A small-business guide

Lodging

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Wayne Krill manages the Electrotechnologies for Small Businesses project.

ABOUT THIS GUIDE

Members of the small business community historically have had little contact with their utility providers. This guidebook was developed to facilitate communication between electric utilities and the motels and hotels in their communities.

The *Lodging* guidebook is intended to familiarize readers with the business of owning and/or operating motels and hotels by providing a historical overview of the lodging industry and summarizing its current issues and challenges. The guide specifically focuses on delineating how electric equipment can address the needs and interests of motel and hotel owners and managers.

This business guide is one of a series of publications about small businesses produced by the Electric Power Research Institute (EPRI). The *Lodging* 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.

This 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.

The economic performance of motels and hotels in the United States is closely tied to the boom and bust cycles of the U.S. economy. The lodging industry is today in an upward swing of the business cycle, enjoying a robust demand for services and, in the flush of the resulting profits, undertaking capital-intensive construction and renovation projects. There are currently approximately 42,600 motels and hotels in the country, employing nearly 1.5 million people and generating revenues of over $71 billion.

Occupancy and operating costs are the watchwords of motel and hotel owners and operators regardless of the health of the economy. Holding the two in balance is necessary for survival; managing resources to achieve higher occupancy rates and lower operating costs is the key to enduring success.

The key driver in the economic health of any particular establishment is occupancy: Guests must be attracted to the facility and find it comfortable and safe. To meet the challenges of attaining a good interior and exterior ambiance cost-effectively, motel and hotel owners and operators are seeking methods and technologies that will ensure a comfortable, healthy indoor environment, a high-visibility profile, and reduced operating costs. The accompanying table identifies specific electrotechnologies that address these small-business concerns. These electrotechnologies and other high-efficiency electric technologies are described in detail in the *Lodging* guide (EPRI TR-106676-V3), which is 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 Motels and Hotels

	Electric Infrared Space Heating	Ozonation of Cooling Tower Water	Ultraviolet Disinfection of Air	Outdoor Lighting
Description	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.	Six different types of lighting technologies are available; each offers different characteristics in wattage, brightness, light tone, efficiency, and lifespan; they can be combined to meet site-specific needs.
Lodging Need	To provide warmth and comfort in hard-to-heat public spaces that guests may occupy.	Can reduce space-conditioning operating costs and create a healthier, more environmentally sound facility through reduced water and chemical consumption.	Providing a safe and healthy environment for guests can include protecting them from exposure to airborne diseases and molds that may cause illness and allergic reactions.	Lighting improves the visibility and attractiveness of a facility (curb appeal), enhances guest safety, and reduces the potential for crime.
Application	Can be used to heat breezy lobbies, walkways, outdoor restaurants, and other public spaces exposed to the environment.	Used by hotels (and other commercial facilities) that operate chillers and cooling towers to provide air conditioning for the facility.	To treat air in hotel public spaces, UV disinfection lamps can be mounted on ceilings, walls, or within ventilation ducts.	Signage on or near the facility; general lighting for driveways, walkways, delivery areas; facade and landscape lighting.
Benefits	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.	Increased public perception of quality, attractiveness, excitement from general signage and facade lighting; improved safety from area lighting.
Cost	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; 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–cubic foot space would require 790 kWh per year.	Systems are custom-designed to meet a facility's needs and budget.

Electrotechnologies for Motels and Hotels (continued)

	Foodservice Equipment	Heat Pump Water Heater	Ozonated Laundering	Ozonation of Swimming Pool Water	Reverse Osmosis of Drinking Water
Description	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.	Ozonated water is used instead of fresh water in the wash and rinse cycles to quickly and effectively break down soils on fabrics with minimal or no use of detergents.	Ozone is used instead of chlorine to treat pool or spa water by injecting the gas into the water return line where, within seconds, it destroys bacteria and viruses and polarizes organic molecules to assist in their capture by filtration.	These modular systems use permeable membranes to filter heavy metals, volatile organic compounds, and chlorine from drinking water.
Lodging Need	Labor-saving, energy-saving, waste-reducing equipment can help control operating costs for foodservice operations.	Technologies that decrease operating costs help motels and hotels maintain competitive prices and overall economic viability.	All lodging facilities generate large quantities of soiled laundry; this technology can help minimize labor and operating costs for laundry operations.	Hotels and most motels have swimming pools; ozonated water is cleaner than chlorinated water, does not irritate the eyes or skin, and does not leave a strong odor.	Providing guests a healthy, high-quality, safe environment can involve ensuring the purity of the water they drink.
Application	Motels can expand operations simply with plug-in countertop equipment, such as the Flash Bake oven; hotels can employ the full range of equipment options, including the induction cooktop and combination ovensteamer.	Best suited to augment existing water heating and space cooling systems by servicing a well-balanced water heating and space cooling load, versus serving peak demand.	Systems are available in many configurations and sizes; ozonation equipment can be retrofit to any commercial laundry system, one washer at a time, or can be built into a new system.	Ozonation systems are available in many sizes, suitable for applications ranging from small spas to olympic-size pools.	Motels and hotels that are concerned about the quality of local water supplies can use reverse osmosis to filter out potential contaminants.
Benefits	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 guest and/or work areas.	Laundries with ozone systems have faster wash and rinse cycles, use less water, less energy, and less or no detergents/chemicals; they generate less wastewater; and stress fabrics less.	Reduces maintenance and materials costs, increases pool equipment life expectancy, and creates a more pleasant exper-ience for motel and hotel guests.	Reverse osmosis systems are modular, require less space, less maintenance, less energy, and cost less than other treatment processes.
Cost	The FlashBake oven costs about $4400; an induction range, about $6700; a combination oven-steamer, about $18,600.	Varies with the needs of the facility, ranging from $125/kBtu/h to $210/kBtu/h.	System costs (ozone generator plus side-stream injector) range from $6000–$143,000, depending on washer size (85–800 pounds).	System costs range from $4–$10 per 100 gallons of water; the equipment cost ranges from $500–$16,000.	Systems cost roughly $10,000–$60,000 to purchase and install; a system processing 5 gallons of water per minute would cost $30,000–$35,000.

CONTENTS

1 Introduction to the Lodging Industry 1-1
Business Overview 1-1
Energy Use 1-4

2 Business Challenges and Needs 2-1
Occupancy 2-1
Operating Costs 2-3
Barriers to Technology Adoption 2-4

3 Technology Solutions 3-1
Heating, Ventilation, and Air Conditioning 3-3
Lighting 3-9
Foodservice 3-11
Water Heating and Other Energy Uses 3-13

4 Electrotechnology Profiles 4-1
Electric Infrared Space Heating 4-1
Ozonation of Cooling Tower Water 4-5
Ultraviolet Disinfection of Air 4-8
Outdoor Lighting 4-11
Foodservice Equipment 4-14
Heat Pump Water Heater 4-17
Ozonated Laundering 4-21
Ozonation of Swimming Pool Water 4-24
Reverse Osmosis of Drinking Water 4-27

5 Resources 5-1
Equipment Suppliers 5-1
Information on Efficiency Technologies 5-9
Trade Associations 5-11

1

INTRODUCTION TO THE LODGING INDUSTRY

A rapid increase in automobile travel and interstate highway construction in the post-World War II era sparked an explosion of growth in the lodging industry, and especially in motel construction. A second boom in hotel and motel construction during the 1980s has resulted in a lodging industry that included approximately 42,600 establishments by 1993. While lodging may not readily come to mind when thinking of small businesses, because of the publicity given mostly to the largest facilities, more than 85% of lodging establishments employ fewer than 50 people. Moreover, the larger hotels often support a variety of small-business-type operations, including foodservice, swimming pool and/or health club, and laundry facilities.

Business Overview

This guide focuses on two basic types of lodging establishments: motels and hotels (SIC 7011). In general, these establishments provide lodging and sometimes meals to the public. The services provided by an individual establishment can range from solely overnight accommodations to accommodations plus food and meeting services for business purposes, or accommodations plus entertainment for vacationers.

Motels are typically smaller, one- to three-story lodging facilities with 30–100 guest rooms, each with an outside entrance (vs. entry from a common interior hallway). They usually have a limited number of meeting rooms, and seldom contain full-service restaurants. The motel industry arose out of a need for simple overnight accommodations for road-weary travelers; as a result, they are normally located close to main highways. When older highways were replaced with new interstate highways after World War II, many of the older motels were replaced with new national chains of motels at highway interchanges. Common motel chains include Comfort Inn, Days Inn, Red Roof Inn, and Courtyard by Marriott.

Hotels are typically larger, full-service facilities with 8–70 floors or more, and more than 100 guest rooms. Hotels also often contain full-service restaurants, indoor fitness facilities, banquet rooms, and gift shops. At the turn of the century, hotels were primarily located in the downtown sections of major cities. Today, almost all hotels, whether located in downtown areas or in the suburbs, exist to support business travelers, conferences, vacationers, and large social gatherings. Hotels are either independently owned or a part of national chains such as Hilton, Marriott, Ritz-Carlton, Ramada, and Embassy Suites.

According to the U.S. Department of Commerce, there were between 41,690 and 42,688 hotel and motel establishments in the United States in 1992 (see Tables 1 and 2). These establishments employed more than 1.4 million people and had annual receipts of more than $67 billion. This figure was up from 38,800 establishments, 1.3 million employees, and $56 billion in revenues in 1988. While there are a number of extremely large hotels, the majority of hotel and motel establishments can be considered small businesses, with 87% employing fewer than 50 people and 93% employing fewer than 100 people in 1993.

Table 1
Profile of the Lodging Industry (1992)

Establishment Type	No. of Establishments	No. of Employees	Annual Receipts ($ million)
Hotels	16,670	1,160,700	55,450
25 rooms or more	12,940	1,144,900	54,850
24 rooms or less	3,730	15,800	600
Motels	25,020	295,200	11,740
TOTAL (SIC 7011)	41,690	1,455,900	67,190

Source: U.S. Department of Commerce, Bureau of the Census, *1992 Census CD-ROM, Report Series*, 1995.

Lodging industry performance tends to be cyclical, with periods of boom and bust that generally mirror the overall U.S. economic pattern. The period of growth and prosperity that followed World War II resulted in a rapid increase in automobile travel and interstate highway construction. For the lodging industry, highways brought not only business for existing establishments, but an opportunity for new hotel and motel development. The energy crisis and recession of the early 1970s, however, drastically curbed auto travel, reducing lodging industry revenues while simultaneously increasing fuel and electricity bills. This precipitated a downturn in new hotel and motel construction.

