Problems and Solutions in Home Cooling

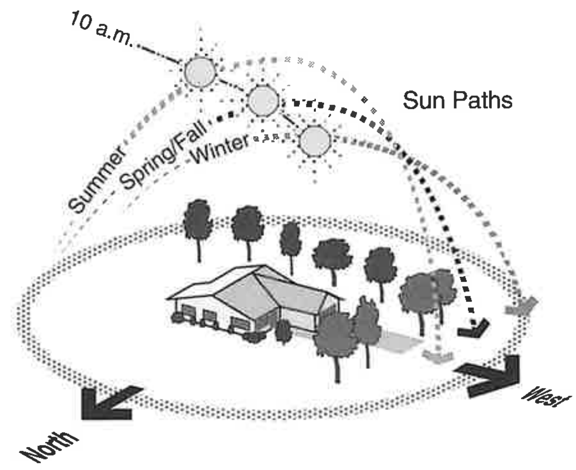
The cooling problems discussed in the book are listed here with page numbers and section where you can find information. We define a problem as a weakness that will cause cooling costs to be higher than necessary. Does your home have any of these problems?

Problem	Suggested Solution	Section & Page #s
Lack of shade	Use all cost-effective shading options including plants, and exterior or interior window shading	2.4.4 to 2.4.7 p. 14–21
Lack of air circulation within the home	Employ ceiling fans and oscillating fans to increase air speed	3.1 and 3.6 p. 23, 31
Failure to use ventilation where it is appropriate	Use ventilation whenever outdoor temperature and humidity permit; employ fans to optimize ventilation	3.1 to 3.5 p. 23–31
Excessive air leakage	Seal air leaks, after measurements of leakage are performed	2.3 p. 8-10
Dark wall and roof color	Lighten roof and wall color to bright white or the lightest acceptable alternative	2.4.1 p. 11-12
Inadequate maintenance of air conditioners or evaporative coolers	Perform necessary maintenance procedures	4.4 to 4.4.5 p. 50–56
Leaky ductwork in central air conditioning system	Seal leaks in ductwork yourself or hire a technician to do it	4.5.2 p. 57,58
Incorrect refrigerant charge and/or low air flow	Hire a qualified technician to measure charge and airflow and to take appropriate action	4.4.5 p. 54
Ductwork runs in unconditioned area	Insulate ductwork yourself or hire technician to insulate ducts	4.5.3 p. 58–60

1.1 Introduction

This section introduces basic cooling principles related to heat, humidity, comfort, and climate. Learning these principles enables you to apply the specific information found in Sections 2, 3, and 4. You can make practical improvements to reduce cooling costs and increase comfort levels during hot weather.

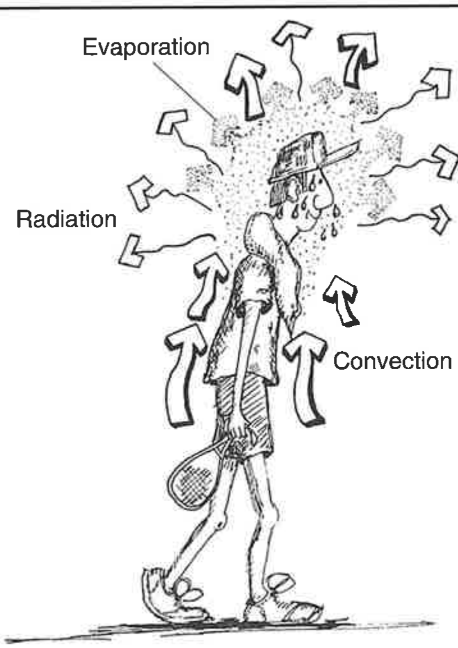
The sun heats the earth, atmosphere, and your home with its rays. In summer, the earth tilts more toward the sun—therefore, the sun rises higher in the sky and stays there longer than in the other seasons (*see figure* **1-1**). The summer abundance of solar energy causes heat to accumulate in your home.



1-1 Sun Trajectories *- Winter weather is cool because the sun's rays come from the south at a low, less direct angle. Summer weather is warmer because the sun is higher in the sky, and its rays strike the earth more directly.*

1.2 Cooling Your Body

Your body constantly produces and releases heat to remain at 98.6°F. Many factors combine to create a feeling of comfort. Air temperature and humidity are the most important. Air movement, sunshine, clothing, activity level, and the temperature of the surfaces around you also influence how comfortable you feel.



