A small-business guide

Shopping Centers

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ORDERING INFORMATION

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REPORT SUMMARY

Many of the challenges faced by small business owners can be addressed through efficient use of electric technology. Each volume in the Small Business Guide describes the current state of a business type and details new or alternative electric equipment that can help it meet its characteristic problems.

Background

Members of the small-business community historically have had little contact with their energy providers. These guides were developed to facilitate communication between electric utilities and the small businesses in their communities.

Objective

To provide utility personnel and small business owners and operators with information on the key electrotechnologies that can help these businesses compete effectively.

Approach

The project team researched small business energy, productivity, and environmental concerns and the electrotechnologies that can meet these needs. Telephone surveys, published reports, directories, buyers guides, and technical journals provided information on technology availability, suppliers, information sources and trade associations.

Results

The Small-Business Guide series covers a range of industries:

Volume 1: Wholesale Bakeries

Volume 2: Auto Body Shops

Volume 3: Lodging

Volume 4: Medical Clinics

Volume 5: Drycleaners and Launderers

Volume 6: Metal Finishers

Volume 7: Shopping Centers

Volume 8: Convenience and Grocery Stores

Each guide is based on extensive and ongoing research and contains the latest information available at the time of publication. The guides have been organized as a reference document for use on an as-needed basis. Section tabs are included to facilitate quick access to topics of interest; and each volume concludes with lists of equipment suppliers, EPRI information resources, and trade organizations.

EPRI Perspective

The EPRI Small Businesses target is dedicated to research, development, and dissemination of information on electrotechnologies that address the energy, productivity, and environmental concerns of small business owners and operators. Future volumes in the Small Business series will cover

- Printers
- Office Buildings
- Electronics
- Apparel manufacturers
- Photofinishers
- Plastic products
- Wood preservers
- Wood furniture.

TR-106676, Volumes 1-8

Interest Categories

Building systems and analysis tools
Appliances

Key Words

Electrotechnologies

HVAC

Lighting

Appliances

Building systems

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Wayne Krill manages the Small Businesses Target at EPRI and directed development of the *Guide.*

ABOUT THIS GUIDE

Members of the small-business community historically have had little contact with their energy providers. This guide was developed to facilitate communication between electric utilities and the shopping centers in their communities.

The *Shopping Centers* guide is intended to familiarize readers with the business of owning and/or operating the most common types of shopping centers—strip malls and enclosed malls—by providing a historical overview of the retail industry and summarizing its current issues and challenges. It specifically delineates how electric equipment can address the needs and interests of shopping center owners and operators.

This business guide is one of a series of publications about small businesses produced by EPRI. The *Shopping Centers* guide is based on extensive and ongoing research and contains the latest information available at the time of publication. Nevertheless, it is a work in progress rather than a definitive and final document. The information and resources presented offer the reader a solid base from which to develop electricity-based solutions to energy and business needs.

The guide is organized as a reference document for use on an as-needed basis. Section tabs are included to facilitate quick access to topics of interest; icons representing energy end uses are also provided to help with locating complete information on electrotechnology solutions.

Shopping centers are ubiquitous across the American landscape. From small-town strip malls to enclosed urban plazas, shopping centers have become the common unit for retail marketing in the United States and now range in size from three-shop strip malls to the 425-shop "Mall of America."

According to the Department of Commerce, there were over 41,000 shopping centers in the United States in 1995; they reported a combined income of $914 billion in retail sales. The number of centers is expected to grow, reflecting the continuing growth of suburbs.

While shopping centers are not in and of themselves small businesses, they serve as hosts to a variety of small businesses—from dry cleaners and photofinishers to restaurants and retail stores. Indeed, the concerns of shopping center owners and/or managers are similar to those of their retail tenants: to provide an inviting, comfortable, and safe environment that attracts shoppers and other quality tenants, and to minimize operating costs to achieve a satisfactory profit.

To meet the challenges of creating and maintaining an appealing facility, shopping center owners and operators are seeking technologies that will ensure a pleasing indoor environment, an enticing exterior ambiance, and reduced operating costs. The accompanying table identifies specific technologies that address these concerns. These electrotechnologies and other high-efficiency electric technologies are described in detail in the *Shopping Centers* guide (EPRI TR-106676-V7), copies of which are available from the EPRI Distribution Center. To order this publication or other guides in the series, call the Center at (510) 934-4212.

Electrotechnologies for Shopping Centers

	Outdoor Lighting	Foodservice Equipment	Heat Pump Water Heater	Electric Infrared Space Heating	Ozonation of Cooling Tower Water	Ultraviolet Disinfection of Air
Description	Six types of lighting technologies are available; each offers different characteristics in wattage, brightness, light tone, efficiency, and life span; they can be combined to meet site-specific needs.	A large variety of energy-efficient electric cooking equipment is available that is smaller, lighter, cleaner, cooler, more versatile, and often less expensive than gas equivalents.	Uses the refrigeration cycle to pull heat from a warm-air region and supply it to a hot water tank, thereby providing coincident space cooling.	Uses ceiling-mounted infrared (electromagnetic radiation) fixtures to heat people and objects in a space, rather than the air around them.	Uses ozone (a powerful oxidizing gas) instead of chemicals to treat the water circulated through a space-conditioning system cooling tower.	Shortwave ultraviolet (UV) light emitted by UV disinfection lamps kills microorganisms such as bacteria and viruses that are carried in the air and transmitted through ventilation systems.
Shopping Center Need	Lighting improves the visibility and attractiveness of a facility, enhances shopper and tenant/employee safety, and reduces the potential for crime.	Foodservice operations in shopping centers need labor-saving, energy-saving, and waste-reducing equipment that can help control operating costs.	Shopping centers and tenant operations (e.g., foodservice facilities) need technologies that help decrease operating costs and support competitive prices and overall economic viability.	Shopping centers need technologies that cost-effectively provide warmth and comfort in hard-to-heat spaces frequented by shoppers and/or tenants/employees.	New methods are needed that can reduce space-conditioning operating costs and create a healthier, more environmentally sound facility.	Providing a safe and healthy environment for shoppers and tenants/employees can include protecting them from exposure to airborne diseases and molds that may cause illnesses and allergic reactions.
Application	Signage on or near the facility; general lighting for driveways, walkways, delivery areas; facade and landscape lighting.	Restaurants, food courts, and other foodservice operations can gain versatility and efficiency by applying new electric equipment such as the FlashBake oven, induction cooktop, combination oven-steamer, and solid-state fryer.	Best suited to augment existing water heating and space cooling systems by serving a well-balanced water heating and space cooling load.	Can be used to heat breezy lobbies, entrances, walkways, outdoor restaurants, loading docks, and other spaces exposed to the environment.	Used by all types of commercial facilities that operate chillers and cooling towers for purposes of air conditioning.	To treat air in public spaces, UV disinfection lamps can be mounted on ceilings and walls, or within ventilation ducts.

	Outdoor Lighting	Foodservice Equipment	Heat Pump Water Heater	Electric Infrared Space Heating	Ozonation of Cooling Tower Water	Ultraviolet Disifection of Air
Benefits	Increased public perception of quality, attractiveness, and success from general signage and facade lighting; improved safety from area lighting.	Electric equipment is simpler to install; less expensive to purchase; smaller, lighter, easier to clean; safer; cooler to work near; and requires less ventilation than gas equivalents.	Provides efficient water heating and free space cooling and dehumidification for facilities that have hot water requirements and overheated public shopping areas or work areas.	Relatively inexpensive and easy to install; ensures people occupying a space are warm, although the background temperature may be only 50–60°F.	In comparison to chemical treatment, reduces water consumption 40%, eliminates use of chemicals, controls algae and scale more effectively, and enhances system efficiency.	UV germicidal light systems ensure against transmission of airborne disease, are easy to install, and are adaptable to virtually all space-conditioning system configurations.
Cost	Systems are custom-designed to meet a facility's needs and budget.	The 1996 list price for the FlashBake oven is \$4400; the induction cooktop, \$6700; the combination oven-steamer, \$18,600; the solid-state fryer, \$4100. The actual cost is typically less than list price.	Varies with the needs of the facility and/or tenants, ranging from \$125/kBtu/h to \$210/kBtu/h.	A small, four-fixture unit costs under \$2000; a large, industrial-size system with specialized controls costs over \$100,000.	Purchase costs for corona discharge systems range from \$8000–\$200,000; total costs (purchase and operating) range from \$5–\$10 per million gallons of water treated.	Purchase and installation costs run \$100–\$500 per lamp; use of three lamps to disinfect a 600-square-foot space would require 790 kWh per year.

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INTRODUCTION TO SHOPPING CENTERS

Where Americans shop has changed significantly over the last 50 years. Prior to World War II, retail sales were limited to small-town specialty and "general" stores and city department stores. As our population grew and moved into the suburbs after the war, department stores followed, and the era of the planned "shopping center" began.

Business Overview

The U.S. Department of Commerce defines a shopping center as a "group of three or more architecturally unified commercial establishments built on a site that is planned, developed, owned, and managed as an operating unit … [that] provides on-site parking in definite relationship to the types and total size of the stores." As a result of the construction boom of the 1970s and 1980s, there are shopping centers—both small strip malls and large enclosed malls—in virtually all metropolitan areas of the country.

Although shopping centers themselves are not "small businesses," they typically serve as sites for a variety of small businesses, such as convenience stores, dry cleaners, photofinishers, printers, restaurants, and retailers. As a result, energy-related decisions made by shopping center owners and operators often affect their small-business tenants.

This guide focuses on two basic types of shopping centers: strip malls and enclosed malls. These two types of shopping centers host the vast majority of retail businesses in the United States. According to the U.S. Department of Commerce, the number of shopping centers in the country increased from 38,966 in 1992 to more than 41,000 in 1995 (see Table 1). Retail sales also grew from $783 billion in 1992 to $914 billion in 1995, an average annual increase of 5.5%. Although many people think of large regional malls when they think of shopping centers, more than 63% of shopping centers within the United States had less than 100,000 square feet of gross leasable space in 1995.

The 1950s and 1960s heralded the development of suburban shopping centers and strip malls typically "anchored" by a major chain or department store. Enclosed suburban malls grew in popularity in the 1970s and early 1980s, while downtown department stores and shopping districts continued to experience a gradual decline as city populations and population growth shifted to the suburbs. The late 1980s and early 1990s brought a revitalization of some downtown shopping areas, moderate continued growth of regional shopping malls, and the appearance of discount outlet malls and mega-malls—facilities with everything from health clubs to amusement parks. Despite the large existing stock of malls, new strip malls are under construction to support the continued development of new suburbs. As this new construction takes place, it is accompanied by the conversion or closing of existing strip malls in older suburban neighborhoods.

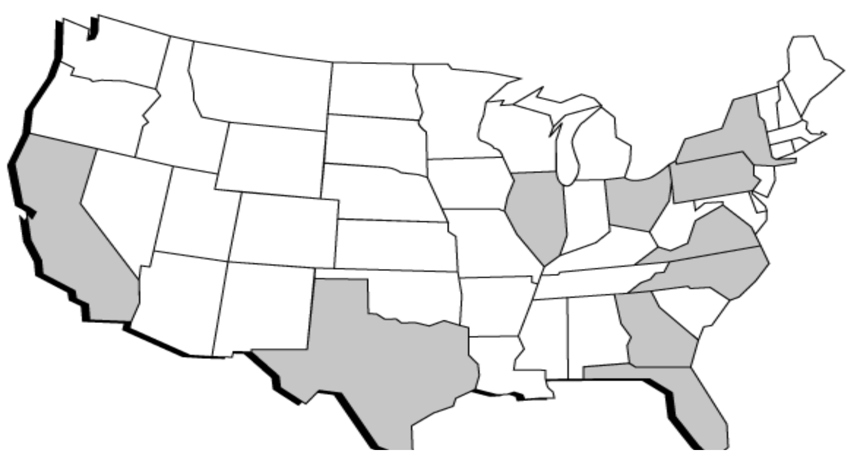
Table 1
Profile of the Shopping Center Industry[1]

Year	No. of Establishments	Retail Sale ($ billion)	Gross Leasable Area (billion sq.ft.)
1992	38,966	783	4.68
1993	39,633	823	4.77
1994	40,638	879	4.86
1995	41,235	914	4.97

[1]Since the term "shopping center" describes a facility rather than a manufacturing or service industry, it does not correspond to a Standard Industrial Classification (SIC) code.

Source: U.S. Department of Commerce and Bureau of Labor Statistics, as communicated by the International Council of Shopping Centers, April 1996.

States	Shopping Centres
CA	5350
FL	3066
TX	2624
IL	1961
OH	1659
NY	1598
PA	1521
GA	1418
NC	1412
VA	1162



Source: International Council of Shoppint Centres, *Shopping Centres Today*, April 1995.

Figure 1
Top 10 States for Shopping Centers

Geographically, the South Atlantic census region, ranging from Delaware to Florida, has the largest number of shopping centers (nearly 8900). The Pacific and East-North Central census regions follow, having 6500 and 5800 centers, respectively. In 1994, California was the state with the largest number of shopping centers, about 5350;

Florida and Texas followed, with approximately 3000 shopping centers each. The remaining top 10 states for shopping centers are Illinois, Ohio, New York, Pennsylvania, Georgia, North Carolina, and Virginia (see Figure 1).