In the late 1970s, high inflation and interest rates made hotels profitable and popular with investors once again. The Reagan Administration's Tax Reform Act of 1981 reinvigorated business investments in the early 1980s. This led to overbuilding and segmentation of the market—into economy inns, limited-service hotels, budget motels, and all-suites hotels—that continued throughout the 1980s. As many as 50% of existing hotels were constructed within the past two decades.

Table 2
Distribution of Hotels and Motels by Size (1993)

Size	No. of Establishments	Percent of Total
Small (0–49 employees)	37,025	87
Medium (50–99 employees)	2,636	6
Large (100+ employees)	2,936	7
TOTAL (SIC 7011)	42,597	100

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns, 1993–United States*, CBP-92-1, 1996.

When the country headed toward a recession again in the early 1990s, the industry began to feel the effects of overbuilding and the impact of a 1986 tax law unfavorable to real estate investment. Industry construction was curbed dramatically once more, such that only 4000 new hotels and motels were constructed during the two-year period from 1990–1992, compared to the 25,000 that were constructed during the two-year period from 1987–1989.

Today, the lodging industry is again in an upswing of the business cycle. The U.S. economy has emerged from the recession of the early 1990s, and slower construction combined with increasing demand for rooms has turned industry losses into profits. Both hotels and motels are currently being built or converted throughout the country; these facilities are replacing older ones or supporting new growth in specific areas, such as revitalized downtown areas or new suburban areas near major highways or airports.

In 1993, California, Florida, Texas, and New York led the list of the top 10 states with the most hotel and motel establishments, with 4909, 3114, 2330, and 1924 establishments, respectively (see Figure 1). This list is rounded out by Michigan, North Carolina, Pennsylvania, Virginia, Georgia, and New Jersey, each of which has approximately 1000 establishments.

While California is the state with the most lodging facilities, the leading region is the South Atlantic census region, ranging from Delaware to Florida, which has nearly 20% of all hotels and motels and significantly higher occupancy rates than the rest of the country. Orlando, with the huge Walt Disney properties, has the largest hotel market in the United States, containing about 85,000 rooms. Other large markets include Los Angeles, Las Vegas, Chicago, and Washington, D.C.

State	Hotels/ Motels
CA	4909
FL	3114
TX	2330
NY	1924
MI	1331
NC	1293
PA	1247
VA	1126
GA	1121
NJ	1119

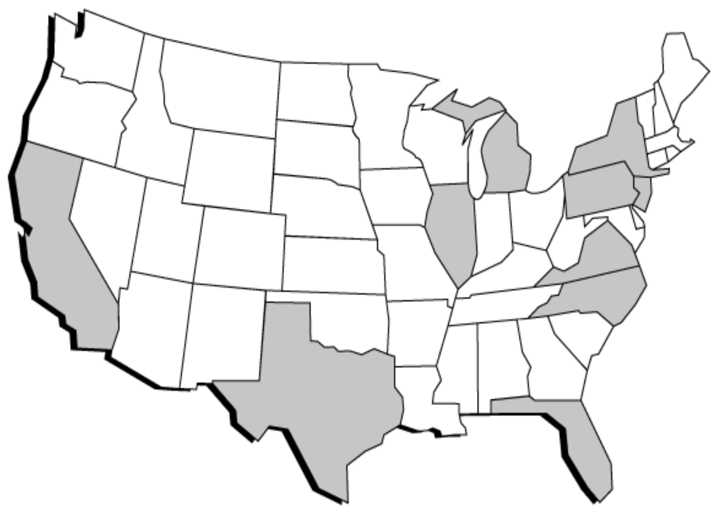


Figure 1
Top 10 States for Lodging Industry

Energy Use

Energy use in hotels and motels can vary widely, depending principally on the type of services a hotel or motel provides, its location, and its size. While the basic function of a hotel or motel is to provide comfortable rooms to overnight guests, these facilities often provide a variety of services, including full-service restaurants, fast-food restaurants, health clubs, swimming pools, laundries, meeting rooms, banquet rooms, gift shops, and travel agencies, each of which have specific energy needs.

According to the U.S. Department of Energy, there are roughly 154,000 lodging industry buildings in the United States—including hotels, motels, inns, shelters, boarding houses, convents, monasteries, dormitories, sororities, fraternities, and orphanages. Together, these facilities consumed 463 trillion Btu in total energy in 1992, the most recent year for which there are data. Hotels and motels alone consumed approximately 142 trillion Btu, more than 30% of the industry total. Electricity (58%) and natural gas (35%) represent the largest portions of energy use for hotels and motels. District heating (5%) and fuel oil (2%) account for the remainder.

Total electricity use by hotels and motels in 1992 was equivalent to 24 billion kWh or 44% of the electricity consumed by the lodging industry. The average electricity intensity for hotels and motels is 33.4 kWh per square foot (see Table 3). This intensity is higher than for foodservice establishments, healthcare buildings, office buildings, and retail stores, but is less than for grocery stores. This is primarily due to the round-the-clock operations of hotels and motels. Lodging facilities in the South and West tend to be more intensive users of electricity than those in the Midwest and Northeast, due to the greater need for air conditioning.

Table 3
Electricity Consumption in Hotels and Motels (1992)

Census Region and Division[1]	**Total Electricity Consumption** (thousand kWh)	**Total Floor Space** (thousand sq ft)	**Total Electric Intensity** (kWh/sq ft)
Northeast	**297,264**	**43,037**	**6.9**
New England	70,353	11,916	5.9
Middle Atlantic	226,911	31,121	7.3
Midwest	**836,585**	**65,523**	**12.8**
East North Central	175,332	11,874	14.7
West North Central	661,253	53,649	12.3
South	**11,825,924**	**371,816**	**31.8**
South Atlantic	7,697,134	216,851	35.5
East South Central	1,875,037	95,423	19.6
West South Central	2,253,753	59,542	37.9
West	**11,081,476**	**239,408**	**46.3**
Mountain	7,985,106	132,545	60.2
Pacific	3,096,370	106,863	28.9
TOTAL	**24,041,247**	**719,783**	**33.4**

[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.

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

As illustrated in Figure 2, heating, ventilation, and air conditioning (HVAC) systems are responsible for the largest percentage of electricity use—46%—in all types of lodging facilities. Lighting accounts for approximately 30%, refrigeration 10%, and cooking 8%. The remaining 6% is accounted for by water heating and miscellaneous equipment use. If a facility includes a service such as a restaurant, swimming pool, or laundry, energy use for water heating and related equipment is often significantly higher.

As noted previously, the energy requirements of a hotel or motel are governed by a number of factors, the leading one being the special services provided, but also the type of building, construction techniques and materials, climate, number of guest rooms, and number and size of public spaces. When comparing among similar facilities, the heating loads increase the further north a facility is located. Cooling loads are more dependent on size than climate and normally increase as the number of floors increase. The water heating load depends on the amount of water heating required for foodservice, laundry, and pool heating.

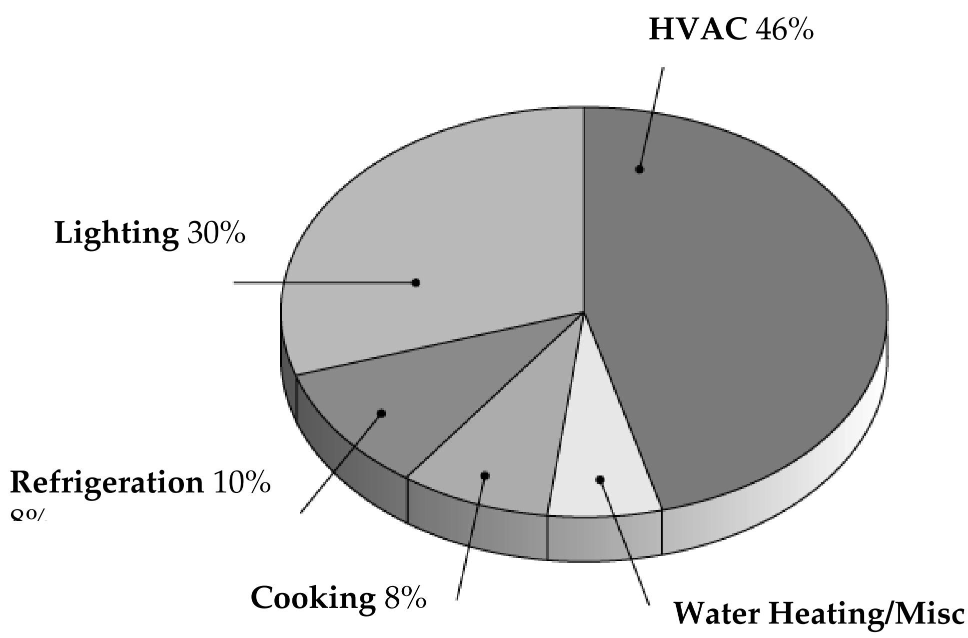


Figure 2
Primary Uses of Electricity in the Lodging Industry

2

BUSINESS CHALLENGES AND NEEDS

The primary concerns of lodging facility owners and managers are occupancy and operating costs. To increase occupancy rates, business principals must maintain a comfortable, attractive indoor environment for guests, ensure their safety, and create an attractive, inviting exterior ambiance. Operating costs, on the other hand, must be contained or reduced to increase profits and counterbalance potentially low occupancy rates.

Occupancy

Occupancy rates—typically more than 60% on any given night, according to industry statistics—can vary dramatically depending on location and regional economic factors, changes in transportation patterns, customer preferences, and new competition (occupancy rates in Florida reach 75%, the highest of any region in the country). To attract customers to a hotel or motel, some facilities advertise and conduct other marketing efforts; others rely more on word-of-mouth and curbside appeal to draw clientele. In all cases, to provide guests a satisfactory experience and potentially entice them to return, a facility must provide a comfortable, healthy, safe, and attractive environment.

Need

Maintain Comfort and Indoor Air Quality

The job of a hotel or motel facility manager is to ensure that guests feel pleased with their environment. Providing a comfortable, healthy, indoor environment is key; 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 guest activities. The lighting should be enough to illuminate surfaces without creating glare. Indoor air should be free of significant odors, dust, and contaminants, and should circulate enough to prevent stuffiness without causing drafts.

Of these environmental attributes, providing comfortable temperature, humidity, and lighting are relatively less problematic tasks than maintaining healthy indoor air quality. Poor indoor air quality can result in discomfort, or worse, illness for guests, which could undermine occupancy rates. 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, cleaning supplies);
- HVAC systems that harbor mold, mildew, bacteria, and other microorganisms, or have low ventilation rates; and
- people and their activities (e.g., cigarette smoking).

