Lesson 18 Objectives

• In terms of your selected Project (#4), clearly and completely describe Operational Energy Measures, both qualitatively (in words) and quantitatively (in numbers)

• Determine approximate energy savings and costs

• Complete qualitative and quantitative descriptions with the right categories of information as required for course project

• Communicate energy improvements and savings to others
In the last Lesson (17 ‘Operational Energy Measures’) you identified energy improvements to make in your building, covering:

- Types of operational energy measures (OEM).
- How to identify a measure; what to look for.
- How to describe a measure in words, numbers; savings, cost.

With these next steps, you’ll see how to do this more completely, so you can:

- Fully describe the Operational Energy Measures
- Determine the amount of energy savings
- Communicate the proposed improvements and savings to others
- Plan the materials and any staffing costs necessary to implement the measure

The follow topics will help you plan and carry out “Operational Energy Improvement Measures” in your facility and during your career as building operator.
Operational Energy Measures (OEM) are: improvements you in the operation of your building’s equipment or systems that save energy and do not decrease the IEQ of the building. They are:

- Measures and actions in your realm of control
- Improvements that can be done by you and your staff

- Operational Energy Measures do not;
  - Involve capital projects, replacing major equipment or
  - Large capital projects by an outside contractor

The focus of OEM actions is to:

1. Reduce energy use
2. Improve or do no harm to IEQ
3. Implement proposed measures with minimal external support
Types of Operational Measures

Reduction of Operation Hours – When it runs
Improve Equipment Efficiency – How it runs

Schedule – When the equipment operates
- Reduce the operating hours of equipment: Heating, Cooling, Ventilation, Motors, Lighting
- Occupied / Unoccupied – Control them with a written schedule
- Adjusting Schedules – Hours of Operations
- Schedules: Thermostat Program, Manual Operation or BAS – Building Automation System

Efficiency – How the equipment operates
- Boiler Plant Adjustments or cleaning the soot off the tubes
- Chiller Plant Adjustment or cleaning the heat exchangers
- Operational problems of equipment are corrected
- Pneumatic Controls – Fix the problems with controls and actuators
- Lighting: more efficient lamps operate on the same schedule
Types of Energy Savings

• Some projects will save both fuel and electricity

• Both the fuel for heating (fuel oil, natural gas or steam) and electricity for the motors.

• These projects are:
  • Boiler operation hours reduced – due to large motors on burners
  • Ventilation by large blowers – hours reduced when the space is not occupied
  • Kitchen exhaust hoods – hrs. reduced when not needed
  • Other projects affecting ventilation motors, exhaust fan motors, or boiler motors
How to Calculate Energy Savings

To determine energy savings of planned improvements, you need to understand how the energy is being saved.

Reduction of Operation Hours – When it runs

Improve Equipment Efficiency – How it runs

Reduction of Operation Hours – When it runs
- Operating hours of the equipment is reduced.
- Operating efficiency of the equipment has not changed.
- Applies to all energy-using equipment: heating, cooling, ventilation, motors, lighting

Example: The old T-12 fluorescent lamps are operated for less hours per day.

Improve Equipment Efficiency – How it runs
- Operational problems of equipment are corrected
- The efficiency at which the equipment operates is improved.
  The operating hours of the equipment have not changed.

Example: The old T-12 fluorescent lamps are replaced with T-8 fluorescent lamps.
How to Calculate Energy Savings

Expected Energy Saving:

To determine the QUANTITY of energy saved by the measure, you need to consider the following:

• How the energy is saved: Which of these is changed?
  - Reduction of Operation Hours – When it runs
  - Improve Equipment Efficiency – How it runs

• How the energy savings is calculated:
  - What is the approach to calculate it?
  - What do you need to calculate?

Energy savings based on the actual equipment energy usage.

Example: Lighting with a specific amount of reduced hours of operation

Energy Savings = Lighting KW x reduction of hours = KW-hours

2 KW x 200 hrs/month = 400 KW-hrs/month Savings
Class Exercise: Motor Energy Savings

Qualitative Description

Your facility has a chiller that operates for 5 months of the year. Normally 2 of the 3 chilled water pumps operate for the full 5 months. Each pump is sized at 50% capacity of the system. You have determined that only one pump is needed during the (2) months of May and September. You will save energy by not operating one (of three) pumps for those two months.