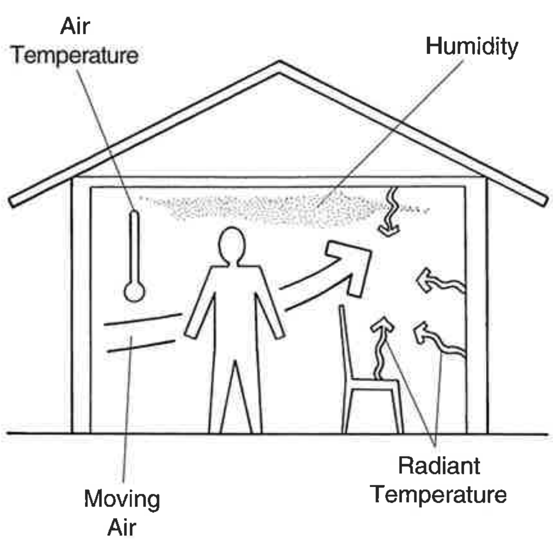
1-2 Cooling Your Body *- Your body cools itself through convection, evaporation, and radiation.*

Body heat is released in three ways: convection, evaporation, and radiation (*see figure* **1-2**). When the air temperature is less than skin temperature (about 92°F), the air absorbs heat from the skin and rises, taking the heat away. This is called convection. As the warmed air rises, cooler air moves in and absorbs more heat from the skin, and the process continues.The faster the air movement, the faster it carries heat away.

Sweating is a very important way to release body heat. Perspiration evaporates and takes excess body heat with it into the air. The rate at which perspiration evaporates from our skin depends on the relative humidity of the air. The less humid the air around us, the more we can cool our bodies by sweating. Humid air reduces evaporation and carries more heat than dry air at the same temperature, which makes it more difficult for our bodies to stay cool. Moving air increases the evaporation of sweat.

In calm air above 92°F with 100 percent relative humidity, the body has great difficulty releasing its excess heat into the environment and can overheat (*see Appendix E, Heat Ailments*). At a comfortable temperature of 75°F with 50 percent relative humidity, the body releases about 20 percent of its excess heat by evaporation and then releases the remainder by convection and radiation. However, when the air temperature rises to 90°F with 50 percent relative humidity, evaporation is responsible for 80 percent of the heat loss from your body.

Your body radiates heat to surrounding objects and objects radiate heat toward you. Heat rays form at the surface of your skin and fly off through the air until they strike another solid object, which either absorbs or reflects the rays. In the same way, heat rays from other objects strike us and we can absorb them to heat our bodies. A block of ice feels cold to us, even at a distance, because we radiate heat to the ice, but it radiates almost none back. A roaring fire feels hot because it radiates more heat than we do.



1-3 What Determines Comfort? *- Comfort is determined by four interrelated factors: air temperature, humidity, radiant temperature, and air movement.*

The temperature of the walls, ceiling, and other objects in our homes (called "radiant temperature") determines if we can cool our bodies by radiation or if our hot surroundings will, instead, heat us. Cooling by radiation can account for up to 50 percent of the body's heat loss under optimum radiant temperatures.

The tolerance of different individuals to heat and humidity varies widely. Healthy people who work or exercise outdoors, regardless of temperature, usually have the best resistance to heat. Reducing caloric intake, wearing loose, lightweight clothing, and exposing plenty of skin indoors helps the body feel comfortable in the heat.

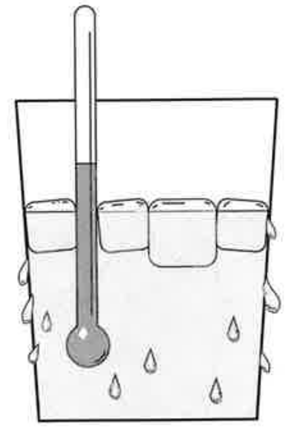
1.3 Elements of a Comfortable Environment

Air temperature, humidity, air movement, and the temperature of the surfaces around us all influence comfort (*see figure* **1-3**). Air temperature and humidity determine how much heat the air can hold. The higher the air temperature and the higher the humidity, the more heat the air can store. The more heat the air contains, the more difficult it is for the human body to release heat. Therefore, it is harder for our bodies to stay cool in a hot, humid climate than in a hot, dry climate.

