People, Energy, and Light

Understanding a few basics about people, energy, and light will help you light homes usefully, efficiently, and attractively. Read this chapter before you use the rest of the book, and refer back to it; refer to the Glossary for definitions of the italicized terms in this chapter.

People

Light enables us to see. When light enters our eyes, it excites microscopic structures at the back of our eyes. These structures, known as rods and cones, send messages to our brains. The messages form our perceptions of the objects and phenomena around us. These perceptions include *color*, *brightness*, and *contrast*. Light can enter our eyes in a direct path from a light source, or it can enter our eyes after it bounces off surfaces. When light shines on an opaque object, some of it is absorbed by the object, and some of it is reflected; we see the part that is reflected. Likewise, our perception of the color of objects is determined by the light reflected from them.

Contrast helps us distinguish shapes, edges, and details on the surface of objects. Contrast is the ratio of the brightness of one area to the brightness of adjacent areas. This page has high contrast between the black letters and the white area around them. In most circumstances, the more contrast that a shape, edge, or detail has, the better we can see it.

Of course, the ability to see depends not only on the light that is available in homes, but also on the visual abilities of the residents. Each person's eyes may differ: normally we all see best as young adults and experience a decline in our ability to see as we age. The older we are, the more light we need to see things as well as we did when we were young. Many people have visual disabilities; they need to be considered when designing and selecting lighting.

As we go through the cycle of each day, and as we move from one space to another, we experience both bright and dark spaces. Our eyes have a marvelous capacity to adjust to different levels of light; this is called adaptation. Everyone at times has been jolted awake from the darkness of sleep by a bright light: for a short period, we cannot see well and must squint. Quickly, though, our eyes adapt. Stepping into a dark staircase from a sunny hallway, we may need to pause a moment before our eyes are able to discern the steps. We can, eventually, see in very dim conditions, but not in complete darkness. A dim night light can help us navigate through the clutter in a child's room, or guide us to the bathroom; it provides enough light for orientation, but not enough for us to see details or to read.

Color, brightness and contrast perception, visual ability, age, and adaptation are all *human factors* that we need to consider when lighting homes. We also need to be sensitive to residents' beliefs, preferences, and behaviors regarding lighting. People's beliefs may guide their preferences and behaviors, even if the beliefs are not based in fact. Negative beliefs about lighting can thwart efforts to encourage efficient lighting in homes. This book attempts to show how we can use light efficiently while allowing people to see and to be comfortable. The following chapters note the disadvantages as well as the advantages of various lighting technologies and designs to help people avoid the problems that can give rise to negative experiences and beliefs. Also, a wide variety of designs is offered in hopes that many aesthetic preferences can be met.

No one knows the diversity of lighting beliefs and preferences better than those who help people choose lighting for their homes. Selecting technologies and using them effectively is a true challenge. Consider all the professionals that can be involved in lighting homes: architects, builders, contractors, distributors, electricians, facility managers, interior designers, lighting designers, salespersons, and utility representatives. Also consider all the places and occasions that people can buy lighting technologies—from the common "light bulb" picked up at the grocery store to the once-in-a-lifetime purchase of a crystal chandelier, lighting a home is not a straightforward activity.

Other complicating factors in lighting a home are electricity, safety, and the need for a qualified professional to install most luminaires and controls. People must seriously weigh the costs and hassles of changing a lighting design in their home. Thus it is important to make careful choices that provide flexible and long-lasting lighting installations, whether replacing luminaires, remodeling, or building a new home. When remodeling and building anew, state and local building codes must be followed, especially for multi-family housing. Some codes contain articles that specify types of lighting technologies, or levels of light for certain areas. For instance, kitchens in California homes must contain at least one luminaire that operates a fluorescent lamp.

The activities and behaviors of residents have an impact on lighting homes, too. People need to conduct many more types of activities at home than they do in other places, particularly workplaces. The homes that are covered in this book are modest, and each room may have to serve several functions. For example, the kitchen is used for preparing food, eating, and socializing, but it may also be used for reading, writing, and hobbies. The lighting techniques that are used must satisfy these and other needs.