Answer these questions:

- What is the current problem that is wasting energy?
- What is the solution: the operational energy measure?
- What measurements before implementing?
- Are there any IEQ impacts?
- Who is involved in project implementation?

Report back to full class
Class Exercise: Motor Energy Savings

Quantitative Problem

Your facility has a chiller that operates 5 months/year. Normally 2 of the 3 chilled water pumps operate for the full 5 months. Each pump is sized at 50% of system capacity. You’ve determined that only one pump needs to be operated during 2 months (May and September), so you’ll save energy by not operating one pump for two months.

Calculate the energy savings of the following:
One 20 HP pump is not operating for 2 months, 24 hours/day, 30 days/month
Use the conversion factor of 0.55 KW / HP

Determine:
The total KW of the pump (not running)
  Use: HP x 0.55 = KW
The total KW-hours saved each week.
  Use: KW x hours = KW-hours
Class Exercise: Motor Energy Savings
Quantitative Solution

Convert pump HP to KW
20 HP x 0.55 KW/HP = 11 KW

Reduction of Operating Hours
The pump can be shut down for 2 months (May+Sept.) 24 hours/day, 30 days/month
The total hours of operation of the pump saved each year:
Total Hours = 2 x 24 x 30 = 1440 hours

The total KW-hours saved each year:
11 KW x 1440 hrs = 15,840 KW-hrs per year

Cost Savings per Year: $0.18/KW-hr x 15,840 KW-hrs/year = $2,851 / year

This is a ‘bottom up’ calculation, based on the actual energy usage of the equipment. A ‘top down’ approach would be based on a percentage of the energy used for the motors (See next Slide)
How to Calculate Energy Savings

There are two ways to calculate energy savings for an Operational Energy Measure.

- **‘Bottom Up’ approach**
- **‘Top Down’ approach**

‘Bottom Up’ approach: based on actual equipment energy usage.
The ‘Bottom Up’ approach is preferred; it provides a more accurate calculation of the energy saved.

To use the ‘Bottom Up’ approach, you need to have some specific numbers about:
Rate of equipment energy usage (kilowatt hours or gallons/day of fuel oil usage).
Reduction in operating hours.

**Bottom Up Approach:** based on the actual equipment energy usage  
Example for Lighting with a specific amount of reduced hours of operation  
Energy Savings = Lighting KW x reduction of hours = KW-hours  
2 KW x 200 hrs/month = 400 KW-hrs/month Savings

The ‘‘Top Down’ approach:’ more big picture, using a large category of energy usage, such as the electric energy used for lighting, expressed in KiloWatt-hours. This approach can be used when you do not have specific numbers about rate of equipment energy usage.

**Top Down Approach:** based on a % savings of original energy usage  
Energy Savings = original energy usage x 10%  
Energy Savings = Lighting KW-hours x % reduction of hours = KW-hours  
4,000 KW-hours x 10% = 400 KW-hrs/month Savings
Group Exercise - Qualitative Description

Select an “Operational Energy Measure” that you would like to do in your building. You can select a measure from the list shown before: *Master List of Examples: Energy Improvement Measures*, or any measure that you select for your building.

**Categories of Equipment**

- Boiler Plant: boiler, boiler controls, boiler operation
- Heating Distribution: thermostats, steam traps, heating controls
- Ventilation: outside air supply by fans and by exhaust fans
- Air Conditioning: chillers, rooftop units, etc.
- Motors: blowers, exhaust fans, pumps, etc.
- Lighting: upgrade lighting & reducing operating hours

**Complete Description:** See the 8 questions on the next slide. Write the answers to all 8 questions.
Group Exercise – Complete Description

1. What is the current problem that is wasting energy?
2. What is the solution: operational energy measure?
3. What are the expected energy savings?
4. Will there be any IEQ Impacts?
5. What measurements would you take before implementing this project?
6. What are the project steps?
7. What are the observable outcomes?
8. Who’s involved in implementing the project?
Example for Exercise – Complete Description

What is the current problem that is wasting energy?
The offices are too hot in the winter: overheating leads the occupants to open the windows. Cause: there is no thermostat in these offices, because the space was divided from a larger area. The thermostat is in the room next door.

