A small-business guide

Wholesale Bakeries

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Wayne Krill of EPRI manages the Electrotechnologies for Small Businesses project.

ABOUT THIS GUIDE

Historically, members of the small-business community have had little contact with their electric utility providers. This guidebook was developed to facilitate communication between utilities and the wholesale bakeries in their communities.

The *Wholesale Bakeries* guidebook is intended to familiarize readers with the business of wholesale baking by providing descriptions of basic processes and practices, and summaries of issues and challenges faced by small- and medium-size wholesale bakeries. It focuses on delineating how electrically driven equipment can address the needs and interests of wholesale bakery owners and operators.

This guidebook is one of a series of publications about small businesses produced by the Electric Power Research Institute. The *Wholesale Bakeries* guidebook 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 guidebook is organized as a reference guide 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.

Business growth for commercial bakeries has been steady but slow over the past few years. Although most baking facilities produce breads and rolls, a high demand for cookies and crackers has made these products the fastest growing bakery category in recent years. Overall industry growth is expected to remain at 1.5% annually through 1997.

Bakeries operate on a slim profit margin. To be competitive, bakeries must continuously produce a consistent product at low operating costs. Although the number of wholesale baking establishments is on the rise, the trend is toward consolidation. Despite this trend and the pressures of business economics, many small, independent bakeries continue to thrive. In fact, more than 70% of all establishments employ fewer than 50 people.

The primary uses of electricity in wholesale bakeries are to power motors (to drive materials handling and processing equipment) and provide lighting. According to the U.S. Department of Energy, electricity represented 25% of total energy use among bakeries in 1991. More than 70% of energy was provided by natural gas; fuel oil accounted for the remainder.

Wholesale bakeries face challenges common to many small businesses: the need to succeed in a competitive market, meet consumer demands, and comply with environmental regulations. The accompanying table identifies specific electrotechnologies that can help wholesale bakeries decrease operating costs, increase productivity and enhance product quality, and/or improve production flexibility. These electrotechnologies and other high-efficiency electric technologies are described in detail in the *Wholesale Bakeries* guide (EPRI TR-106676-V1), 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 Wholesale Bakeries

	Outdoor Lighting	Microwave Baking	Radio-Frequency Drying/ Heating	Heat Pump Water Heater	Dissolved Air Flotation	Ultrafiltration
Description	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.	A typical system combines microwave heating with conventional heating methods so that the interior of the product is baked by microwave and the exterior is browned by the conventional heat.	Uses radio-frequency waves to cause molecular motion and generate heat in the dough, evaporating water within the product; it is typically used in combination with a conventional baking method.	Uses the refrigeration cycle to pull heat from a warm-air region and supply it to a hot water tank, thereby providing water heating and coincident space cooling.	These systems pretreat wastewater by bubbling air through a wastewater holding tank to float insoluble materials to the surface for removal. Chemical additives can allow removal of solids and emulsified oils.	Wastewater is pumped through a membrane that allows water and some dissolved matter to pass through but filters out selected components based on their molecular size and weight.
Bakery Need	Lighting improves the visibility and attractiveness of a facility (advertising), reduces the potential for crime, and increases employee safety.	Faster, more flexible production processes are needed to increase production volume and/or allow many short runs of a greater variety of goods.	Processes that ensure product uniformity, maximize quality, and minimize baking time are essential to attracting and retaining consumer demand.	Technologies that decrease operating costs help bakeries maintain competitive prices.	Increasingly stringent regulations on waste-water discharges mean steeper sewer rates and potential surcharges for wastewater with a high waste load.	Increasingly stringent regulations on waste-water discharges mean steeper sewer rates and potential surcharges for wastewater with a high waste load.

Application	Signage on or near the facility; general lighting in parking lots, walkways, delivery areas; facade and landscape lighting.	Finish proofing of breads; partial baking of "brown-and-serve" products; baking of breads cakes, and biscuits; frying of doughnuts.	Ideal for cookie and cracker production as it allows precise moisture control and crisping of products without further browning.	Best suited to augment existing water heating and space cooling systems by servicing a well-balanced water heating and space cooling load, vs serving peak demand.	Bakeries producing pies, cakes, pastries that generate high volumes of wastewater, especially where wastewater is sent to a treatment plant operating under a federal discharge limit.	Bakeries producing pies, cakes, pastries that generate high volumes of wastewater, especially where wastewater is sent to a treatment plant operating under a federal discharge limit.
Benefits	Increased public perception of goodwill, success, and quality from general signage and facade lighting; reduced accidents, injuries, and crime from area lighting.	Can reduce baking time and energy use by 50%, uses stan-dard metal pans, provides greater pro-cess control, and has potential for control of microorganis-ms in packaged goods.	Combined with conventional heating, reduces baking time up to 50% and energy use up to 40%; can increase cookie production by 18–50%.	Provides efficient water heating and free space cooling and dehumidifi-cation for facilities that have hot water requirements and over-heated work areas.	Reduces fats, oils, and grease by 97%, emulsified oils by 60–80% (80–90% with additives), and suspended solids by 60% (85–95% with flocculent).	No need for flocculent for capture of emulsified oils; high reliability due to absence of moving parts; allows recycling and reuse of the permeate.
Cost	Systems are custom-designed to meet a facility's needs and budget.	Installed costs range from $2000–$750,000; continuous systems are more expensive than batch.	Largely determined by size; purchase cost ranges from $2500–$800,000.	Varies with needs of the facility, ranging from $125 kBtu/h–$210 kBtu/h.	Depends on nature and concentration of wastewater and flow rate; ranges from $20,000–$75,000.	Purchase cost of a system processing 0.1–5.0 gallons per minute is $5000–$40,000.

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INTRODUCTION TO WHOLESALE BAKERIES

Commercial baking is thought to be one of the world's oldest industries, with evidence of commercial bakeries dating back to the Egyptians. In the late 19th century, technological innovations such as the development of "tame" yeast and the mechanization of bread kneading enabled mass production of baked goods. As a result, larger "wholesale" baking facilities began to replace smaller local bakeries. Today, there are over 3000 wholesale bakeries across the United States.

Business Statistics

A wholesale bakery is defined as a bakery that distributes more than half of its production to other outlets. The wholesale baking industry is divided into three standard industrial classification (SIC) code subsegments: bakeries that manufacture fresh or frozen breads, cakes, and related products, such as bagels and doughnuts (SIC 2051); bakeries that manufacture cookies, crackers, pretzels, and biscuits (SIC 2052); and bakeries that manufacture other frozen bakery products, such as croissants, pies, and danish (SIC 2053). More than 80% of current facilities are bread and roll bakeries (SIC 2051).

In general, the baking industry has experienced steady but slow growth over the past few years. The number of commercial baking establishments rose from 2851 in 1987 to more than 3150 in 1992 (see Table 1). The value of industry shipments also increased from $23.6–$28.5 billion in this period. Increasing automation of the baking process, however, has led to a decrease in employment of 1% since 1987.

Although the number of baking establishments is rising, the business trend is toward consolidation. Corporate mergers are creating a few very large baking companies, such as Nabisco, Keebler, and Continental Baking, that have numerous production facilities but centralized planning and management. So, while the total number of production facilities is increasing, the number of organizations is falling.

