# Construction and Industry

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## Question: 1

A building owner replaced a #2 fuel oil fired boiler having an efficiency of 80% with a natural gas condensing boiler having an efficiency of 92%. The price of oil is S2.10 per gallon and the price of gas is SO.38 per therm. If the facility uses 4,100 MMBtu each year and the new boiler will cost S 140,000, what is the simple payback period?

A. 2.3 years
B. 2.5 years
C. 2.7 years
D. 3.1 years

**Answer: B**

Explanation:
The price of fuel oil per Btu is:

$$\frac{\$2.10}{\text{gallon}} \times \frac{1 \text{ gallon}}{140{,}000 \text{ Btu}} \times \frac{1{,}000{,}000 \text{ Btu}}{\text{MMBtu}} \times \frac{1}{0.80} = \$18.75/\text{MMBtu}$$

The price of natural gas per Btu is:

$$\frac{\$0.38}{\text{therm}} \times \frac{1 \text{ therm}}{100{,}000 \text{ Btu}} \times \frac{1{,}000{,}000 \text{ Btu}}{\text{MMBtu}} \times \frac{1}{0.92} = \$4.13/\text{MMBtu}$$

The savings are therefore $14.62/MMBtu. The annual fuel cost savings are therefore $14.62/MMBtu \times 4,100$ MMBtu $= \$59{,}942$. The simple payback period will be $160,000 ÷ $59,942 = 2.7 years.

## Question: 2

A 130,000 square foot facility used 1,250,000 kWh of electricity and 7 ,500 MMBtu of natural gas during the most recent 12 months. The cost of electricity is SO.075/kWh and the cost of natural gas is S7.00/Mcf. What is the Energy Cost Index of the facility? (Assume 1 Mcf= 1.037 MMBtu).

A. $1.09/ft2
B. $1.11/ft2
C. $1.13/ft2
D. $1.15/ft2

**Answer: B**

Explanation:
The cost of electricity was 1,250,000 kWh x $0.075/kWh= $93,750. The cost of natural gas was:

$$\frac{7{,}500 \text{ MMBtu}}{1.037 \frac{\text{MMBtu}}{\text{Mcf}}} \times \frac{\$7.00}{\text{Mcf}} = \$50{,}627$$

So the total cost of energy was $144,377. The Energy Cost Index is:

$$\frac{\$144{,}377}{130{,}000 \text{ sq. ft.}} = \frac{\$1.11}{\text{sq. ft.}}$$

## Question: 3

A 20 HP motor operates at full load for 7,000 hours each year at an efficiency of 91%. It is replaced by a new 20 HP motor with an efficiency of 93%. What are the annual energy savings achieved by installing the new motor?

A. 2,206kWh
B. 2,520kWh
C. 2,840 kWh
D. 3,308kWh

**Answer: B**

Explanation:
The power savings are:

$$Savings\ (\text{kW}) = \left(\frac{\text{hp} \times 0.746 \times \%\ Load}{Efficiency}\right)_{Original} - \left(\frac{\text{hp} \times 0.746 \times \%\ Load}{Efficiency}\right)_{New}$$

$$Savings\ (\text{kW}) = \frac{20 \times 0.746 \times 100\%}{91\%} - \frac{20 \times 0.746 \times 100\%}{93\%} = 16.40 - 16.04 = 0.36 \text{ kW}$$

The energy savings in kWh are: 0.36 kW × 7,000 hours = 2,520 kWh.

## Question: 4

A natural gas boiler with an efficiency of 70% will be replaced by a boiler having an efficiency of 90%. If the building heating demand is 1, 700 MMBtu, how much energy will the new boiler save?

A. 485 MMBtu
B. 540 MMBtu
C. 340 MMBtu
D. 285 MMBtu

**Answer: B**

Explanation:
The energy' savings from improving boiler efficiency are calculated by:

$$Savings = \frac{New\ Efficiency - Old\ Efficiency}{New\ Efficiency} \times Fuel\ Consumption$$

The fuel consumption using the old boiler is 1,700 MMBtu ÷ 70% = 2,428.57 MMBtu. Therefore, the energy savings will be:

$$Savings = \frac{90\% - 70\%}{90\%} \times 2428.57\ \text{MMBtu} = 540\ \text{MMBtu}$$

## Question: 5

An audit of a building's ventilation system has determined that the supply of outside air can be reduced from 7 ,OOO cfm to 6,000 cfm. If the fan power is currently 7 hp, what will the new power be at the reduced airflow?

A. 3.9 hp
B. 5.1 hp
C. 4.4
D. 6.0 hp

**Answer: C**

Explanation:
The power of a fan is related to the cube of the flow rate according to the fan affinity laws:

$$\frac{hp_{new}}{hp_{old}} = \left(\frac{Flowrate_{new}\ (\text{cfm})}{Flowrate_{old}\ (\text{cfm})}\right)^3$$

$$hp_{new} = 7 \times \left(\frac{6{,}000}{7{,}000}\right)^3 = 7 \times 0.63 = 4.4\ \text{hp}$$

## Question: 6

What is the load factor of a 10 HP motor with an efficiency of 94.1% when it is producing 6.3 kW of power?

A. 79%
B. 81%
C. 83%
D. 85%

**Answer: A**

Explanation:
The load factor of the motor may be calculated by:

$$Load\ factor = \frac{Power\ (\text{kW}) \times Efficiency}{HP \times 0.746} = \frac{6.3 \times 0.941}{10 \times 0.746} = 0.79$$

## Question: 7

A wall is constructed from the following materials:
Brick facade: R = 0.5
Masonry block: R: 1.9
Insulation: R = 6.6
Plaster board: U = 1.8
What is the total resistance to heat flow in (R-value) of this wall?

