Chapter 8 Cooling

This chapter contains a mixture of information about the building shell, landscaping, windows, and mechanical cooling systems. This mixture of topics is necessary to develop an energy-efficient cooling strategy.

How Cooling is Different than Heating

Cooling is the most variable type of energy consumption in American homes. Two similar homes in the same neighborhood could differ by a factor of 50 for cooling costs. For example, an inefficient home with air conditioning could use $500 worth of electricity in a hot month, while a neighbor in a well-designed home—with no mechanical air conditioning—might spend only $10 per month on electricity to operate room fans and evaporative coolers.

The most effective strategies for improving cooling efficiency are different from the strategies to improve heating efficiency. For example:

- Shade trees and nighttime ventilation will reduce the need for air conditioning, but they won't reduce heating consumption.
- Window glass with a low solar heat gain coefficient (SHGC) will reduce cooling load, but heating efficiency is improved by windows with a low U-factor.
- Low humidity helps reduce cooling energy consumption but not heating consumption.

A home's cooling energy consumption depends on its shading, insulation, reflectivity, and the heat-tolerance of its residents. Shading the home, making it as reflective as possible, and using nighttime ventilation can reduce air-conditioning costs or eliminate the need for air conditioning altogether.

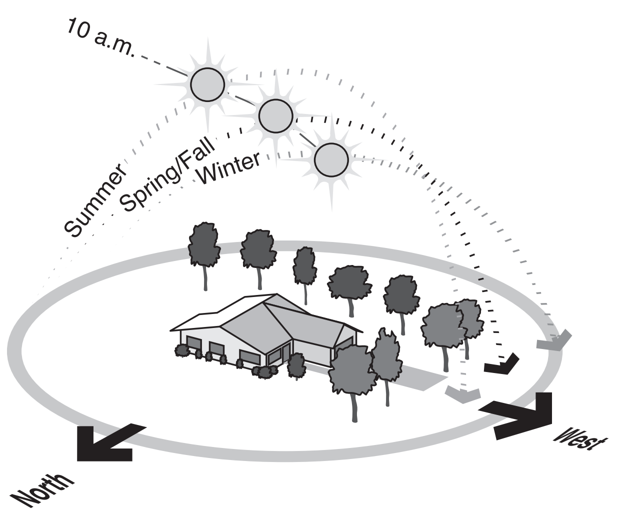
See "Analyzing Annual Energy Costs" on page 277 and "Annual Average Household Energy Cost by Region (1997)" on page 14 for information on cooling energy consumption.

Annual Air-Conditioning Energy Use (kWh/yr)

Region & A/C Type	Single Family	Multi-family	Mobile Home
North	**kWh/yr**	**kWh/yr**	**kWh/yr**
Room	200–500	100–300	300–600
Central	900–1400	400–600	1200–1800
South	**kWh/yr**	**kWh/yr**	**kWh/yr**
Room	1100–1500	300–600	1000–1400
Central	3000–4600	1000–1600	2600–3400

From: Lawrence Berkeley National Laboratory, Energy Information Administration, and utility sources. For U.S, households.

Solar Radiation: Winter and Summer



The angle of impact of the sun's rays on the earth changes between seasons. The changes become more extreme farther away from the equator.

Summer Comfort Principles

The combination of air temperature, radiant temperature, humidity, and air movement determine comfort. Air temperature and radiant temperature determine the rate that a human body can lose heat by convection and radiation, which are the body's preferred cooling mechanisms. The relative humidity determines the rate that a human body can reject heat by evaporation of sweat, the body's last-resort cooling system.

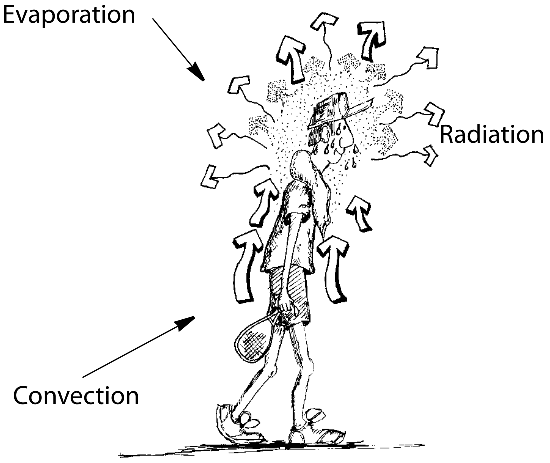
Air temperature and radiant temperature have a combined effect on human comfort. Air temperature is widely recognized as a comfort determinant, but radiant temperature is equally important. Absorbed summer sunlight raises wall and ceiling temperatures, making these surfaces radiant heaters.

