Seneca College BES 710

(20160824 revision)

1 – Methods of Energy Management in Buildings

Guided Research Activity 1.3: The Electrical Load Inventory

Download the document entitled **Electrical Load Inventory**, and using the forms provided, follow the instructions given in the document.

Guided Research Activity 1.4: Thermal Load Inventory

Download the document entitled **Thermal Load Inventory**, and using the forms provided, follow the instructions given in the document.

SAQ 1.1: End-Use Cost of Electricity

5¢/kWh is pretty cheap for electricity in Ontario these days. 9¢/kWh is probably more reasonable, all things considered. Repeat the analysis in Table 1.6 using 9¢/kWh as the price at the utility meter. What is the end-use cost in the piping network?

Solution:

A Table similar to the one in the text can be prepared, starting with the electricity purchase price of 9.00 cents/kWh. In each step of the system, the output cost is the input cost divided by the step efficiency.

Component	Typical Efficiency	Unit Cost at Input ¢/kWh	Unit Cost at Output ¢/kWh
Utility Meter	100%	9.00	9.00
Distribution System	96%	9.00	9.375
Motor	85%	9.375	11.029
Bearing	98%	11.029	11.254
Pump	60%	11.254	18.758
Valve	70%	18.758	26.796
Piping Network	60%	26.796	44.661
		Ratio of Overall Unit Cost	**5:1**

Of course the ratio of end-use to purchase cost remains about 5:1, but the effective cost of the electricity at the end-use is a whopping 44.66 cents/kWh.

SAQ 1.2: Simple Payback

A lighting retrofit is being proposed for a building. The total project cost is estimated to be $150,000, and the savings expected in electricity billings have been calculated to be $35,000 per year. What is the simple payback period for this project?

Solution:

Simple Payback Period is simply the project cost divided by the annual savings. So, in this case,
SPP = 150,000/35,000 = 4.3 years, or about 4 years and 4 months.

SAQ 1.3: Cash Flow and Net Project Value

For the lighting retrofit described in SAQ 1.2, further analysis reveals that the lighting retrofit will add $8,500 per year to the heating energy bill due to the lower heat load of the more efficient lights. Given that the project is installed in year 0, that for various reasons only 80% of the projected annual savings are realized in year 1, with 100% thereafter, and taking into account the additional annual cost for heating, prepare a cash flow table for the 10 year life expectancy of the new system (i.e. prior to expected fixture replacement). In light of this, what is the new simple payback period, and what is the net project value at the end of year 10?

Solution:

A cash flow table similar to that in the text (Table 1.7) is constructed as follows:
The capital cost of the project is $150,000
The annual saving in electricity costs is $35,000, except for year 1 when it is $28,000
The additional annual heating cost is $8,500.
The simple payback period is:
SPP = 150,000/(35,000 – 8,500) = 5.67 years.
The net project value at the end of year 10 is $108,000

Cash Flow Table for Lighting Retrofit

Capital Expenditure $150,000
Expected Savings $35,000
Additional heating cost $8,500

80% of savings in year 1, full amount in all remaining years.

(Values in $'000)

Year	0	1	2	3	4	5	6	7	8	9	10
Costs	150,000	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500
Savings	0	28,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000
Net cash flow	(150,000)	19,500	26,500	26,500	26,500	26,500	26,500	26,500	26,500	26,500	26,500
Net Project Value	(150,000)	(130,500)	(104,000)	(77,500)	(51,000)	(24,500)	2,000	28,500	55,000	81,500	108,000

2 – Energy Accounting

SAQ 2.1: Power Factor

An electrical system operating at 600 volts is drawing a current of 20 amperes. A power meter measures the power drawn by the system at 10.8 kW. What is the power factor?