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.

Ventilating with outdoor air carries heat away from the home and reduces air conditioning costs whenever the outdoor air temperature and humidity are comfortable.

High outdoor temperatures and absorbed sunlight heat the walls and ceilings of a home. These surfaces then become radiant heaters and the air temperature in the home rises. The higher the indoor air temperature and relative humidity, the more discomfort and desire for mechanical cooling.

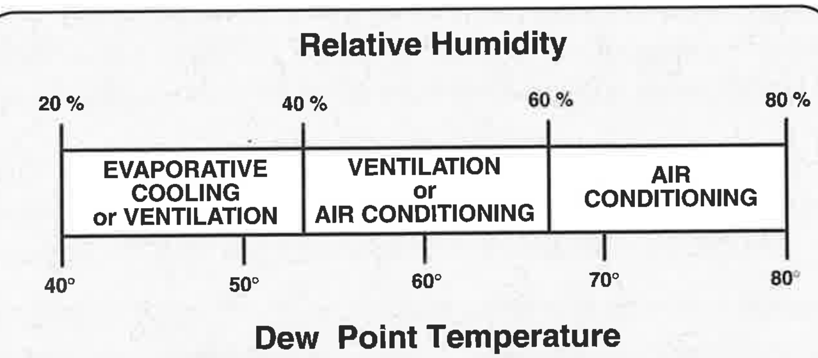


***1-4 Dew Point** - Fill a beverage glass with warm water. Then slowly add ice. When condensation begins to appear, the temperature of the glass has reached the dew point of the air.*

Humidity is very important to comfort. Humidity is measured by either relative humidity or dew point. Dew point is the highest temperature of an object on which water from the surrounding air will condense (change from a gas to a liquid). Dew point is the temperature in a mixture of air and water vapor at which condensation begins (*see figure* **1-4**).

Figure **1-5** demonstrates how humidity affects your choice of a cooling strategy during hot weather. At low relative humidity and low dew point, evaporative cooling and ventilation are good cooling methods. Ventilation works well up to about 70 percent relative humidity (or a dew point in the high 60°s). People want air conditioning during hot weather to achieve modern standards of comfort when the dew point is above 68°F or when the relative humidity is over 70 percent.

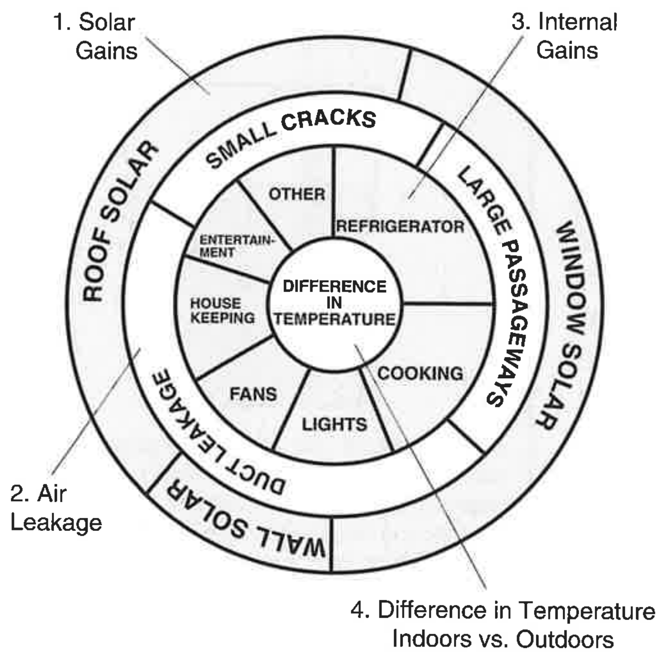
At 100 percent relative humidity, the air is saturated and can hold no more moisture. At 70 percent relative humidity or above, the air feels either hot and sticky, or cold and clammy, and is not comfortable to most people.



