APPENDIX A
Lighting background information

Lighting functions

It is important to assess the function for which lighting is needed when considering options for efficiency improvements. Lighting functions include:

- Ambient lighting provides general illumination indoors for daily activities, and outdoors for safety and security.
- Task lighting facilitates particular tasks that require more light than is needed for general illumination, for example, desk lamps.
- Accent lighting draws attention to special features or enhances the aesthetic qualities of an indoor or outdoor environment, such as lights in lobbies and conference rooms.

Matching the amount and quality of lighting to the needed function is a key strategy to improving overall lighting environment and efficiency in any space. For example, using task lighting to reduce ambient lighting may not only reduce energy demand, but will also allow for greater flexibility and higher quality working conditions.

Light sources

Within the lighting industry, electric light sources are referred to as lamps, which include bulbs and tubes. Common light sources include:

- Incandescent: Incandescent lamps are one of the oldest electric lighting technologies available. Incandescent bulbs produce light by passing a current through a filament, causing it to become hot and glow (also releasing waste heat).
- Tungsten halogen: Tungsten halogen lamps are slightly more energy efficient and last longer than standard incandescents. One advantage of the tungsten halogen lamp is its controlled beam spread, which makes it ideal for accent lighting. Tungsten halogen lamps can be used in track, recessed, outdoor spot, and floodlight settings.
- Fluorescent:

✓ Fluorescent tube lamps: Fluorescent tube lamps are very commonly used in business applications; these lamps are generally identified as T12 and T8, referring to the diameter of the tube. T12s are 12/8 of an inch in diameter, while T8s are 8/8 of an inch. Typically, T8s are more efficient than T12s.

✓ Compact Fluorescent Lamps (CFL): CFLs have higher efficacy and longer life than comparable incandescent lamps. CFLs come in a variety of shapes and sizes and are compatible with most fixtures designed for incandescent bulbs.

- Light emitting diodes (LED): LEDs are a solid-state light source that delivers a direct beam of light at a very low wattage. LEDs currently have efficiencies comparable to that of compact fluorescent lamps, between 20-60 lumens per watt. Over the next twenty years, however, technology is projected to be able to achieve more than 150 lumens per watt. Although the efficiency of the individual LEDs currently may not be significantly higher than other conventional sources, the efficiency of the entire lamp and luminaire combination is very high, as nearly all of the light gets directed out of the luminaire.

- High-intensity discharge (HID): HID bulbs have a longer life and provide more light per watt than any other light source. HID bulbs are commonly used for outdoor security and landscape lighting. Mercury vapor lamps, which originally produced a bluish-green light, were the first commercially available HID lamps. Today, they are also available in a color-corrected, whiter light. Increasingly, the more efficient high-pressure sodium and metal halide lamps are replacing mercury vapor lamps. Standard high-pressure sodium lamps have the highest efficacy of all HID lamps, but they produce a yellowish light. High-pressure sodium lamps that produce a whiter light are now available, but their efficiency is somewhat lower than traditional high-pressure sodium lamps. Metal halide lamps are less efficient but produce an even whiter, more natural light. Colored metal halide lamps are also available.

Guidelines for lighting design

Seven steps should be considered when designing or renovating a lighting system. These steps are:

1. Improve the visual quality of the task. Identify specific visual tasks and recommend appropriate illumination, including task lighting.

2. Improve geometry of space, cavity reflectance. Use light and color of the room to increase the use of natural light; rearrange furniture for optimal lighting.

3. Improve lighting quality. Cut veiling reflections through more indirect light distribution and reduce glare.

4. Optimize lighting quantity. Balance levels of ambient and task lighting and ensure adequate light levels for tasks being performed.

5. Harvest/distribute natural light. Daylight improves the visual environment and results in increased productivity and energy savings. It is important to shade windows to prevent glare and heat gain and control the amount of daylight entering the building. Daylight can be redirected to where it is needed and be integrated with electric lights.

6. Optimize technical equipment. Lamps, ballasts, reflectors, and other technology must be optimized for maximum performance.

7. Control, maintain, and train. Proper maintenance of equipment is a crucial component to keeping technology in the best shape it can be.

Additional information

For additional information on lighting design optimization, see:

Mark S. Rea, Rensselaer Polytechnic Institute. *Illuminating Engineering Society of North America Lighting Handbook*. 2000.