Solution:

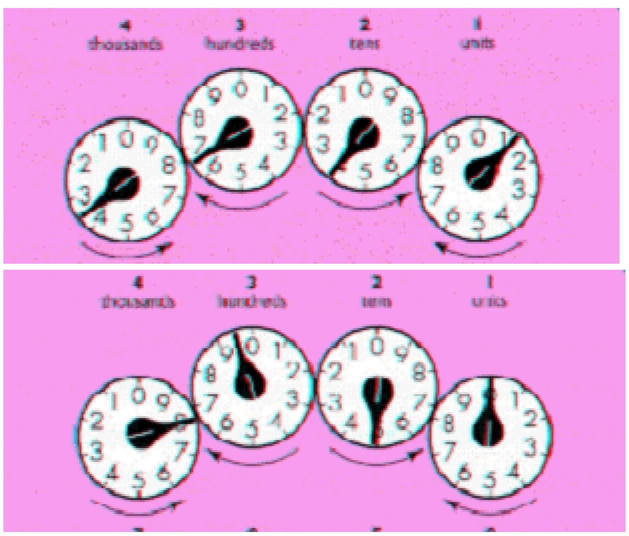
$$PF\ (\%) = \frac{kW}{kVA} \times 100 = \frac{10.8\ kW}{600V \times 20A/1000} \times 100\% = \frac{10.8\ kW}{12.0\ kVA} \times 100\% = 90\%$$

Electric Distribution Systems Video

https://senema.senecac.on.ca/videos/3399/electrical-systems

SAQ 2.2: Reading the Electricity Meter

The dials of an electricity meter are shown at two times below. What is the consumption in kWh for this period?



Solution:

The meter is read as follows: Read each dial (working from right to left—i.e. from units to thousands), rounding off each to the number less than the dial position. In the case of the top figure, the reading would be 3641. Note that for any given dial, the dial to its right must do a complete rotation for it to move one digit. If a pointer is directly on a number, and you can't determine whether it should be read as the number it is on or one less, the case of the lower figure may help.

In the lower figure, dial 1 reads 0, dial 2 reads 5, dial 3 reads 9 and dial 4 appears to be at the digit 8. However since dial 3 has not completed an entire revolution (to 0), dial 4 has not moved all the way from 7 to 8. The reading of these dials is 7950.

Therefore the consumption is 7950 – 3641 = **4309 Wh** or **4.3 kWh**.

SAQ 2.3: BEPI Calculation

Use the BEPI calculation sheet to calculate BEPI, given the following data:

Floor area: 2000 m2
Natural gas use 41,000 m3/yr
$8,200/yr
Electricity use 150,000 kWh/yr
$7,500/yr

Solution:

BEPI calculation form

Month	Natural Gas		Propane		No. 2 Fuel Oil		Electricity	
	Quantity (m^3)	Total Cost	Quantity (L)	Total Cost	Quantity (L)	Total Cost	Quantity (kWh)	Total Cost
1	2	3	4	5	6	7	8	9
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								
Total Per year	41,000	$8,200	0	0	0	0	150,000	$7,500

Grand Total Energy Cost From Columns 3, 5, 7 and 9 $

Type of fuel	Actual Consumption Quantity x Conversion Factor = Energy Use (ekWh/yr)
Natural Gas	41000 X 10.3 = 422,300
Propane	X 7.2 =
No. 2 Fuel Oil	X 10.6 =
Electricity	150,000 X 1.0 = 150,000
Total energy	Total = 572,300

Building Energy Performance Index

$$BEPI = \frac{572{,}300}{2{,}000} = 286.15 \text{ ekWh/yr/m}^2$$

$$BEPI = \frac{\text{Total Energy Use (ekWh/yr)}}{\text{Gross Floor Area (m}^2\text{)}}$$

$$= \frac{\qquad\qquad \text{ekWh/yr}}{\text{m}^2}$$

SAQ 2.4: Heating Degree Days

1. What is a heating degree day by definition?

2. How many heating degree days, based on 18°C are there in the following five day period:

Day 1 10°C
Day 2 12°C
Day 3 15°C
Day 4 17°C
Day 5 20°C

Solution:
1. A heating degree day is the sum of the difference between the average outdoor temperature and a specified base temperature (usually 18°C unless indicated otherwise) per day over the period in question.

2. The HDD for this period is:

Day 1 = 18 – 10 = 8
Day 2 = 18 – 12 = 6
Day 3 = 18 – 15 = 3
Day 4 = 18 – 17 = 1
Day 5 = 18 – 20 = 0
Total HDD = **18**

Note that a temperature above 18° as in Day 5 does not contribute a negative value; HDD is an indication of how much heat is required, and if the temperature is above 18, no heat is required (i.e. it is not a negative that offsets some of the heat required in the previous four days).