For maximum guest comfort, a hotel or motel infrastructure must be flexible enough to allow for individual guests' needs. For example, some guests may want their rooms at 65°F and others may want theirs at 80°F; the HVAC system should enable individual temperature adjustment. Similarly, if 90% of the guests want to shower between 6:00 and 8:00 a.m., the water heating system should be designed to meet demand during those hours.

Technology Solutions

Energy-efficient HVAC and water heating technologies, including heat pump water heaters, can reduce energy use as well as often improve temperature and humidity control in public spaces, kitchen areas, and guest rooms. Electric infrared space-heating equipment can be used to provide heat in outdoor or semi-outdoor areas typically used during cold weather, such as walkways, patios, and outdoor dining areas. Electric foodservice equipment offers opportunities to improve the comfort of foodservice employees, by providing a cooler kitchen environment, for example. Ultraviolet disinfection of air—a technology now used to control transmission of airborne diseases such as tuberculosis—presents hotels and motels with the opportunity to improve the quality of indoor air by killing all types of viruses and bacteria, as well as yeasts, mildew, and mold spores, thereby better protecting the health of guests.

See pages 3-4, 3-7, 3-9, 3-12

Need

Improve Visibility and Safety

An attractive, eye-catching exterior appearance is often a decisive factor in drawing new guests. Many hotels and motels could increase their visibility and curb appeal by upgrading existing outdoor lighting and/or adding new outdoor lighting. Inadequate lighting of walkways, driveways, and parking lots creates potential security and safety hazards for guests and employees.

Technology Solutions

Energy-efficient outdoor lighting can improve the appearance of a hotel or motel, and the safety of guests and employees. Ozonated swimming pool and spa water effectively controls bacteria in these public places with only minimal use of chemicals such as chlorine. In an era when many people prefer bottled water to tap water, reverse osmosis can be used to filter drinking water, thereby providing guests with extremely pure drinking water.

See pages 3-9, 3-14

Operating Costs

Once guests' needs are addressed, the primary goal of the hotel or motel owner is to make a profit. This is most likely to be achieved by minimizing operating costs and maximizing occupancy and revenues. Operating costs are influenced by a range of factors including facility size, location, occupancy, and additional services offered.

Need

Reduce Operating Costs

A recent trend in the hotel and motel industry, according to *The Host Report*, has been to improve operating profits by cutting costs. According to statistics compiled by the U.S. Department of Energy and the U.S. Department of Commerce, energy represents nearly 10% of revenues, indicating a major target for cost-cutting efforts after payroll, which represents nearly 18% of revenues. According to a 1994 report by PKF Consulting (*Trends in the Hotel Industry*), energy represents 5.7% of the total costs and expenses of an average hotel; electricity represents about half these costs. This makes energy the seventh largest area of expenditure. The top two operating expense categories are food and beverages (including labor) and rooms (including housekeeping labor).

Technology Solutions

A range of electric technologies are available to help hotels and motels reduce operating costs. For example, energy-efficient HVAC, indoor lighting, refrigeration technologies, and office equipment can reduce operating costs by reducing electricity use. Heat pump water heaters and heat recovery heat exchangers can recover waste heat to heat water, thereby reducing the amount of electricity or natural gas needed for water heating. Ozonation of cooling tower water can reduce operating costs by reducing the use of chemicals for water treatment, reducing the use of water in the cooling tower, and increasing the efficiency of heat transfer. Ozone can also be used to reduce operating costs in on-site laundries and swimming pools.

See pages 3-4, 3-5, 3-7, 3-10, 3-13, 3-14

Barriers to Technology Adoption

Adoption of new technologies is influenced by the manner in which the hotel or motel is owned and the type of facility operations that will be affected.

There are three types of ownership in the lodging industry: straight ownership, management agreements, and franchises. Straight ownership is the most capital intensive and risky, but allows maximum control over the facility. The current trend, however, is away from straight (or "independent") ownership and toward management agreements and franchises. In a management agreement, the operator manages, but does not own the facility. The owner can be a single investor or group of investors. Under a management agreement, Marriott, for example, might take over management of a hotel still owned by an investor. Chains use this as a lower-risk way of expanding in a depressed market. In a franchise arrangement, a hotel or motel operator pays a straight fee or a percentage of revenues to the owner of the hotel or motel name. The advantage to the franchisee is relatively low risk (low capital investment) and use of a name that connotes a certain familiar standard of quality.

Owner-operators are the owners most in touch with the day-to-day functioning of a facility, and, potentially, the most interested in new technologies that promise lower operating costs and/or otherwise improved operations. Under a management agreement or franchise situation, an owner has little incentive to sink capital into new equipment—unless it offers a short enough payback. In an independently owned hotel or motel, the site building engineer or facility manager makes purchase decisions about new energy-related equipment. In the case of facilities managed by national chains, however, decisions may require regional and/or national review and approval.

The decision process, the decision makers involved, and the payback criteria vary depending on the type of ownership. For example, the owner of a small, independently owned motel may make all of the purchase decisions himself or herself and require a short (one- or two-year) payback period due to lack of access to large amounts of capital. A purchasing decision made by a hotel that is part of a national chain, however, might involve the local facility manager and general manager, as well as a regional manager and accounting department at the chain's national headquarters. Easier access to large amounts of capital might allow the hotel to find a payback of three to four years acceptable.

In any of these situations, the financial decision maker(s) may collaborate with equipment operators to determine the equipment of choice. For example, a hotel restaurant chef or foodservice manager may be involved in selecting cooking equipment, while a pool management company may be responsible for selecting a water treatment system for the pool; the operations director may select the HVAC system, and the building engineer may select the type of lamp used in the lighting system.

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,” “efficiency technology,” “partnering opportunity,” or “emerging electrotechnology.”

Electrotechnologies are selected new or alternative electric equipment options. In many lodging applications, the electrotechnologies can reduce operating costs, maintain or increase service comfort and air quality, or improve facility visibility and safety. Efficiency technologies are electric technologies that offer opportunities to decrease energy use, but have little or no direct impact on operations. Partnering opportunities are situations in which a utility might conduct educational or other activities to enhance lodging facilities or operations. Emerging electrotechnologies are electrotechnologies not currently in use in the industry that have the potential to meet a business need in the future.

Each electrotechnology is more completely described in Section 4. Vendors of these 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 “Heating, Ventilation, and Air Conditioning,” the end use that consumes the greatest percentage of total lodging industry electricity use. Table 4 summarizes these solutions.

Table 4
Technology Solutions to Lodging Industry Needs

End Use	Solution Type	Technology Type	Business Needs: Reduce Operating Costs	Business Needs: Maintain Comfort/ Indoor Air Quality	Business Needs: Improve Visibility and Safety
Motel/Hotel HVAC	Efficiency Technology	Air-to-Air Heat Pumps	■	■	
Motel/Hotel HVAC	Efficiency Technology	Closed-Loop Water-Source Heat Pumps	■	■	
Motel/Hotel HVAC	Efficiency Technology	Ground-Source Heat Pumps	■	■	
Hotel HVAC	Efficiency Technology	Electric Chillers	■	■	
Hotel HVAC	Efficiency Technology	Thermal Energy Storage	■	■	
Hotel HVAC	Efficiency Technology	Heat Recovery	■	■	
HVAC	Electrotechnology	Electric Infrared Space Heating		■	
HVAC	Electrotechnology	Ozonation of Cooling Tower Water	■		
HVAC	Emerging Electrotechnology	Ultraviolet Disinfection of Air	■	■	
HVAC and Foodservice	Partnering Opportunity	CFC Education			
Lighting	Efficiency Technology	Energy-Efficient Indoor Lighting	■		■
Lighting	Electrotechnology	Energy-Efficient Outdoor Lighting	■		■
Foodservice	Efficiency Technology	Energy-Efficient Refrigeration Technologies	■		
Foodservice	Electrotechnology	Electric Foodservice Equipment	■		■
Water Heating/ Miscellaneous	Electrotechnology	Heat Pump Water Heater	■	■	
Water Heating/ Miscellaneous	Efficiency Technology	Heat Recovery Heat Exchanger	■		
Water Heating/ Miscellaneous	Efficiency Technology	Energy-Efficient Office Equipment	■		
Water Heating/ Miscellaneous	Electrotechnology	Ozonated Laundering	■		
Water Heating/ Miscellaneous	Electrotechnology	Ozonation of Swimming Pool Water	■		■
Water Heating/ Miscellaneous	Electrotechnology	Reverse Osmosis of Drinking Water			■

Heating, Ventilation, and Air Conditioning

Heating, ventilation, and air conditioning (HVAC) systems consume roughly 46% of the electricity used in hotels and motels. Over half of the total HVAC load is required for facility cooling; the remainder is split between heating and ventilation loads.

The HVAC systems used in these facilities typically provide individual in-room controls for guests. This requires a system with the capability to provide heating or cooling on command. Despite these similar requirements, the HVAC systems used in motels are normally very different than those used in large hotels. Motels typically use numerous small in-room units, while hotels use centralized systems that duct conditioned air to individual rooms under the control of a room thermostat.

The public space in hotels and motels can vary from only a small registration lobby in some motels to large lobbies, banquet halls, lounges, and shops in large hotels. It is most likely that a facility with room air conditioners will also have packaged units for the public spaces—usually one unit for each distinct area. These are usually rooftop units for one-story applications and split-system package units for multistory situations. A facility that has a central chilled-water system for the guest rooms will tend to condition public spaces with a central air handling unit with built-in cooling coils, heating coils, a fan, and a means for providing filtration, ventilation, and elimination of exhaust air.

Motel HVAC Technologies

In most motels, the HVAC system is selected based on first cost. This means that quality and energy efficiency are not typically major factors in the decision. In addition, to minimize costs, air distribution systems are held to a minimum. The lack of need for high-cost duct work helps to make air-to-air heat pumps, four-pipe fan-coil units, and packaged terminal air conditioners (PTACs) quite popular. In a typical motel, roof-mounted packaged systems are used for meeting rooms and common areas, while through-the-wall heat pumps or PTACs with electric heat are used for individual guest rooms.

Each system has advantages and disadvantages. Air-to-air electric heat pumps are efficient and have relatively low initial costs. These systems are offered for through-the-wall, roof-mounted, or ground-mounted installation and provide heating and cooling. Similarly, PTACs are also low-cost and both heat and cool. Since PTACs are room-specific, when a unit fails, only one room is affected; repair and replacement of single modules lessens the need for highly skilled maintenance staff. The disadvantages of PTACs include comparatively noisy operation and unappealing aesthetics due to grille faces protruding from each room.