Energy Use

According to the U.S. Department of Energy (DOE), there were approximately 39,000 shopping center buildings in the United States in 1992, and they consumed a total of 142 trillion Btu of energy that year. Fifty-eight percent of this energy use was in the form of electricity, 39% in the form of natural gas, and 3% in the form of fuel oil.

Total electricity use by these buildings equaled 25 billion kWh. The average electricity intensity for shopping centers was 11.3 kWh per square foot in 1992 (see Table 2). This electricity intensity is relatively low when compared to other commercial building categories. For example, stores selling food, such as grocery and convenience stores, are the most electricity-intensive, with electricity use equal to 43.6 kWh per square foot; office buildings use 16.7 kWh per square foot.

Table 2
Electricity Consumption in Shopping Centers in 1992

Census Region and Division[1]	**Total Electricity Consumption** (thousand kWh)	**Total Floor Space**[2] (thousand sq ft)	**Total Electricity Intensity** (kWh/sq ft)
Northeast	**2,857,811**	**424,729**	**6.7**
New England	1,336,010	243,292	5.5
Middle Atlantic	1,521,800	181,437	8.4
Midwest	**6,292,988**	**550,156**	**11.4**
East North Central	2,937,832	275,745	10.7
West North Central	3,355,156	274,411	12.2
South	**9,564,706**	**632,569**	**15.1**
South Atlantic	6,066,690	354,480	17.1
East South Central	1,579,811	115,294	13.7
West South Central	1,918,205	162,794	11.8
West	**6,389,191**	**609,607**	**10.5**
Mountain	494,551	92,537	5.3
Pacific	5,894,640	517,070	11.4
TOTAL	**25,104,695**	**2,217,062**	**11.3**

[1]New England: CT, MA, ME, NH, RI, VT. Middle Atlantic: NJ, NY, PA. East North Central: IL, IN, MI, OH, WI. West North Central: IA, KS, MN, MO, NE, ND, SD. South Atlantic: DC, DE, FL, GA, MD, NC, SC, VA, WV. East South Central: AL, KY, MS, TN. West South Central: AR, LA, OK, TX. Mountain: AZ, CO, ID, MT, NM, NV, UT, WY. Pacific: AK, CA, HI, OR, WA.

[2]Data on gross leasable area (Table 1) and total floor space were obtained from different sources; floor space may refer to only enclosed areas of retail facilities versus common areas and grounds.

Source: U.S. Department of Energy, Energy Information Administration, *Commercial Building Energy Consumption* and *Expenditures*, and *Commercial Building Characteristics*, 1992.

The energy use of an individual shopping center depends on a number of variables, including the size of the facility, size and number of common areas, location, age of the center, whether the center is an enclosed mall or a strip mall, and the efficiency of installed equipment. In general, the two largest uses of electricity in shopping centers are lighting (38%) and miscellaneous equipment, such as foodservice appliances, water heating systems, elevators, and escalators (31%); (see Figure 2). The remainder is used for HVAC systems (17%) and office-type equipment, such as computers, cash registers, and other electronic systems (14%).

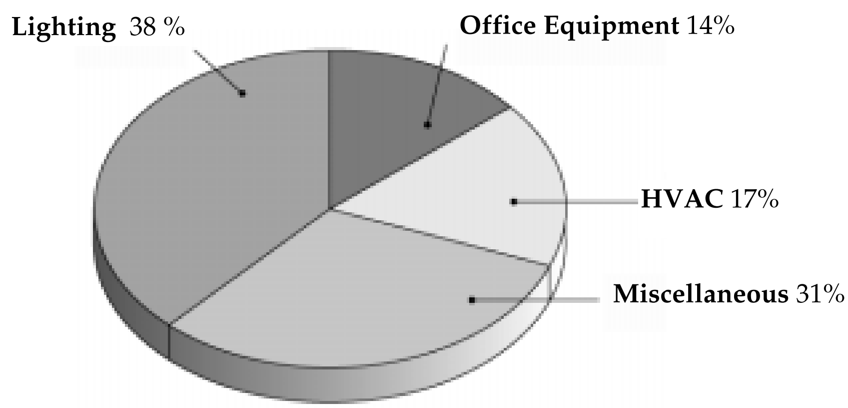


Figure 2
Primary Electricity Use in shopping Centers

2

BUSINESS CHALLENGES AND NEEDS

The primary business concern of a shopping center owner and/or operator is occupancy, both tenant occupancy and shopper traffic. Increasing or maintaining occupancy involves providing tenants and shoppers with a comfortable indoor environment and a safe and attractive outdoor environment. Of related concern to most shopping center owners and operators are operating costs, because the expense of providing amenities must be exceeded by overall revenues.

Occupancy

A number of factors contribute to achieving high tenant occupancy rates. Tenants are drawn to a shopping center that provides an (indoor and outdoor) environment that appeals to its target customers. A shopping center that is comfortable, healthy, attractive, and safe will lure many customers. Tenants are also concerned with the price they must pay for their space. Shopping centers that keep their operating costs low may be better able to attract and retain tenants via a low rental rate.

Need

Provide a Comfortable, Healthy Environment

It is the job of the shopping center operator to provide shoppers with a healthy, comfortable indoor environment, both in individual shops and in public areas. Comfort and health are related to indoor temperature and humidity, lighting, and air quality. The temperature and humidity should be appropriate to the season and to the activities in any given area. The lighting system should illuminate surfaces without creating glare. The indoor air should be free of significant odors, dust, and contaminants, and should circulate enough to prevent stuffiness without causing drafts.

While it is relatively easy to maintain comfortable levels of indoor temperature, humidity, and lighting, achieving healthy indoor air quality remains a challenge for owners and operators of many types of commercial facilities. Poor indoor air quality can result in discomfort for shoppers and tenants, which could undermine occupancy goals. Sources of poor indoor air quality include

- outdoor air that contains pollen, dust, or other contaminants;
- furnishings, materials, and equipment that give off emissions of volatile organic compounds or particulates (e.g., new carpet or furniture, ceiling insulation, and cleaning supplies);
- HVAC systems that harbor mold, mildew, bacteria, and other microorganisms, and/or have low ventilation rates; and
- people and their activities (e.g., cigarette smoking).

Technology Solutions

Energy-efficient HVAC technologies can reduce energy use and often improve temperature and humidity control in retail and public spaces. Electric infrared space heating can be used to provide heat in outdoor or semi-outdoor areas, such as entrance areas and loading docks, to enhance the comfort of shoppers and/or tenants and their employees. Retrofitting a space with energy-efficient indoor lighting often results in better indoor lighting levels. Ultraviolet disinfection of air—a technique now used to control transmission of airborne diseases in some public places—presents an opportunity to create a healthier environment for shoppers and employees.

See pages 3-3, 3-8, 3-9, 3-11, 3-12

Need

Provide a Safe and Attractive Shopping Environment

It is also a shopping center owner and/or operator's responsibility to provide an attractive and safe shopping environment. Appearance is a long-standing priority; today, shopping mall operators are finding that shoppers are increasingly concerned with mall safety. While the public's fears are not always based on fact, the mere perception of a security problem can have an impact on mall attendance. Malls that have well-lit parking lots, driveways, and walkways are preferred by customers. In fact, one Pennsylvania mall recently launched an advertising campaign that highlighted its improved indoor and outdoor lighting, along with other security measures such as bike patrols and rooftop surveillance, in an attempt to demonstrate its commitment to public safety.

Technology Solutions

By upgrading an existing outdoor lighting system and/or by adding new outdoor lighting, a shopping center owner or operator can increase the visibility of a mall, thereby potentially attracting the interest of both shoppers and new tenants. Better outdoor security lighting can increase the safety of shoppers and tenants on walkways, driveways, and in parking lots.

See pages 3-3

Need

Reduce Operating Costs

Shopping center owners and operators can potentially improve profits by minimizing operating costs. Reducing electricity use and, therefore, utility bills, is one facet of this solution. By increasing the energy efficiency of lighting, HVAC, refrigeration, and office equipment, and using heat recovery technologies, a mall owner or operator can potentially significantly reduce electricity consumption. The indirect impact of a change in HVAC equipment should also be considered before making a purchase decision. Customer comfort is one area where a facility operator should not cut corners: Saving a few dollars on lighting or air conditioning does not improve the bottom line if shoppers find conditions unpleasant and decide to stop patronizing a mall.

Technology Solutions

Technologies that can help a shopping center to reduce operating costs include energy-efficient indoor and outdoor lighting, energy-efficient refrigeration and HVAC technologies, heat recovery heat exchangers, heat pump water heaters, energy-efficient office equipment, and ozonation of cooling tower water.

See pages 3-3, 3-6, 3-8, 3-9, 3-12, 3-15

Barriers to Technology Adoption

A shopping center owner or operator's interest in new energy-related technologies largely depends on who is paying the energy bill and, therefore, who would reap the benefits of changes in equipment. Some rules of thumb apply for strip malls and enclosed malls.

Strip Malls

Strip malls can be as small as three stores or as large as several blocks; some strip malls have restaurants, anchor stores, hotels, and over 100 tenant spaces. Strip malls differ from enclosed malls in that there typically is no indoor common area. Instead, tenant spaces are normally self-contained, separately metered facilities with their own heating, cooling, lighting, and water heating systems. Tenants pay their own bills for electric service and other utilities. The cost of common-area equipment, such as outdoor lighting, is normally passed on to tenants on the basis of square footage of rental space. As a result, individual tenants typically are not interested in energy improvements in common-area equipment. Mall management and large anchor stores, however, may be interested in making energy improvements to a facility if it improves the safety, comfort, or look of the mall and is likely to attract new tenants and/or customers.

Like smaller stores, large strip-mall anchor stores—such as Wal-Mart, Kmart, or Safeway—maintain their own systems and typically have separate electric meters. If the anchor store is part of a major regional or national chain, its energy use is likely monitored by a corporate energy manager. The corporate energy manager is responsible for analyzing energy use in the facility and comparing it to other company facilities. If a store lags behind in meeting energy-efficiency standards established by the chain, the local store management may be interested in making improvements in energy efficiency.

Enclosed Malls

As with strip malls, energy-improvement decisions in enclosed malls reflect the individual interests of mall management, anchor stores, and other tenants. The indoor common areas of an enclosed mall are managed by the mall owner or facility manager. This typically includes responsibility for heating, cooling, and lighting common areas; maintaining restrooms and loading docks; providing lighting for parking lots and garages; operating the elevators and escalators; and providing fire, safety, security, and surveillance services. Management may also be responsible for advertising, lease negotiations, and renovation and expansion coordination.

Typically, anchor stores are nationally recognized department stores such as Sears, JC Penney, Nordstrom, and Macy's. Anchor stores normally operate independently from the rest of a mall in terms of building management and electric service; have their own building engineer who maintains HVAC, lighting, and electrical systems; and pay their own electric bills. As a result, anchor store management may be receptive to opportunities for HVAC, lighting, and other energy-related improvements. In many cases, the overall success of a mall depends on the success and visibility of its anchor store(s), which makes each anchor store an important and influential tenant. Mall management may therefore be willing to pay for some energy-related anchor store improvements.

Small tenants, on the other hand, are not likely to be interested in energy-related technology improvements unless they also pay their own utility bills. In some malls, tenants have separate utility meters. In others, an energy cost is part of the lease fee; in others, tenants are charged a specified percentage of the mall's total energy bill. The percentage charged to a particular tenant can reflect a tenant's metered energy use or the store's floor area relative to the total footage of the mall. In either case, energy use is low on the list of priorities for the small-business tenant. Their primary focus is to attract customers and sell products and/or services.

3

TECHNOLOGY SOLUTIONS

This section describes each of the technology solutions identified in the previous section. Each technology is summarized, linked by end-use application to a business need, and categorized as an “electrotechnology” or an “efficiency technology.” Electrotechnologies are selected new or alternative electric equipment options. In many shopping center applications, the electrotechnologies can help provide a comfortable, healthy, safe, and attractive environment, and may combine increased energy costs with an overall decrease in operating costs. Efficiency technologies, in contrast, offer opportunities to decrease energy use, but have little or no direct impact on operations.

Also discussed are “emerging electrotechnologies,” electrotechnologies not currently in use in the industry that have the potential to meet a need in the future, and “partnering opportunities,” situations in which a utility might conduct educational or other activities to enhance shopping center facilities or operations. Each electrotechnology is more completely described in Section 4, Electrotechnology Profiles. Vendors of the electrotechnologies, sources of information on efficiency technologies, and trade associations are listed in Section 5, Resources.

In this section, technologies are grouped and discussed by end use, beginning with “Lighting,” the end use that represents the greatest percentage of total shopping center electricity use. Table 3 summarizes the technology solutions.