The solution: the operational energy measure?
Steam radiators in the offices with steam supply valves and pneumatic actuators, controlled by the thermostat in the room next door. Solution: install local thermostats in these offices, tie into the existing pneumatic branch line to the steam valves.

What are the expected energy savings? Will this change the operating hours or the operating efficiency of the equipment?
Yes, this will change operating hours because the steam valves on the radiators are currently open for too long, which leads to overheating of the offices.

Will there be any IEQ impacts?
Yes, this will make an improvement in the IEQ. The offices are currently overheated, and this will be corrected.
Example for Exercise – Complete Description

What measurements would you take before implementing this project?
Take room temperature measurements in the offices. Data loggers can be used to record the temperatures over one week.

What are the project steps?
What is the scope? How many units are involved?
There are two offices with three radiators per office, for a total of six radiators.
The plan: install two new thermostats, each controlling three steam valves. These will tie into the existing pneumatic lines. Investigate existing equipment and pneumatic lines, to provide as much detail as possible to managers and trades who will install the new thermostats. Arrange installation date for new thermostats and pneumatic lines.

What are the observable outcomes?
Better control of office temperature, eliminating office overheating.

Who is involved in implementing the project?
Thermostat installation to be done by the building operators with support by the trades.
Class Exercise: Exhaust Fans

Quantitative Problem Description

You’ve determined that 10 Exhaust Fans do not need to run overnight and weekends, while your building is unoccupied.

- Each exhaust fan motor is 3 HP and draws 2 KW
- Each exhaust fan can be shutdown for 12 hours, 5 days/week
- Each exhaust fan can be shutdown for 48 hours on weekends

Determine:

- The total hours of operation of exhaust fans saved each week.
- The total KW-hours saved each week.
- Use: $KW \times \text{hours} = \text{KW-hours}$
Class Exercise: Exhaust fans

Quantitative Description of Solution

Each exhaust fan can be shutdown for 12 hours, 5 days/week = 60 hours
Each exhaust fan can be shutdown for 48 hours on weekends = 48 hours
Total 108 hours

The total hours of operation of exhaust fans saved each week:
10 fans x 108 hours = 1080 hours

The total KW-hours saved each week:
KW x hours = KW-hours
2 KW x 1080 hrs = 2160 KW-hrs per Week

Extra Info (not requested – but interesting – the $$ )
The total KW-hours saved each year: 2160 KW-hrs per Week x 52 weeks/yr = 112,320 KW-hrs/year

Cost Savings per Year: $0.18/KW-hr x 112,320 KW-hrs/year = $20,218 / year
Quantification: Using the Calculation Guidance Sheet: Overheating Example

**Heating Control:** Improved heating control allows you to reduce temperature in the building from average 78 dF to 71 dF. Use 1% savings per each 1 dF reduction in overheating. Building uses 80,000 gallons of fuel oil per year. 80% of Fuel Oil is for heating, 20% of Fuel Oil is for hot water

Category of Energy: Fuel Oil for heating
80% of Fuel Oil is for heating, 20% of Fuel Oil is for hot water
80% x 80,000 gallons/year = 64,000 gallons

Reduction of heating temperature: 78 dF to 71 dF = 7 dF
Using 1% savings per each 1 dF reduction = 7% savings

Amount of Energy Savings = % saved x original energy usage
Amount of Energy Savings = 7% x 64,000 gallons = 4,200 gallons

Cost Savings / year = 4,4800 gallons x $2.20/gal = $9,856 /year
Quantification

Some measures can only be calculated by using the “Calculation Guidance Sheet”

