potential

The technical survey combined with a utility billing analysis indicates that ACME Office Building is not operating optimally. The building consumes 49 percent more energy than expected, when compared to a hypothetical office building with similar occupancy and energy systems, resulting in almost \$72,000 a year in potential energy cost savings.

Recommended Plan of Action

With a savings potential of \$72,000, significant benefits are possible through completion of an Energy Tune-up for ACME Office Building. The Tune-up consists of identification of appropriate fixes through diagnostics, and implementation, focusing on opportunities with a 2 year or less simple payback. Six areas of interest were identified for the diagnostic portion of the Energy Tune-up, based on the completed technical survey:

1. Schedule Exhaust Air
2. Decrease After-Hour Use by Cleaning Crews
3. Schedule Major Equipment
4. Schedule Pumps
5. Correct Stack Effect Air Loss
6. Implement Variable Flow Pumping

Section Three of this Scoping Report outlines the recommended plan of action for the diagnostics portion of the Energy Tune-Up and a review of Operations and Maintenance (O&M) Practices. The implementation scope of work will be developed through the Tune-Up diagnostics and O&M review. Proposed operational changes and enhanced O&M practices, along with cost-benefit estimates, will be presented and discussed prior to implementation. With appropriate approvals, resources can be assembled and organized to carry out specific implementation steps.

2.0 Building Characteristics

Constructed in 1985, ACME Office Building is a 10 story office building located in the Metropolitan area consisting of approximately 100,000 square feet of office space. Occupancy is 7:30 am to 6 pm Monday through Friday with some Saturday usage.

2.1.1 Heating Ventilating & Air Conditioning (HVAC)

The HVAC system consists of multiple variable air volume (VAV) rooftop air handlers. Fan powered VAV boxes with electric reheat serve the perimeter zones of the building and standard VAV boxes without reheat serve the core. Cooling is provided by two air-cooled chillers. One of the air handlers is dedicated to the computer room. Main coil heating is provided by natural gas fired hot water boilers.

HVAC controls are full direct digital control (DDC). The system is reasonably flexible, but is somewhat underutilized. Current controls provide supply air reset, economizer control, start/stop of the water chillers, boilers, fans, and space temperatures, but it does not provide monitoring or control of lighting or the VAV boxes.

Although occupancy is typical for an office, the HVAC system operates extra hours to maintain space temperatures for cleaning crews. Additionally, the boilers and chillers are available and used year-round, due to occupant comfort issues.

Staff Identified Complaints/Problems

Facility staff identified several on-going operational problems including:

- Very high energy bills;
- Boiler operations required all year;
- Numerous occupant comfort complaints.

2.1.2 Interior Loads

Internal equipment loads are typical for an office, with standard occupant density. There is a computer server room that requires 24 hour cooling. The lighting system is fluorescent energy efficient T8 electronic fixtures and compact fluorescents with manual switch controls with nighttime sweeps.

2.1.3 Utility Usage

The building consumed 2,375,445 kWh in the twelve-month period ending December 20xx. Peak demand occurred in August and was 554 kW. Natural gas usage for the same period was 15,000 therms. Peak natural gas usage occurred in January. This results in a total Energy Use Index (EUI) of 96.0 kBtu/sq.ft. – 45 percent greater than expected for a commercial building with similar occupancy and systems in the Metropolitan area

2.2 POTENTIAL OPPORTUNITIES

The site visit, completed Month Day, 20xx, identified several potential opportunities. The list includes low cost opportunities as well as more capital-intensive opportunities. Five of those opportunities are considered low cost. Table 2, Opportunity Potential, on page 6 outlines the estimated savings potential by opportunity.

2.2.1 Schedule Exhaust Air

This is a simple programming fix which will yield significant savings. It was found that the bathroom exhaust fan was running 24/7. Other exhaust fans will be reviewed during the tune-up phase.

2.2.2 Decrease After-Hour Use by Cleaning Crew

The analysis of electric interval data showed a much higher than expected use after hours. The main reason appears to be lighting and space conditioning for the cleaning crew. It is estimated that about 300,000 kWh per year could be saved by scheduling of lights and HVAC as well as adjusting cleaning practices.

2.2.3 Boiler & Other Major Equipment Scheduling

During the walkthrough the hot water boiler was found to be in stand-by mode. Since it is only used for warm-up, it should be scheduled off. It is also recommended to determine whether the warm-up could be accomplished only with the electric reheat and if this would be more economical. Schedules and lockouts of other major equipment should also be closely examined.

2.2.4 Schedule DHW Pump

During the night walk it was noted that the circulating pump for the domestic hot water was operating, and evidently not scheduled. Since the purpose of the pump is only to supply immediate hot water to tenants, it should be scheduled off during unoccupied periods.

2.2.5 Correct Stack Effect Airflow in Stairwell/Other

There were several indications of loss of conditioned air through the building envelope. Dirt build-up on the stairwell grill connecting to a back draft damper shows there is a steady stream of air leaving the building. There are also gaps at the top of the elevator shaft which are steadily leaking air at night.