With centralized heating and cooling equipment, two-pipe and four-pipe water distribution systems allow space conditioning service throughout a facility and, since piping is less expensive to install than ductwork, these systems also offer relatively low first costs. In these systems, heated or cooled water is piped to coils in each room needing conditioning; a fan moves air over the coil, transferring heat to or from the room.

In a two-pipe distribution system, the chiller and boiler work in parallel with the distribution system, which means only heating or cooling can be performed at any one time. A four-pipe system places the chiller and boiler in parallel with two distribution systems so that heating and cooling can be provided concurrently. This feature is essential for large facilities that have a range of heating and cooling needs. A key disadvantage to these systems is condensation on the cooling coils under humid conditions.

Heat pumps are the most efficient HVAC systems available for motels—air-to-air heat pumps, closed-loop water-source heat pumps, and ground-coupled heat pumps. These systems combine high-efficiency and year-round comfort with simple-to-operate controls. Any one of the three heat pump options can be installed in a through-the-wall arrangement. This allows guests to select the cooling, heating, and ventilation rates for their rooms. In addition, a failed unit can be more easily replaced by one person in a short period of time.

Efficiency Technology Solution
Air-to-Air Heat Pumps

Among all HVAC options, the efficiency of air-to-air heat pumps is second only to ground-coupled heat pumps. Air-to-air heat pumps can be an attractive replacement option for motels with electric air conditioning and a fossil-fuel-fired heating system.

Efficiency Technology Solution
Closed-Loop Water-Source Heat Pumps

The closed-loop water-source heat pump system offers the advantage of removing heat from one section of a building and delivering it to another area where it is needed, thereby cooling and heating different parts of a motel simultaneously and cost-effectively.

Efficiency Technology Solution
Ground-Source Heat Pumps

Instead of exchanging heat with 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 water and antifreeze are buried in the ground to take advantage of ground temperatures.

Hotel HVAC Technologies

Hotels tend to use large, centralized HVAC systems that can better handle the larger load and diversity of facility requirements. Flexibility is important—it allows guests in individual rooms to obtain heating or cooling on demand, and to provide the option of space cooling year-round in situations where there is significant internal heat gain from lights. Often, hotel HVAC systems include a number of components such as

- 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 assembled in a variety of ways—and modified/expanded as a facility grows. As such, it is almost impossible to compile a finite list of HVAC system types for hotels.

However, some systems are more common than others. In large hotels, the most common systems are electric chillers with natural gas/oil boilers and two- or four-pipe water distribution systems. Two-pipe systems can be used where there is a clear break between cooling and heating seasons. Four-pipe systems are used in regions with extended warm or cool weather. In other hotels, guest rooms are often served by individual air-to-air heat pumps or PTACs with electric heating. Ventilation air is normally provided by a central fresh air system producing air at a delivery temperature of 70°F.

Some of the same technologies appropriate for motels are also the most efficient and economical HVAC systems available for hotels: air-to-air heat pumps, closed-loop water-source heat pumps, and ground-source heat pumps. These systems are very energy-efficient, provide both heating and cooling, and provide guest rooms with individual heating and cooling control. In addition, the ground-source and closed-loop water-source heat pump systems have the advantage of being able to utilize waste heat. Electric chillers, thermal energy storage, and heat recovery are also applicable to hotels.

Efficiency Technology Solution
Electric Chillers

Electric chillers are highly efficient cooling systems; combined with boiler-supplied heat, they condition room air with two principal distribution systems: air and water. Variable-air systems use ductwork to transport heated or cooled air to rooms. The room temperature is controlled by regulating the amount of air entering the room. A key advantage to electric chiller–boiler systems is improved humidity control because variable-air-volume (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 heated 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.)

Electric chillers have relatively low capital and operating costs. Newer compressor designs also allow for high energy efficiency. In hotels operating with a central system, there is rarely economic justification for updating fan-coil units. However, it is possible to realize major reductions in operating costs by replacing older, inefficient chillers with modern, high-efficiency models. Replacing a chiller with a high-efficiency unit purely to reduce energy costs is often not cost-effective on its own merit.

Efficiency Technology Solution
Thermal Energy Storage

Thermal energy storage is used for moving part or all of a facility's cooling load from the 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 building's chiller. While the system may actually use more electricity, it ordinarily costs a facility operator less overall than a conventional system because most of the electricity is consumed at lower off-peak rates. Thermal energy storage for space cooling is particularly attractive for hotels with high peak cooling loads and high on-peak demand charges.

Efficiency Technology Solution
Heat Recovery

Heat recovery systems maintain indoor air quality and reduce energy usage for space conditioning by recovering the heat (or coolness) from a building's exhaust air. This 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 hotels and motels 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) heaters are appropriate for a variety of hotel and motel applications, including hallways, stairwells, lobbies, patios, and outdoor restaurant areas that are difficult to heat. The most cost-effective applications are in areas exposed to the outdoors or areas that require high ventilation rates.

IR space heating is accomplished through electromagnetic radiation. In addition to electricity, 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. The heaters and their radiation are typically directed at the people in a space, but also heat other objects such as floors, walls, and furnishings. These objects, in turn, retransmit the heat they receive; in time, this process raises the temperature of the overall 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 maintained at 50–60°F. Their primary disadvantage is that if used to maintain temperatures of 70°F or more, the overall efficiency of the system 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. The technology is mature; units are available from several manufacturers.

Electrotechnology Solution
Ozonation of Cooling Tower Water

There is growing interest among HVAC mechanics and building engineers at hotels (and other facilities) that operate chillers and cooling towers in treating cooling tower water with ozone. Ozonation of cooling tower water eliminates the use of potentially hazardous chemicals and reduces total water use, thereby increasing the operating efficiency of the cooling tower system and creating a more environmentally sound building.

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* (the cause of Legionnaire's 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 distributed to the cooling tower. Ozone can also be used to treat drinking water, swimming pool water, laundry water, and dishwashing water.

The primary benefits of ozonation of cooling tower water are the limited use of chemicals, the 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 the increased efficiency of the heat transfer due to reduced scale and biological growth on pipes and heat exchangers. To their disadvantage, ozonation systems require precise control and maintenance to be effective, and are more complex to install and operate than conventional chemical treatment systems. For example, it is essential to establish the correct ozone dosage. Too much ozone can oxidize materials such as rubber fittings, gaskets, and some types of metals; too little results in ineffective treatment.

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. Many successful examples of ozonation of cooling tower water exist, although most are in office buildings. While penetration of this technology in the lodging industry is low—estimated at 1% by one vendor—successful lodging applications do exist. For example, selected Sheraton and Radisson hotels are using this technology. As the technology proves its cost-effectiveness in the industry, other hotels are likely to adopt it as well.

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 any place people congregate, but especially in hospitals, offices, hotels, and homeless shelters.

High occupancy rates in many hotel public spaces dictate high ventilation rates, special air filters, or electrostatic air-cleaning devices. Although filters and proper ventilation are effective in removing dust, pollen, and other airborne particles, they are not effective in destroying microorganisms such as bacteria and viruses. Air sanitation units utilizing UV light, however, can kill microorganisms and can be used to sterilize the air, improving indoor air quality and decreasing 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. In appearance, these lamps are similar to fluorescent tube lamps, but they are made of quartz glass and are not coated inside with phosphor. The fixtures are easy to install and can be ceiling- or wall-mounted, or mounted within ventilation ducts. Care must be taken to prevent direct or indirect exposure to the rays. Although the UV-C rays do not cause skin cancer, they can cause a reddening of the skin and conjunctivitis in the eyes. UV radiation can also deteriorate plastics and fade colors in paint and carpet.

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 use of higher mechanical ventilation rates (which reduced the effectiveness of the lamps) and the availability of new drugs (which reduced concern over microbiological problems).

Concerns about airborne viruses are on the increase today, and the technical problems of combining UV disinfection 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 hotels, motels, and other facilities in evaluating this technology.

Partnering Opportunity
CFC Education

The lodging industry is also facing some capital investment requirements to replace HVAC, refrigerator, and freezer equipment that will become obsolete due to the January 1996 phaseout of chlorofluorocarbon (CFC) production in the United States. While some lodging facilities, especially those with foodservice operations, 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 lodging operators review chiller and refrigeration options and calculate payback periods for replacement of equipment.

EPRI information resources are listed in Section 5.

Lighting

Lighting can be a significant load in hotels or motels, especially those with large public spaces that require 24-hour illumination and extensive outside security and display lighting. In 1992, lighting accounted for 30% of the total electricity consumption of the lodging industry.

The majority of indoor lighting systems used in motels and hotels are incandescent lamps and fluorescent tubes with magnetic ballasts. Approximately 97% of all hotels and motels use incandescent systems. Incandescent lamps are used to light guest rooms, common areas, hallways, and banquet rooms. They are also used for decorative lighting (e.g., on signs and displays) and for exit lights. The most common applications are in wall fixtures, chandeliers, and ceiling-mounted down lights, also referred to as recessed cans.

The second most common source of lighting in hotels and motels is fluorescent lighting (70%). Fluorescent fixtures come in a variety of shapes and sizes, but typically appear as four-foot-long tubes used in two-, three-, or four-tube fixtures. The basic components of the fluorescent lighting system are a fixture, reflector and switch, tubes, ballast, and lenses. Compact fluorescent bulbs, which are more energy-efficient but not always easy to retrofit, are becoming popular and are currently used in 15% of hotels and motels.

Another type of lighting used in the lodging industry is the high-intensity discharge (HID) lamp. The HID family includes mercury vapor, metal halide, and high-pressure sodium lamps. Although these lamps are most commonly used in parking lots and driveways, they can be used in atriums and other large, open areas. All of the HID lamps have significantly longer lives than incandescent lamps and many fluorescent lamps. To date, HID lamps are used by only 1% of hotel and motel facilities.

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 guest rooms and hallways. Incandescent lamps in guest rooms also can be successfully replaced with compact fluorescent lamps (but may require retrofitting of the fixture).

Electrotechnology Solution
Energy-Efficient Outdoor Lighting

Outdoor lighting is also a part of a motel's or hotel's energy bill. Existing applications include incandescent lights on building signage, fluorescent lights in parking garages, and mercury vapor lights in parking lots and driveways. These lighting systems can represent a significant portion of the energy bill—especially when they are on 24 hours per day, as in a parking garage—and can be cost-effectively upgraded. In addition, other important benefits can be realized by increasing outdoor lighting levels: Better lighting can reduce the potential for crime, increase guest safety, and improve the visibility of the building exterior and grounds (i.e., provide a form of advertising), projecting an image of high quality.