Despite this trend, many small, independent bakeries remain in business. While there is no industry-accepted definition of small, medium, and large, these size categories are typically defined by the U.S. Environmental Protection Agency and Small Business Administration in terms of the number of employees. As illustrated in Table 2, more than 70% of all baking establishments employ fewer than 50 people and can be considered small businesses. In fact, only 20% of all establishments employ more than 100 people and can be defined as "large."

Table 1
Profile of the Wholesale Baking Trade (1992)

Subsegment	No. of Establishments	No. of Employees	Value of Shipments ($ million)
Bread and Other Bakery Products (SIC 2051)	2,540	155,100	18,140
Cookies and Crackers (SIC 2052)	440	47,200	8,690
Frozen Bakery Products (SIC 2053)	170	12,700	1,670
TOTAL	3,150	215,000	28,500

Source: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census, *1992 Census of Manufactures—Industry Series—Bakery Products Industries 2051, 2052, and 2053*, 1995.

The cookies and crackers industry (SIC 2052) has been the fastest growing bakery category in recent years, growing at 2.3% from 1987 to 1992, compared to 1.3% for the industry as a whole. The primary reason for this growth is the recent introduction of low-fat, low-calorie, low-cholesterol cookies and crackers—products that are especially attractive to adult consumers. Sales of these products are expected to remain strong in the near future.

Shipments of frozen bakery products (SIC 2053), on the other hand, have been declining as consumers increasingly prefer products that require no thawing or baking time. Frozen waffles meet these criteria and are doing well; however, overall sales in this segment are expected to continue to decline at 0.5% per year through 1997.

Table 2
Distribution of Bakeries by Size (1992)

Subsegment	Bakeries by Number of Employees						
	Small (0-50)		Medium (50-150)		Large (100+)		Total
	No.	% of Total	No.	% of Total	No.	% of Total	
Bread and Other Bakery Products (SIC 2051)	1543	71	194	9	425	20	2162
Cookies and Crackers (SIC 2052)	284	68	46	11	91	22	421
Frozen Bakery Products (SIC 2053)	108	71	14	9	30	20	152
TOTAL	1935	71	254	9	546	20	2735

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns 1992—United States*, (CBP-92-1), 1995.

Despite the Department of Commerce's prediction of a continued increase in the annual per capita consumption of bread—due in part to the U.S. Department of Agriculture's

(USDA's) new Food Guide Pyramid, which recommends 6–11 daily servings of bread and grains—overall industry growth is expected to remain at 1.5% annually through 1997. Certain products, however, are expected to exceed this growth rate. These include bagels, snack cakes, and doughnuts. While demand for bagels is driven by the increasing health-consciousness of consumers, demand for snack cakes and doughnuts is, ironically, driven by the consumer's desire for convenience.

State	Bakeries
CA	370
NY	365
PA	210
TX	141
IL	139
NJ	123
FL	115
MA	105
OH	96
MI	77

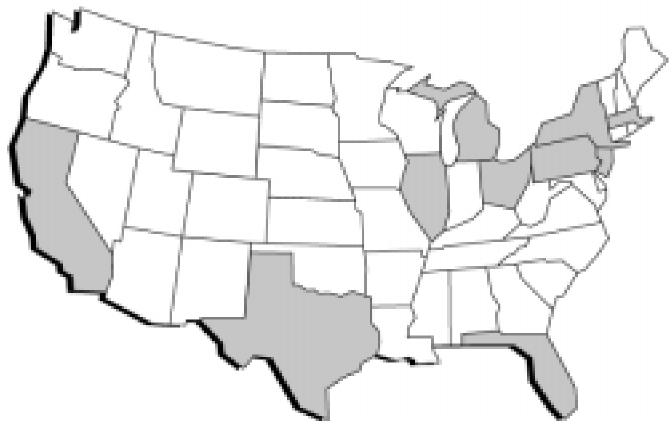


Figure 1
Top 10 States for Wholesale Bakeries

Freshness is the most important measure of product quality in the baking trade. To enable the delivery of fresh products, most bread and roll bakeries are located near the consumer, in the larger cities of all states. This is less true for cookie and cracker and frozen baked good manufacturers, due to the nature of the products.

While there are wholesale bakeries in every state, California, New York, Pennsylvania, Florida, and New Jersey account for over 30% of total industry shipments. Other states with a significant number of wholesale baking facilities include Texas, Massachusetts, Illinois, Ohio, and Michigan (see Figure 1).

This diagram shows bakery production processes for bread and cookies. The use of electricity, steam, or fossil fuel is noted in each step. The production of cookies and crackers differs from bread in that no yeast is used, and therefore no fermenting or proofing steps are required. Products stored for later sale are frozen, sometimes after partial baking. Although not illustrated, cleanup is also an important step in the baking production process.

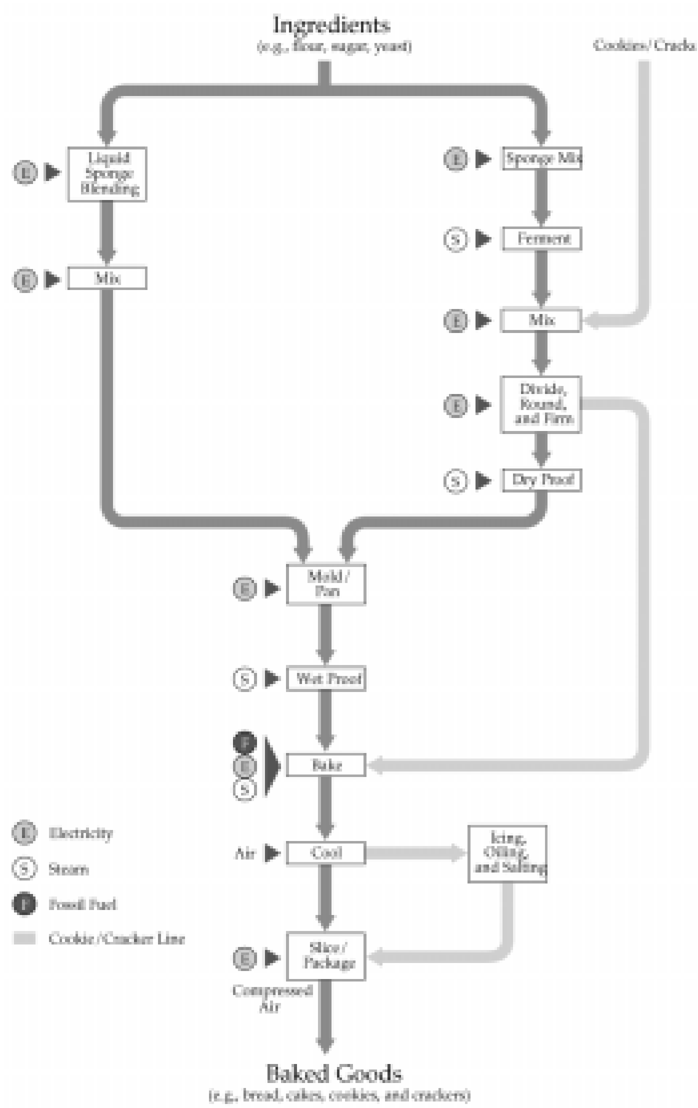


Figure 2
The Baking Process

Bakery Operations

Wholesale bakeries typically operate five to seven days per week, two to three shifts per day. Maintenance and sanitation requirements make it necessary to follow a revolving schedule, such that certain equipment is taken off-line on a predetermined day each week. This allows a bakery to meet Food and Drug Administration (FDA) food safety regulations while keeping production constant.