2.2.6 VFD on Boiler Pump

If the hydronic heat to the air handlers is retained, putting a variable frequency drive on the boiler pump may make sense. Currently flow is being throttled with the valve only 60% open.

2.2.7 Immediate Needs

An Energy Tune-up enhances and optimizes current building operations. Prior to completion of the Energy Tune-up it is necessary that all quarterly scheduled maintenance be completed to ensure a consistent baseline from which optimization can occur. In addition, the site visit noted that the outside air temperature sensor was in need of calibration. Completion of these minor items reduces the cost to complete the Energy Tune-up and will enhance the optimization process.

2.3 SAVINGS POTENTIAL

The analysis indicates that ACME Office Building is using 49 percent more energy than expected, resulting in overall energy cost savings potential of \$72,000 annually if the building operations are optimized. Table 2, Opportunity Potential, outlines the initial economics for the low cost opportunities. On the left side of the table is the overall grade given to the measure and on the right side, the potential cost savings range (see Key at end of table for definition of symbols). The savings potential for the opportunities are preliminary in nature and presented here to provide very rough estimates of the potential economics.

TABLE 2 – Opportunity Potential

| ECM | Grade | Opportunities | Savings |
|------------|-----------------------------|---|-----------------------------|
| 1 | A | Schedule Exhaust Air | \$\$ |
| 2 | A | Decrease After-Hour Use by Cleaning Crew | \$\$\$ |
| 3 | A | Boiler & Other Major Equipment Scheduling | \$\$ |
| 5 | A | Schedule DHW Pump | \$ |
| 4 | B | Correct Stack Effect Airflow in Stairwell/Other | \$\$ |
| 6 | C | VFD on Boiler Pumps | \$\$ |
| 7 | N/A | Immediate Needs | \$\$\$ |
| Key | | | |
| A | Payback estimated < 1 year | \$ | Minor cost savings |
| B | Payback estimated < 3 years | \$\$ | Significant cost savings |
| C | Payback estimated < 5 years | \$\$\$ | Substantial cost savings |
| D | Payback estimated > 5 years | \$\$\$\$ | Major impact on energy cost |
| ? | Unknown (requires analysis) | | |

3.0 Scope of Work

The ACME Facilities Group proposes to complete an Energy Tune-up and O&M Practice Review for ACME Office Building.

3.1 TUNE-UP DIAGNOSTIC SCOPE OF WORK

The objectives of the Tune-up are to:

1. Identify performance discrepancies within the building,
2. Diagnose the root cause of the discrepancy,
3. Define performance parameters necessary to improve performance,
4. Quantify the value of opportunities that improve operational performance, and
5. Implement the cost effective opportunities.

The diagnostic scope will examine and evaluate the opportunities listed in the Scoping Report in order to develop an Action Plan that will identify specific operational changes needed to improve building performance. ACME Facilities Group shall prepare and submit an Action Plan that describes the problems, the proposed fixes, the calculated savings estimates, and the cost to complete the proposed modifications.

ACME Facilities Group will complete the Following Activities Associated with ACME Office Building's Energy Tune-up:

1. Complete a kick-off meeting with key ACME Office Building personnel to review the scope, strategy, and schedule of activities including access requirements.
2. Following the kick-off meeting, perform necessary site visit(s) in order to review the facility and gain familiarity with equipment and building utility infrastructure related to the areas of interest identified in the Scoping Report.
3. Review utility bills for the facility, mechanical drawings, sequence of operations, and etceteras as needed. Mechanical and other drawings will be made available upon request.
4. Monitor equipment and/or take instantaneous energy readings and other parameters where appropriate. The data, if collected, will be used to identify operational issues, establish baseline energy usage, and calculate energy savings.
5. Develop and implement a testing plan to evaluate the identified opportunity areas listed below:

- Schedule Exhaust Air
 - Decrease After-Hour Use by Cleaning Crew
 - Boiler & Other Major Equipment Scheduling
 - Schedule DHW Pump
 - Correct Stack Effect Airflow in Stairwell/Other
 - VFD on Boiler Pumps
6. Prepare and submit an Action Plan that describes the problem, the proposed fix, the calculated savings estimates, and the cost to complete the proposed modifications.

3.2 OWNERSHIP AND BUILDING PERSONNEL RESPONSIBILITIES

ACME Office Building Ownership and Personnel will provide the following:

1. Provide access to all available pertinent mechanical and architectural drawings, test and balance reports, sequences of operations, waivers for utility billing data, and time with facility personnel for review of building energy systems and operations and implementation of test plan.
2. Provide reasonable access to data available through the facility's control system.
3. Provide reasonable and timely access to the building.
4. Complete scheduled preventive maintenance (PM) work and any identified basic or deferred maintenance work, such as calibration of outside air temperature sensor.

3.3 SCHEDULE AND COMPENSATION

Schedule

ACME Facilities Group shall complete the Scope of Work as described above in ten (10) weeks following ACME Explosives management approval. At the completion of the study, ACME Facilities Group shall submit and present the Tune-Up Action Plan(s).