3 – The Building Envelope

The Building Envelope Video

https://senema.senecac.on.ca/videos/3393/building-envelope

4 – The Heating System

Boiler Room Video

https://senema.senecac.on.ca/videos/3394/heating-plant-tour

Burners Video

https://senema.senecac.on.ca/videos/3395/oil-burner-operation

5 – Cooling Systems and Heat Pumps

SAQ 5.1: Sensible and Latent Heat

Distinguish between and give examples of the sensible and latent heat loads referred to in section 5.2

Solution:

There are sensible and latent heat loads associated with both infiltration air and ventilation air. In both instances the sensible load relates to the dry bulb temperature of the air; for example, infiltration air in the winter creates a heat demand in the building that in part is indicated by its dry bulb temperature.

The latent heat load is associated with the moisture contained in the air, and is equivalent to the energy involved in the condensation or evaporation of water (i.e. the latent heat of vaporization). For example, moist summer air that infiltrates the building creates a demand on the cooling system that is indicated both by its dry bulb temperature and its relative humidity since energy must be removed from this air in order to condense enough moisture to bring its relative humidity down to the desired indoor level.

Refrigeration Cycle Video

https://senema.senecac.on.ca/videos/3396/refrigeration-cycle

6 – Air Handling Systems

Air Handling Systems Video

https://senema.senecac.on.ca/videos/3398/air-handling

7 – Indoor Air Quality

SAQ 7.1: Ventilation Air Rate

For the situation described below, using building type, occupancy and system details, and measurements taken from the system, determine if sufficient outside air is being supplied:

Solution:

An air handling unit, rated at 10,000 CFM, supplies air to a cocktail lounge that holds 100 persons. Measurements taken in the fan system show return air at 75°F (23.9°C). Mixed air at 70°F (21.1°C), and outside air at 50°F (10.0°C). Is sufficient outside air being introduced?

Hint: If 10% outside air is introduced in a 10,000 CFM fan system, it means (10% of 10,000 CFM or 1,000 CFM of outside air is provided to the space, along with 9000 CFM of recirculated air).

$$\%\ Outside\ Air = \frac{RAT - MAT}{RAT - OAT}\ x\ \ 100 = \frac{23.9 - 21.1}{23.9 - 10.0}\ x\ 100 = \frac{2.8}{13.9}\ x\ 100 = 20.1$$

Therefore the 10,000 cfm unit is delivering 2010 cfm of outside air and 7990 cfm of return air. This is equivalent to 2010/100 = 20.1 cfm per person occupying the room. Although cocktail lounges are not specified in the data in the text, a web search indicates that 30 cfm per person is recommended for bars; therefore, this lounge is probably being supplied with insufficient fresh air.

8 – Motors

Electric Motor Video

https://senema.senecac.on.ca/videos/3388/electric-motors-video

9 – Lighting Systems

There are no web materials for this chapter.

10 – Building Control Systems

There are no web materials for this chapter.

11 – Operations and Maintenance

SAQ 11.1: Boiler Efficiency and Flue Gas

What is the critical flue gas measurement, and in what way does it indicate boiler efficiency?

Solution:

The critical flue gas measurement is the O_2 concentration. A high O_2 concentration indicates that too much excess air is being introduced to the burner, and that the excess air supply should be "trimmed" to be closer to the stoichiometric requirement. The excess air simply carries heat out of the boiler, thereby increasing this source of energy loss.

SAQ 11.2: Air Balancing

How can you check the ratio of fresh air and return air?

Solution:

The ratio of fresh air and return air can be checked by measuring the temperatures of the outside air (OAT), the return air (RAT) and the mixed air (MAT), and using them in the following equation to calculate the %outside air:

$$\%\ Outside\ Air = \frac{RAT - MAT}{RAT - OAT}\ x\ \ 100$$

SAQ 11.3: Lighting System Maintenance

Why should room surfaces be cleaned as part of the lighting system maintenance program?

Solution:

The ambient light level in a space is determined not only by light directly from fixtures, but also light that reflects off walls, ceiling and other surfaces. If these surfaces are dirty, they absorb more light than if they are clean (dark surfaces also absorb more light than light-coloured surfaces); therefore, ensuring that such surfaces are clean can reduce the demand for light directly from the fixtures.