Example: Improve Boiler Sequencing – Reduce Cycling

<table>
<thead>
<tr>
<th>CATEGORY / MEASURES</th>
<th>CALCULATION GUIDANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BOILER PLANT</strong></td>
<td></td>
</tr>
<tr>
<td>Test and improve CE</td>
<td>1. Test CE. ((84 - \text{test}) / \text{test} = % \text{improvement.})</td>
</tr>
<tr>
<td>Firing rate modulation</td>
<td>2. For cycling reduction, (1 - 10%) improvement based on how bad current operation</td>
</tr>
<tr>
<td>Reduce cycling</td>
<td>is assessed to be</td>
</tr>
<tr>
<td>Improve boiler sequencing</td>
<td>3. Estimate how many operating hours/day can be saved; divide by total operating</td>
</tr>
<tr>
<td>Reduce cycling</td>
<td>hours/day = % improvement.</td>
</tr>
<tr>
<td>Optimize start-up</td>
<td>4. Note - if you are reducing boiler operating hours, you also have motor savings</td>
</tr>
<tr>
<td>Optimize shut-down</td>
<td>(see below).</td>
</tr>
<tr>
<td><strong>HEATING SYSTEM</strong></td>
<td></td>
</tr>
<tr>
<td>Balance steam distribution</td>
<td>1. Most general – use 1- 10% reduction based on how much overheating to be</td>
</tr>
<tr>
<td>Reduce overheating</td>
<td>eliminated and how much zoning possible.</td>
</tr>
<tr>
<td>Reduce pneumatic air</td>
<td>2. More specific - 1% reduction for every degree of overheating removed; pro-rated</td>
</tr>
<tr>
<td>Leakage</td>
<td>by portion of school affected.</td>
</tr>
<tr>
<td>Zone system for after-school</td>
<td></td>
</tr>
<tr>
<td>programming</td>
<td></td>
</tr>
<tr>
<td>Maintain steam traps</td>
<td></td>
</tr>
<tr>
<td>(replace disc elements)</td>
<td></td>
</tr>
<tr>
<td><strong>TABLE OF IMPROVEMENT MEASURES AND CALCULATION GUIDANCE</strong></td>
<td></td>
</tr>
</tbody>
</table>
Quantification

Determine the energy savings by using the “Calculation Guidance Sheet”

Example: Improve Boiler Sequencing – Reduce Cycling

• There are 2 boilers, both cycling on and off, when only one boiler needs to be running after 11 AM. The boilers are not controlled by the lead-lag controller, or the pressure setpoints on the Pressure-trols are set wrong, so they are both cycling on and off. The problem is severe: building uses 80,000 gallons of fuel oil/yr.

• Category of Energy: Fuel Oil for heating
  • 80% of Fuel Oil is for heating, 20% of Fuel Oil is for hot water
  • 100% of Fuel Oil usage is affected by the short cycling problem

• Using the “Calculation Guidance Sheet” the savings of energy is 9%.

• Solution: in Red to reveal on the next click

• Amount of Energy Savings: 9% x 80,000 gallons = 7,200 gallons/year
Quantification – Steam Traps Replaced

Determine energy savings using the “Calculation Guidance Sheet”

Example: Replace Steam Traps to improve Efficiency of Heating System

• Description of Problem: Steam traps have failed and need to be replaced.
• Description of Solution: Replace the thermostatic steam trap elements on 60 radiators.
• Replacing all of the steam traps will provide an energy savings of 8% of heating energy.

• Category of Energy: Fuel Oil for heating
• 75% of Fuel Oil is for heating, 25% of Fuel Oil is for hot water
• 75% x 40,000 gallons/year = 30,000 gallons

• Using the “Calculation Guidance Sheet” in “Heating System”
• Amount of Energy Savings: 8% energy savings for all steam traps replaced

Solution: in Red to reveal on the next click
Amount of Energy Savings: 8% x 30,000 gallons = 2,400 gallons
Quantification – Cost to Implement

• What kinds of costs?
  • Cost of materials and labor
  • Costs of supervision and contingency (10% each)

• Spreadsheet for easy calculation
  • Format is set up for use
  • Determine the labor for the energy measure
  • Determine the materials for the energy measure
Quantification – Project Cost Estimate