Foodservice

Refrigeration and cooking combined represent approximately 18% of the total electricity use in the lodging industry. Most hotels and some motels have foodservice facilities that typically operate an assortment of gas or electric ranges, griddles, fryers, steamers, refrigerators, freezers, and dishwashers.

Refrigeration

Refrigeration accounts for 10% of lodging industry electricity use. Hotels with foodservice operations need refrigerators and freezers for storing ingredients. Although few motels have full-service restaurants, some offer a breakfast buffet and therefore require a refrigerator and freezer. Given the phaseout of CFC production in 1996, lodging facilities replacing refrigeration equipment may need information on the currently available options. See the Partnering Opportunity on CFC Education (page 3-9) for further discussion.

Efficiency Technology Solution
Energy-Efficient Refrigeration Technologies

Hotel and motel foodservice operations can cut refrigeration electricity use by 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.

Cooking

Approximately 8% of total lodging industry electricity use is for cooking. In general, electricity is not the common energy source for most major foodservice appliances such as broilers, ranges, griddles, and fryers. This is typically due to the tradition of cooking with natural gas. In addition, since most of the operating costs of a foodservice operation are for food and labor, energy efficiency is not a key concern. Electric cooking 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 ensures better air quality in the kitchen than natural gas equipment and requires less kitchen-area ventilation and space conditioning.

Electrotechnology Solution
Electric Foodservice Equipment

A number of new electric foodservice appliances are available to hotels and motels. In addition to the now ubiquitous microwave oven—used to thaw and reheat food—this equipment includes the following:

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 area, reducing space-conditioning costs and increasing comfort for workers.

Induction Range. An induction range uses a magnetic field to transfer energy from a coil underneath the cooktop to the cookware. Pots and pans of 430 stainless steel and cast iron turn the magnetic energy into heat. 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 combines 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 high 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, and lower operating and maintenance costs. The Electrotechnology Profile in Section 4 provides more details on these technologies.

Water Heating and Other Energy Uses

Water heating and other energy uses account for 6% of the electricity used in the lodging industry. Hot water is provided to individual guest rooms as well as to public restrooms, kitchen areas (for dishwashers and other cleanup tasks), and laundries. Other miscellaneous electricity uses can include elevators and escalators, office equipment, laundry equipment, and swimming pool equipment.

Electrotechnology Solution
Heat Pump Water Heater

By removing excess heat from work areas and transferring it to hot water storage tanks, a heat pump water heater (HPWH) can both lower water heating costs for foodservice or laundering and improve comfort in the kitchen or laundry workspace. HPWHs exploit the inherent efficiencies of heat pump systems to cost-effectively heat water, 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—plus no-cost cooling.

Efficiency Technology Solution
Heat Recovery Heat Exchanger

Heat recovery heat exchangers offer facilities that use large amounts of hot water, such as laundries and foodservice operations, an opportunity to lower water heating costs. Relatively inexpensive and simple to install, a heat recovery heat exchanger transfers energy from a warm wastewater discharge line to a freshwater supply line.

Efficiency Technology Solution
Energy-Efficient Office Equipment

All hotels and motels use office equipment in their business operations, including computers, printers, copiers, and facsimile machines. This type of equipment is a growing use of electricity. Not only does office equipment consume electricity, but it generates waste heat that must be offset by space-conditioning systems.

Office equipment energy consumption can be reduced significantly by purchasing new energy-efficient equipment and operating equipment in an energy-efficient manner. Besides the direct energy savings, there are a number of indirect benefits, including reduced demand on electric service in the building, increased comfort due to reduced fan noise and waste heat generation, and increased operator flexibility from the use of energy-saving laptop computers. Energy-efficient equipment is available that offers the speed, quality, and reliability of conventional models.

Electrotechnology Solution
Ozonated Laundering

For lodging establishments that do laundry on-site, energy use for water heating, washing machines, and dryers can be significant. The addition of a fine-dining facility adds table linen to the already large volume of guest bed and bath linens. Hot water for the commercial laundry machines is produced by gas, oil, or electric water heaters; the washers are powered by electricity, and the drying is done by gas or electric dryers.

Use of ozonated water for laundering has the potential to reduce a hotel's water and detergent usage, thereby reducing operating costs. Ozonated laundering systems substitute ozone (O_3) for some or all of the cleaning agents, allowing dirt and other organics to be removed with less detergent and cooler water. Ozone—a powerful oxidizing agent that breaks down organic molecules—is produced by the corona discharge method, which involves passing air or oxygen between high-voltage electrodes, or passing air through a path irradiated with UV light. Most applications use the corona discharge method, since the UV excitation method is relatively inefficient at producing ozone.

Electrotechnology Solution
Ozonation of Swimming Pool Water

Most hotels and many motels have swimming pools. While these pools use electricity for pumping, electricity also has the potential to reduce the use of hazardous pool-sanitizing chemicals. Ozone can be used in place of chlorine to treat pool water, killing harmful microorganisms that can easily multiply in the warm, wet pool environment.

Electrotechnology Solution
Reverse Osmosis of Drinking Water

Some hotels that are concerned about providing high-quality drinking water for guests are using reverse osmosis filtration units to filter out potential contaminants, such as heavy metals, volatile organic compounds, and chlorine. Reverse osmosis is a membrane separation technique that utilizes permeable membranes to separate out selected components from a liquid. In a reverse osmosis system, water is circulated under pressure, in contact with a specially constructed polymeric film that filters out larger molecules (i.e., contaminants). The units are modular and compact, taking up less floor space than other water treatment systems, and have low energy requirements. One disadvantage is that fouling or clogging of the membrane can occur when particles collect on the membrane surface. Reverse osmosis units are commercially available in sizes ranging from small units for home water filtration to large units for industrial water treatment.

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 guidebook. For further information, turn to Section 5 for a list of equipment vendors who can provide specific details.

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 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.

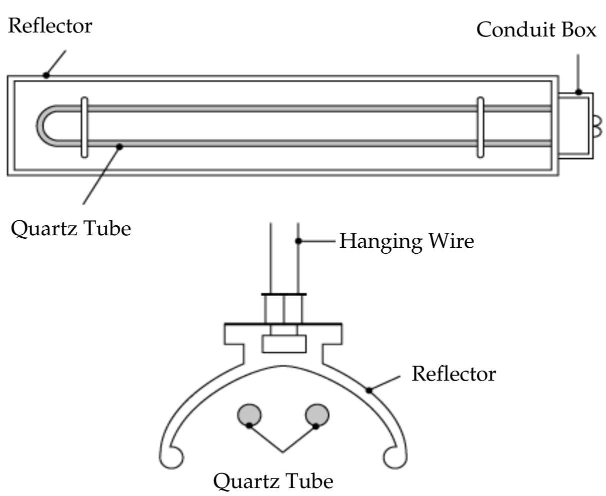
The lamp efficiency depends on the material of the resistor or radiator. Clear quartz lamps have an efficiency of about 96%. Tungsten wire and quartz tubes have efficiencies of 60–80%. Metal rods have lamp efficiencies as low as 50%. The overall efficiency of the IR system depends on the type of IR element 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.

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.
- Mounted at ceiling heights of over 30 feet, IR lamps do not 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.



Electric Infrared Space Heating

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
Minimum Mounting Height	10–14 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
Installation	Minimal
Other Supplies	$40–$160 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 8h/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 frequent system shutdown for cleaning. Too many chemicals can lead to metal corrosion and unusually 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 ferroso-ferric oxide (Fe_3O_4) with the metal. In addition, no residual chemicals are left in the water.

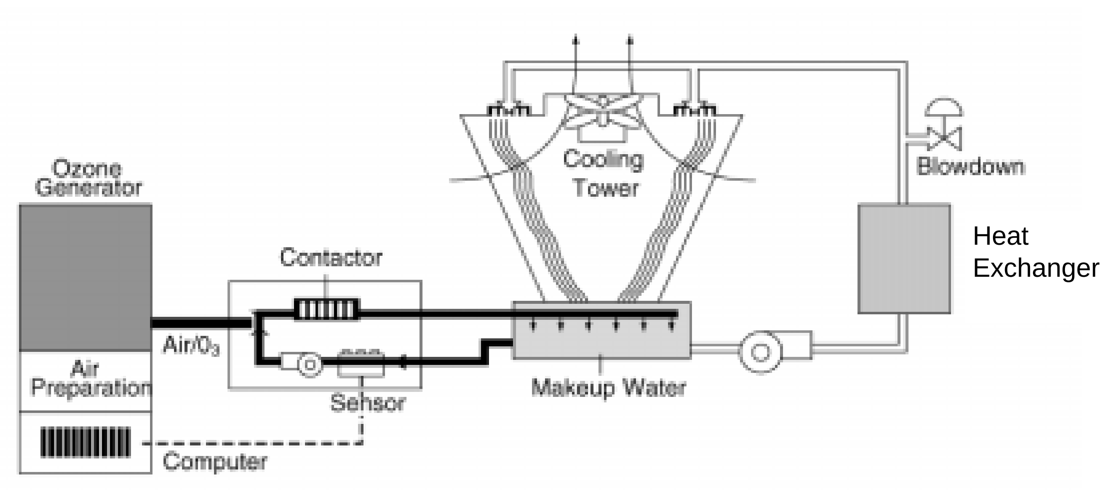
Because it is highly reactive, ozone must be generated on-site as needed and, for best economics, injected in concentrations proportional to the organic and biological demand of the water being treated. Ozone can be generated by corona discharge or by ultraviolet (UV) excitation. In the corona discharge 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.