Storage of Ingredients

Some bakery raw material requires heating, some refrigeration. For example, yeast, milk products, and spices are subject to bacterial growth and are refrigerated at about 40°F, about the same temperature as a home refrigerator. Preservation of some materials, such as fruit, may require freezing. On the other hand, products that will be pumped, such as corn syrup, liquid sugar, and vegetable oil, must be held at room temperature to ensure that they retain their viscosity and do not crystallize.

Blending/Mixing

The first step in the production process is blending or mixing the ingredients or raw materials. This step ensures uniform distribution of ingredients throughout the finished product. Electric motors drive the blenders and mixers. Two speeds are generally available—high speed (about 70 revolutions per minute [rpm]) is used for dough development, while low speed (about 3 rpm) is used primarily for initial incorporation of water. Two different blending/mixing methods are generally used. In straight blending/mixing, all of the ingredients are mixed together at the same time. Sponge dough blending/mixing involves an intermediate fermentation step.

A great deal of heat is generated during high-speed blending/mixing. To keep temperatures down, water used in the dough mix may be precooled directly in small chillers. As an alternative, the mixers may be cooled from the outside with a "jacket" that surrounds the mixing vessel itself. The jacket is cooled either by direct expansion into the cavity or by chilled water produced in central chillers.

Fermentation

After mixing, bread dough is placed in special rooms for fermentation. Temperature and humidity control are important in this step since the rate and quality of fermentation is strongly dependent upon temperature, and the handling properties of the dough surface are dependent upon the extent to which drying occurs. Fermentation takes three to five hours per batch.

Forming

Once the dough has been fermented, it is divided, rounded, molded, panned, and proofed—a step known as forming. The dough is removed from the fermentation rooms and emptied into dough-divider machines that cut the dough into one-loaf pieces. The pieces are then put through a rounder, which agitates and removes gas from the dough. The pieces are then allowed to rise further in a dough proofer.

The rounded pieces of dough next pass through an electrically driven sheeter-molder, which flattens each piece, rolls it into an elongated shape, and drops it into a baking pan. The products are then enclosed in intermediate proofing cabinets to store the dough at controlled temperature and humidity levels until the baking step.

Baking

Baking is the process of heating the dough to cause starch gelatinization and gluten coagulation (giving the bread its firmness and texture) as well as sugar carmelization (which is responsible for exterior browning and flavor development). Most ovens are fueled by natural gas, although some are oil-fired and a few are capable of using both fuels. Electricity is used in only a few small bread ovens.

Cooling

After baking, the products are cooled. Cooling is accomplished by stacking the product in open racks or by passing the product through cooling tunnels. In the cooling tunnels, ambient air is blown over the product. In some cases the air is mechanically cooled.

Icing, Oiling, and Salting

After cooling, the baked goods are finished in preparation for final packaging and sale. Cookies, for example, are iced, and crackers are oiled and salted.

Packaging

After cooling, the product is sliced and wrapped or bagged. In slicing, electric motor drives are used to power the high-speed cutting blades. Refrigeration is required if baggers are used; such equipment is typically supplied as an integral part of the wrapping process. The refrigeration load increases as the wrapping speed increases.

Freezing

Wholesale bakery products are not typically manufactured and purchased on the same schedule. Bakeries generally work at an even pace throughout the week, while the vast bulk of bread and other bakery products is sold on Friday and Saturday. To solve the problem of fluctuating demand, bakeries ship some products during the week and freeze the remainder. On Friday, the day’s production and whatever product was frozen is shipped for the weekend rush. Bread freezes at about 18°F; freeze rooms or tunnels are held at 0°F to -30°F. After the initial quick freeze, the product is moved to holding rooms kept at 0°F for stabilization and storage.

Cleanup

Cleanup is an important part of a bakery operation, as the establishment must comply with all FDA sanitation standards in order to remain in business. More than 90% of a bakery's total wasteload comes from wasted ingredients that are discharged via floor drains during processing and cleanup. Flour, yeast, and shortening are the major components. Wastewater may also contain cleaning agents, lubricants, and solids removed from the equipment and floors. Moreover, weekly shutdown and sterilization, required by the FDA, uses large amounts of hot water for washdown and can result in peaks in wastewater pollutant levels and ultimately higher sewer surcharge costs.

Energy Use

According to the Department of Energy (DOE), the bread baking industry (SIC 2051) consumed approximately 32 trillion Btu of total energy in 1991 (electricity equaled 2.24 billion kilowatthours [kWh]). Estimates of total energy consumption were not available for SICs 2052 and 2053.

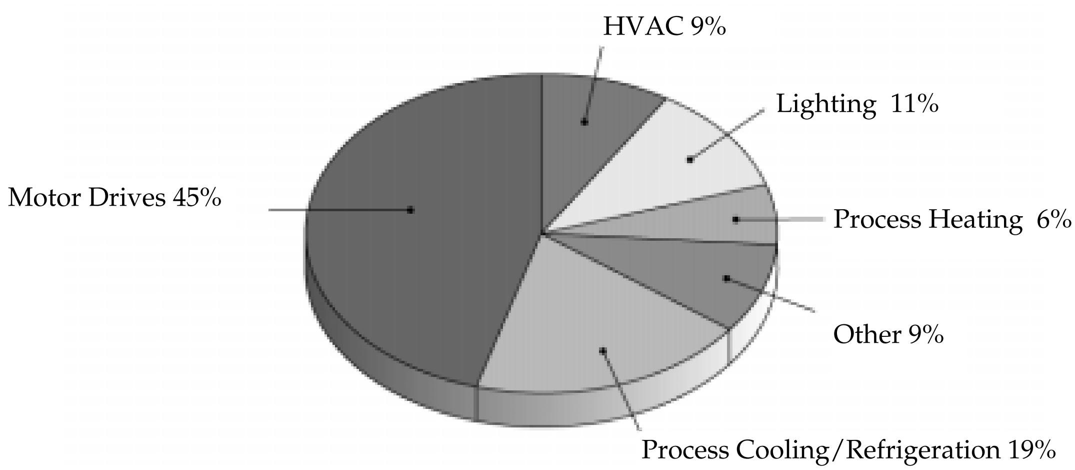


Figure 3
Typical Electricity Use in Wholesale Bakeries

More than 70% of the energy use in SIC 2051 was provided by natural gas. Electricity represented only 25% of total energy use. Fuel oil accounted for most of the remaining 5%. Electricity's share was up from 15% in 1980.