Intuitively, we expect that the more a room is used, the more the lighting in that room will be used. Thus the number of hours per day that the lights are on in the kitchen will probably exceed the number of hours that the lights are used in the bedrooms. The Economics chapter gives more information on this topic. Of course, we all know that the lights stay on unless they are turned off, and we know that people may forget to turn off lights when they are not needed. Energy-conserving habits should include using daylight when it is available, dimming lights if lower light outputs are acceptable, and turning off lights whenever they are not needed. In some areas of the home, automatic controls can supplement or substitute for manual controls. Making lighting controls easily accessible enables residents to make the best use of a lighting design.

Energy

Understanding a bit about energy will help you fully take advantage of today's lighting technologies. This book deals with light that is created and controlled by means of the electricity that is supplied by a utility company to the home. Knowing that most electricity is generated and transmitted at a cost to ourselves and our environment can inspire residents to want to save electricity. Additionally, many organizations, including the United States Environmental Protection Agency, environmental groups, affordable housing advocates, and utility companies, conduct programs that are intended to reduce residential demand for electricity.

Most people understand that appliances consume electricity, but they may not realize that the *lamps* (bulbs) and *luminaires* (fixtures) scattered throughout their homes are appliances, too. In fact, it would be best to think of lamps and luminaires all together as one appliance, because lighting accounts for 6 to 20 percent of the electricity consumed in homes. When people choose a refrigerator or dishwasher, they are likely to seek information on the label that will tell them how much it will cost to operate the appliance each year. They may also be willing to pay more for a more efficient appliance, because they will recover the added expense in a few months or years. It is far more difficult to calculate efficiency and savings for lighting, because there are many types of lighting technologies used throughout the home. Nevertheless, such calculations can be done, and the Economics chapter provides a helpful worksheet. To satisfy consumers' demands for information and to comply with new United States federal legislation, manufacturers of lamps soon will be listing more details about energy and light quality on packaging. Some independent groups are also encouraging manufacturers to provide more information, and are offering "seals of approval" to help consumers choose environmentally acceptable products.

Before using the worksheet, though, note that the *power* that is used to create light in the home is measured in a unit called the *watt*. One thousand watts equals one *kilowatt*. Lamps operate with a specific range of watts; the maximum watts in the range is used to label the *wattage* of the lamp. For example, common incandescent A-lamps (light bulbs) are available in a variety of wattages, including 40-watt, 60-watt, 75-watt, and 100-watt. *Ballasts* and some *controls* also consume power.

The amount of electric energy supplied to a lighting technology to operate it over time is measured in *watt-hours*. It is the result of multiplying *input power*, measured in watts, by time, measured in hours. Utility companies bill residential customers for the number of *kilowatt-hours* (kWh) they use. For example, ten 100-watt lamps operated for 1 hour would use 1 kilowatt-hour of energy (10 lamps × 100 watts × 1 hour = 1 kWh). Thus energy used for lighting can be saved either by reducing the amount of power required for lighting or by reducing the amount of time that the lighting is used. The cost per kilowatt-hour varies considerably in North America: some customers pay as little as $0.03 per kilowatt-hour while others pay as much as $0.18 per kilowatt-hour.

The amount of light that is produced by a lamp, or its *light output*, is measured in *lumens*. The *efficacy* of a lamp is the ratio of lumens produced to watts consumed. This *lumen-per-watt* (LPW) ratio is similar to the miles-per-gallon ratio used for automobiles, in that a higher ratio indicates a more efficacious lamp. The lumen-per-watt ratio is an important factor for selecting lamps. The Lamps and Economics chapters contain tables that list light output and wattage for lamps commonly used in homes. As a result of the Energy Policy Act of 1992, several types of lamps, including some cool white fluorescent lamps and reflector lamps, will soon be phased out of the market in the United States due to their low efficacies. Other, higher-efficacy lamps exist that can be used to replace these low-efficacy lamps.

Efficacy is used to rate lamps; *efficiency* is the measure used for luminaires. Efficiency expresses the light output from a luminaire as a percentage of the light output from the lamps. For example, if a luminaire contains one fluorescent lamp that emits 1000 lumens, and the luminaire in turn emits 900 lumens, then the luminaire has an efficiency of 90 percent. Choose luminaires with high efficiencies to make the best use of energy.