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 between 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 one 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 with 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 Towers System Characteristics

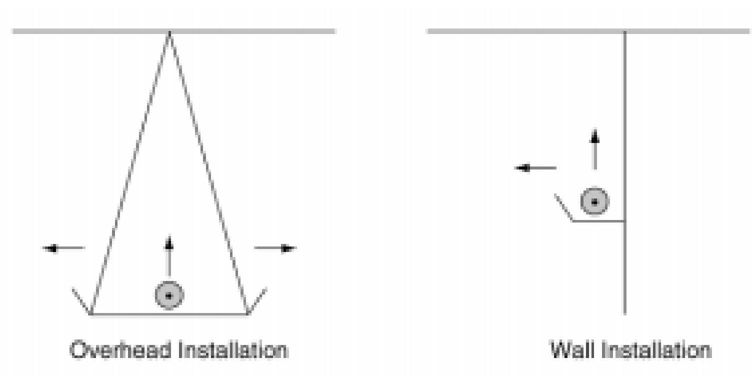
Dimensions	Length: 30–37" Width: 30–64" Height: 55–82"
Capacity	1–50 lb/d of ozone
Energy Consumption	6–20 kWh/lb of ozone
Key Inputs Power Other	 Electricity None
Key Outputs Solid Waste Air Emissions Water Effluent	 None None None
Cost Purchase Installation Other Supplies	Corona discharge system: $8000–$25,000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

Ultraviolet Disinfection of Air

Basic Principle

Filters and proper ventilation are an effective means of removing dust, pollen, and other airborne particles from indoor air, but are not effective against microorganisms such as bacteria and viruses. These germs are most prevalent where people congregate—in hospitals, offices, hotels, and stores. Since the indoor air is often recirculated in these places, the chances of transmission of an infection through coughing, sneezing, and/or talking are great. To prevent transmission of airborne diseases such as tuberculosis (TB), many institutions (office buildings, shopping centers, hospitals, and hotel/motels) are installing air sanitization units.

Certain ultraviolet (UV) wavelengths are capable of sterilizing airborne germs. The UV spectrum lies between X rays and the visible spectrum (180–400 nm). Within this range, UV rays are further divided into three spectrums: the longwave UV-A (315–400 nm) rays are generally used in tanning salons; the medium wave UV-B (280–315 nm) rays are found in sunlight and cause skin cancer and tanning; and the shortwave UV-C (<280 nm) rays are used for disinfection of airborne germs. UV-C rays cannot penetrate the skin to cause cancer, nor can they reach the lens of the eye to produce cataracts. UV-C can, however, penetrate the cell wall of a microorganism and cause photo chemical breakdown of its DNA.

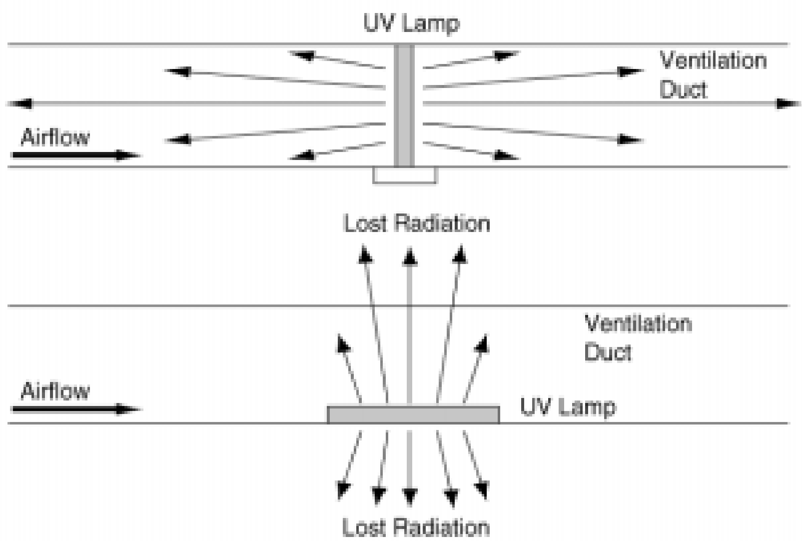


Overhead Irradiation

System Description

The peak UV absorption efficiency for DNA (thus, the optimal range for destruction of airborne germs) is between 250–260 nm. UV lamps are an ideal source because the energized cathodes are designed to emit rays at 253.7 nm. These lamps are similar to fluorescent tube lamps except the tubes are made of quartz glass and the tube’s inner surfaces are not coated with phosphor. There are two ways to install UV lamps for air disinfection: as ceiling- or wall-mounted fixtures, or within ventilation ducts.

The first method, known as overhead or upper-air irradiation, mounts the light fixture to either the ceiling or a wall, depending on the height of the room. Overhead installations are best for ceilings that are at least nine feet high, so the fixtures extend no lower than seven feet. This is necessary so people 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 so the UV rays radiate upward or out the side, but not down, to protect people from direct exposure.



Air Duct Irradiation

The second method is to install UV lamps inside the ventilation ducts of a recirculating system. Very high levels of UV light can be used in this system because the ducts shield people from direct exposure to the rays. Since the effectiveness of UV rays increases with duration of exposure, it is best to install the lamps where airflow is slowest, perhaps behind the filters. It is also ideal to install the lamps perpendicular to the airflow so that the light radiates in both directions throughout the length of the air duct. If the lamp is installed at the bottom of the duct, light can only radiate upward at the air that passes over the lamp. The system should also be designed with an inspection window to allow periodic checking of the lamps. Note that the lamp must automatically shut off when the window is opened to protect maintenance personnel from direct contact with the UV beams.

Advantages

- Eliminates airborne bacteria such as TB: Even in places where air is recirculated and bacteria and virus levels are relatively high, UV rays can effectively disinfect the air.

- Easy to install: UV disinfection is adaptable to air conditioning systems, combined air heating and cooling systems, and exhaust systems.

Disadvantages

- Must prevent direct or indirect exposure to the rays: Although UV-C rays do not cause skin cancer, they can still cause reddening of the skin and conjunctivitis in the eyes.
- Increased deterioration of plastics: UV radiation can cause plastics (in furnishings) to deteriorate and wall paint and carpet to fade more quickly.

Commercial Status

Currently, a hospital in southern California and homeless shelters in Boston, Massachusetts, use UV lamps to fight TB and other airborne diseases. A recent resurgence of TB 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. To make matters worse, many patients who contracted TB at homeless shelters are not returning for follow-up treatments, leading to a 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, prisons, schools, and public buildings throughout the country.

Cost and Electrical Requirements

Installation of a single UV lamp unit costs $100–$500, depending on the design. Each lamp tube costs $50–$100, depending on wattage and bulb length. For maximum effect, lamp units should run continuously because frequent on/off cycles may shorten bulb life. Manufacturers also suggest installation of one 30-watt fixture (or two 15-watt fixtures) for every 200 cubic feet of floor space, or for every seven people in a room—whichever is greater. Therefore, a lodging facility space with a capacity of 20 people would require three 30-watt systems. Running this system continuously for a year (8760 hours), the hotel/motel would use about 790 kWh to operate the three units.

Ultraviolet Disinfection of Air System Characteristics

Dimensions Air Duct System	Width: 2.5" Length: 4.25–11" Insertion Depth: 16"
Power Rating	30–120 watts (1–4 lamps)
Energy Consumption	Approximately 790 kWh annually*
Key Inputs Power Other	 Electricity Dry air source
Key Outputs Solid Waste Air Emissions Water Effluent	 None None None
Cost Purchase and Installation Replacement Lamp Tubes	 $100–$500/unit $50–$100/tube

*Assuming three 30-watt units used 8760 hours in a 20-person area.

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.

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.

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.

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.

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.

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

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 are 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, and the combination oven.

FlashBake Oven

The FlashBake oven is a countertop lightwave oven that uses infrared energy to brown a food surface, and intense visible light to cook a food from within 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.

Combination Oven-Steamer

The combination oven, 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 rethermalizing previously cooked foods.

Other Equipment

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

- Induction fryer
- Solid-state 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 radiates less heat to a kitchen, which reduces air conditioning costs and makes the equipment cooler to work near.
- 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.

EPRI Information

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

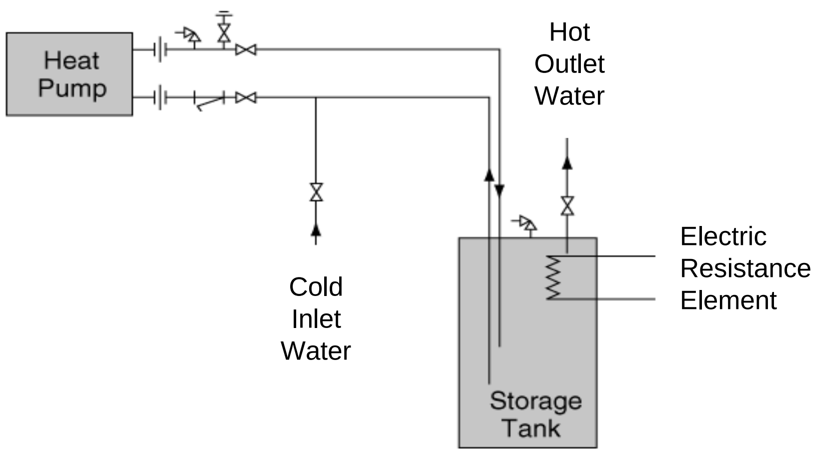
Foodservice Equipment Applications Handbook, TR-105991, December 1995.

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.

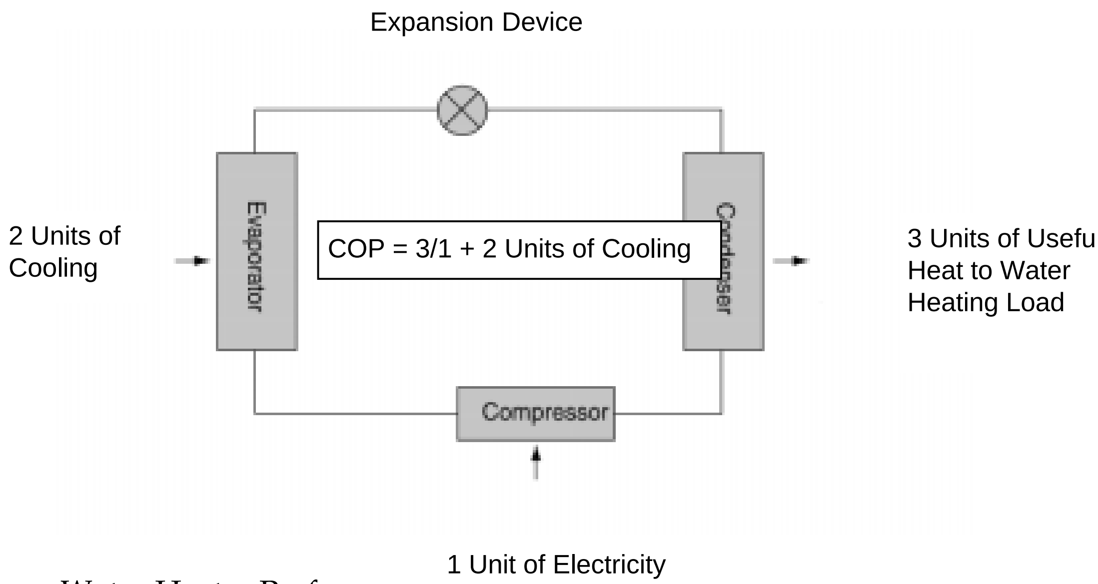
By offering water heating at costs roughly comparable to those of fossil-fuel-fired systems—and no-cost cooling—HPWHs make it attractive for businesses to take advantage of the lower rates associated with all-electric service.