More than 45% (1 billion kWh) of this electricity was used by motors to drive materials handling and processing equipment (see Figure 3). Process cooling and refrigeration accounted for nearly 20% of electricity use. The remainder was for lighting (11%); heating, ventilating, and air conditioning (HVAC) (9%); process heating (6%); and other uses (9%). This "other" category includes wastewater treatment, facility support, and additional process and non-process uses. While electricity is used throughout the entire baking process (e.g., mixing, fermentation, forming, cooling, and freezing), the baking step of the process is predominately fueled by natural gas.

2

BUSINESS CHALLENGES AND NEEDS

Energy costs are typically not a key concern of most bakeries, making up a significant but relatively small fraction (3–4%) of the total cost of bakery materials. In fact, this figure is only as large as it is because the basic ingredients of the trade—flour, yeast, milk, and eggs—are relatively inexpensive. Bakeries are therefore typically less concerned about energy issues and more concerned about other business issues such as operating cost, productivity, product quality, and environmental regulations. As a result, electric-based technologies that help bakeries address these issues are likely to elicit interest. This guide links business challenges and potentially problem-solving electric-based technologies.

Barriers to Technology Adoption

Commercial bakeries tend to be extremely conservative when it comes to purchasing new equipment, particularly new technologies. One concern is, of course, the investment capital; but perhaps more importantly, installation of new equipment often results in lengthy periods of reduced production. Unlike the manufacture of inorganic products (e.g., metal parts), the routines of a commercial bakery must be tightly synchronized.

A product cannot pause between process steps or it will be ruined. Therefore, a bakery can be severely affected when a change in equipment or process cannot be accomplished during a routine period of downtime or may interrupt the flow of product. New technologies also involve an element of risk. The most convincing argument for a technology is an example of a successful application; e.g., a visit to a facility where the technology is already in place.

Competition

At one time, volume production ensured success. Today, however, bakeries face significant marketplace challenges from other independent and chain wholesale bakery operations. With numerous bakeries in each major metropolitan area, there is considerable competition for customers.

Although there is disagreement among industry experts as to the extent, wholesale bakeries may also face competition from in-store bakeries. By 1990, several thousand grocery stores and supermarkets had opened their own in-store bakeries. These in-store bakeries have the advantages of being able to provide specialty breads and cakes that may not be available from wholesalers, and enjoying the customer perception of freshness.

An in-store bakery may not always mean competition for a wholesale bakery, however. Under the growing practice of "private labeling," a store orders fully and partially baked products from a central (wholesale) facility and then "preps" the goods in an oven at the store location. In addition, boutique bakeries increasingly use the services of central bakeries to provide their baked goods. Under these circumstances, a wholesale bakery may be producing the goods offered by many regional retailers.

Need

Decrease Operating Costs

A bakery can improve its competitiveness by decreasing operating costs. While increased energy efficiency would reduce a facility's energy bill and therefore operating costs, it is actually the labor-saving advantages of electric technologies that are likely to have the greatest value. Labor is not only one of a bakery's largest operating costs, it is also an area of vulnerability. Due to the nature of the baking business—specifically the requirement of fresh products on a continuous basis—work slowdowns or stoppages due to employee absence can quickly inflict an adverse impact on business. New equipment and processes that reduce a bakery's reliance on labor and vulnerability to employee absence would relieve some pressure.

Technology Solutions

While they do not address the labor factor, energy-efficient motors, adjustable speed drives, energy-efficient indoor and outdoor lighting, electric chillers, heat recovery technologies, and heat pump water heaters all offer bakeries the opportunity to reduce their energy expenditures.

See Pages 3-3, 3-5, 3-7, 3-10

Need

Increase Productivity and Product Quality

To be competitive, bakeries must continuously produce a consistent product. Productivity and product quality are therefore just as important to a bakery's success as keeping operating costs low. As a result, any kind of equipment or process change that can appreciably improve throughput (by increasing production speeds or reducing wastage) or improve product quality is worthy of serious consideration.

Technology Solutions

Microwave baking and radio-frequency heating are two electric technologies that may offer long-term potential to speed up the proofing and baking portion of the production process and improve the quality of bread or cookies/cracker products. Indirectly, proper indoor and outdoor lighting can also improve productivity by enhancing the indoor working environment and increasing the health and safety of employees. A well-lit building may also make a company more competitive by cultivating the image and perception of high quality.

See Pages 3-5, 3-9

Consumer Demands

The primary goal of a wholesale bakery is to provide consumers with the consistently fresh, healthy, and good-tasting products that they demand. Sales are influenced by price, convenience, health concerns, and consumer perception of freshness. Commercial bakeries are challenged to meet the fickle demands of a nation of consumers who demonstrate conflicting desires for healthy diets and taste gratification.

Consumption of traditional sweet baked goods began to decline in 1992 as consumers changed their buying habits and sought out bakery products that were lower in calories and fat content. As a result, many bakeries have changed their ingredients—replacing tropical oils and white flour, for example, with canola oil and whole wheat flour—and developed new products to suit consumer tastes.

Need

Improve Flexibility

Many wholesale bakeries have begun offering a greater variety of specialty products to address the full range of consumer desires. Faster, more flexible production processes will benefit a bakery by allowing it to increase productivity and/or handle short runs of a greater assortment of products.

Technology Solutions

No electric technology solutions have been developed to meet this need, although the use of microwave baking and radio-frequency heating is increasing and may offer long-term potential to speed up the proofing and baking portion of the production process.

See Pages 3-9

Environmental Issues

In addition to production-related challenges, wholesale bakeries are also confronted with several environmental challenges. Two of the most important issues are the emission of ethanol, a volatile organic compound (VOC), from bakery ovens, and the use of large volumes of sometimes costly water with the resulting generation of large amounts of wastewater.

Need

Control Ethanol Emissions

Emission of ethanol is only a concern for bakeries in SIC 2051 that manufacture yeast-containing bread products. Ethanol ($C_6H_{12}O_6$) is produced by the fermentation of yeast and is released from the dough in the high-temperature environment of the baking oven. About 8 pounds of ethanol are released per ton of bread dough. Many large bread bakeries emit enough ethanol during production to classify them as major sources of VOCs, precursors of ozone (smog). To comply with the Clean Air Act Amendments (CAAA) of 1990, bakeries in areas that have not met Environmental Protection Agency (EPA) ozone standards (known as “non-attainment areas”) and that themselves exceed the EPA ethanol standard may be required by their state or local environmental regulatory body to control their emissions.

According to the larger bakeries, there are significant problems with the EPA emissions calculations, which are based on a facility’s “potential to emit” rather than on actual emissions. The maximum production capacity of a bakery is used to determine the total amount of VOC emissions, assuming a 24-hour per day, 365-day per year production schedule, even if the bakery does not operate on such a schedule. The larger bakeries, now under scrutiny, argue that such calculation methods overestimate emissions and force some bakeries to control their emissions when they are not actually exceeding the limits. In some areas of the country, states are refusing to enforce the EPA regulations in fear of losing business to competing states. This is especially true in the Northeast, where a bakery can easily shift production from one state to another and continue to serve the same market.

Formula modifications, such as lowering the amount of yeast added to a product, or its fermentation time, could lower or nearly eliminate the amount of ethanol produced per product. Unfortunately this would also affect the quality of the bread itself. Currently, no modified yeast, additive, or enzyme that lowers VOC emissions provides an acceptable-tasting bread. Process changes, therefore, are not considered a feasible means of reducing bakery VOC emissions.