***1-5 Humidity and Cooling Methods** - In hot, dry weather, evaporative coolers reduce the temperature of the air by adding moisture. In warm and moderately humid weather, ventilation can effectively remove solar gains and internal gains to cool the home. In hot and humid weather, air conditioning is required for modern standards of indoor comfort.*

1.4 Heat Gain, Climate, and Cost

Absorbed sunlight, heat generated inside the home, high humidity, high outdoor temperatures, and air leakage make homes uncomfortably hot and necessitate using various cooling strategies. Solar gain through windows accounts for 15 to 20 percent of



***1-6 Heat Gains** - Unwanted heat comes from four sources as shown here. The amount of area on the circle that a source occupies is proportional to the amount of heat it adds to an average home.*

cooling costs. Solar gain through the roof and walls accounts for another 20 to 30 percent. Air leakage varies widely and accounts for 5 to 30 percent of the cooling costs, depending on the amount of air leakage, the outdoor temperature, and relative humidity. Another 15 to 25 percent of the cost comes from internal gains caused by bathing, cooking, and operating electric appliances. Heat conduction through the walls and roof due to temperature differences between indoor air and outdoor air is a modest 5 to 15 percent of cooling costs (*see figure* **1-6**).

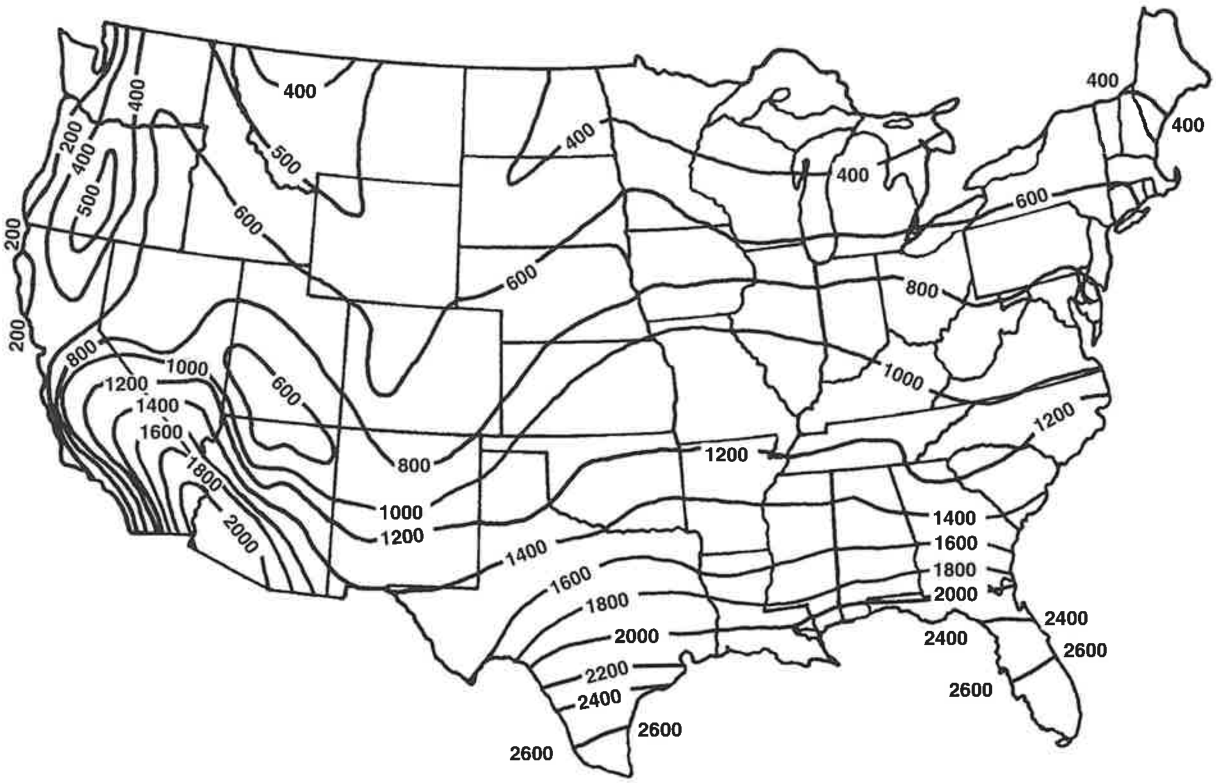
The most cost-effective cooling strategies are those which prevent heat from building up in your home. These strategies include: shading windows, roofs and walls; using light-colored roofs and walls; removing hot air with fans; and circulating indoor air with fans, creating a wind-chill effect. Shade is the most important cooling strategy in a hot, sunny climate.

Internal gains are a big factor in all cooling efforts, but are more of a problem in humid climates. The extra humidity added by showers and cooking must often be removed by the air conditioner.