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). These units can deliver cool, dry air directly to over-heated workstations in cook lines and laundry facilities, for example.



Heat Pump Water Heater Performance

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.

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 gal/d 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	Electricity
Heat Source	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

Ozonated Laundering

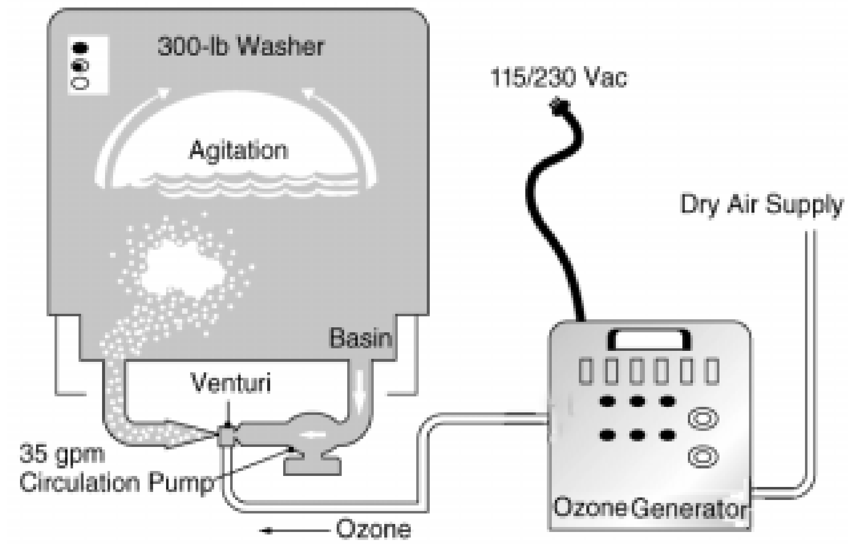
Basic Principle

Ozone (O_3) is a highly reactive oxidant that has been used for years to purify, disinfect, and deodorize water. Since 1990, ozone laundry systems have been installed in commercial laundries for washing fabric. Ozone has proven to quickly and effectively help break down soil, thereby reducing the amount of detergent and wash/rinse time needed. According to one explanation, when the electron-rich organics and hydrocarbons of laundry soils and stains are exposed to the electron-deficient ozone, an oxidizing reaction takes place, releasing the third oxygen atom from ozone. The highly electronegative oxygen atom then breaks many of the chemical bonds in the soils, fragmenting the molecules, making them easier to remove from the fabric. As a result, less water, less chemicals and detergents, less energy, and less wash time are required. In addition, the effluent wastewater's biological oxygen demand (BOD) and chemical oxygen demand (COD) are reduced by up to 50%, because the ozone dissipates into harmless oxygen.

System Description

Because ozone is highly reactive, it must be generated on-site as needed. 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 method, ozone is generated photochemically by passing air through a path irradiated with UV light. In both methods, a portion of the air dissociates and recombines to form ozone. The most commonly used ozone generation method is corona discharge. The UV excitation method has limited use because of its high energy requirements (20 kWh per pound of ozone produced) and relatively low ozone production rate.

In an open-loop system, the soil-laden water is treated as effluent wastewater and discharged to the local treatment works. In a closed-loop system, the wastewater is drained from the washer, pumped through a screen or coarse bag filter, and then through an automatic backwashing sand filter—to remove all particles larger than 20 microns in diameter. The water then flows into a storage tank, where more ozone gas is injected and more microscopic bubbles are created. As the bubbles rise to the top of the tank, they oxidize odor molecules, viruses, and bacteria, and carry with them smaller remaining particles, such as oil and grease molecules. In the final step, the water is filtered a third time to remove particles larger than 5 microns and cleansed again with ozone. The recycled water is then ready for reuse in the washing machine.



Ozone Laundering System

Advantages

- Ozone is more powerful than chlorine in water: Ozone can vastly enhance cleaning capabilities of detergents and chemicals, sometimes even making them unnecessary. A correction facility was able to reduce chemical costs by 65%.
- Wash and rinse times are reduced: Oxidation of organics and hydrocarbons loosen the soils from the textile surface, making the mechanical agitation and use of detergent more effective.
- Water usage reduced: Cutting down on detergent means the rinse cycle can be reduced by an average of two cycles. In a closed-loop system where the wastewater is recycled, water usage can be reduced another 70–75%.
- Reduced energy consumption: Shorter operating time requires less electricity. In addition, since ozone lasts longer and works better in colder temperatures, there is less demand for hot water. A correction facility, for example, cut hot water demand by 78%.
- Extended textile life: Less mechanical agitation, lower alkalinity, lower wash temperature, and shorter wash time all contribute to longer-lasting fabric.
- BOD and COD reduced: In an open-loop system, effluent concentrations of BOD and COD can be reduced by 50%.
- Low operating cost: Less water, less detergent, less energy consumption, and less water treatment all contribute to lower bills.

Disadvantages

- Rewashing is sometimes necessary: Oil-based stains and heavily soiled fabric often must be rewashed.
- Ozone is highly toxic and hazardous: Care must be taken to ensure that there is minimal potential for worker exposure.
- High first cost: Leasing or purchasing an ozone generator and sidestream injector is expensive, but can be repaid through lower operating costs.

Ozone-Generating/Pumping System Characteristics

Dimensions	Length: 24–26" Width: 12–19" Height: 30–65"
Power Rating	1 kW (75-lb load washer) to 60 kW (800-lb load washer)
Energy Consumption	15–480 kWh/d (8 h)
Key Inputs Power Other	 Electricity Dry air source
Key Outputs Solid Waste Air Emissions Water Effluent	 None None None
Cost Purchase Installation Other Supplies	 $4000–$140,000 None Sidestream injector, $2000–$3000

Commercial Status

Ozone-generating technology was developed almost 100 years ago. Currently, ozone laundering is used by many industries, including commercial laundries, hotels, hospitals, and correctional institutions. Manufacturers of ozone laundering equipment report they are targeting businesses that process at least 1500–2000 lb of laundry per day. Other applications of ozone include the treatment of wastewater and cooling tower water and the disinfection of hot tubs and swimming pools.

Cost and Electrical Requirements

The ozone generator and sidestream injector are two separate components that must be purchased and retrofitted to existing washing machines. The price of an ozone generator varies dramatically, from around $4000 to over $140,000, depending on the size of the washer (75 lb up to 800 lb). A sidestream injector costs $2000–$3000, also depending on washer size.

An ozone-generating/pumping unit suitable for use with a 200- to 450-lb load-capacity washer (typically used by industrial laundries) would consume about 27.5 kWh per day and draw 4.9 kW. A typical laundry might own six such washers and operate them 8 hours per day. This would result in an electricity consumption of 165 kWh per day and electrical demand of 29.4 kW to operate the ozone-generating/pumping equipment.

Ozonation of Swimming Pool Water

Basic Principle

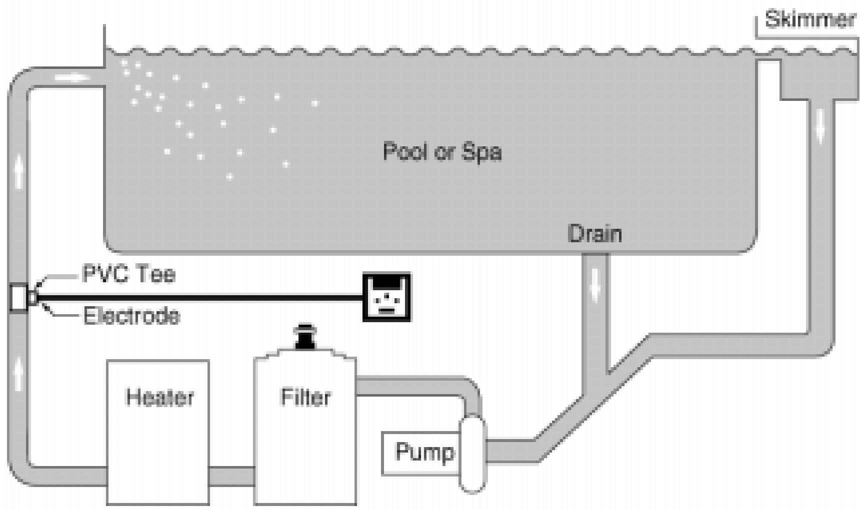
Viruses and bacteria survive in well-chlorinated pools and spas, mainly because of the buildup of total dissolved solids (such as body oils, suntan lotion, and cosmetics). As total dissolved solids build up, a buffer solution is produced, reducing the efficiency of chlorine as a sanitizer. Thus, viruses and bacteria—including *pseudomonas*—survive, even when the level of free chlorine residual exceeds most health-department standards. Another disadvantage of chlorine is that it reacts with organic and inorganic contaminants in pools and spas to form toxic trihalomethane, a carcinogen. For these reasons, many lodging facilities are exploring alternative treatments.

Ozonation is a viable option; it reduces the need for chlorine by 70–97%. Ozone has one of the highest oxidation potentials, surpassed only by fluorine (F_2) and the hydroxyl free radical (-OH) in reactivity. In water treatment, ozone is typically the strongest oxidant used. It is about 3000 times more effective than chlorine in controlling viruses and bacteria. Ozone also destroys mold, fungi, spores, cysts, and algae, leaving no residue, and breaks down into harmless oxygen.

System Description

Because ozone is highly reactive, it must be generated on-site as needed. 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 method, ozone is generated photochemically by passing air through a path irradiated with UV light. In both methods, a portion of the air dissociates and recombines to form ozone. The most commonly used ozone generation method is corona discharge. The UV excitation method has limited use because of its high energy requirements (20 kWh per pound of ozone produced) and relatively low ozone production rate.

Once ozone has been generated, it is then injected into the return line of the pool. When it comes in contact with the water, ozone destroys bacteria and viruses by bursting the cellular membrane and scattering the bacterium cytoplasm. This process takes about two to three seconds; with chlorine, the same process takes approximately 30 to 60 minutes.