The cost of VOC control technologies can be significant—from $100,000–$1,000,000 per facility. While only the largest bakeries are likely to need to control their ethanol emissions in the near future, the trend in environmental regulation is to focus on smaller and smaller "point" sources of pollution. Incineration is the control technology currently recommended by EPA. The agency has also published an alternative control technology (ACT) document to help states identify technologies for bakery oven emissions.[1]

Technology Solutions

There are currently no commercially available electric technologies for ethanol control.

Need

Pretreat Wastewater

Water and wastewater issues particularly concern bakeries involved in "wet baking," the manufacture of cakes and pies. These bakeries are categorized as either SIC 2051 or SIC 2053, depending on the product they manufacture. Wet baking generates much larger volumes of wastewater contaminated with flour, yeast, oil, and grease than does dry or bread baking. Some bakeries—depending on where they are located and the requirements of local regulations—are facing increasingly strict pretreatment standards for discharge of their process wastewater to publicly owned treatment works (POTWs). Bakeries that exceed their set discharge limits can be required to pay surcharges or to develop a pretreatment plan to meet the standards.

In addition, all bakeries are required by FDA regulations to maintain strict sanitary conditions; this involves daily cleaning and, typically, partial or complete shutdown for cleaning and maintenance one or two days per week. Cleaning routines thus contribute significantly to the volumes of wastewater generated by this industry. While water costs vary dramatically across the country, water and sewer service costs have been rising rapidly in many areas. As the cost of treating wastewater at the POTW rises due

[1] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, *Alternate Control Technology Document for Bakery Oven Emissions*, EPA 453/R-92-017, December 1992.

to more stringent environmental regulations, the POTWs have passed these costs on to their nonresidential users. At today's rates, a bakery's wasteload can have a significant impact on profitability. As a result, some bakeries may look toward installing their own pretreatment systems.

There are a number of options for reducing the amount and strength of wastewater produced by the baking process and for treating the wastewater prior to discharge. General housekeeping and waste minimization measures—such as forcing dry cleanup of spills and mopping the floor instead of using hoses to clean up—can often significantly reduce the amount of water used and the wasteload of that water, resulting in significant cost savings. Some bakeries have succeeded in cutting their plant's water use by as much as 50% through implementation of waste minimization measures.

Other bakeries, however, may find good housekeeping practices insufficient to reduce their wasteload enough to comply with local public treatment works standards. In this case, the installation of a pretreatment system must be considered. The typical wastewater pretreatment process involves the control of fats, oils, and grease; the control of pH; and sometimes the reduction of biological oxygen demand and total suspended solids. These wastes are treated and disposed of by a variety of methods, including conventional screening, settling, and basic filtration, as well as electric-based technologies such as dissolved air flotation and ultrafiltration.

Technology Solutions

Two electrotechnology solutions exist for pretreating bakery wastewater: dissolved air flotation and ultrafiltration.

See Page 3-12

3

TECHNOLOGY SOLUTIONS AND PARTNERING OPPORTUNITIES

This section describes each of the technology solutions identified in the previous section. Each technology is summarized, linked by end-use application to a business need, and categorized as an “electrotechnology” or an “efficiency technology.” Electrotechnologies are selected new or alternative electrically driven equipment options. Efficiency technologies are electrically driven technologies that offer opportunities to decrease energy use. In many bakery applications, the electrotechnologies can increase production, improve product quality, or control pollution, and may couple increased energy costs with an overall decrease in operating costs. Each electrotechnology is more completely described in Section 4, Electrotechnology Profiles. Vendors of these technologies, sources for information on efficiency technologies, and trade associations are listed in the Resources section of this guide.

This section also identifies “partnering opportunities,” opportunities for a utility to conduct energy-related educational or other activities that might enhance bakery facilities or operations. For example, with the phaseout of familiar chlorofluorocarbon refrigerants, bakeries need to know about cost-effective electric options so they can make informed decisions.

Technologies and partnering opportunities are grouped and discussed according to their end use, beginning with “Motors and Drives,” the end use that consumes the greatest percentage of total baking industry electricity use. Table 3 summarizes these end uses, solutions, and opportunities.

Table 3
Technology Solutions to Wholesale Bakery Needs

			Business Needs			
End Use	**Solution Type**	**Technology Type**	**Decrease Operating Costs**	**Increase Productivity/ Product Quality**	**Improve Flexibility**	**Control/ Prevent Ethanol & Wastewater Emissions**
Motors and Drives	Efficiency Technology	Energy-Efficient Motors	■			
Motors and Drives	Efficiency Technology	Adjustable Speed Drives	■	■		
Process Cooling/ Refrigeration	Partnering Opportunity	Education on Electric-Based Alternatives to CFC Refrigeration				
Lighting	Efficiency Technology	Energy-Efficient Indoor Lighting	■	■		
Lighting	Electrotechnology	Energy-Efficient Outdoor Lighting		■		
HVAC	Efficiency Technology	High-Efficiency Heat Pumps	■			
HVAC	Efficiency Technology	High-Efficiency Electric Chillers	■			
HVAC	Efficiency Technology	Thermal Energy Storage	■			
HVAC	Efficiency Technology	Heat Recovery	■			
Process Heating/Baking	Partnering Opportunity	Education on Ethanol Emission Control Technologies				■
Process Heating/Baking	Electrotechnology	Microwave Baking		■	■	
Process Heating/Baking	Electrotechnology	Radio- Frequency Drying and Heating		■	■	
Water Heating	Electrotechnology	Heat Pump Water Heater	■			
Wastewater Treatment	Electrotechnology	Dissolved Air Flotation	■			■
Wastewater Treatment	Electrotechnology	Ultrafiltration	■			■

Motors and Drives

Electric motors and drives account for 45% of electricity use in commercial bakeries. This electricity powers motor-driven equipment such as pumps, oven fans, and compressors for cooling; conveyors and packaging equipment; and other equipment such as mixers and slicers. Therefore, the efficiency of motor systems used in a bakery significantly influences the overall energy efficiency of the facility. Adjustable speed drives can efficiently reduce energy usage by throttling a motor to reduce the output of chillers, fans, and pumps according to process needs.

Power factor also affects energy usage. Power factor refers to the relationship or "phase" of current and voltage in an ac electrical distribution system; in other words, the relationship between the power being drawn from the distribution system and the actual power used. Theoretically, when power factor is 100%, current and voltage are in phase. In practice, a fully loaded motor typically has a power factor of about 80%, while a lightly loaded motor may have a power factor of 40% or less. The effect of poor power factor is increased current flow, increased power loss, and less-efficient motors. This results in higher demand charges, as well as any applicable power factor penalties (some utility rate schedules include these), and therefore higher electric bills.

Power factor correction can reduce current flow and power loss and improve voltage regulation, thereby improving the performance of motors. Poor power factor is usually corrected through the installation of capacitors. In bakeries, however, poor power factor is typically caused by underloaded or idling motors and can be corrected by changing the way the equipment is operated. Motors that are continuously underloaded should be replaced with smaller motors, and motors that regularly idle for more than a few minutes should be equipped with load controllers to stop them when they are not needed.