Table 3
Technology Solutions to Shopping Center Needs

End Use	Solution Type	Technology Type	Business Needs: Provide Comfortable, Healthy Environment	Business Needs: Provide Safe, Attractive Environment	Business Needs: Reduce Operating Costs
Lighting	Efficiency Technology	Energy-Efficient Indoor Lighting	■	■	■
Lighting	Electrotechnology	Energy-Efficient Outdoor Lighting		■	■
Miscellaneous/ Foodservice	Electrotechnology	Electric Foodservice Equipment		■	■
Miscellaneous/ Foodservice	Efficiency Technology	Energy-Efficient Refrigeration Equipment			■
Miscellaneous/ Foodservice	Partnering Opportunity	CFC Education			
Miscellaneous/ Water Heating	Electrotechnology	Heat Pump Water Heater			■
Miscellaneous/ Water Heating	Efficiency Technology	Heat Recovery Heat Exchanger			■
Miscellaneous/ Elevators and Escalators	Efficiency Technology	Energy-Efficient Electric Motors			■
Miscellaneous/ Elevators and Escalators	Efficiency Technology	Adjustable Speed Drives			■
HVAC/ Strip Mall	Efficiency Technology	Air-to-Air Heat Pumps	■		■
HVAC/ Strip Mall	Efficiency Technology	Closed-Loop Water-Source Heat Pumps	■		■
HVAC/ Strip Mall	Efficiency Technology	Ground-Source Heat Pumps	■		■
HVAC/ Enclosed Mall	Efficiency Technology	Electric Chillers	■		■
HVAC/ Enclosed Mall	Efficiency Technology	Thermal Energy Storage	■		■
HVAC/ Enclosed Mall	Efficiency Technology	Heat Recovery	■		■
HVAC/ Strip and Enclosed Mall	Electrotechnology Space Heating	Electric Infrared	■		
HVAC/ Strip and Enclosed Mall	Electrotechnology	Ozonation of Cooling Tower Water		■	■
HVAC/ Strip and Enclosed Mall	Emerging Electrotechnology	Ultraviolet Disinfection of Air	■		
Office	Efficiency Technology	Energy-Efficient Office Equipment			■

Lighting

Lighting is often the most significant load in a shopping center, especially in centers with large common areas that require illumination 18–24 hours per day, or centers that have extensive outside security and display lighting. In 1992, lighting accounted for 38% of all shopping center electricity use.

The majority of indoor lighting systems used in shopping centers are fluorescent lamps (tubes or bulbs) with magnetic ballasts. Fluorescent systems have been the workhorse for commercial lighting for many years. The basic components of a fluorescent lighting system are fixture, reflector, switch, lamp, ballast, and lens. Fluorescent fixtures come in a variety of shapes and sizes; the most common fixtures hold 4-foot-long tubes used in two-, three-, or four-tube configurations. In large warehouse-type or anchor stores, 8-foot-long tubes are also used.

The second most common lighting source in shopping centers is the incandescent lamp. Incandescent lamps are sometimes used for hallways, restroom areas, and for highlighting certain products. They are also used for decorative lighting on signs and displays, and for exit lighting. The most common application is in ceiling-mounted down lights, also referred to as “recessed cans.” These fixtures are relatively inexpensive and easy to install, but are the least efficient lighting source available.

High-intensity discharge (HID) lamps are another type of lighting used in shopping centers. The HID family of lamps includes mercury vapor, metal halide, and high-pressure sodium lamps. Although these lamps are most commonly used in parking lots and driveways, they are sometimes used inside malls in large open areas or in large, warehouse-style or anchor stores. Mercury-vapor lamps are the least efficient of the HID types of lighting.

Efficiency Technology Solution

Energy-Efficient Indoor Lighting. The most efficient form of fluorescent lighting available today is the T-8 fluorescent lamp with an electronic ballast. Conversion from a magnetic (T-12, 40-watt) ballast to an electronic (T-8, 32-watt) ballast can be accomplished by either retrofitting the existing fixture or installing a new fixture designed for T-8 lamps, at a cost of roughly $40 and $100, respectively. Ceiling-mounted incandescent lamps can be successfully replaced with compact fluorescent lamps when the ceiling height is less than 12 feet, such as in restrooms and hallways. Mercury vapor lamps can be replaced with either metal halide or high-pressure sodium lamps, with a relatively short payback. All of the HID lamps have significantly longer lives than incandescent lamps and many fluorescent lamps.

Electrotechnology Solution

Energy-Efficient Outdoor Lighting. Outdoor lighting is also a part of a shopping center's electric bill. Existing applications include incandescent lights on signs, fluorescent lights in parking garages, and mercury vapor lights in walkways, parking lots, and driveways. These lighting systems can be on for extended periods of time and often contribute to a facility's peak electrical demand. In particular, parking lot and/or garage lights that operate 24 hours a day can be cost-effectively upgraded. In addition, a shopping center can realize a different set of benefits by increasing outdoor lighting levels to reduce the potential for crime, increase employee and shopper safety, and increase the visibility and attractiveness of the shopping center and grounds.

Miscellaneous Equipment

Electricity use by miscellaneous equipment represents 31% of all electricity consumed in shopping centers. Most of this energy is used to power foodservice and water heating equipment, elevators, and escalators.

Foodservice

Most enclosed shopping centers and many strip malls contain foodservice operations, such as restaurants or food courts. Sometimes these operations are the establishments that draw people to a specific shopping center; however, few of them are owned or operated by their host mall. Nevertheless, they represent a significant proportion of center electricity use.

Shopping center foodservice operations typically utilize an assortment of gas or electric ranges, griddles, fryers, and steamers. Electricity generally is not the common energy source for most major foodservice appliances, such as broilers, ranges, griddles, ovens, and fryers. This is usually due to the tradition of cooking with natural gas. In addition, the energy efficiency aspect of cooking appliances is rarely a key concern, since most of the operating costs of a foodservice operation are for food and labor. Electric foodservice technologies, however, are not only much more energy-efficient, but can be used to increase productivity (thereby decreasing labor costs) and to reduce waste (thereby decreasing food costs). Because of the lack of combustion by-products, electric equipment also ensures better air quality in a kitchen than natural gas equipment and requires less ventilation and cooling of a kitchen.

Foodservice operations also utilize walk-in coolers and freezers to store ingredients. New or retrofitted refrigeration systems have higher efficiencies, allowing shopping centers to reduce the operating costs of their foodservice facilities.

Electrotechnology Solution
Electric Foodservice Equipment

A number of new electric foodservice appliances are available. In addition to the now-common microwave oven, used to thaw, cook, and reheat food, this equipment includes the FlashBake oven, induction range, combination oven-steamer, and electric fryers.

FlashBake Oven. The FlashBake oven cooks food quickly with a combination of visible light and infrared radiation. It can cook nachos in 30 seconds, a pizza in 60 seconds, and a salmon fillet in 120 seconds. The oven is energy-efficient because there is no preheat time, and no energy is wasted in maintaining the cooking temperature. In addition, short cooking times minimize the heat emitted in the kitchen or food court area, reducing space-conditioning costs and increasing comfort for workers and customers.

Induction Range. An induction range uses a magnetic field to transfer energy from the cooktop to the cookware. Pots and pans of 430 stainless steel or cast iron turn the magnetic energy into heat inside the cookware. A key benefit is instantaneous heat, which provides energy efficiency and gives cooks precise control. In addition, the top of the induction range remains cool to the touch, increasing worker safety and facilitating cleanup.

Combination Oven-Steamer. Known as a “combi-oven,” this electric cooking technology comprises five appliances in one: a convection oven, a pressureless steamer, a wet roaster (combining dry heat and steam), a proofer for dough, and a cook-and-hold appliance. This technology also allows menu flexibility, saves space, and, as a result of its programmable controls, can also increase productivity.

Electric Fryer. Electric fryers are two to three times more efficient than conventional gas fryers at peak production rates and up to four times as efficient at lower (more common) production rates. This higher energy efficiency often compensates for the higher price of electricity. In addition, the technology can help to extend fat life, thereby reducing fat costs.

All of these electric cooking technologies have the advantage of higher efficiency, faster cooking times, reduced generation of heat in the kitchen, elimination of combustion by-products, and lower operating and maintenance costs.

Efficiency Technology Solution
Energy-Efficient Refrigeration Technologies

Most shopping center foodservice operations and/or restaurants use walk-in coolers and freezers for storing ingredients. Foodservice facilities can cut refrigeration electricity use as much as 25–30% by adopting energy-efficient refrigeration technologies. These include humidity control, high-efficiency compressors, floating head pressure, multiplexing compressors, and evaporative condensers.

Partnering Opportunity
CFC Education

The shopping center industry is also facing some capital investment requirements to replace heating, ventilation, and air conditioning (HVAC); refrigeration; and freezing equipment that will become obsolete, due to the January 1996 phaseout of chlorofluorocarbon (CFC) production in the United States. While some shopping center owners/operators may have already formulated a CFC-replacement strategy, many others may need information on the advantages and disadvantages of available alternatives such as absorption chilling and ammonia-based technologies, as well as the use of hydrochlorofluorocarbons (HCFCs) and non-chlorine refrigerants.

This situation presents a partnering opportunity for utilities to provide educational information on CFC alternatives and to help shopping center owners/operators review HVAC and refrigeration options and calculate payback periods for replacement of equipment.

Water Heating

A shopping center requires heated water primarily for preparation and cleanup in foodservice operations. While total electricity use for water heating may be relatively low, technologies such as the heat pump water heater (HPWH) and/or heat recovery heat exchanger represent opportunities for further reducing energy consumption.

Electrotechnology Solution
Heat Pump Water Heater

By removing excess heat from work areas and transferring it to hot water storage tanks, a HPWH can both lower water heating costs for foodservice and improve comfort in the kitchen work area. HPWHs exploit the inherent efficiencies of heat pump systems to heat water cost-effectively, coincidentally providing cooling and dehumidification. They are normally applied in conjunction with a conventional water heating system and provide water heating at costs roughly comparable to fossil-fuel-fired systems, in addition to no-cost cooling.

Efficiency Technology Solution
Heat Recovery Heat Exchanger

Heat recovery heat exchangers are useful for transferring heat from two principal sources: exhaust air and wastewater. Wastewater from restaurant and other foodservice facilities offers an opportunity for heat recovery. In this case, heat exchangers designed for water applications transfer energy from a dishwashing wastewater line to a freshwater supply line, thereby supplying a passive preheat function. Installation and maintenance costs for these simple heat exchangers depend significantly on the host facility's piping layout and the temperature and volume of the wastewater.

Elevators and Escalators

Elevators and escalators in multi-floor shopping centers can be large electricity consumers, especially if traffic exists during both day and evening hours. Large motors are used to operate these services; their efficiency influences the overall energy efficiency of the host facility. Both ac and dc motors are used in these applications, and each has a unique type of motor control system. The motors, control systems, and braking features of elevators and escalators must meet American National Standards Institute (ANSI) codes as well as local regulations.

Since escalators typically operate continuously during business hours, high-efficiency motors that meet the requirements for safe design and operation can provide attractive opportunities for lower energy costs throughout the operating life of a system. High-efficiency motors also tend to operate more reliably and less noisily. Similarly, effective elevator speed control is essential for comfortable stops and starts. Since adjustable speed drives operate efficiently and maintain high power factors during changes in motor speed, they are well-suited for this application.

Efficiency Technology Solution
Energy-Efficient Electric Motors

Energy-efficient electric motors (also known as high- or premium-efficiency motors) are typically 2–6% more efficient than their standard counterparts. The price premium is 15–30% above the cost of a standard motor. Over a typical 10-year operating life, a motor can consume electricity valued at over 50 times the initial cost of the motor. As a result, energy-efficient motors are usually extremely cost-effective, with simple paybacks on investment of less than 2 years when compared to purchasing a standard-efficiency motor. Energy-efficient motors are also typically manufactured to closer tolerances from better materials and offer more robust construction than standard motors. This improved construction translates into improved reliability and reduced maintenance requirements.

In escalator and elevator applications, motor overhaul or replacement is typically incorporated into the routine maintenance schedule. Although scheduled inspections sometimes identify unpredicted deterioration, motor overhaul or replacement is normally well-anticipated and provides an opportunity for equipment upgrade. Old dc motors used in elevators can be replaced with new energy-efficient dc motors, but the new motor must have the same reducer assembly and frame size or structure and must operate at the same revolutions per minute as the old one. (Ideally, the new motor would come from the manufacturer that provided the original equipment.) Another option is to replace the dc motor with an ac motor. In this case, both the motor and controls must be replaced, which could prove more costly. Advantages such as lower maintenance and a simpler control system can outweigh this disadvantage.

Efficiency Technology Solution Adjustable Speed Drives

ASDs, also known as variable-speed drives, use solid-state electronics to vary the frequency of the electricity applied to a motor. By reducing the frequency below the nominal 60 hertz, ASDs can efficiently reduce the speed or output of a motor, thereby eliminating energy use that otherwise would have been wasted.

When considering adding an ASD to an elevator or escalator motor, several factors must be evaluated, including horsepower rating, torque, current, voltage, speed, starting and stopping characteristics, and economics. For elevators and escalators operating at speeds up to 100 feet per minute (fpm), an ASD is not beneficial. For elevators and escalators with speeds of 100 fpm or greater, an ASD may be effective. Most commercial-type elevators and escalators are 100 fpm or more. DC motors, which are typically found in older elevators, rely on voltage regulation for speed control. ASD technology uses frequency control to adjust motor speed; thus, it is not a practical dc motor upgrade option unless the entire drive system is a candidate for replacement.

Heating, Ventilation, and Air Conditioning

HVAC systems represent roughly 17% of the electricity used in shopping centers. In small shopping centers and small tenant areas, the heating and cooling loads are roughly equal. However, in large shopping malls and large anchor stores, the cooling load may be two to three times greater than the heating load. In these large stores, the cooling load is primarily driven by internal heat gain from lights and people, which necessitates year-round cooling in at least part of the facility.

The HVAC systems used in strip malls are normally very different than the HVAC systems used in large anchor stores and enclosed malls.

