

BEYOND

SMART CITIES

ENERGY MANAGEMENT AND AUDIT - CEM
REFRESHER TRAINING COURSE

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CEM REFRESHER TRAINING COURSE

ENERGY MANAGEMENT SPECIALIST
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ENERGY PURCHASING
FOR ENERGY PROFESSIONALS

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WHAT SHOULD YOU LEARN

ENERGY MANAGEMENT SPECIALIST
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Energy Procurement

Natural Gas Purchasing

Electrical Energy Purchasing

Basic Energy Accounting

ENERGY PROCUREMENT

- ✓ Procurement of energy (electricity, natural gas, fuel oil, coal, etc.) is becoming a major part of the energy manager's job
- ✓ Cost effective energy procurement requires understanding of the market, regulatory limitations and opportunities, and contingency planning
- ✓ Optimal energy choice involves many issues including purchase price, efficiency, availability, and environmental impacts



TYPES OF ENERGY TYPICALLY USED

- ✓ Electricity
- ✓ Natural gas
- ✓ Light oil (Number 2)
- ✓ Heavy oil (Number 6)
- ✓ Coal
- ✓ Propane or LPG
- ✓ Renewables (Extra cost of green tags)



NATURAL GAS PURCHASING

There may be some local, regional or national laws or regulations that control or prevent some of these choices:

- ✓ LDC is your Local Distribution Company
- ✓ Buy from your LDC at Firm Rate
- ✓ Buy from your LDC at Interruptible Rate
- ✓ Buy from some non-LDC pipeline company
- ✓ Buy from Gas Marketer or Gas Broker
- ✓ Must pay any transportation charges



ELECTRICAL ENERGY PURCHASING

Electric Purchase Opportunities
Subject to local, regional and national laws and regulations

Everyone

- ☒ Buy firm power from your LDC
- ☒ Buy interruptible power from your LDC

Some

- ☒ Buy from Power Marketer (LDC or other)
- ☒ Buy from Power Broker
- ☒ Must pay all wheeling charges and other regulatory charges



BASIC ENERGY ACCOUNTING

Energy Costs and Cost Comparisons
Basic energy accounting deals with the following ideas:

- ☒ Recognizing different energy and fuel types
 - Electricity, gas, light oil, steam, chilled water
- ☒ Understanding energy related units
 - kWh, kJ, MJ, GJ, kW, kJ/h, L or kg of oil, m³ of gas
- ☒ Performing conversions to different energy related units
 - For example, 1 kWh = 3600 kJ = 3.6 MJ



ENERGY CONVERSION UNIT TABLE



kWh	3.6 MJ
1 m ³ natural gas	37 MJ
1 kg #2 fuel oil	42 MJ
1 litre gasoline.....	35 MJ
1 m ³ #2 fuel oil	39 GJ
1 m ³ propane (LPG).....	25.5 GJ
1 kg propane (LPG).....	45.65 MJ
1 MJ	1000 kJ
1 GJ	10 ⁶ kJ



ENERGY CONVERSION EXAMPLE - 1



How many kJ are in 10 kWh?

Solution

$$\begin{aligned} \text{X kJ} &= \frac{10 \text{ kWh}}{1 \text{ kWh}} \times \frac{3600 \text{ kJ}}{1 \text{ kWh}} \\ &= 36,000 \text{ kJ} \end{aligned}$$

In this example, the two kWh units cancel out, leaving the remaining unit on the right side as kJ.

As another example, if we want to find the number (X) of kJ in 1000 cubic metres of natural gas, we can use the following method:

$$\begin{aligned} \text{X kJ of gas} &= \frac{1000 \text{ m}^3}{1 \text{ m}^3} \times \frac{37,000 \text{ kJ}}{1 \text{ m}^3} \\ &= \frac{1000 \text{ m}^3}{1 \text{ m}^3} \times \frac{37,000 \text{ kJ}}{1 \text{ m}^3} \\ &= 1000 \times 37,000 \text{ kJ} \\ &= 37,000,000 \text{ kJ} \\ &= 37.0 \times 10^6 \text{ kJ} \\ &= 37 \text{ GJ} \end{aligned}$$

POINT OF USE COST



True operating cost or "point of use" (POU) cost depends on purchase price and efficiency of use.

All energy sources can be compared with POU for each converted to some base measure (GJ, kWh, etc.). We will use GJ as the common unit to start with

$$\text{POU} = \frac{\text{purchase price per common unit}}{\text{efficiency of use}}$$

POU is only for operating costs. No capital cost is considered in the calculation.