Efficiency Technology Solution
Energy-Efficient Motors

Energy-efficient electric motors (also known as premium- or high-efficiency motors) are typically 2–6% more efficient than their standard counterparts. The price premium is 15–30% above the cost of a standard motor. Over a typical 10-year operating life, a motor can consume electricity valued at over 50 times the initial cost of the motor. As a result, energy-efficient motors are usually extremely cost-effective, with simple paybacks on investment of less than two years when compared to purchasing a standard-efficiency motor. Paybacks are typically attractive unless electricity prices are very low or a motor is operated very infrequently.

High-efficiency motors offer more than just reduced electricity consumption. They are typically manufactured to closer tolerances, use better materials, and offer more robust construction when compared to standard motors. This translates into improved reliability and reduced maintenance requirements. Energy-efficient motors are available for virtually all bakery applications above one horsepower.

Efficiency Technology Solution
Adjustable Speed Drives

Adjustable speed drives (ASDs), also known as variable-speed drives, should be considered for large motors, particularly on ingredient, water, and wastewater pumps, and on oven and exhaust fans. These drives use solid-state electronics to vary the frequency of the electricity applied to the motor. By reducing the frequency below the nominal 60 hertz, ASDs can efficiently reduce the speed or output of the motor, thereby eliminating energy use that otherwise would have been wasted. Prior to ASDs, valves and dampers were used to throttle motor output. Today, ASDs efficiently reduce the output of the chillers, fans, and pumps by decreasing the electrical energy supplied.

Process Cooling/Refrigeration

Refrigeration and cooling processes account for 19% of total electricity use in the wholesale baking trade. Electricity is used for refrigerating or freezing ingredients, cooling dough during mixing, cooling products after baking, refrigerating products prior to packaging, and freezing products for delivery or later baking on site. To accomplish these tasks, bakeries use a variety of equipment, including dough mixers with jackets that cool the mixers with chilled water, low-temperature antifreeze, or direct-expansion refrigerant; cooling tunnels with counter-flow refrigerated air movement; medium-temperature cool rooms for storing refrigerated dough products; freezing tunnels for bread; and spiral freezer chambers that hold products at -30°F for 20–60 minutes.

As of January 1, 1996, the production of chlorofluorocarbons (CFCs) in the United States is banned. As a result, many bakeries are facing or will face the need to invest potentially significant amounts of capital to switch to a replacement refrigerant, or replace current CFC-using refrigeration and freezing equipment altogether. Alternatives include the use of hydrochlorofluorocarbons (HCFCs), non-CFC refrigerants, as well as absorption chilling and ammonia-based technologies. In addition, thermal energy storage, which uses electricity off-peak, is potentially applicable for refrigeration and/or cooling in situations where on-peak demand and energy charges are significantly higher than off-peak charges and the bakery does not operate more than one shift.

Partnering Opportunity
Education on Electric-Based Alternatives to CFC Refrigeration

While some bakeries may already have formulated a CFC-replacement strategy, many others, particularly small bakeries, may lack information on the advantages and disadvantages of available alternatives. This is a partnering opportunity for a utility to provide education on CFC alternatives and assist wholesale bakeries in reviewing refrigeration options and calculating paybacks for refrigeration equipment options.

Lighting

Lighting accounts for approximately 11% of the baking industry’s total electricity consumption. Since wholesale bakeries are most often located in warehouse-type facilities, the majority of lighting systems are fluorescent tubes with magnetic ballasts. Fluorescent fixtures are available in a variety of shapes and sizes. Some of the most common are four-foot-long tubes used in two-tube, three-tube, or four-tube fixtures. Eight-foot-long tubes are also used, particularly in larger bakery facilities. The basic components of the fluorescent lighting system are fixtures, reflectors, switches, tubes, ballasts, and lenses.

Incandescent lamps are found in some older bakeries, especially in storage rooms and hallways, but also for decorative lighting (e.g., on signs and displays) and for exit lights. These fixtures are relatively inexpensive and easy to install. However, incandescent lighting is the least efficient lighting source available.

High-intensity discharge (HID) lamps are also used in bakeries with warehouse-style facilities, although these lamps are most commonly used in parking lots and driveways. The HID family of lamps includes mercury vapor, metal halide, and high-pressure sodium lamps. Mercury vapor lamps are the least efficient lighting source in this category.

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 or $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 hallways. Mercury vapor lamps can be replaced with either metalhalide or high-pressure sodium lamps with relatively short payback. All of the HID lamps have significantly longer lives than incandescent lamps and many fluorescent lamps.

Electrotechnology Solution
Energy-Efficient Outdoor Lighting

All bakeries have some form of outdoor lighting, ranging from incandescent lights in signage on the building to mercury vapor lights in the loading dock area, parking lot, and driveway. These lighting systems normally represent only a small portion of the energy bill because they are on for limited periods of time and because they seldom contribute to a facility’s peak electrical demand. This means there may be relatively small savings potential from energy conservation projects. Conversely, a bakery can realize a different set of benefits by increasing its level of outdoor lighting to reduce the potential for crime, increase employee safety, and improve the visibility and attractiveness of the facility exterior and grounds (a form of advertising). Heightened visibility not only enhances the safety and well-being of employees, thereby indirectly improving productivity, it helps a company to project a corporate image of high quality.

Heating, Ventilating, and Air Conditioning

Heating, ventilating, and air-conditioning systems (HVAC) represent roughly 9% of electricity use in the baking industry. Their primary usage is for space cooling; the cooling load is typically driven by internal heat gain from lights and the baking process, and at least part of a facility may require year-round cooling. HVAC systems are also used to maintain indoor air quality according to the fresh-air ventilation rates specified in the American Society of Heating, Refrigeration, and Air-conditioning Engineers (ASHRAE) Standard 62-1981, “Ventilation for Acceptable Indoor Air.”

Small Bakeries

In most small bakeries, the HVAC system is selected based on lowest first cost; quality and energy efficiency are not primary criteria. In addition, the air distribution systems are held down to minimize costs. For these reasons, roof-mounted packaged systems are very popular.

The HVAC systems typically found in small bakeries include air-to-air heat pumps, natural gas furnaces with electric air conditioning, and electric resistance heating with electric air conditioning. Each system has advantages and disadvantages. For example, air-to-air electric heat pumps are relatively efficient, come in a variety of sizes, and can be roof-mounted or ground-mounted. Natural gas furnaces also come in packaged, roof-mounted units, but can pose health and safety concerns (such as carbon monoxide poisoning) if not maintained properly. Electric resistance heating is very clean and simple to operate, but it is not as cost-effective as other available options.

Efficiency Technology Solution
Air-to-Air Heat Pumps

The most energy-efficient HVAC system available for small bakeries is the air-to-air heat pump. This system combines energy efficiency and year-round comfort with simple-to-operate controls, and can increase market share of electricity if it replaces a gas furnace.

Medium-Size and Large Bakeries

Medium-size and large bakeries tend to favor roof-top packaged systems; natural gas, oil, and electric boilers; electric air conditioners and chillers; constant-volume air distribution systems; and electric resistance heating in ducts or terminal units, fan coil units, radiators, and other terminal units. These systems and components can be assembled in a wide variety of ways and modified after installation, making all the potential configurations and options impossible to list.

