Heat in the building

Electrical equipment and appliances, from lighting systems and office equipment to motors and water heaters, produce useful services. But the electrical energy they use also appears as heat within the building, which can either be useful or detrimental to the building's heating, ventilating and air conditioning systems, depending on the season.

In cold weather, heat produced by the electrical equipment can help reduce the load on the building's heating system. In contrast, during warm weather, this heat adds to the building's air conditioning load.

Energy efficient equipment and appliances consume less energy to produce the same useful work, but they also produce less heat. As a result, efficient equipment increases the load on your heating systems in winter and reduces the load on your air conditioning systems in summer.

The impacts of energy efficient electrical equipment and appliances on the energy use for building heating and air conditioning systems are commonly called interactive effects or cross effects.

When considering the overall net savings of an energy efficient product it is very important to consider the interactive effects of the product on building heating, cooling and refrigeration systems. Weighing the interactive effects will result in better informed decisions and realistic expectations of savings.

The percentage of heat that is useful in your specific building or room will depend on several factors, including:

- The location of light fixtures
- The locations of heaters and their thermostats
- Type of ceiling
- Size of the building or room
- Whether the room is an interior space (no outside walls or ceiling) or an exterior space (perimeter of the building)
- The seasons when the building is used
- Type of heating, ventilation and air conditioning system used in each room

Please note that interactive effects are often quite complex and may require assessment by an experienced mechanical engineer or technologist.

Changing to energy efficient metal halide lighting fixtures in this curling rink saved electricity and reduced the amount of heat generated by the lighting. As a result, the saving gained from installing energy efficient lighting was (in part) offset by the additional heat required for the building.

Figure 8.1 - Curling rink using energy efficient lighting

Indoor lighting

Energy efficient lighting reduces system operating and maintenance costs. In addition, it improves lighting quality and increases lighting levels.

However, lighting systems also contribute to the space heating requirements of recreational facilities, which often operate almost entirely during winter.

Electrical energy is transformed initially by a light fixture into visual and infrared light and two types of heating energy (conducted and convective), which ultimately all becomes heat.

For example, 10 kilowatts of T-12 fluorescent luminaires (light fixtures) operating for 10 hours will transform 100 kWh of energy into:

- 42 kWh of heat transferred directly from the ballasts and lamps by convection to the surrounding air
- 36 kWh of infrared radiant energy which is absorbed by objects within view of the light fixtures, to be absorbed as heat, which is then transferred to the air by convection
- 22 kWh of visible lighting energy which is also absorbed by objects within view of the fixture and then transferred to the air by convection
- Ultimately all 100 kWh of electrical energy consumed by these light fixtures will appear as heat in the building

If the same amount of light can be produced by retrofitting to T-8 fluorescent luminaires that draw only 6.5 kW, then in 10 hours of operation, the new lighting fixtures will produce only 65 kWh of heat. If the building is heated, then the heaters may have to produce a large portion of the 35 kWh of lost heat to maintain the same level of heating in the building. On a winter's day, when heating is required, the net energy saving will be the cost of the heating source (likely natural gas) needed to replace the heat from the lights.

In this way, the energy you have saved by installing more efficient lighting will be offset by the additional heating required. Currently, natural gas heating for commercial facilities is one-quarter to one-third cheaper than electricity when using the balance rate of $0.05139/kWh.

The amount of electrical energy that is transformed directly into heat, infrared radiation, and visible light will be different for the various light sources commonly used. However, the result is the same: 100 per cent of the electricity used by the lighting system ultimately becomes heat. If you install energy efficient lighting that reduces the amount of heat during the heating season, much of the loss will have to be made up by the heating system in the building.

If the source of heating energy is less expensive than electrical radiant heating (typically geothermal heat pump or natural gas are cheaper, depending on utility rates and furnace efficiency) the incremental cost difference of the two heat sources will be saved. If it is more expensive (typically oil or propane cost more) the incremental cost difference of the two heat sources will be lost. If it is the same (electricity) you will break even.

When the lighting system operates in the spring and fall and neither heating nor air conditioning is needed, the net energy savings will be the same as the lighting system savings. When the lighting system operates in summer while air conditioning is required, an additional 33 to 40 per cent for air conditioning savings can be added to the lighting energy savings.

Figure 8.2 - Heat from arena luminaires

In a hockey arena, because the lighting is generally mounted above and away from the heaters and their thermostats, it is difficult to predict how much heat from the light is useful in space heating.

In a hockey arena, most of the luminaires are usually mounted high over the rink surface, while the heaters and their thermostats are at a lower level over the spectator stands, (Figure 8.2). With this configuration, the heat transferred by convection directly off the luminaires is so high up that it is not of direct use to the area where the heaters are in the stands. However, some of the air heated by the luminaires will mix within the building air and be of some use. The exact portion of heat that will be useful as space heating is difficult, if not impossible, to predict.

In a curling rink, luminaires are usually mounted in close proximity to the heaters and thermostats, with a much lower ceiling height and within the heated space of the curlers. Under this configuration, very close to 100 per cent of the lighting heat will be useful. Any loss of this heat will have to be made up by the heating system.

Outdoor or indoor lighting in unheated areas

Lighting outdoors or in unheated indoor areas such as hockey rinks is not affected by interactive heating effects. Net overall savings will be the same as the energy savings calculated for retrofitting to energy efficient lighting.

In unheated rinks where several kilowatts of incandescent lamps have been converted to much more efficient metal halide fixtures, the switch will yield significant energy and demand savings. However, the loss of waste heat from the inefficient incandescent lamps has also resulted in slightly cooler air temperatures in the rinks.

Ice plants

You can take advantage of interactive effects to lower the cost of operating your ice plant.

For example, a 20 hp brine pump draws about 15 kW. About 10 per cent (1.5 kW) comes off the motor as heat in the motor room. The remaining 90 per cent (13.5 kW) appears as heat in the circulating brine solution. Reducing the run time of the brine pump saves energy and money in two ways:

- It lowers the cost of operating the brine pump
- It cuts back on the operation of the ice plant which needs to cool less brine, resulting in 33 to 40 per cent in additional savings