Some lighting technologies, particularly lamps that require electronic ballasts, do more than consume power: they can also affect the *power quality* in a home. Power quality refers to the characteristics of the current and voltage supplied to electrical equipment. Poor power quality can cause inefficient operation of the utility company's equipment and may also interfere with other electrical equipment in the home. Potential problems with certain technologies are noted in the text that describes the technology, and in the captions in the Designs chapter. Also, a more detailed explanation of lighting and power quality is given in the Appendix.

Light

Light is a form of energy that stimulates our eyes. Light has several characteristics that can be measured. These characteristics are not well understood by many people, and the vocabulary used to describe them is rather technical. Nevertheless, familiarity with these characteristics is essential to creating successful and efficient lighting designs.

As noted previously, the amount of light emitted by a lamp is measured in lumens. In homes, this light output is important because it illuminates our surroundings. When the light emitted by a lamp falls on a surface, it is best referred to as *illuminance,* although it is sometimes called light level. Illuminance is measured in units called *footcandles* (lumens per square foot) or *lux* (lumens per square meter). Generally, casual activities require approximately 20 footcandles; more visually demanding activities such as preparing food or reading require approximately 50 footcandles; and difficult-to-see tasks like sewing require approximately 150 footcandles. These recommended illuminances vary based on the age of the person performing the work, the size and contrast of the task materials, and the speed and accuracy with which the work must be performed. The designs should provide enough light for the tasks that typically are conducted in each room. If more precision is required when designing a lighting system, consult the Illuminating Engineering Society of North America's *Lighting Handbook.*

Another characteristic of light that is helpful to understand is *distribution.* Distribution includes both the direction in which the light moves, and the amount, or intensity of light that moves in a particular direction. For example, think of the beam of light emitted by an automobile headlight. The luminaire directs most of the light forward, in a narrow beam. This *light distribution pattern* differs from that created by the small luminaire inside the automobile, above the passengers. Inside, the luminaire has a very diffuse and broad light distribution pattern. Choose technologies that distribute light to the area where it is most needed. If light is distributed to an area where it is not needed, it is wasted, and the design is not efficient. The Lamps and Luminaires chapters give specific information on light distribution for each of the technologies.

The most frequently mentioned characteristic of light in homes is color. When people talk about light that is "like daylight," they usually have the yellowish, or "sunny" color of light from incandescent lamps in mind. Yet consider the wide range of colors of daylight: a cloudy day has a grey-blue color; sunsets are orange, red, and purple. As the hours pass in the day, the color of light changes, too. Even so, incandescent lamps emit the most familiar color of light in homes. One of the purposes of this book is to persuade people that incandescent lamps are not the only option for lighting homes; in fact, fluorescent lamps can produce a wide range of colors of light that are suitable for people, their furnishings, and the architecture of the home.

Color is characterized in two ways: by its color temperature and by its ability to render colors. *Correlated color temperature* (CCT) describes the color appearance of the light in terms of its perceived warmth or coolness. If "pure white" is considered to be neutral, then a "yellow white" is warm and a "blue white" is cool. Correlated color temperature is measured on the Kelvin scale. A low correlated color temperature, less than 3100 K, identifies a warm white light, such as that emitted by an incandescent lamp. A high correlated color temperature, more than 4000 K, identifies a cool white light, such as that produced by an overcast sky.

The *color rendering index* (CRI) measures the effect of light on the perceived color of objects. To determine the color rendering index, the color appearances of eight standard color chips are measured with special equipment under a reference light source with the same correlated color temperature as the lamp being evaluated. Then the eight color chips are measured under the lamp being evaluated. If these colors are exactly like those measured under the reference source, the rated color rendering index for the lamp is 100. If the measured color of the eight standard chips shifts from the reference condition, the color rendering index is less than 100.

A low color rendering index indicates that some colors may appear unnatural when illuminated by the lamp. Incandescent lamps render color like the reference source does so they typically have color rendering indices of 95 to 100. Cool white fluorescent lamps have a color rendering index of 62; premium fluorescent lamps are available with color rendering indexes of 80 and above. Both the correlated color temperature and the color rendering index of each lamp are given in the Lamps and Economics chapters.

In the Designs chapter, the alternatives to typical lighting designs incorporate the basic principles described in this chapter. Each design considers people and their activities in a particular room of the home, offers ways to use lighting energy responsibly, and maximizes the quality of light that is available from a variety of technologies.