Efficiency Technology Solution
High-Efficiency Heat Pumps

Air-to-air or water-source heat pumps can be attractive replacement options for buildings with electric air conditioning and a fossil-fueled heating system.

Efficiency Technology Solution
High-Efficiency Electric Chillers with Terminal Reheat

In an electric chiller, the refrigeration cycle collects heat from the indoor space via the evaporator, boosts its temperature, and rejects the heat to the atmosphere via an air-cooled or water-cooled condenser. A new system can often pay for itself through energy savings in about four years.

Efficiency Technology Solution
Thermal Energy Storage

Thermal energy storage moves part 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. The system's storage tanks are charged or frozen by the building's chiller at night and the stored energy is used to provide cooling during the day. This technology may not be applicable to bakeries operating more than one shift per day or smaller bakeries that do not face demand changes.

Efficiency Technology Solution
Heat Recovery

Heat recovery systems maintain indoor air quality and reduce energy usage by recovering the heat (or coolness) from the building's exhaust air. This reduces the energy needed to condition incoming air. In a typical bakery, a large amount of warm air is exhausted from the facility, particularly from the ovens. The energy from this warm air can be used to heat other spaces or to preheat domestic water (see Water Heating, page 22). Depending on the method of heat recovery and the installed heating technology, this approach may increase or decrease electricity consumption.

Process Heating/Baking

Process heating and baking account for 6% of baking industry electricity use. Most of this electricity is used in the storage of ingredients, and in the fermentation and proofing steps of the production process.

Ovens fueled by natural gas dominate the baking step of the production process. More than 95% of ovens are natural gas fired, 4% are capable of using both natural gas and fuel oil, and less than 1% are fueled by electricity. While electric-based heating or baking technologies hold some promise, they have not been able to compete thus far, primarily because of the maturity of natural gas technologies.

Conventional drying and baking techniques that use natural gas and steam are not very energy efficient. Heat losses, which can be high in natural gas and steam systems, are minimized in electric drying systems, such as microwave baking and radio-frequency heating, because the heat is directed at the food to be baked, dried, or predried. These systems can significantly reduce baking and drying times, thereby improving productivity and, in some cases, product quality.

Partnering Opportunity
Education on Ethanol Emission Control Technologies

Within the 400 or so large commercial bakeries in the United States, emission control devices are installed on 58 bakery ovens. Systems employing catalytic oxidation, a type of flameless incineration, are employed on 54 of these ovens. Two of the remaining four have installed condenser systems, one has a scrubber, and one has a modified heat exchanger.

While catalytic oxidation units are relatively large and have a high capital cost, smaller units may be introduced to the market if the demand for such a unit increases. The EPA found that, based on the volume of product produced, neither catalytic nor thermal oxidation would be cost-effective for smaller bakeries to use to control their ethanol emissions. Although both catalytic and thermal oxidizers use some electricity in their operation (e.g., to power fans), no electric-based technology has proven to be both technically and economically feasible for controlling bakery VOC emissions.

Despite the lack of an electrotechnology solution to this bakery need, utilities can provide a valuable service by helping bakeries become informed about the available oxidation-type ethanol emission control technology alternatives. Ongoing research is taking place to identify electrotechnology solutions to ethanol emissions.

Electrotechnology Solution
Microwave Baking

Microwaves have been used experimentally to bake bread and cakes and to assist in the frying of doughnuts since the 1970s. The primary benefits of microwave baking are in reduced baking or frying times and a drop of up to 50% in every use. In addition, microwave baking reduces loss of thiamin (an important vitamin) and moisture from bread, resulting in an improved product.

The typical system combines microwave baking or frying with conventional baking or frying methods to produce the same product in roughly one-third the time. For example, bread that would usually take 60 minutes to bake might be baked with conventional heat for 10–12 minutes and then finished with 10–12 minutes of simultaneous microwave and conventional heat. This technique bakes the interior of the product with the microwave energy while the exterior is browned and crusted by conventional heat. Microwaves can also be used to finish proofing and partially bake bread products intended to be finished and browned by the consumer before serving.

To its disadvantage, microwave baking equipment is not currently available in small units and has relatively high capital costs ($2000–$4000 per kW), making it economical only for large applications. In addition, experimentation has shown that microwave baking can leave an unfavorable yeasty flavor in breads. Due to the magnitude of the potential productivity and operating cost benefits, research continues on a variety of microwave baking applications. The current trend toward shorter runs of specialty baked goods (putting the pressure on bakeries to turn out more product in less time) could improve the outlook for this electrotechnology. In addition, microwaves also have a potential application in the control of microorganisms in packaged biscuits and breads.

Electrotechnology Solution
Radio-Frequency Heating

Like microwave baking and frying, radio- frequency (RF) heating has been experimented with since the 1970s. RF waves rapidly and uniformly heat water molecules in baked goods, causing them to evaporate. Therefore, RF heating can be used to further dry (i.e., crisp) baked goods such as cookies and crackers without additional browning. There are two basic methods for utilizing RF heating in the baking process: (1) combining RF with conventional heat in the same oven or (2) applying RF after first baking in a conventional oven. The second method has proven to be more effective because RF equipment that operates in the high-temperature environment of the conventional oven may suffer early insulation breakdown and eventual failure. In the post-drying RF technique, baked goods either pass through a continuous RF heating unit on a conveyor belt or are processed in a batch system similar to a home oven.

The selective removal of moisture allows for a high degree of product uniformity as well as close control of the product's final moisture content. RF heating can also reduce baking time by as much as 50% and energy use by as much as 40% when combined with conventional heating. Reduced baking time can lead to increased product output of 18–50% for different types of cookies.

Although RF technology has been successfully applied to the heating and drying of cookies and crackers in Europe, accounting for 80–90% of overall production there, it has not yet been widely adopted in the U.S. cookie and cracker industry. The postdrying, continuous systems are available for large baking applications, but the high initial capital costs ($1000–$3500 per kW) are not economically feasible for many applications, especially for smaller bakeries. To date, Nabisco is the only U.S. manufacturer known to be using RF technology.

Water Heating

Water heating accounts for approximately 9% of the electricity consumed by commercial bakeries. Hot water is used primarily in the washing and cleanup steps of the production process.

Electrotechnology Solution
Heat Pump Water Heater

Heat pump water heaters have been successfully applied in bakeries, recovering waste heat from baking, refrigeration, and air conditioning to heat service water. They supply coincident cooling, which can be used to cool over-heated areas. They can be installed in new-construction or retrofit situations and are best applied to augment existing water heating and space cooling systems. Heat pump water heaters represent a highly competitive alternative to fossil fuel-fired water heating systems.

Wastewater Treatment

Wastewater treatment currently accounts for an estimated 1–2% of total bakery electricity use. While this figure is not large, it is expected to grow as the costs of water and wastewater disposal continue to rise due to increasingly stringent environmental regulations.

Table 4
Typical Sewer and Surcharge Costs

Costs	Average	Range
Sewer	$1.50/thousand gallons	$0.20-$8.00/thousand gallons
Surcharges	$0.20/lb BOD	$0.25-$3.00/lb BOD

Source: North Carolina Cooperative Extension Service, "Liquid Assets for Your Bakery," December 1991.