Strip Malls

In most strip shopping malls, each retail space has its own HVAC system. In this case, the tenants select, purchase, and operate the HVAC systems and typically base their selection on first cost; quality and energy efficiency are lower priorities. Tenants also tend to select simple air distribution systems to minimize their first cost. These two factors contribute to the popularity of roof-mounted, packaged systems, particularly with smaller stores.

The HVAC systems typically found in strip malls include air-to-air electric heat pumps, electric resistance heating with electric air conditioning, and natural gas furnaces with electric air conditioning. All of these systems can function very effectively in small facilities, and each system has its advantages and disadvantages. Air-to-air electric heat pumps are relatively efficient, come in a variety of sizes, and can be roof-mounted or ground-mounted. Electric resistance heating is very clean, simple to operate, and has low initial costs, but it is not as cost-effective to operate as other options currently available. Natural gas furnaces are very popular, and also come in packaged roof-mounted units, but can pose potential health and safety issues, particularly if not maintained properly.

The most efficient HVAC systems available for small retail stores in strip malls are electric air-to-air heat pumps, closed-loop water-source heat pumps, and ground-source heat pumps. These systems use the same equipment and piping to provide both heating and cooling services, have simple-to-operate controls, and provide both high energy efficiency and year-round comfort.

Efficiency Technology Solution
Air-to-Air Heat Pumps

Among all the HVAC options, the efficiency of air-to-air heat pumps is second only to ground-source heat pumps. Air-to-air heat pumps can be an attractive replacement option for buildings with electric air conditioning and fossil-fueled heating systems.

Efficiency Technology Solution
Closed-Loop Water-Source Heat Pumps

A closed-loop water-source heat pump system removes heat from an overheated section of a building and delivers it to an area where it is needed, thereby cooling and heating different parts of a facility simultaneously and cost-effectively. While this technology is generally not feasible for facilities with relatively small square footage, there are many factors other than store size that affect feasibility; each site should be evaluated on its own merit.

Efficiency Technology Solution
Ground-Source Heat Pumps

Instead of exchanging heat with the outside air (as in a conventional air-to-air heat pump), these systems use the ground, with its almost constant 45–55°F temperatures, as a heat source and sink to heat and cool a building. In these systems, loops of pipes containing water or a water and antifreeze mixture are buried in the ground to take advantage of the constant temperatures. This technology is suited for larger applications, particularly for malls in which the owner/operator provides centralized heating and cooling services for tenants. Soil conditions that ensure adequate heat exchange or reasonable access to another natural heat source and sink (such as a lake) are generally needed for a cost-effective installation.

Enclosed Malls

The HVAC systems typically found in enclosed shopping malls and anchor stores include

- natural gas, oil and electric boilers;
- electric air conditioners and chillers;
- air-to-air heat pumps;
- two-pipe or four-pipe cold/hot water distribution systems;
- constant volume or variable air volume air distribution systems;
- electric resistance heating in ducts or terminal units; and
- fan coil units, radiators, and other terminal units.

These systems and components can be installed in a variety of ways—and modified/expanded as a store or mall grows and/or ages. The most common systems in large shopping malls and major anchor stores are electric chillers with terminal reheat, and electric chillers with natural gas/oil boilers and two- or four-pipe water distribution systems. Tenant areas are often served by individual air-to-air heat pumps or natural gas furnaces with electric air conditioning.

As with strip malls, the most efficient and economical HVAC systems available for large shopping centers and anchor stores are air-to-air heat pumps, closed-loop water-source heat pumps, and ground-source heat pumps (see descriptions above). For enclosed malls, the closed-loop water-source heat pump system offers the particular advantage of being able to transfer energy from one area to another.

Large shopping centers and anchor stores can also utilize other efficient technologies such as electric chillers, thermal energy storage, or heat recovery.

Efficiency Technology Solution
Electric Chillers

Electric chillers are efficient cooling systems; combined with boiler-supplied heat, they condition room air with two principal distribution systems: air and water. Air distribution systems use ductwork to transport heated or cooled air throughout a facility; the indoor temperature is controlled by regulating the amount of air entering the space. A key advantage to electric chiller-boiler systems with variable air volume (VAV) is improved humidity control because VAV systems dehumidify differently than chilled water systems. In VAV systems, the central air conditioning plant cools the air below its dew point, which condenses out moisture and sends only cool, dry air throughout the building. Frequently, however, the air is too cold for comfort and must be reheated with waste heat or mixed with unconditioned air. (Recent energy conservation guidelines discourage the use of terminal reheat methods that use electric resistance heating elements to bring the temperature of the airstream back to a comfortable level.)

Efficiency Technology Solution
Thermal Energy Storage

Thermal energy storage is used for moving part or all of a facility’s cooling load from an electric utility’s on-peak period during the day to the off-peak period during the night. These systems employ water or ice storage tanks that are charged or frozen at night by the shopping center’s chiller. While the system may actually use more electricity than a conventional system, it ordinarily costs a facility operator less overall because most of the electricity is consumed at lower off-peak rates. Thermal energy storage for space cooling is particularly attractive for enclosed malls and large stores with high peak-cooling loads and high on-peak demand charges. Different utilities use different pricing schedules; in general, however, customers who keep facility peak demand low or who shift their facility’s electricity consumption to a time of system-wide low electrical demand are rewarded with lower electricity rates.

Efficiency Technology Solution
Heat Recovery

Heat recovery systems maintain indoor air quality and reduce energy usage for space conditioning by recovering heat from (or discharging heat to) a mall’s exhaust air. This strategy reduces the energy needed to condition incoming air. The most popular heat recovery systems are heat wheels, heat pipes, runaround systems, and air-to-air heat exchangers.

Other HVAC-Related Technologies

In addition to traditional HVAC technologies, there are three innovative HVAC-related electrotechnologies that can potentially help shopping centers reduce operating costs and increase comfort and indoor air quality. These technologies include electric infrared space heating, ozonation of cooling tower water, and ultraviolet disinfection of air.

Electrotechnology Solution
Electric Infrared Space Heating

Electric infrared (IR) space heating can provide an attractive option for shopping center areas that are difficult to heat cost-effectively with conventional HVAC systems. Entrances and lobbies, loading platforms, and garages—areas exposed to the outdoors—are ideal applications.

IR space heating is accomplished through electromagnetic radiation. In addition to electric power, units are available that run on natural gas or propane. Although they are referred to as “space heaters,” these heaters actually heat the objects (e.g., the people) in a space. In drafty areas, radiative heat transfer is more effective than conventional heat transfer because the energy is not carried by air and thus swept away by air movement. The heaters and their radiation are typically directed at the people in a space but also heat objects such as floors, walls, and furnishings. These objects, in turn, retransmit the heat they receive; over time, this process raises the temperature of a given space.

IR heaters have the advantage of being relatively inexpensive to purchase and easy to install and operate, compared to conventional space heating systems. They reduce overall energy requirements by keeping people warm even though the background temperature is just 50–60°F. Their primary disadvantage is that if used to maintain temperatures of 70°F or more, their overall efficiency is no better than conventional resistance heating. In addition, for people to feel comfortable, they must be radiated from both sides, which requires installing the heaters in a criss-cross pattern. This technology is mature, and units are available from several manufacturers.

Electrotechnology Solution
Ozonation of Cooling Tower Water

The HVAC mechanics and building engineers who operate chillers and cooling towers show growing interest in treating cooling tower water with ozone. Ozonation of cooling tower water eliminates the use of potentially hazardous water treatment chemicals and reduces total water use, thereby increasing the operating efficiency of a cooling tower system and creating a more environmentally sound facility.

Ozone (O_3) is a very powerful oxidant—over 150% more powerful than chlorine-based chemicals—that destroys all forms of algae, bacteria, and viruses, including *pneumophilia* (which causes Legionnaires' disease). Ozone is produced by passing dry air or oxygen through an electric discharge corona, causing O_2 to form O_3; the ozone is then injected into the water that is distributed to the cooling tower.

There are three primary benefits of ozonation of cooling tower water: limited use of chemicals; reduced use of water, as a result of less blowdown (mineral-containing water drained from the cooling tower that must be collected and transported for off-site treatment and disposal); and increased efficiency of heat transfer, due to reduced scale and biological growth on pipes and heat exchangers.

Ozonation systems are relatively simple, primarily consisting of pumps, air compressors, and an ozonating element similar to a cathode ray tube. System maintenance is straightforward and typically can be performed by HVAC mechanics and electricians. One disadvantage of an ozonation system is the potential for degradation of carbon steel, carbon piping, and rubber gaskets. Therefore, when considering this technology, water piping materials should be evaluated for compatibility with ozone.

The use of ozone to treat cooling tower water arose in the 1970s out of environmental interest in limiting chemical use and providing effective water treatment. Ozonation is an established technology for treatment of cooling tower water. While office buildings are currently the primary users of this technology, it is just as applicable to other types of large commercial buildings. Shopping centers that reject heat to a cooling tower and are subject to relatively high costs for water are well-suited to apply the technology. Since ozonation of cooling tower water is somewhat new to the United States and is relatively expensive, however, the shopping center market is just developing.

Emerging Electrotechnology Solution
Ultraviolet Disinfection of Air

Another technology of growing interest among commercial building operators is ultraviolet (UV) disinfection of air. Airborne diseases such as tuberculosis are on the rise and can be transmitted through the air or through ventilation systems in any place people congregate. Although filters and proper ventilation are effective in removing dust, pollen, other airborne particles, and some microorganisms, they are not able to capture some very small bacteria and viruses, making additional safeguards necessary. Air sanitation units utilizing UV light, however, kill microorganisms and can be used to sterilize the air, improving indoor air quality and helping to prevent transmission of disease.

UV light kills microorganisms by penetrating their cell walls and photochemically breaking down their DNA. Unable to reproduce, the microorganisms die. Shortwave UV-C light (< 280 nanometers) is generated by UV lamps, which are similar to fluorescent tube lamps, except that the tubes are made of quartz glass and are not coated with phosphor. The fixtures are easy to install and can be mounted on the ceiling, wall, or within ventilation ducts. The within-duct fixtures are adaptable to air conditioning systems, combined air heating and cooling systems, and exhaust systems.

UV lamps were commonly used for disinfection in hospitals, bakeries, kitchens, and pharmaceutical and animal laboratories after World War II. Their use declined during the 1960s, however, due to the adoption of higher mechanical ventilation rates (which reduced the effectiveness of the lamps) and the availability of new drugs (which reduced concern about microbiological infections). Concern about airborne viruses is on the rise today, and the technical problems of combining UV with higher ventilation rates have been overcome. This technology is currently being used by hospitals and homeless shelters in several areas of the country, including Boston and southern California. The National Tuberculosis Coalition, a joint effort of EPRI's Healthcare Initiative, Consolidated Edison of New York, Harvard University Medical School, and other utilities and health organizations, is conducting a five-year test of UV germicidal light at homeless shelters in six cities. The development of these field data will assist shopping centers and other facilities in evaluating this technology.

Office Equipment

A variety of electronic office equipment, such as computers, cash registers, inventory tracking systems, and security systems, can be found in any shopping center, both in mall management offices and in the various tenant spaces. This equipment is responsible for an estimated 14% of a typical shopping center's total electricity consumption. In fact, because of the increasing automation of specific tasks, office equipment is believed to be the fastest growing category of electricity use in shopping centers. Not only does office equipment consume electricity, but it generates waste heat that must be offset by HVAC systems. Together, these two energy uses are expected to increase fivefold by 2005.

The energy consumption among different makes or models of any particular type of office equipment can vary as much as tenfold. Unfortunately, for most types of equipment there are no standard test procedures for determining energy consumption. As a result, it is difficult for consumers to make accurate comparisons between models. Two programs are now addressing this issue: the EPA's "Energy Star" program and a testing and information program mandated by Congress.

Initiated in June 1992, the Energy Star program is designed to encourage the development and sale of energy-efficient, power-managed office equipment. Manufacturers of personal computers and monitors that power down to 30 watts or less during inactive periods can use the Energy Star logo on their products. Currently, more than 2000 models qualify as Energy Star computers. The program was recently extended to apply to printers, copiers, and fax machines that have a similarly specified low-power state. The logo makes it easier for consumers to determine which office equipment is energy-efficient. More information can be obtained by contacting the Energy Star hotline at (202) 775-6650 by phone or the EPA website at www.epa.gov by computer.

In addition, the Energy Policy Act of 1992 (EPACT) mandated development of a voluntary, private-sector program to standardize test procedures and provide consumers with information on office equipment energy use. The program is currently being developed by the Council on Office Product Energy Efficiency (COPEE) and will address personal computers, copiers, fax machines, and printers.

Efficiency Technology Solution
Energy-Efficient Office Equipment

Office equipment energy consumption can be reduced significantly by purchasing energy-efficient equipment and operating equipment in an energy-efficient manner. When purchasing office equipment, most buyers consider price, speed, reliability, and quality, but rarely consider energy efficiency or waste heat generated by the equipment. Besides the direct energy savings, there are a number of indirect benefits of energy-efficient equipment, including reduced demand on electrical wiring in the facility, increased comfort due to reduced fan noise and waste heat generation, increased operator flexibility (with laptop computers), and reduced operator exposure to electromagnetic emissions (with laptop monitors).