POINT OF USE COST EXAMPLE



The steam boiler for a facility can operate on LPG gas or oil. Using LPG gas at \$1.25 per kg and 45,650 kJ/kg, the boiler is 75% efficient. Using diesel oil at \$1.00/L and 39,000 kJ/L, the boiler is 78% efficient. Which fuel source provides the lowest operating cost?

Solution in \$/GJ

Select 1 GJ as the common unit of steam output.

$$\text{POU}_{\text{LPG}} = \frac{\$1.25}{1 \text{ kg}} \times \frac{1 \text{ kg}}{45,650 \text{ kJ}} \times \frac{1,000,000 \text{ kJ}}{1 \text{ GJ}} \times \frac{1}{0.75}$$

$$= \$36.51/\text{GJ}$$

$$\text{POU}_{\text{oil}} = \frac{\$1.00}{1 \text{ L}} \times \frac{1 \text{ L}}{39,000 \text{ kJ}} \times \frac{1,000,000 \text{ kJ}}{1 \text{ GJ}} \times \frac{1}{0.78}$$

$$= \$32.87/\text{GJ}$$

Use oil if possible

Solution in \$/kWh

Select 1 kWh as the common unit of steam output.

$$\text{POU}_{\text{LPG}} = \frac{\$1.25}{1 \text{ kg}} \times \frac{1 \text{ kg}}{45,650 \text{ kJ}} \times \frac{3,600 \text{ kJ}}{1 \text{ kWh}} \times \frac{1}{0.75}$$

$$= \$0.1314/\text{kWh}$$

$$\text{POU}_{\text{oil}} = \frac{\$1.00}{1 \text{ L}} \times \frac{1 \text{ L}}{39,000 \text{ kJ}} \times \frac{3,600 \text{ kJ}}{1 \text{ kWh}} \times \frac{1}{0.78}$$

$$= \$0.1183/\text{kWh}$$

Use oil if possible

CEM EXAM FORMULAS



- GEOMETRY
- Area of circle = $\pi \times r^2$
- Circumference of circle = $\pi \times D$
- Area of rectangle = $L \times W$
- Perimeter of rectangle = $2 \times L + 2 \times W$

- ELECTRICAL
- $V = I \times R$ Ohm's Law (single phase)
- $P = I^2 \times R$ Ohm's law for power (single phase)
- $kW = (V \times A \times 1.73 \times PF) / 1000$ (3 phase) PF = Cos phi
- $kW = kVA \times PF$ PF = Cos phi
- $kVA = 1.73 \times kW \times A$ (3 phase)

- MOTORS
- Percent load = $(NLRPM - RPM) / (NLRPM - FLRPM)$
- Synchronous speed = $(\text{frequency} \times 50) / (\text{number of pole pairs})$
- $kW \times \text{Percent load} = (V \times A \times 1.73 \times PF \times \text{Efficiency}) / 3$ (3 phase)
- PF = $kW / kVA = \text{Cos phi}$
- FANS AND FAN LAWS
- $LPSn / LPSo = (RPMn / RPMo)^3$ n=new; o=old
- $SPn / SPo = (RPMn / RPMo)^2$
- $kWn / kWo = (RPMn / RPMo)^3$
- RPM-driven $\times$ diameter-driven = RPM-driver $\times$ diameter-driver
- Percent OA = $(RAT - MAT) / (RAT - OAT)$

CEM EXAM FORMULAS



- LIGHTING
- $RCR = (2.5 \times \text{cavity height} \times \text{perimeter}) / (\text{area})$ General
- $RCR = (5 \times \text{height} \times (L + W)) / (L \times W)$ Rectangular room
- Number of lamps = $(\text{LUX desired} \times \text{area}) / (\text{Lumens-per-lamp} \times \text{Cu} \times \text{LI} \times \text{L2})$
- Lux = Lumens/d²
- Efficacy = Lumens/watt

- HEAT FLOW
- $q = u \times A \times \Delta T$ W
- $q = M \times Cp \times \Delta T$ W sensible heat only
- $q = M \times \Delta h$ W sensible and latent heat
- Q cooling = $U \times A \times 24 \times CDD$ Wh/yr
- Q heating = $U \times A \times 24 \times HDD$ Wh/yr

- MISCELLANEOUS
- $q = LPS \times 1.2 \times \Delta T$ W (sensible heat for air)
- $q = LPS \times 4.2 \times \Delta T$ kW (sensible heat for water)
- POU energy cost = $(\text{output/efficiency}) \times (\text{cost per unit})$
- Density of dry air at standard conditions 1.204 kg/m³
- Specific heat of dry air at standard conditions 1.006 kJ/kg°C
- Density of water at standard conditions 1 kg/L
- Specific heat of water at standard conditions 4.2 kJ/kg°C
- Density of water 1000 kg/m³

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