A. 9.6
B. 10.8
C. 11.2
D. 13.1

**Answer: A**

Explanation:

The total R-value of a composite wall is calculated by:

$$R_{total} = R_1 + R_2 + R_3 \ldots$$

$$R = \frac{1}{U}$$

The total R-value for the wall is:

$$R_{total} = 0.5 + 1.9 + 6.6 + \frac{1}{1.8} = 9.6$$

The total R-value of a composite wall is calculated by:

$$R_{total} = R_1 + R_2 + R_3 \ldots$$

$$R = \frac{1}{U}$$

## Question: 8

How many years does an energy saving project need to produce S 15,000 in energy savings to have a 10% minimum attractive rate of return on an investment of S50,OOO?

A. 3 years
B. 5 years
C. 6 years
D. 4 years

**Answer: D**

Explanation:
The energy savings project must have a capital recovery interest factor less than $15,000 + $45,000 = 0.33. The year with the closest value less than 0.33 is n = 4 years.

## Question: 9

If the input rating of a boiler is 1,340,000 Btu/hour and it is 80% efficient, what is its output in boiler horsepower?

A. 32 bhp
B. 50 bhp
C. 40 bhp
D. 44 bhp

**Answer: A**

Explanation:
The output ofa boiler can be given in boiler horsepower. 1 boiler horsepower is 33,475 Btu/hour. If the input rating of a boiler is 1,340,000 Btu/hour and it is 80% efficient, then the output of the boiler is 1,340,000 X 80% = 1,072,000 Btu/hour. This is 1,072,000 + 33,475 Btu/hour = 32 boiler horsepower.

## Question: 10

What is the rate of heat loss per square foot through a 4-inch cinder block wall when the internal temperature is 69 OF and the outside temperature is 37 OF?

A. 16.3 Btu/hour.ft2
B. 18.3 Btu/hour.ft2
C. 56.0 Btu/hour.ft2
D. 264.1 Btu/hour.ft2

**Answer: A**

Explanation:

The rate of heat loss through a building element is given by:

$$q = U \times A \times \Delta T$$

The conductance, $U$, is the reciprocal of the sum of the resistances:

$$U = \frac{1}{R_1 + R_2 + R_3 + \cdots} = \frac{1}{0.68 + \frac{1}{0.9} + 0.17} = 0.51$$

Therefore,

$$\frac{q}{A} = 0.51 \times (69 - 37) = 16.3 \frac{\text{Btu}}{\text{hour} \cdot \text{ft}^2}$$

## Question: 11

Which of the following economic analysis methods does not consider the time value of money?

A. Simple Payback Period
B. Present Worth Analysis
C. Life Cycle Cost
D. Benefit Cost Ratio

**Answer: A**

Explanation:
Simple Payback Period is calculated by dividing the initial costs by the annual savings and does not consider how costs or the value of money changes over time.

## Question: 12

An office uses 300,000 gallons of water each year for toilet flushing. The toilets use 3.5 gallons per flush. How much water could be saved if the toilets are replaced with new ones using the maximum amount of water per flush allowed under the Energy Policy Act of 1992?

A. 85,714
B. 137,142
C. 162,857
D. 187,500

**Answer: C**

Explanation:
The maximum amount of water allowed per flush under the Energy Policy Act of 1992 is 1.6 gpf. The water savings would therefore be:

$$Gallons\ saved = 300{,}000\ \text{gallons} - \left( \frac{300{,}000\ \text{gallons}}{3.5\ \frac{\text{gallons}}{\text{flush}}} \times 1.6\ \frac{\text{gallons}}{\text{flush}} \right) = 162{,}857$$

## Question: 13

The electrical rate structure for a company is:
Customer Charge = $25.00 per month
Electricity Charge = SO.032/kV,Q1
Fuel Charge = SO.027/k-11Ql
Demand Charge = $7.50/kW
Taxes = 5%
The peak demand at the company's facility is between 8 am and 9 am or 2 pm and 4 pm each day. If an energy efficiency measure is recommended that will reduce outdoor lighting by 5 kW from 6 pm to 6 am, what are the estimated potential cost savings each month (30 days)?

A. $22.30
B. $111.51
C. $150.89
D. $106.20

**Answer: B**

Explanation:
The energy savings are 5 kW x 12 hours/day X 30 days/month = 1,800 kl%/month. There are no demand savings because the demand is reduced at a time when the facility is not near its peak The cost savings are therefore 1,800 kWh/month x (SO.032 + $0.027)/kWh x 1.05 = SIII.51/month.

## Question: 14

Which of the following systems would be most suitable to have measurements taken with a bourdon gauge?

A. Lighting
B. Electrical supply
C. Building envelope
D. Boiler

**Answer: D**

Explanation:
A bourdon gauge is a mechanical pressure measurement device. They are often installed in boiler systems to measure the pressure in steam or hot water pipes.

## Question: 15

During a compressed air system audit, a pressure drop of 20 psi was observed over 15 minutes. The system operates at 110 psi and has a total volume of 400 cubic feet. Calculate the average leakage rate in the system.

A. 36 cfm
B. 40 cfm
C. 42 cfm
D. 46 cfm

**Answer: A**

Explanation:
The leakage rate in a compressed air system is given by:

$$Leakage\ Rate = \frac{V \times \Delta P}{t \times 14.7} = \frac{400 \times 20}{15 \times 14.7} = 36\ \text{cfm}$$

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