4

ELECTROTECHNOLOGY PROFILES

This section provides profiles of the electrotechnologies identified in Sections 2 and 3. Each profile explains the technology, its advantages and disadvantages, commercial status, and costs. The profiles have been designed as stand-alone descriptions so they can be utilized separately from the rest of this guide. For further information, turn to Section 5 for a list of equipment vendors that can provide specific details.

Outdoor Lighting

Basic Principle

Many small businesses benefit from enhanced outdoor lighting through reduced potential for crime, increased employee safety, and improved visibility and attractiveness of the facility.

These benefits are obtained for a relatively small operating cost because, in most cases, outdoor lighting does not contribute to a facility's peak electrical demand. This means that the average energy cost for outdoor lighting (in terms of cents/kWh) is typically less than the energy cost of other improvements.

There are three principal methods for using outdoor lighting in small businesses:

1. Signage on the exterior of the building or illuminated signs near the building to generate attention for the building or the small business
2. General lighting in parking lots, driveways, parking garages, and walkways
3. Facade lighting to increase the visibility of the structure and surrounding architectural features and landscaping

Different lighting technologies are typically used for different applications. Existing lighting systems can often be retrofitted or replaced by energy-efficient lighting systems. In addition, existing lighting systems can be supplemented with new lighting systems to increase safety, security, visibility, and name recognition.

Typical Outdoor Lighting Applications

Type of Light	Exterior Signage	Parking Garages	Parking Lots/ Driveways	Walkways	Facade and Landscaping
Incandescent	■			■	■
Compact Fluorescent		■		■	■
Fluorescent	■	■		■	■
Metal Halide		■	■	■	■
High-Pressure Sodium			■		
Mercury Vapor			■		

Note: Additional applications are possible for each of the lighting types, but the chart identifies the most efficient applications for each of the light sources. Low-pressure sodium lamps are not normally used in small businesses because of their poor color quality.

System Description

Mercury vapor, high-pressure sodium (HPS), and metal halide lamps are referred to as high-intensity discharge (HID) lamps. Metal halide lamps and HPS lamps provide approximately 100 and 140 lumens per watt, respectively, while mercury vapor lamps provide up to 60 lumens per watt. Mercury vapor lamps emit a bluish green light while HPS lamps emit a yellow orange light. Metal halide lamps emit a predominately white light. Most HID lamps require a spacing-to-mounting height ratio of 1.0–1.9, which means that the spacing is roughly one to two times the pole height.

Each HID lamp requires a specific ballast to drive the lamp; however, some manufacturers offer metal halide and HPS lamps that can be operated by a mercury vapor lamp ballast. This allows easier conversion from inefficient mercury vapor lamps to higher-efficiency metal halide and HPS lamps. HID lamps are available in a variety of wattages from 35–1500. The HID ballast adds approximately 8–15% to the wattage of the lamp.

Fluorescent lamps are also used as outdoor lighting sources for small businesses. Conventional 4-foot and 8-foot tubes are used in many parking garages and covered walkways. Compact fluorescent lamps are also becoming popular as replacements to incandescent lamps in stairways. Newer T-8 lamps and electronic ballasts are approximately 30% more energy-efficient than older 40-watt T-12 lamps with magnetic ballasts.

Incandescent lamps are the least efficient form of outdoor lighting. However, incandescent lamps are still used as spotlights on signs and as floodlights on building facades and landscaping. The short lifetime of incandescent lamps often has a bigger impact on operating costs than does the additional energy use.

Common controls used for outdoor lighting systems include time clocks, photocells, and programmable controllers.

Advantages

Well-designed outdoor lighting systems can offer the following advantages:

- Increased perception of comfort and friendliness
- Increased security for customers and employees
- Reduced accidents in driveways, parking areas, and walkways
- Increased visibility for the facility and the small business

Typical Lamp Characteristics for Outdoor Applications

Type of Lamp	Typical Wattages	Initial Lumens/Watt	Avg. Rated Life (h)
Incandescent	60–1,500	15–24	750–2,500
Compact Fluorescent	12–35	25–75	8,000–12,000
Fluorescent	20–215	50–100	9,000–20,000
Metal Halide	175–1,500	69–115	10,000–20,000
High Pressure Sodium	35–1,000	51–140	7,500–24,000
Mercury Vapor	40–1,000	24–60	12,000–24,000

Note: Initial lumens/watt includes ballast losses.

Disadvantages

Other than installation and operating costs, there are no overall disadvantages of outdoor lighting. However, specific lamps do have weaknesses:

- HID lamps require 2–7 minutes to warm up before reaching full output.
- Metal halide lamps require up to 15 minutes to cool before restrike.
- Special low-temperature fluorescent lamps are required in cold climates to maintain a relatively constant lumen output below freezing.

Commercial Status

All of the lamps described above are readily available from a variety of manufacturers. However, mercury vapor and older T-12 fluorescent lamps are being phased out of production.

Gradual improvements have been made in the efficiency of outdoor lighting systems. In addition, color-corrected HPS lamps are available, as well as improved metal halide lamps that contain incandescent or fluorescent lamps that come on if the power is interrupted.

EPRI Information

Additional information on lighting technologies is available from the EPRI Lighting Information Office, (800) 525-8555.

Foodservice Equipment

Basic Principle

A large selection of new electric technologies is available to support the foodservice needs of small businesses. Many of these technologies are well known because they have already been adopted in the residential market, such as microwave ovens. Other technologies are newly developed, such as the FlashBake oven, the induction cooktop, the combination oven-steamer, and the solid-state electric fryer.

FlashBake Oven

The FlashBake oven is a countertop lightwave oven that uses infrared energy to brown food surfaces, and intense visible light to cook food from the inside out in an extremely short amount of time. For example, a fresh 9-inch pizza can be cooked in 60 seconds, or quesadillas in just 30 seconds. In addition to speed, the FlashBake oven delivers product quality equal to or better than conventional ovens. The ovens are energy-efficient, cool to work around, and require no ventilation. The FlashBake oven is a trademarked product of Quadlux, Inc.

Induction Cooktop

The induction range consists of a flat ceramic cooking surface over an induction coil; heat is generated only in the cooking pot without heating the cooktop surface. These units are instant “on” and “off,” producing very high energy efficiency and quick cooking (8 ounces of water will boil in 30 seconds). They are cool and safe to work near and extremely easy to clean. Ferrous metal pans, made of materials such as 430 stainless steel or cast iron, must be used with these ranges.

Combination Oven-Steamer

The combination oven-steamer, also referred to as a "combi-oven," can perform all the functions of either a convection oven or a convection steamer, or combine these functions to allow cooking at higher temperatures in a moist environment. The combi-oven effectively replaces three pieces of equipment with a single unit, which saves first cost, kitchen space, and hood requirements. It is appropriate for roasting meats; steaming vegetables, rice, and shellfish; baking breads and pastries; and reheating previously cooked foods.

Solid-State Electric Fryer

Electric fryers have much higher operating efficiencies than equivalent gas fryers and afford better temperature control of the frying medium, helping to reduce the amount of overcooked food and extend fat life (thereby reducing costs and waste). The new solid-state fryer significantly increases electric fryer reliability by replacing electromagnetic controls with solid-state controls. It is also noted for very high efficiency and easy cleaning. It is especially well-suited to low- and medium-volume applications because electric efficiency is very good in comparison to gas fryer efficiency in these situations. Gas fryers lose efficiency in part-load applications (short usage followed by idle time) due to excessive flue losses.

Other Equipment

Other electric cooking appliances offer a variety of benefits. The advanced/innovative electric equipment includes:

- Induction fryer
- Convection/microwave oven
- Air impingement/microwave oven
- Convection/steam/microwave oven
- Skittle
- Rofry (oil-free fryer)
- Electric rotisserie
- Electric conveyor broiler
- Blast chiller

Advantages

- The first cost of electric equipment is generally lower than that of equivalent gas models.
- Electric equipment is typically lighter than its gas counterparts, making it easier to move and less expensive to ship.
- The footprint of electric equipment is generally smaller, which saves valuable kitchen space.
- Electric equipment maintenance costs are generally lower.
- Electric equipment is easier to clean, which saves labor.
- Electric equipment cooks food more quickly and has a faster recovery time, which can improve productivity.
- Better temperature control can reduce waste by ensuring that foods are not overcooked.
- Electric equipment radiates less heat to a kitchen, which reduces air conditioning costs and makes the equipment cooler to work around.
- Because no gas lines are required and electric equipment does not always have to be under a hood, electricity provides increased flexibility in kitchen layout.
- Overall, electricity provides a cleaner and safer work environment.

Disadvantages

- Adding electric equipment may require electrical upgrades.
- Some chefs prefer gas equipment because they can see the flame, like the instantaneous response, were trained on gas equipment, and have not compared the options side-by-side.

Commercial Status

All of the technologies described above are commercially available. However, some of the technologies are only available from one manufacturer.

Cost and Electrical Requirements

Cost and electrical requirements vary significantly from one technology to the other. To estimate the cost of a specific application, the type of food being prepared, the cooking technique, the physical size of the food, and the quantity of food processed must be known. In mid-1996, the list price for a 28 x 29" FlashBake oven was $4400; the list price for a 50-lb, 14-kW induction range was $6710; and the list price for a 14-pan (12 x 20") combi-oven was $18,636; and the list price for a 50-lb solid-state fryer was $4100.

EPRI Information

A Business Guide to Foodservice, TR-106841, November 1996.

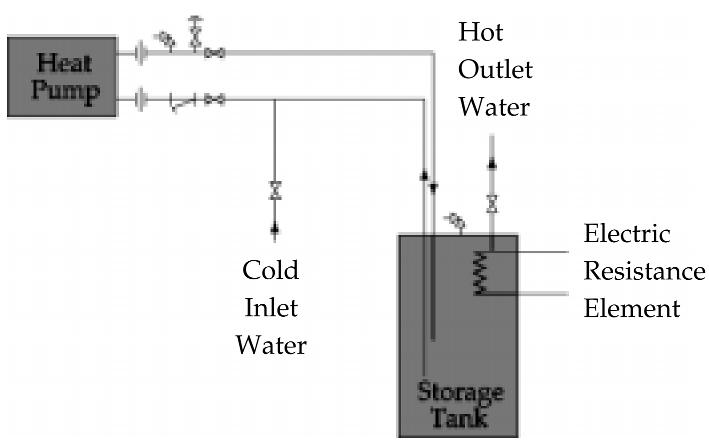
Foodservice Equipment Applications Handbook, TR-105991, March 1996.

Copies of these publications are available from the EPRI Distribution Center, (510) 934-4212.

Heat Pump Water Heater

Basic Principle

A heat pump water heater (HPWH) is an electrotechnology that uses the refrigeration cycle to supply both water heating and space cooling. Exploiting the heat pump's ability to transfer energy, a HPWH typically moves heat from a warm-air region (e.g., a kitchen) to a hot water tank, thus heating water and coincidently providing space cooling. By this mechanism, the technology efficiently serves two important facility needs and, if applied properly, provides good economic value.



Heat Pump Water Heater System Configuration

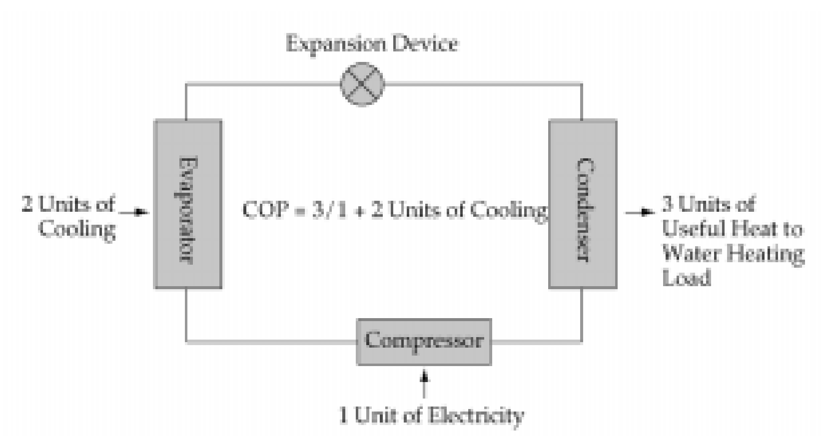
Applications

HPWHs are ideally suited for kitchen, bakery, laundry, and pool facilities that have a concurrent need for water heating and space cooling. Often, the type of environment that creates favorable economics for a HPWH also enhances its operational performance. Specifically, high wet-bulb temperatures, common around processes that use a lot of hot water, lead to higher HPWH output and efficiency.

HPWHs are normally applied in conjunction with conventional water heating systems. In these applications, the HPWH is sized to serve the average water heating load and the conventional system augments the supply, as needed, during periods of greatest hot water demand. In contrast to conventional systems, which are typically oversized, HPWHs provide the best economic return when they are carefully sized to maximize system run time. Indeed, the more a HPWH is operated, the shorter its payback period. Ideally, HPWH operation should consistently service well-balanced water heating and space cooling needs, while peak loads are handled by the primary heating and cooling systems. Use of large hot water storage tanks can increase a HPWH's contribution to the water heating load.

While HPWHs efficiently supply hot water, their most notable feature is free supply of space cooling. Assigning a quantitative value to the cooling is difficult, however, and is frequently subjective—a matter of the user's perspective. For example, the HPWH's free air conditioning may not result in a lower utility bill if the equipment is installed in a facility that previously had no air conditioning. Instead, in this case, the benefit is a less easily quantified but significant improvement in the work environment, potentially contributing to employee productivity and long-term retention.