Swimming Pool or Spa Ozonation Unit

Ozone System Characteristics for Swimming Pools and Spas

Dimensions	Length: 24–26" Width: 12–19" Height: 30–65" Weight: 75–800 lb
Capacity	800–800,000 gal
Energy Consumption	6–15 kWh/lb of ozone
Key Inputs Power Other	 Electricity None
Key Outputs Solid Waste Air Emissions Water Effluent	 None None None
Cost Purchase Installation Other Supplies	 $500–$16,000 Minimal None

Ozone oxidizes and removes solids in pools and spas by polarizing the organic molecules. This process allows the molecules to attract each other, thus increasing their size. The enlarged molecules can then be efficiently removed by the pool's or spa's filtration system.

Advantages

- Ozone is more powerful than chlorine: Ozone has twice the oxidation power of chlorine.
- No strong odors, stinging eyes, or skin irritations: Since minimal chlorine is used, chemical irritations are limited.
- Low operating cost: Less maintenance, less chemical usage, and less water treatment all contribute to reduced operating costs.
- Destroys bacteria and viruses faster than chlorine: Ozone can kill bacteria, viruses, and other microorganisms about 3000 times faster than chlorine.
- Pool life expectancy increases: Since little or no chlorine is used, pool plaster, paint, epoxy, and liners double in life expectancy. Also, because there is no buildup of scale, pool equipment does not deteriorate as quickly.
- No oil rings: Ozone oxidizes suntan lotions and other oils that contaminate the water and produce a "bathtub ring" around a pool.
- No fading or bleaching: Since little chlorine is used, fabrics do not fade and hair is not bleached.

Disadvantages

- Ozone is highly toxic and hazardous: Care must be taken to minimize the potential for worker exposure.
- High first cost: On its own, leasing or purchasing an ozone generator might appear expensive. When reduced chemical consumption and labor costs are taken into consideration, the technology can be economically feasible.

Commercial Status

Ozone-generating technology was developed almost 100 years ago; however, the use of ozone in swimming pools and spas began in the late 1950s. Currently, ozone is used to treat pools and spas in hotels, motels, and other public and private facilities. Other applications include the treatment of wastewater and cooling tower water and commercial laundering.

Cost and Electrical Requirements

The capital and operating costs depend primarily on the pool or spa size. In general, total costs for an ozone system range from $4 to $10 per hundred gallons of water. For example, a corona discharge ozonation system for a 30,000 gallon pool would cost $1200–$3000 to purchase and install.

Electricity requirements depend on water composition and concentration. Requirements for ozone generators can range from 6 to 15 kWh per pound of ozone. The low figure is representative of the energy requirements when generating large volumes of ozone (100 lb per day) through corona discharge. Energy requirements for a corona discharge generator producing less than 10 lb of ozone per day are about 10 kWh per pound.

Reverse Osmosis of Drinking Water

Basic Principle

Reverse osmosis is a membrane separation technique that utilizes permeable membranes to filter selected components from a liquid. The membrane selects molecules on the basis of shape and size. Hotels could potentially use this process to reduce the levels of heavy metals, volatile organic compounds (VOCs), and chlorine in the drinking water.

Reverse osmosis is a very refined filtration method and utilizes a membrane with smaller pores than are used with microfiltration or ultrafiltration, two other methods of membrane separation. This system allows compounds smaller than 5–20 angstroms to pass through, while retaining larger compounds.

System Description

In a reverse osmosis system, water is circulated under pressure, in contact with a specially constructed polymeric film. Some dissolved matter passes through while other contaminants, such as heavy metals and chlorine, do not. The systems are modular, each designed as a self-contained pressure vessel containing the membranes and fluid distribution system. The systems typically operate at pressures of 200–1500 psi.

Four basic module designs or configurations exist:

- Tubular: The least susceptible to plugging, but the most expensive
- Flat plate: Compact and less costly, with greater maintenance requirements

- Spiral wound: Compact, low capital cost per unit, but requires more prefiltration and makes leak detection more difficult
- Hollow fiber: Relatively low capital cost, but requires prefiltration and has limited operating pressures

In all these configurations, solids build up on the membrane, usually because only hydrogen-bonding substances (e.g., water, ammonia) are allowed to pass through the membrane. The remedy for this membrane fouling involves either rinsing or back-flushing the membrane.

In rinsing, the membrane is flushed with feedwater at reduced pressures and increased velocity (two or three times normal). The turbulent action of the fluid loosens the particles and carries them away. Additives such as dilute hydrochloric acid, citric acid, dilute caustic soda, sodium hypochlorite, or detergent can assist in loosening the particles.

In back-flushing, the flow of the permeate (high-quality water) is reversed through the membrane. This process loosens and lifts particles from the membrane and washes them away with the concentrate (rejected particle stream). This ensures high filtration rates over long periods of time.

Source: Culligan International Company

Reverse Osmosis Unit

Advantages

- Low energy requirements: Membrane filtration systems require less energy than conventional phase-change processes.
- Limited maintenance requirements: There are no moving parts, which reduces the need for maintenance.
- Systems are modular and compact: The reverse osmosis system requires less space than most other water treatment systems, and can be added onto existing water treatment processes.
- Cost savings: In general, membrane filtration systems cost a fraction of phase-change systems.

Disadvantages

- Reverse osmosis membranes are susceptible to damage by a variety of organic and inorganic compounds.
- Fouling occurs when particles collect on the membrane surface.

Commercial Status

Reverse osmosis systems for water treatment are now commercially available in numerous sizes, ranging from small units for home drinking supplies to large units for hotel water treatment. It would, however, be expensive for a hotel to treat all of its water with reverse osmosis, and to treat only drinking water would require a separate piping system for distribution. Many hotels might find installation of a separate piping system too expensive, whether done at the time of hotel construction or retrofit later. A hotel wanting to provide this type of “ultra-pure” drinking water for its guests could use reverse osmosis to treat its restaurant/kitchen water and/or to treat the water used in hotel ice machines. Alternatively, a reverse osmosis unit could be installed on each floor of the hotel for easy guest access.

Cost and Electrical Requirements

Capital and operating costs depend primarily on the type of membrane and its specific application. A reverse osmosis system processing 5 gallons of water per minute would cost $15,000–$30,000. This system might be appropriate for a medium-sized hotel that processes all of its drinking water.

Electricity requirements depend on the type of application, membrane, area, permeability, temperature, pressure, and feed flow rate. Electricity is required for pumping water through the system. Units ranging in size from 0.1–100 gallons per minute (gpm) require 0.2–30 kW of energy, respectively. Therefore, for most systems, the electricity requirement for a reverse osmosis unit would be 0.5–4 kWh per 100 gallons of water.

Reverse Osmosis System Characteristics

Capacity	0.1–100 gal/min
Approximate Size	Length: 15–210" Width: 10–70" Height: 30–90"
Approximate Weight	70–5200 lb
Power Rating	0.2–30 kW
Energy Consumption	0.5–4 kWh/100 gal of water
Key Inputs	
Power	Electricity
Other	Membrane replacement (once every 1–3 years)
Key Outputs	
Solid Waste	Heavy metal, salts
Air Emissions	None
Water Effluent	Drinking water supply
Cost	
Purchase	$3300–$100,000
Installation	10% of purchase cost
Other Supplies	$1–$3/1000 gal of feed rate

5

RESOURCES

This section contains three lists: 1) equipment suppliers for the electrotechnologies profiled in this guidebook, by equipment type; 2) EPRI information resources on efficiency technologies; and 3) lodging trade associations. 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.

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 S.W. 34th Ave., Suite 905-448, Ocala, FL 34474
(352) 622-8772, fax: (352) 622-1290

Aqua-Flo, Inc.
6244 Frankford Ave. Dept. T-93, 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, Ste. 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 Blvd., Hauppauge, NY 11788
(516) 273-0500, fax: (516) 273-0771

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

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

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 Div. 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

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 Road, 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 Drive, 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 Court, 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 Street, 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

Ozonated Laundering

Equipment Suppliers

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

Cyclo$_3$pss Textile Systems, Inc.
3646 West 2100 South, Salt Lake City, UT 84120
(801) 972-9090, fax: (801) 972-9092

GuestCare, Inc.
3030 LBJ Freeway, Ste. 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

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

Tri-O-Clean Systems, Inc.
4 Appletree Dr., Annandale, NJ 08801
(908) 735-5362, fax: (908) 735-9362

Ozonation of Swimming Pool Water

Equipment Suppliers

Aqua-Flo, Inc.
6244 Frankford Ave., 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

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

Prozone International, Inc.
3122 12th Ave. SW, Huntsville, AL 35805
(205) 881-4570, fax: (205) 880-2227

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

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

Reverse Osmosis of Drinking Water

Equipment Suppliers

Aquamatch, Inc.
22732 Granite Way, Unit C, Laguna Hills, CA 92653
(714) 472-8166, fax: (714) 472-9315

Aquathin Corp.
950 South Andrews Ave., Pampano Beach, FL 33069
(954) 781-7777, fax: (954) 781-7336

Culligan International Co.
One Culligan Parkway, Northbrook, IL 60062-6209
(800) 451-3260, fax: (847) 205-5920

Enting Water Conditioning, Inc.
P.O. Box 546, 3211 Dryden Rd., Dayton, OH 45449
(800) 735-5100, fax: (513) 294-5485

Osmonics, Inc.
5951 Clearwater Dr., Minnetonka, MN 55343
(800) 351-9008, (612) 933-2277, fax: (612) 933-0141

Res-Kem Corp.
P.O. Box 1059, Media, PA 19363
(800) 323-1983, fax: (610) 358-4642

Water Group Systems
310 Trousdale Dr., San Diego, CA 91910
(619) 476-0043, fax: (619) 476-7807

Information on Efficiency Technologies

This list provides EPRI resources on efficiency technologies identified in this guidebook. Copies of 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.

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 Office Equipment

Guide to Energy-Efficient Office Equipment, TR-102545-R1, 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

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.

Thermal Energy Storage

Water Thermal Energy Storage: Using Off-Peak Energy for Low-Cost Space Conditioning, BR-105176, 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.

Thermal Energy Storage: Using Off-Peak Energy for Low-Cost Space Conditioning, BR-020252, 1992.

Thermal Energy Storage Design Guides, FS-9021A, May 1990.

Expected Energy Use of Ice Storage and Cold Air Distribution Systems in Large Commercial Buildings, CU-6643, February 1990.

Trade Associations

American Hotel and Motel Association
1201 New York Ave., N.W., Suite 600, Washington, DC, 20005-3931
(202) 289-3100, fax: (202) 289-3199

Educational Institute of the American Hotel and Motel Association
P.O. Box 1240, East Lansing, MI 48823
(800) 752-4567