Table **1-A** shows the number of watts of electric power drawn by the mechanical cooling devices discussed in this guide, and their hourly cost of operation. As you can see, the most expensive cooling method is air conditioning. The more you reduce heat gain and use low cost

Cooling Device	Watts	Cost/Hour
Central Air Conditioning	2000-5000	16¢-52¢
Room Air Conditioner	500-3000	4¢-24¢
Evaporative Cooler	400-1800	3¢-15¢
Whole-House Fan	300-600	2¢-5¢
Circulating/Exhaust Fan	25-200	0.2¢-1.6¢

***Table 1-A - Wattage and Hourly Cost for Cooling Devices** - The ranges of watts and cost represent the different sizes of the cooling devices. The hourly cost assumes 8¢ per kilowatt-hour.*



1-7 ***Cooling Hours Map*** *- This map shows the number of hours per year when the temperature and humidity outdoors are uncomfortably high, leading to a build-up of heat indoors. (Courtesy of The Air Conditioning and Refrigeration Institute)*

alternatives to air conditioning, the lower your cooling costs will be.

Flaws in the original installation and neglect of routine maintenance are common air conditioning problems. These problems can waste 30 percent or more of the electricity used for cooling. Your summer thermostat setting determines cooling costs. The thermostat setting can make a difference of 2 to 4 percent of your total cooling costs per degree.

The differences between cooling costs in different parts of the United States relate to the relative humidity, the amount of sunshine, and the average outdoor temperature. Solar heat gain is a more important factor in sunny climates than in wetter, cloudier climates. Air leakage is more important in humid climates than it is in drier climates. In climates that are both humid and very sunny, minimize cooling costs by employing all the shading strategies and by making sure your home is reasonably airtight.

The Air Conditioning and Refrigeration Institute (ARI) estimates the average number of hours that people use air conditioners to maintain comfort in different U. S. climates. Figure **1-7** shows the continental United States with these "cooling hours" shown as lines on the map. ARI publishes a method for estimating cooling costs: multiply the number of cooling hours by the number of watts drawn by the air conditioner; then multiply by the cost per kilowatt hour.

Hours x Watts x $/kWh = Cost

Use Table **1-A** with figure **1-7** to roughly estimate the yearly costs of the cooling devices discussed in this guide. Appendix D, Regional Cooling Solutions, discusses the differences in strategies for different climatic regions of the country.

1.5 Cooling Cost and Investment in Energy Savings

You can figure your monthly or yearly cooling costs by estimating how much extra electricity you buy when turning on your air conditioner. Table **1-B** demonstrates home electricity costs and illustrates how to record your cooling costs. First, estimate the basic monthly cost of operating lights and appliances (from energy bills for months using no electric heating or cooling). Subtract that lighting and appliance cost from each cooling month's electricity cost. This figure provides the monthly air conditioning cost (last column in the example). Total all the monthly air conditioning costs.

Month	kwh	$ Electrical		$ Appliance		$ Cooling
April	275	22	-	22	=	$ 0
May	1188	95	-	22	=	73
June	2075	166	-	22	=	144
July	2650	212	-	22	=	190
Aug.	1938	155	-	22	=	133
Sept.	1226	98	-	22	=	76
Oct.	700	56	-	22	=	34
Nov.	274	22	-	22	=	0
Total Cooling Costs						**$650**

Table 1-B *- Shows monthly kilowatt hour consumption and cost for an example discussed in the text. The cost of appliance use is subtracted from each monthly total to get monthly cooling costs which are added together to arrive at total yearly cooling cost. You can make a table like this one to determine the yearly cooling cost for your home.*

This yearly cooling cost allows you to estimate possible yearly savings from various cooling energy saving measures. For example, if a group of improvements will save 20 percent, and you spend $650 a year for air conditioning, then you will save 20% x $650 = $130 each year.

If you made an investment of $520 in improvements and they will save $130 per year, your initial investment will be repaid completely in 4 years ($520 ÷ $130/year). If you think of it like an investment in stocks or bonds: dividing the $130 yearly savings by the larger initial investment figure of $520 gives you annual return on investment of 25 percent ($130 ÷ $520). A very good investment!

$ Initial Investment ÷ $ Yearly Savings = Payback Period (years)

$ Yearly Savings ÷ $ Investment = Yearly Return (%)