By offering water heating at costs roughly comparable to those of fossil-fuel-fired systems—and no-cost cooling—HPWHs make it attractive for businesses to take advantage of the lower rates associated with all-electric service.



Heat Pump Water Heater Performance Cycle

System Description

A typical HPWH provides about 10,000 Btu/h of water heating capacity for every 1 kW of compressor electrical input. The coefficient of performance (COP) for water heating is approximately 3. Thus, water heating is available at roughly one-third the cost of electric resistance technologies. In addition to the high-efficiency water heating, a HPWH provides 2 units of cooling at no additional energy cost.

HPWHs typically produce hot water up to 140°F, although some models can produce water temperatures of 180°F. HPWH evaporators commonly operate over a wide range of temperatures, from 40–120°F; they are most effective when applied in hot, humid places and when servicing a small temperature lift in water heating. To illustrate: for a typical HPWH, locating the evaporator in a 95°F, 70% relative humidity environment versus a 75°F, 50% relative humidity environment increases the efficiency, water heating output, and cooling output of the unit by about 30%.

HPWHs are sold in many types and configurations to suit the needs of every appropriate application. For space-constrained facilities, for example, stand-alone HPWHs are available that require no more floor space than a conventional water heating system. For dispersed cooling, units with remote evaporators are available that provide spot cooling opportunities (whereas smaller, simpler HPWHs discharge their cooling to their immediate environment). For example, these units can deliver cool, dry air directly to over-heated workstations in cook lines and laundry facilities.

Advantages

- High-efficiency water heating with space cooling at no additional cost.
- Provides no-cost cooling that can be directed to solve overheating problems.
- May decrease the cooling load on an existing HVAC system as the HPWH removes energy from overheated areas and uses it to heat water.
- Dehumidification is provided as the process removes moisture from humid environments.
- Heat pumps typically operate with low repair and maintenance requirements.

Disadvantages

- For a given water heating capacity, HPWHs are more expensive to purchase and install than conventional equipment. Consequently, care should be taken to avoid oversizing units.

- Even though HPWHs are very similar to conventional water heating and air conditioning systems, it may be more difficult to find a contractor who has experience with HPWH installation and maintenance.

- Corrosive, humid environments, such as pools and spas, warrant special attention to material selection. Pool and spa environments usually require copper-nickel or stainless-steel alloys for heat exchange surfaces.

Commercial Status

HPWHs are available in a variety of sizes and configurations from many manufacturers, and the range of equipment continues to expand. In the last year, two nationally known companies have entered the HPWH market.

This technology is being used across the United States—from Minnesota to Hawaii—in all commercial building types. Successful applications vary broadly, from fast-food restaurants to 30-story apartment buildings. Some manufacturers specialize in supplying equipment for specific applications, such as swimming pools. In most applications, the manufacturer sizes and sources the equipment; however, installation is generally performed by a local contractor. Currently, HCFC-22 is the commonly used refrigerant; manufacturers are gradually switching to HFC-134a.

Cost and Electrical Requirements

HPWH system costs vary significantly and in accordance with the requirements of the application, so it is difficult to generalize; there are no good “rules of thumb.” Performance capacities, operating temperature ranges, and environmental conditions all have an impact on system design and first cost. Energy costs are keenly tied to system sizing. A properly sized HPWH will operate over many hours of the day; an oversized unit will turn on and off throughout the day, thereby potentially adding to electrical demand. Typically, a commercial electric bill is influenced as much by demand and related charges as by actual energy usage.

Heat Pump Water Heater System Characteristics

Dimensions	Packaged Height: 21"–72" Width: 19"–57" Depth: 11"–42" Split-System Evaporator — Height: Approx. 30"; Width: Approx. 60"; Depth: Approx. 40" Condenser — Height: Approx. 30"; Width: Approx. 60"; Depth: Approx. 30"
Power Rating	110–460 V ac, 60 Hz, 1- or 3-phase Compressor: 0.60–65 kW Fan or blower: 0.02–2 kW
Energy Consumption	Assuming 1000 gallons/day hot water use 250 days of operation annually 60°F inlet water 140°F outlet water COP for heating = 3 $0.10 per kWh Resulting annual operating cost for water heating is $1627; the cooling service is free
Key Inputs Power Heat Source	 Electricity Warm air (40–120°F)
Key Outputs Heat Sink	 Hot water (typically 100–140°F; specialized equip. up to 180°)
Cost	$125 kBtu/h–$210 kBtu/h

EPRI Information

Commercial Water Heating Applications Handbook, TR-100212, December 1992.

Commercial Heat Pump Water Heaters, Applications Handbook, CU-6666, January 1991.

Commercial Heat Pump Water Heaters: Cost-Competitive Electric Water Heating with No-Cost Cooling and Dehumidification, BR-103415, February 1994.

Copies of these publications can be ordered from the EPRI Distribution Center, (510) 934-4212.

Additional information on HPWHs and a *Directory of Heat Pump Water Heater Manufacturers and Equipment* is available from the EPRI Water Heating Information Office, which can be contacted at (404) 874-9563 by phone, at whio@dwabrams.com by e-mail, or at http://www.dwabrams.com/whio through the World Wide Web.

Electric Infrared Space Heating

Basic Principle

Heat is transferred in three ways: convection, conduction, and radiation. In most space heating systems, convection and conduction are the principle heat transfer mechanisms. Infrared (IR) space heating is accomplished through electromagnetic radiation. Natural gas, propane, and electricity are the fuels commonly used by IR heaters. Although these heaters are referred to as “space heaters,” they do not directly heat the space; they heat the people and objects in the space which, in turn, eventually heat the space. The term “infrared space heating” is used to distinguish comfort heating applications from IR process heating.

Electric IR heaters have two basic components: an IR heating element and a reflector. The IR heating element is composed of a resistor material (or radiator) that gives off electromagnetic energy in the IR portion of the spectrum when excited by an electric current. The resistor material is partially enclosed in the reflector, a fixture that reflects the radiation toward the people to be heated. Resistor materials include tungsten wire in a quartz tube, nickel chromium alloy in a quartz tube, tungsten wire in a reflector lamp, and nickel chromium alloy in a metal rod. In space heating applications, the IR radiation is normally directed toward the people in the area. However, the radiation also strikes objects, such as the floors, walls, equipment, and furnishings. These objects then retransmit the heat they receive, through secondary convection, conduction, and radiation. In this way, IR heaters can be used to warm the air in a room to a set temperature, much like a conventional heating system.

Tungsten wires in quartz lamps and reflector lamps operate at filament temperatures of about 4050°F and radiate energy in the “near-infrared” portion of the spectrum. These lamps have the added advantage of providing visible light of approximately 8 lumens per watt. This light can help illuminate work areas. The potential downside is that when heating is not needed, the extra light is not provided. Other lamp elements, such as metal sheath, open wire, and ribbon elements, operate between 1200°F and 1800°F and emit in the “far-infrared” portion of the spectrum.

Applications

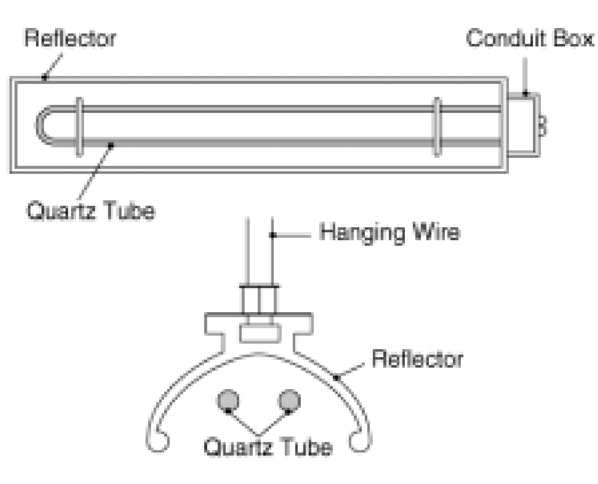
IR heaters are used in a variety of applications, including golf driving ranges, storage rooms, fire station garages, loading docks, covered walkways, warehouses, commercial/industrial plants and shops, outdoor restaurants, hotels and motels, shopping centers, and store entrances. The most cost-effective applications are in areas exposed to the outdoors and/or areas that require high ventilation rates.

An IR system can be designed to maintain an air temperature of over 70°F in an enclosed room. In this case, the overall efficiency of the system approaches 100%, but as little as 50% of the radiated energy actually reaches the people or objects. The ideal application is an area maintained at 50°F in which IR heaters are used only to warm people. An example is a large warehouse watched over by a stock person near the main door. IR heaters could be installed where the stock person spends the most time, providing the stock person heating comfort irrespective of the overall warehouse temperature.

System Description

IR lamps and fixtures are available in a variety of shapes and sizes. They are normally hung from or attached directly to the ceiling, in a manner similar to a lighting system, with careful attention to the maximum height of forklifts, trucks, cranes, etc., that operate in the area. The IR-system designer determines the desired energy levels for the different parts of the facility and then estimates the equipment wattage required to produce the desired energy levels. The fixtures are typically available in 120-, 240-, 277, and 480-volt systems. Simple switches, time clocks, timers, and thermostats are used to control fixture output.

The lamp efficiency depends on the material of the resistor or radiator. Clear quartz lamps have an efficiency of about 96%. Tungsten wire and quartz tubes have efficiencies of 60–80%. Metal rods have lamp efficiencies as low as 50%. The overall efficiency of the IR system depends on the type of IR element in the lamp, the absorptivity of the people and the objects near the lamp, and the efficiency of the fixture (including the reflectivity of the reflector and the directional efficiency of the fixture). Other factors to consider in selecting an IR element include amount of visible light output, time required to develop full output, vibration resistance, and color of light. The life expectancy of any IR lamp is about 5000 or more hours.



Electric Infrared Space Heating

Advantages

- Relatively inexpensive and easy to install compared to conventional HVAC systems
- Keeps people comfortable in relatively open areas such as bus stops, covered breezeways, loading docks, outdoor restaurants, and garages
- Reduces the overall energy required to heat an area by allowing a background temperature of 50–60°F
- Simple to lay out, control, and maintain
- Can be used to heat "trouble spots" such as lobby areas, hallways, and entrances
- Less complicated than gas heating because neither gas piping nor ventilation of combustion by-products is necessary

Disadvantages

- If systems are used to maintain space temperatures of 68–70°F, the overall efficiency is no better than conventional resistance heating.
- If mounted at ceiling heights of over 30 feet, IR lamps cannot keep people warm.

- People need to be radiated from both sides to feel comfortable. That is, enough lamps must be installed to produce a criss-cross pattern.

Commercial Status

Electric IR space heaters are available from several manufacturers in a variety of shapes, sizes, voltages, and radiant output. They come in both conventional fixtures and radiant wall and ceiling panels. A manufacturer's sales representative normally assists in estimating the required energy output and in planning unit locations. Sales representatives can also assist in performing a simple heat loss calculation for the facility or area to be heated.

Electric Infrared Heating Fixture Characteristics

Dimensions	Length: 15'–58' Width: 8'–32' Height: 4'–13' Weight: 9-55 lb
Power Rating	0.5–13.5 kW
Mounting Height	Minimum: 10-44 ft. Maximum: 30 ft.
Key Inputs	
Power	Electricity
Other	Infrared lamp replacements
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Purchase	Small: \$100-\$3000 Large: \$2000-\$100,000
Installed	Minimal
Other Supplies	\$40–\$1160 per 1-3 years

Cost and Electrical Requirements

The cost for electric IR systems varies significantly depending on the complexity of the unit and the number of fixtures used. For example, a simple loading dock application with four fixtures and an on/off switch costs under \$2000. However, a large industrial application with specialized controls and fixtures costs over \$100,000.

The electrical requirements are very straight-forward. Once the supply voltage is decided, the individual wattages of the lamps required to produce the desired results can be estimated. The total electrical requirements are simply the total wattage of the lamps installed on a particular electrical circuit in the facility. For example, a facility using four fixtures at 7 kW (total) for 8 h/d (2000 h/yr) would require 56 kWh/d (14,000 kWh/yr) of electricity.

Ozonation of Cooling Tower Water

Basic Principle

Air conditioners, heat exchangers, power generators, and other large machines generate heat while operating. Cooling tower systems are often used to absorb the heat discharged from these units by circulating water through and around them. The cooling tower itself removes the heat absorbed by the water so the water can be reused.

A combination of chemicals are typically used to treat cooling tower water; research has identified ozonation as a potential alternative. Ozone is a powerful antioxidant; it readily attacks and breaks down exposed carbon bonds, leaving no residue. Ozone itself breaks down into oxygen, so there is no chemical waste product. Ozonation systems are a proven success in water and wastewater treatment.