Relative humidity is the percent at which air at any temperature is saturated with water vapor. Air at 100% relative humidity is saturated and can hold no more water vapor. Dew point is the temperature at which condensation begins. At 100% relative humidity the dew point is the same as the air temperature. Below 100% relative humidity, the dew point is less than the air temperature.

Humidity affects the choice of a cooling strategy during hot weather. At low relative humidity and low dew point, evaporative cooling and ventilation are effective cooling methods. Ventilation works well up to about 70% relative humidity (or a dew point in the high 60°s). Most Americans use air conditioning during hot weather—when the dew point is above 68°F or when the relative humidity outdoors is over 70%.

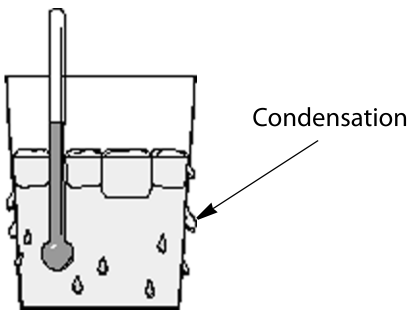
At 70% relative humidity or above, the air feels either hot and sticky, or cold and clammy, and is not comfortable to most people. Air conditioners must remove moisture from indoor air to achieve comfort.

Convection, Radiation, and Evaporation



The human body loses heat steadily by convection, radiation, and evaporation. Summer comfort is often defined as staying cool with a minimum of sweat.

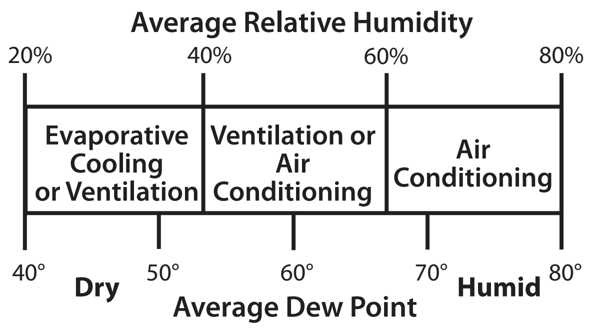
Dew Point



Fill a beverage glass with warm water. Then slowly add ice. When condensation begins to appear, the temperature of the glass has reached the dew point temperature of the air.

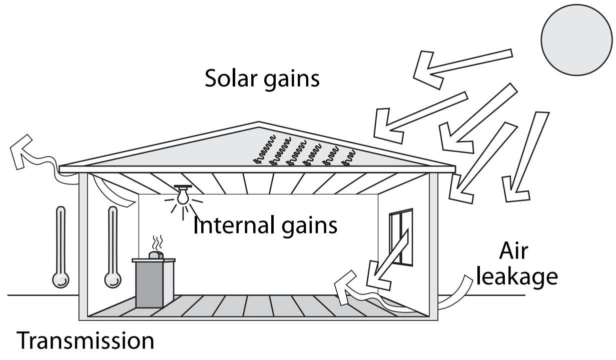
Moving air always makes you feel cooler, because it carries heat away from the skin and increases the evaporation of sweat. Circulating air inside your home is the key element to staying comfortable during hot weather. Rapidly moving air works well by itself, and can be combined with air conditioners, evaporative coolers, and whole-house fans to further improve comfort.

Humidity's Effect on Cooling Strategies



Dew point and relative humidity are two commonly reported indicators of summer humidity. The higher these values are, the more difficult it becomes to provide acceptable comfort without air conditioning.

Four Types of Heat Gains



Solar gain is the dominant heat gain. Air leakage and internal gains are about equally important. Transmission heat gains are usually least important.

Whenever the outdoor air temperature and humidity are comfortable, ventilating with outdoor air will carry heat away from the home and reduce air-conditioning costs.

See "Energy, Comfort, Climate" on page 38 for more information on human comfort.

Heat Gain

During the cooling season, unwanted indoor heat is called *heat gain*. There are four types of heat gain in the home: solar heat, internal heat, air leakage, and temperature-driven heat transmission.

Solar Gain — In most climates, solar heat is the largest heat gain, contributing about 50% of the heat accumulating indoors. Solar energy falling on the roof and coming through the windows accounts for most of this. Walls are less important as a source of solar heat.

Internal Gains — Internal gains include the waste heat from lighting, refrigeration, water heating, and other appliances, as well as the body heat from people inside the home. Efficient appliances produce less waste heat, and so contribute less to summer overheating. Internal gains usually account for around 20% of summer heat gain.

Air Leakage — Air leakage allows hot outdoor air to leak into the home, and cold indoor air to leave. Air sealing helps reduce both summer heat gain and winter heat loss. Air leakage contributes about 20% to summer heat gain.

Heat transmission — Heat transmission through the shell of the home is the least important summer heat gain because the temperature difference between indoors and outdoors is much smaller in summer than in winter. Heat transmission typically represents around 10% of the total cooling load.

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