- **Example: Install Occupancy Sensors for Lighting**

  - Install 20 sensors
  - Install 2 sensors per hour
  - Sensor cost: $30 each

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit Cost</th>
<th>Hrs or Qty</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal manpower, __ man-hours @ $50 per hour =</td>
<td>$ 50.00</td>
<td>10</td>
<td>$ 500.00</td>
</tr>
<tr>
<td>External manpower, __ man-hours @ $75 per hour =</td>
<td>$ 75.00</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Materials (itemized)</td>
<td>$30</td>
<td>20</td>
<td>$ 600.00</td>
</tr>
<tr>
<td>Sut-total, direct costs</td>
<td></td>
<td></td>
<td>$ 1,100.00</td>
</tr>
<tr>
<td>Supervision &amp; overhead</td>
<td>10%</td>
<td></td>
<td>$ 110.00</td>
</tr>
<tr>
<td>Sut-total</td>
<td></td>
<td></td>
<td>$ 1,210.00</td>
</tr>
<tr>
<td>Contingency</td>
<td>10%</td>
<td></td>
<td>$ 121.00</td>
</tr>
<tr>
<td>Total Estimated</td>
<td></td>
<td></td>
<td>$ 1,331.00</td>
</tr>
</tbody>
</table>
### Quantification – Project Cost Estimate

- **Example:** Replace steam trap elements (thermostatic bellows)
- Replace 60 elements
- Replace 3 per hour
- Element cost: $30 each

<table>
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<td>20</td>
<td>$ 1,000.00</td>
</tr>
<tr>
<td>External manpower, ___ man-hours @ $75 per hour =</td>
<td>$ 75.00</td>
<td></td>
<td>$ -</td>
</tr>
<tr>
<td>Materials (itemized)</td>
<td>$ -</td>
<td></td>
<td>$ -</td>
</tr>
<tr>
<td>Steam Trap Elements</td>
<td>$30</td>
<td>60</td>
<td>$ 1,800.00</td>
</tr>
<tr>
<td>Pipe Wrench</td>
<td>25</td>
<td>1</td>
<td>$ 25.00</td>
</tr>
<tr>
<td>Thread Sealant</td>
<td>5</td>
<td>1</td>
<td>$ 5.00</td>
</tr>
</tbody>
</table>

**Sut-total, direct costs** $2,830.00

**Supervision & overhead** 10% $283.00

**Sut-total** $3,113.00

**Contingency** 10% $311.30

**Total Estimated** $3,424.30
Class Exercise: 
Quantification – Project Cost Estimate

Given:

You have determined that 20 pneumatic thermostats in your building need to be replaced, and your staff is able to replace these.

• Cost per thermostat: $85
• Supplies per thermostat (plastic tubing) $5
• Labor for each thermostat: half hour – one person

Determine:

The total cost of the Operational Energy Measure, including: materials, labor, supervision and contingency.
Class Exercise – Project Cost Estimate

- **Solution**: Replace Thermostats
  
  - Replace 20 stats
  
  - Replace 2 per hour

- **Material cost**:

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit Cost</th>
<th>Hrs or Qty</th>
<th>Cost</th>
</tr>
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<tbody>
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<td>Internal manpower, __ man-hours @ $50 per hour =</td>
<td>$ 50.00</td>
<td>10</td>
<td>$ 500.00</td>
</tr>
<tr>
<td>External manpower, __ man-hours @ $75 per hour =</td>
<td>$ 75.00</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Thermostat - Pneumatic</td>
<td>$85</td>
<td>20</td>
<td>$1,700.00</td>
</tr>
<tr>
<td>Plastic Tubing</td>
<td>$5</td>
<td>20</td>
<td>$100.00</td>
</tr>
</tbody>
</table>

  **Sut-total, direct costs**: $2,300.00

  **Supervision & overhead**: 10% $230.00

  **Sut-total**: $2,530.00

  **Contingency**: 10% $253.00

  **Total Estimated**: $2,783.00
In-Class Workshop: Project #4 Prep

- Class Participants will pair up and;
- Review Project Description, from Description of Measure to Problem Addressed
- Pre-Project Measurements and Project Steps;
- Observable Outcomes
- Following discussion, group discussion of ‘Calc Guidance’ Worksheet and Costs Estimates (from Class 18 slides)
Lesson 18 Review and Assignment

- Review of Operational Energy Measures
- Qualitative and Quantitative Descriptions of Energy Savings
- Qualitative Descriptions of Operational Energy Measures
- Quantification of Operational Energy Measures
- Quantification Using the Calculation Guidance Sheet
- Implementation Costs of Operational Energy Measures

- For Class 19 (Thursday): Herzog, Appendix A+B
  - Energy Audit Handout (pages 2-25)