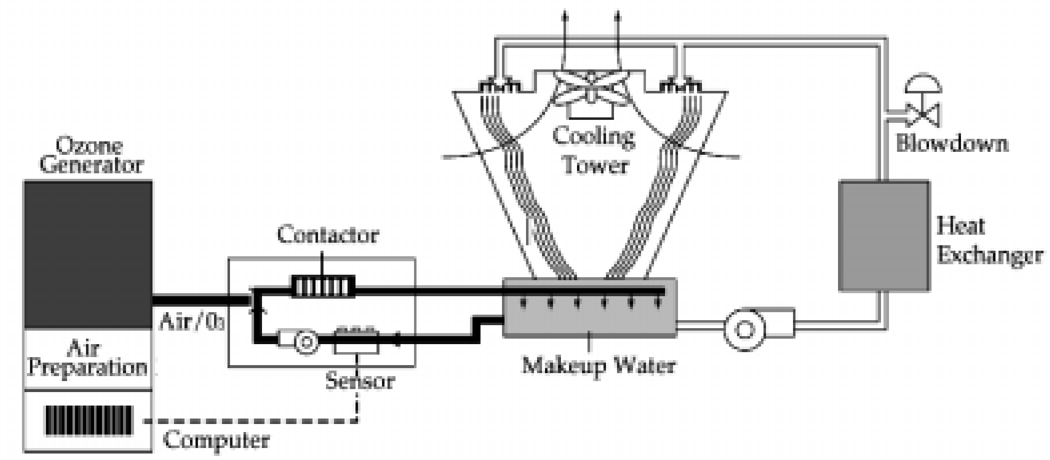
System Description

Most cooling towers use an evaporation process to remove the heat absorbed by the cooling water. In this process, heated water flows into the cooling tower and is then sprayed as small droplets onto wet decking surfaces. After cooling, the droplets fall into a cold water basin and are pumped back into circulation. Some of the droplets, of course, evaporate and exit as steam; therefore, the water supply must be replenished periodically. It also must be treated regularly to prevent algae growth and scale buildup.

Conventional cooling tower systems use multiple chemicals for water treatment, but this is problematic. If not enough chemicals are used, scale buildup causes inefficiency in energy use and necessitates frequent system shutdown for cleaning. Too many chemicals can lead to metal corrosion and high chemical concentrations in the wastewater and atmosphere. Over time, the continual addition of chemicals plus water loss through evaporation results in water that is saturated with chemicals and debris, making emptying and refilling with a new water supply necessary.

Using ozone solves many of these problems. Ozone acts as a biocide by oxidizing the cellular structure of microorganisms in water. It inhibits scale deposits and limits spontaneous oxidation in metals by forming ferrosoferric oxide (Fe_3O_4) with the metal. In addition, no residual chemicals are left in the water.

Because it is highly reactive, ozone must be generated on-site as needed and, for best economics, injected in concentrations proportional to the organic and biological demand of the water being treated. Ozone can be generated by corona discharge or by ultraviolet (UV) excitation. In the corona discharge method, air or oxygen is passed between two electrodes, and a corona discharge is generated by applying high voltage to the electrodes. In the UV excitation process, ozone is generated photochemically by passing air through a path irradiated with UV light. A portion of the air dissociates and recombines to form ozone. The corona discharge method is the most commonly used. The UV excitation method is limited in application because of its high energy requirements (20 kWh per pound of ozone produced) and relatively low ozone production rate.



Cooling Tower Water Ozonation Unit

Advantages

- More effective in algae and scale control than chemical methods, thus making the entire process more efficient
- No residual left in the water; therefore, the water can be recycled more often
- Eliminates the need for chemicals and chemical wastewater disposal
- Reduces water consumption by 40%
- Reduces operating costs, when compared to chemical treatment, through less maintenance, less material usage, and less water usage and disposal

Disadvantage

- High capital cost in comparison to chemical treatment; however, can be cost-effective when reduced chemical consumption and labor costs are considered

Commercial Status

Ozone-generating technology was developed almost 100 years ago. It is currently used in the treatment of drinking water, laundry wash water, swimming pool and spa water, municipal wastewater, and sewage sludge. Ozonation of cooling tower water, however, is a relatively new practice that began during the 1970s.

Cost and Electrical Requirements

The cost and energy impact of ozonation for cooling towers varies by project size, water composition and concentration, and feed gas utilized (e.g., air or oxygen). In general, ozonation systems for cooling towers generate 1–50 lb of ozone per day; although most systems fall in the range of 1–10 lb per day. The approximate capital cost of a small system (generating 1–10 lb per day) ranges from $8000 to $25,000. For large systems (20–50 lb per day), the capital cost ranges from $75,000 to $200,000. In general, total costs for an ozone system range from $5 to $10 for every 1 million gallons of water treated.

Electricity requirements also differ significantly depending on whether air or oxygen is used as the feed gas. The cost of electricity represents 75% of total ozone system operating costs. For ozonation systems using the corona discharge method with oxygen as the feed gas, the cost of oxygen (approximately 2–3 cents per lb) must be added. Energy requirements for ozone generators can range from 20 kWh per lb of ozone for the UV excitation method to 6 kWh per lb of ozone generation for the corona discharge method. The latter figure is representative of the energy requirements when generating large volumes of ozone through corona discharge.

Ozonation of Cooling Tower System Characteristics

Dimensions	Length: 30'–37' Width: 30'–64' Height: 55'–82'
Capacity	1.50 lb/d of ozone
Energy Consumption	6-20 kWh/lb of ozone
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	Corona discharge system:
Purchase	\$8000-\$25,000 (1-10 lb/d)
	\$75,000-\$200,000 (20-50 lb/d)
Installed	Minimal
Other Supplies	None

Ultraviolet Disinfection of Air

Basic Principle

Properly maintained air filters and ventilation systems can effectively remove dust, pollen, other airborne particles, and some microorganisms from indoor air. However, some microorganisms are so small that even the most efficient filters may be unable to capture them, making additional safeguards desirable.

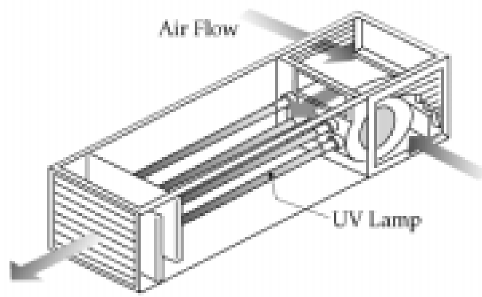
Bacteria and viruses are most prevalent where people congregate—in medical clinics, hospitals, offices, hotels, and stores. The recirculation of indoor air in these places produces the threat of infection. To prevent airborne diseases such as tuberculosis (TB), many institutions (medical facilities, office buildings, hotels/motels, and shopping centers) are considering the installation of air sanitation units.

Ultraviolet (UV) germicidal irradiation is a scientifically proven technology that helps prevent the transmission of disease by killing many types of airborne microbes, including those responsible for TB. The UV spectrum lies between X rays and the visible spectrum (180-400 nm). Within this range, UV rays are further divided into longwave UV-A rays (315–400 nm), which are generally used in tanning salons; medium wave UV-B rays (280–315 nm), which are found in sunlight and cause skin cancer and tanning; and shortwave UV-C rays (<280 nm), which are used for disinfection of airborne germs. UV-C rays penetrate the cell walls of microorganisms and cause photochemical breakdown of their DNA; this prevents replication and causes cell death.

System Description

The peak UV absorption efficiency for DNA is 250–260 nm. UV-C lamps are an ideal technology for destruction of airborne germs because their energized cathodes are designed to emit rays at 253.7 nm. These lamps are similar to fluorescent lamps except the tubes are made of quartz glass and their inner surfaces are not coated with phosphor. They can kill microbes that are brought by air currents into their zone of irradiation.

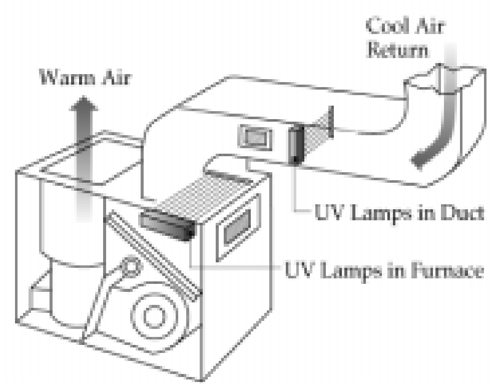
There are two ways of utilizing UV-C lamps: 1) through overhead or upper-air irradiation, in which the lamps are installed in the upper part of a room in the form of simple fixtures or enclosed units; and 2) air duct irradiation, in which the lamps are installed in the ventilation ducts of air handling systems.



Enclosed UV Unit

- Overhead or Upper-Air Irradiation: The UV-C light fixture or enclosed unit is mounted to either the ceiling or a wall, depending on the height of the room. Overhead installations are best for ceilings that are at least 9 feet high, so the fixtures extend no lower than 7 feet. This is necessary so that room occupants do not bump their heads on the fixtures or look directly into the UV rays. These fixtures should be shielded on the bottom and partially on the side to deflect the UV rays upward or sideways instead of downward. Enclosed, fan-powered UV-C units purify and recirculate air while minimizing the potential for human exposure to UV rays. In this case, the germicidal lamps are completely contained within a stainless steel chamber. Room air is drawn past a particulate filter, forced into a UV-C exposure chamber, and then pushed past baffles and reintroduced into the room. In some units, the exposure chamber is lined with reflective brushed aluminum to boost the effectiveness of the rays.

- Air Duct Irradiation: UV-C lamps are installed inside the ventilation ducts of an air handling system. Air handling systems are known conduits for the spread of infectious disease. Until recently UV germicial irradiation could not be applied, because conventional UV-C lamps suffer a drastic loss of output and thus “killing power” when exposed to moving air, and even greater losses when exposed to cold air. New technology has overcome these problems, and UV-C units are available that are effective for temperatures of 32–90°F. Air duct UV-C units can be installed in new or existing air handling systems. Since the effectiveness of the rays increases with the duration of exposure, the lamps should be installed where airflow is slowest, and preferrably perpendicular to the airflow so that the light radiates along the length of the air duct. The number of lamps required depends on the volume of air handled by the duct, the height and length of the duct, and the disinfection rate desired.



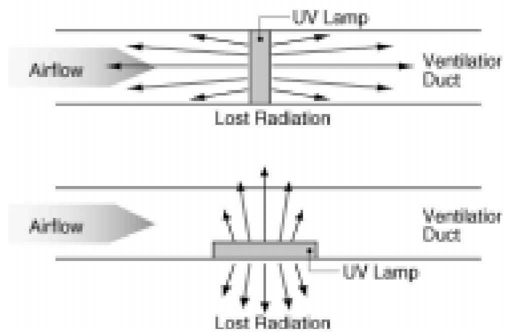
Air Duct UV Unit

Advantages

- Effective germicidal treatment of airborne microorganisms
- Easy to install and remove; no building downtime required
- Adaptable to air conditioning systems, combined air heating and cooling systems, and exhaust systems
- No fumes or secondary contaminants produced
- Relatively low maintenance requirements
- Destroys rather than traps biological contaminants, resulting in less risk for service personnel

Disadvantages

- HVAC ducts may be difficult to access in some existing buildings.
- With upper-air irradiation, caution must be exercised to avoid prolonged direct or indirect exposure to the UV rays.
- Upper-air irradiation can cause plastics in furnishings to deteriorate and wall paint and carpet colors to fade more quickly.



Air Duct Irradiation

Commercial Status

Current applications of UV disinfection of air include a hospital in Southern California and homeless shelters in Boston, Massachusetts. A recent resurgence of TB and other airborne diseases is causing alarm across the country. Data from 1992 show a 20% increase in TB cases nationwide since 1985; 75% of these cases were among the homeless. Many individuals who contracted TB at homeless shelters are not returning for follow-up treatments, resulting in new, drug-resistant strains of the disease.

In support of UV disinfection of air, a five-year study is being launched by the National Tuberculosis Coalition—a joint effort of EPRI's Healthcare Initiative, Consolidated Edison of New York, Harvard University Medical School, and other utilities and health organizations, to conduct collaborative research, development, and demonstration projects to stop the spread of TB and other airborne diseases. The study will test the effectiveness of UV germicidal light in fighting the new, drug-resistant strains of TB at homeless shelters in six cities (New York City and Birmingham, Alabama, are the known participants to date). Data collected in the study will support promotion of the use of UV disinfection at healthcare facilities, schools, prisons, and public buildings throughout the country.

Ultraviolet Disinfection of Air System Characteristics

Dimensions	Very with room size and/or duct size and air change requirements; fixtures can be custom built.
Power Rating	30-120 watts (1-4 lamps)
Energy Consumption	Approximately 790 kWh annually*
Key Inputs	
Power	Electricity
Other	Dry air source
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Purchase and Installation	Upper-Air Irradiation: $300-$1700/unit Air Duct Irradiation: $300-$700/unit
Replacement Lamp Tubes	$60-$100/tube

* Assuming three 30-watt units used 8760 hours in a 600-square foot area.

Cost and Electrical Requirements

UV-C lamps and units are available nationwide in a variety of models to suit different applications. They are sold through HVAC distributors as well as independent agents. Upper-air irradiation units come in models to accommodate different room sizes and air change requirements. Manufacturers' list prices range from $300–$1700 for enclosed units, depending on the size and number of lamps in the unit. Air duct units are available in many configurations and sizes and can be modified as needed to fit any duct system or air change rate requirement. Manufacturers' list prices range from $300–$700 per unit, depending on the size and number of lamps in the unit. Replacement lamps cost $60–$100 each, depending on wattage and bulb length. For maximum effect, lamp units should run continuously; frequent on/off cycles can shorten bulb life.

Manufacturers also suggest installation of one 30-watt fixture (or two 15-watt fixtures) for every 200 square feet of floor space, or for every seven people in a room—which ever is greater. Therefore, an area with a capacity of 20 people would require three 30-watt units. A facility running these units continuously for one year (8760 hours) would use about 790 kWh in their operation.

