

Tutorial on Air Conditioning

All electrical appliances (TVs, refrigerators, light bulbs) that consume energy generate heat. The quantity of heat generated is approximately equal to the quantity of energy consumed. For example, a 100 watt light bulb that is on for 1 hour consumes 100 watt-hours of electricity and generates about 100 watt-hours of heat.

Normally, heat (which is just a form of energy) is not measured in watt-hours, but in units such as calories or joules or BTUs. The conversion from watt-hours is straightforward and is defined as:

$$1 \text{ watt-hour} = 3.41 \text{ BTUs}$$

(Note: watt-hours could also be expressed in calories or joules as 1 watt-hour = 860 calories or 1 watt-hour = 3600 joules, but we will use the units of BTUs)

[Refer to tutorial on Power & Energy to understand the difference between power (watts) and energy (watt-hours)].

Referring back to the 100 watt light bulb example, the heat generated is as follows:

$$\begin{aligned} \text{Heat generated} &= 100 \text{ watt-hours} \times 3.41 \text{ BTUs/watt-hour} \\ \text{Heat generated} &= 341 \text{ BTUs} \end{aligned}$$

The 341 BTUs of heat generated must be removed from the building to keep the temperature inside the building from rising. To give you a feel for how much heat 341 BTUs is, we refer back to the basic definition of a BTU. A BTU (British Thermal Unit) is the amount of energy (heat) required to raise the temperature of 1 pound of water 1 degree Fahrenheit. If a gallon of water weighs 7 pounds, then the heat generated from one 100 watt light bulb burning for 1 hour will raise the temperature of 1 gallon of water 48.7°F .

$$(1 \text{ gallon} \times 7 \text{ lbs/gallon} \times 48.7^\circ\text{F} \times 1 \text{ BTU/lb } ^\circ\text{F} = 341 \text{ BTUs}).$$

With the above as background, let's focus on the heat generated by a computer monitor and the requirements on the air conditioning system. A typical monitor uses approximately 1 amp of current, which at 120 volts is 120 watts of power. Assuming an installation of 100 PCs, we can calculate the heat generated each hour:

$$\begin{aligned}\text{Hourly Heat Generated} &= 100 \text{ PCs} \times 120 \text{ watt-hours/PC} \times \\ &\quad 3.41 \text{ BTUs/watt-hour} \\ \text{Hourly Heat Generated} &= 40,920 \text{ BTUs}\end{aligned}$$

Each hour the 100 PCs would generate 40,920 BTUs. Therefore, the air conditioner would have to provide 40,920 BTUs of cooling each hour to keep the inside temperature from rising.

Air conditioners are measured in "tons" of cooling where 1 ton equals 12,000 BTUs of cooling per hour. Therefore, the 100 PCs would require 3.4 tons of cooling. This is approximately the size of an air conditioner required for a 3000 square foot house—to cool the entire house!

As you can see, there is quite a bit of heat generated by the monitor. Multiply this by 10 or 20 for a 1000 or 2000 PC installation and you can see the load on the air conditioning system.

Air conditioning is not free—it uses electricity. To calculate the energy cost of air conditioning, the efficiency of the system needs to be known. System efficiency is known as the "K factor" and is a component in the Energy Analysis Program.

Before we calculate the energy cost of running an air conditioner, let's spend some time on what an air conditioner is. An air conditioner is basically a heat pump; it pumps heat from a cold region (the inside of the building that you are trying to keep cool) to a warm region (outside). Normally heat wants to move from warm regions to cold regions. To reverse this natural flow of heat, the air conditioner must pump the heat outside, which takes energy.

Old (inefficient) air conditioning systems would require about 1 BTU of energy to remove 1 BTU of heat. This is a performance factor of 1 (K = 1 in Energy Analysis Program).

High efficiency air conditioning systems may require as little as 0.33 BTUs of energy to remove 1 BTU of heat. This is a performance factor of 3 (K = 3 in Energy Analysis Program).

Typical air conditioning systems would require 0.5 BTUs of energy to remove 1 BTU of heat. This is a performance factor of 2 (K = 2 in Energy Analysis Program). If the customer is not sure of the K factor, use 2 because it is fairly typical of an air conditioning system in an office building. Using a K factor of 2, let's calculate the cost of running the air conditioning system for the 100 PC installation discussed above.

The 100 PCs generated 40,920 BTUs/hour. This can be converted back to watt-hours. This is the reverse of what was done to calculate the heat generated from the energy used by the PCs.

$$\text{Energy Required Per Day} = \frac{40,920 \text{ BTUs}}{\text{hour}} \times \frac{9 \text{ hours}}{\text{day}} \times \frac{1 \text{ watt-hour}}{3.41 \text{ BTUs}} \times K$$

$$\text{Energy Required Per Day} = 108,000 / 2 \text{ (K factor) watt-hours}$$

$$\text{Energy Required Per Day} = 54 \text{ kw hrs}$$

$$\text{Energy Cost Per Day} = 54 \text{ kw hrs} \times \$0.13/\text{kw hr}$$

$$\text{Energy Cost Per Day} = \$7$$

$$\text{Energy Cost Per Year Assuming 100 days of A/C per year (20 weeks)}$$

$$\text{Energy Cost Per Year} = \$700$$

$$\text{Energy Cost Per Year Per Monitor} = \$7$$

If the MonitorMiser Plus resulted in the monitor being on only 3 hours a day, vs the 9 hours a day used in the calculation above, then 2/3 of the energy costs of air conditioning could be saved (6 hours/9 hours). This means the MonitorMiser Plus could save \$4.60/year per monitor in energy cost just associated with air conditioning.

Likewise, some installations have thousands or tens of thousands of PCs. An installation of 10,000 PCs use over \$250,000 per year in air conditioning costs just associated with cooling the monitors.

The air conditioning cost savings associated with the MonitorMiser Plus can be significant, not to mention the fact that the work environment will be cooler and more comfortable in the summer months. And the positive impact on the environment is also significant and should not be overlooked.

Does your office get hot in the summer months? Not a bad sales question to ask!

The question might be asked... “What about the winter? Won’t the MonitorMiser Plus increase my heating costs in the winter months because the monitors are not generating heat?”. The answer is no!

The most inefficient way to generate heat is through electricity. By eliminating the heat generated by the monitors the building’s heating system will need to produce additional heat to maintain the temperature desired. However the heat generated by the building’s heating system is more energy efficient and less costly because it uses natural gas or heating oil, rather than electricity. Thus, even in winter the MonitorMiser Plus reduces energy costs. The energy savings generated by the MonitorMiser Plus in the winter months are not included in our Energy Analysis Program.