EPRI Information

Information on the EPRI Healthcare Initiative is available from the Northeast Regional Community Environmental Center, (800) 424-3774.

5

RESOURCES

This section contains three lists: 1) equipment suppliers for the electrotechnologies profiled in this guide, by equipment type; 2) EPRI information resources on efficiency technologies; and 3) shopping center trade associations. The information used to compile these lists was based on a combination of a telephone survey, published reports, directories, buyer's guides, and technical journals. The information was current at the time of publication and is expected to change over time.

Outdoor Lighting

Equipment Suppliers

Bairnco Corp.
2251 Lucien Way, No. 300, Maitland, FL 32751
(407) 875-2222, fax: (407) 875-3398

Bieber Lighting Corp.
970 W. Manchester Blvd., Inglewood, CA 90301
(213) 776-4744, fax: (310) 216-0333

Bulbtronic, Inc.
45 Banfi Plaza, Farmingdale, NY 11735
(800) 647-2852, (516) 249-2272, fax: (516) 249-6066

Carlon (Lanson & Sessions Co.)
25701 Science Park Dr., Cleveland, OH 44122
(216) 831-4000, fax: (216) 831-5579

Cooper Lighting Group
400 Busse Rd., Elk Grove Village, IL 60007-2195
(847) 956-8400, fax: (847) 956-1475

Crouse-Hinds Co.
Lighting Production Div., P.O. Box 4999, Syracuse, NY 13221
(315) 477-8185

Doane, L.C., Co.
55 Plains Rd., P.O. Box 975, Essex, CT 06428
(203) 767-8295, fax: (203) 767-1397

Duro-Test Corp.
9 Law Dr., Fairfield, NJ 07004
(201) 808-1800, fax: (201) 808-6622

Federal APD, Inc., Federal Signal Corp.
24700 Crestview Ct., Farmington Hills, MI 48335
(800) 521-9330, (810) 477-2700, fax: (810) 477-0742

Gardco Lighting
2661 Alvarado St., San Leandro, CA 94577
(510) 357-6900, fax: (510) 357-3088

G.E. Company
3135 Easton Turnpike, Fairfield, CT 06431
(800) 626-2004, fax: (518) 869-2828

Hapco Division of Kearney-National, Inc.
P.O. Box 547-KN, Abingdon, VA 24210
(540) 628-7171, fax: (540) 628-7707

Litetronics International
4101 W. 123rd St., Alsip, IL 60658
(708) 389-8000 ext 195, fax: (708) 371-0627

Mason, L.E., Co.
98 Business St., Boston, MA 02136
(617) 361-1710, fax: (617) 361-6876

Philips Lighting Co.
200 Franklin Sq. Dr. Somerset, NJ 08875
(908) 563-3000, (800) 631-1259, fax: (908) 563-3975

Rig-A-Light
P.O. Box 12942, Houston, TX 77217
(713) 943-0340, fax: (713) 943-8354

Sterner Lighting Systems
351 Lewis Ave., Winisted, MN 55395
(320) 485-2141, fax: (320) 485- 2899

Thomas and Betts
Corporate Headquarters, Memphis, TN 38119
(800) 888-0211, fax: (800) 888-1366

Unique Solution/Manville
515 McKinley Ave., Newark, OH 43055
(614) 349-4194, fax: (800) 346-5923

Foodservice

Equipment Suppliers

FlashBake Oven

Quadlux, Inc.
47817 Fremont Blvd., Fremont, CA 94538
(800) 843-6836, fax: (510) 498-4224

Induction Cooktop

CookTek, Inc.
954 W. Washington MC37, Chicago, IL 60607
(800) 908-0004, fax: (888) 266-5329

Garland Commercial Industries
185 E. South St., Freeland, PA 18224
(800) 424-2411, fax: (717) 636-3903

Vulcan-Hart Co.
P.O. Box 696, Louisville, KY 40201
(800) 814-2028, fax: (502) 775-4053

Combination Oven-Steamer

Alto-Shaam, Inc.
W164 N9221 Water St., Menomonee Falls, WI 53051
(800) 558-8744, fax: (800) 329-8744

Blodgett Combi
P.O. Box 1440, Williston,, VT 05495-1440
(888) 992-6624, fax: (802) 860-3784

Groen
1900 Pratt Blvd., Elk Grove Village, IL 60007
(847) 439-2400, fax: (847) 439-6018

Solid-State Electric Fryer

Frymaster Corporation
P.O. Box 51000, Shrieveport, LA 71135-1000
(800) 221-4583, fax: (318) 868-5987

Heat Pump Water Heater

Equipment Suppliers

Addison Products Company
7050 Overland Rd., Orlando, FL 32810
(407) 292-4400, fax: (407) 290-1329

Colmac Coil Manufacturing, Inc.
370 North Lincoln St., Colville, WA 99114
(509) 684-2595, fax: (509) 684-8331

Crispaire Corporation
3570 American Dr., Atlanta, GA 30341
(404) 458-6643, fax: (404) 457-2352

DEC International, Therma-Stor Products Group
1919 South Stoughton Rd., Madison, WI 53716
(800) 533-7533, (608) 222-5301, fax: (608) 222-1447

Econar Energy Systems Corporation
33 West Veum, Appleton, MN 56208
(800) 432-6627, fax: (612) 422-1551

FHP Manufacturing, A Harrow Company
601 NW 65th Ct., Fort Lauderdale, FL 33309
(305) 776-5471, fax: (305) 776-5529

Paul Mueller Company, Commercial Refrigeration Products Division
P.O. Box 828, Springfield, MO 65801
(800) 683-5537, fax: (800) 436-2466

The Trane Company
P.O. Box 7916, Waco, TX 76714
(817) 840-3244, fax: (817) 840-2221

Wallace Energy Systems
831 Dorsey St., Gainesville, GA 30501
(404) 534-5971, fax: (404) 534-3410

WaterFurnace International, Inc.
9000 Conservation Way, Fort Wayne, IN 46809
(800) 222-5667, fax: (219) 478-3029

Electric Infrared Space Heating

Equipment Suppliers

Aitken Products, Inc.
P.O. Box 151, 566 North Eagle St., Geneva, OH 44041
(216) 466-5711, fax: (216) 466-5716

Chromalox Industrial, Heating Products
641 Alpha Dr., Pittsburgh, PA 15238
(412) 967-3800, fax: (412) 967-5148

Fostoria Industries, Inc.
1200 N. Main St., P.O. Box 986, Fostoria, OH 44830
(419) 435-9201, fax: (419) 435-0842

Heatrex, Inc.
P.O Box 515, Meadville, PA 16335
(814) 724-1800, fax: (814) 333-6580

InfraTech Corp.
1684 Industrial Park St., Covina, CA 91722
(800) 421-9455, (818) 331-9400, fax: (818) 858-1951

Ozonation of Cooling Tower Water

Equipment Suppliers

Americlear Corp.
3101 SW 34th Ave., Suite 905-448, Ocala, FL 34474
(352) 622-8772, fax: (352) 622-1290

Aqua-Flo, Inc.
6244 Frankford Ave. Dept. 96, Baltimore, MD 21206
(410) 485-7600, fax: (410) 488-2030

EDC Ozone Systems
3110 W. Story Rd., Irving, TX 75038
(972) 257-0322, fax: (972) 257-9769

Enviropure, Inc.
7140 Madison Ave. West, Golden Valley, MN 55427
(612) 591-1350, fax: (612) 591-0292

GuestCare, Inc.
3030 LBJ Freeway, Suite 1460, Dallas, TX 75234
(972) 243-3035, fax: (972) 243-0706

Oxygen Technologies, Inc.
8229 Melrose Dr. Shawnee Mission, KS 66214
(913) 894-2828, fax: (913) 894-5455

Ozonia North America
178 Route 46, P.O. Box 330, Lodi, NJ 07644
(201) 778-2131, fax: (201) 778-2357

PCI Ozone & Control Systems, Inc.
One Fairfield Crescent, West Caldwell, NJ 07006
(201) 575-7052, fax: (201) 575-8941

Pure Water
3725 Touzalin Ave., Lincoln, NE 68507
(402) 467-9300, fax: (402) 467-9393

REZ-TEK
11-15 Avenue E, Hopkinton, MA 01748
(508) 435-8554, fax: (508) 435-8722

Ultraviolet Disinfection of Air

Equipment Suppliers

American Ultraviolet Corp.
212 North Mt. Zion Rd., Lebanon, IN 46052
(317) 483-9514, fax: (317) 483-9525

Atlantic Ultraviolet
375 Marcus Boulevard, Hauppauge, NY 11788
(516) 273-0500, fax: (516) 273-0771

Fuller Ultraviolet Corp.
P.O. Box 667, 9416 Gulfstream Road, Frankfort, IL 60423
(815) 469-3301, fax: (815) 469-1438

Steril-Aire, Inc.
11100 E. Artesia Blvd., Suite D, Cerritos, CA 90703
(310) 467-8484, fax: (310) 467-8481

Ultraviolet Systems and Equipment, Inc.
9135 Spring Branch Dr. Suite 202, Houston, TX 77080
(713) 461-7666, fax: (713) 461-7760

UV Technologies
4728 Brayton Terrace S. Palm Harbor, FL 34685
(813) 937-4022, fax: (813) 943-0911

Information on Efficiency Technologies

This list provides EPRI resources on efficiency technologies identified in this guide. Copies of these publications can be ordered through the EPRI Distribution Center, (510) 934-4212.

CFC Education/Information

Chiller Retrofit Issues, SU-102513-R1, November 1995.

Status of HCFC-22 Alternatives for Unitary HVAC, SU-104230-R1, July 1995.

Electric Chillers and CFCs, BR-102967, April 1994.

"Refrigerants for an Ozone-Safe World," *EPRI Journal*, JR-101543, July/Aug. 1992.

Adjustable Speed Drives

Medium-Voltage Adjustable Speed Drives: A Basic Specification Guide, BR-104420, May 1995.

Assessment of Electric Motor Technology: Present Status, Future Trends, and R&D, TR-101264, December 1992.

Adjustable Speed Drives: Application Guide, TR-101140, December 1992.

Adjustable Speed Drive Directory, Third Edition, CU-7544, December 1991.

Energy-Efficient HVAC

Electric Chiller Handbook, TR-105951, February 1996.

Space-Conditioning System Selection Guide, TR-103329, December 1993.

Packaged Terminal Heat Pump Assessment Study, CU-6777, March 1990.

Additional information on HVAC can be obtained from the EPRI HVAC&R Center, (800) 858-3774.

Energy-Efficient Lighting

Proceedings: Efficient Lighting 1993: A Lighting Symposium for Electric Utility Lighting and DSM Professionals, TR-105963, January 1996.

Electronic Ballasts, BR-101886, May 1993.

High-Intensity Discharge Lighting, BR-101739, May 1993.

Advanced Lighting Technologies Application Guidelines: 1990, TR-101022-R1, May 1993.

Lighting Fundamentals Handbook, TR-101710, March 1993.

Commercial Lighting Efficiency Resource Book, CU-7427, September 1991.

Additional information on lighting can be obtained from the EPRI Lighting Information Office, (800) 525-8555.

Energy-Efficient Motors

Electric Motors, TR-100423, June 1992.

Assessment of Electric Motor Technology: Present Status, Future Trends, and R&D Needs, TR-101264, December 1992.

Energy-Efficient Office Equipment

Guide to Energy-Efficient Office Equipment, TR-102545R1, February 1996.

Proceedings: Energy-Efficient Office Technologies 1994, TR-105549, December 1995.

Electronic Office Equipment: Ensuring Energy Efficiency in the Workplace, BR-101965, April 1993.

Heat Recovery/Water-Loop Heat Pumps

Field Performance of Heat Recovery Chillers and Heat Recovery Heat Pumps, TR-103416, November 1993.

Water-Loop Heat Pump Systems, TR-101863, May 1993.

Commercial Building Water-Loop Heat Pump Field Test, TR-101865, April 1993.

Water-Loop Heat Pump Systems, Volumes 1 and 2, TR-101134, December 1992.

Refrigeration

Analysis of Supermarket Dehumidification Alternatives, TR-100352, November 1992.

Field Testing of High-Efficiency Supermarket Refrigeration Systems, TR-100351, December 1992.

Proceedings: Electric Dehumidification—State-of-the-Art Humidity Control for Supermarkets Seminar, TR-101154, October 1992.

Guide for the Selection of Supermarket Refrigeration Systems, CU-6740, March 1990.

Thermal Energy Storage

Water Thermal Energy Storage: Using Off-Peak Energy for Low-Cost Space Conditioning, BR-100690-R1, 1996.

Thermal Energy Storage for the Small Packaged Terminal Air Conditioning Unit, TR-106729, July 1996.

Proceedings: 1992 Electric Thermal Storage (ETS) and Thermal Energy Storage (TES) Conference, TR-103729, September 1994.

Thermal Storage Evaluation, TR-104429, June 1994.

Trade Associations

Building Owners and Managers Association International
1201 New York Ave., NW, Suite 300, Washington, DC 20005
(202) 408-2662, fax: (202) 371-0181

International Council of Shopping Centers
1033 N. Fairfax Dr. Suite 404, Alexandria, VA 22314
(703) 549-7404, fax: (703) 549-8712

National Retail Federation
325 7th Street, NW, Suite 1000, Washington, DC 20004-2608
(202) 783-7971, fax: (202) 737-2849