Water use in bakeries ranges from 10,000 gallons per day in small bakeries to 20,000–100,000 gallons per day in medium-size bakeries, and up to 1,000,000 gallons per day in the largest bakeries. As a general rule, at least 30% of the water used is discharged as wastewater (the remaining 70% is used in products or evaporates as steam or cooling tower discharge). Bakery wastewater drains to publicly owned treatment works (POTWs). Because so much wastewater is generated—especially during production of muffins, cakes, pies, and danish—the costs associated with its disposal can have a dramatic impact on the cost of operating a bakery.

The wasteload or "strength" of wastewater is usually measured by biochemical oxygen demand (BOD); total suspended solids (TSS); and, fats, oils, and grease (FOG).

The three pollutant categories tend to overlap. Flour, sugar, grease, and other ingredients in the wastewater create a condition known as biochemical oxygen demand: The more food there is in the water, the more oxygen is needed by bacteria in the water. When bacteria demand oxygen faster than the water can replace it, the amount available for fish and other organisms decreases. Therefore, a reduction in BOD can imply reduced levels of TSS and FOG.

Bakeries are indirectly subject to federal Clean Water Act (CWA) regulations. A bakery that discharges to a local POTW is required to meet permitted discharge levels of BOD, TSS, and FOG set by the POTW. The POTW sets these standards based on the standard it must meet to stay in compliance with its own federal discharge permit. In high enough concentrations, solid and viscous pollutants such as BOD, TSS, and FOG could interfere with POTW operations and cause a violation of the POTW's own permit. If a bakery exceeds the standards set by the POTW, it must pay a surcharge, based on the amount of the exceedance, in addition to the regular wastewater disposal or sewer cost.

Typical Sewer and Surcharge Costs

In the past, surcharges were nonexistent or minimal. Now, however, as a result of more stringent environmental regulations on POTWs, surcharges have increased rapidly—by as much as 50% annually in some areas. As a result, management and disposal of bakery wastewater has become increasingly difficult and costly for some bakeries.

Bakeries located in urban areas are more likely to be affected by the increase in regulations surcharges.

While a bakery may be able to avoid the need for wastewater pretreatment by adopting pollution prevention or waste minimization measures—such as sweeping the floor before hosing it down or installing screens over drains—wastewater may still exceed a POTW's discharge limits by 10–15%.

There are three potential electric-based wastewater treatment technologies: biological oxidation, dissolved air flotation, and ultrafiltration. Although biological oxidation—a technology that uses biological agents such as bacteria, algae, or fungi to degrade fats, oils, and grease and other organic matter—is theoretically able to treat bakery industry wastewater, its application is limited. Units are typically very large and cannot handle the variable flow of wastewater that a bakery generates. As a result, vendors rarely sell units to wholesale bakeries.

Electrotechnology Solution
Dissolved Air Flotation

Bakery wastes are typically heavily emulsified. A process such as dissolved air flotation (DAF) can usually separate a large amount of suspended solids and insoluble BOD prior to primary and secondary treatment. The solids either adhere to or are entrapped by air bubbles pumped into the wastewater and then float to the surface where they can be skimmed off. Electricity is used to drive the blowers that produce the air bubbles and to drive the pumps that move the wastewater through the system.

If oils are emulsified in the wastewater, chemical coagulants such as organic polyelectrolytes, iron and aluminum salts, and sulfuric and nitric acids are added before separation is performed. Such pretreatment can often help to reduce the ultimate processing cost.

To its disadvantage, DAF is usually unable to remove soluble contaminants, such as sugar. A DAF unit can also prevent solids, such as pieces of dough and bits of fruit, nuts, raisins, and product, from settling to the bottom of the tank where they could be removed. Finally, the sludge or "float" must be removed and disposed of.

Electrotechnology Solution
Ultrafiltration

Ultrafiltration can be used to reduce levels of dissolved solids and BOD in bakery wastewater. The process uses a permeable membrane to filter selected components from wastewater. Akin to reverse osmosis and microfiltration, molecules are separated on the basis of their shape or size; in this case, molecules between 10 angstroms and 0.1 micron in size are allowed to pass through, while larger molecules are retained.

The ultrafiltration process uses electricity to pump wastewater through the membrane. The advantages of the membrane separation process include low maintenance; the system contains no moving parts, has no emissions, and operates near room temperature. In addition, systems are relatively compact and modular. Each module is designed as a self-contained pressure vessel containing the membranes and fluid distribution system.

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. For further information, or to learn more specific technical details, turn to Section 5 for a list of equipment vendors. The profiles have been designed as stand-alone descriptions so they can be utilized separately from this guidebook.

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.

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			■		
Neon	■				

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.

There are three principle 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.

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 spot lights on signs and as flood lights 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.

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.

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

Advantages

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

- Increased perception of comfort and friendliness
- Increased security for customers and employee
- 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

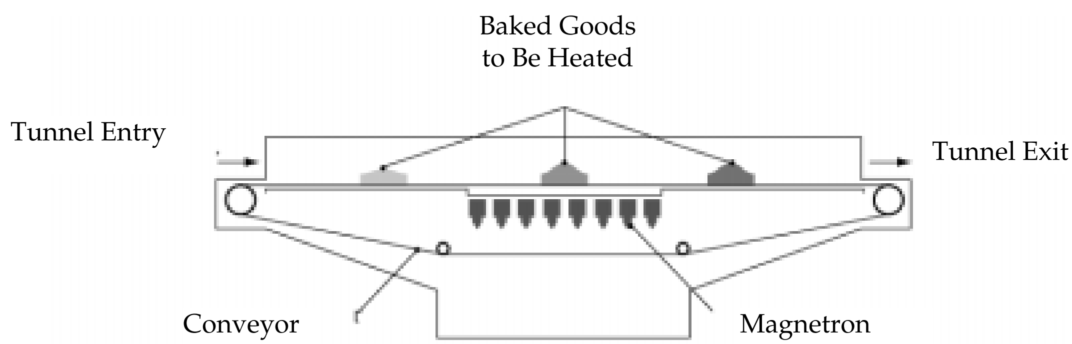
Additional information on lighting technologies is available from the EPRI Lighting Information Office, (800) 525-8555.

Microwave Baking

Basic Principle

Microwave processing uses microwaves (915–2450 MHz) to electrically heat non-conductive materials (e.g., food products) that contain polar molecules, such as water. Microwave beams heat the baking goods by striking the water molecules within the dough, causing the polar water molecules to constantly reverse their alignment. This rapid, repeating shift in direction produces heat, which evaporates the water.

Microwave energy is generated by magnetron tubes like those found in conventional microwave ovens. A magnetron tube consists of a rod-shaped cathode within a cylindrical anode that allows electrons to flow from the cathode to the anode once power is supplied. The electron flow creates an electromagnetic field whose frequency is determined by the size of the slots and cavities within the walls of the anode. The oscillations of the electrons within these slots and cavities produce microwaves.



Microwave Baking Process

System Description

A typical microwave baking system combines microwave heating with conventional, natural-gas-fired heating to produce the same quality products—such as breads and cakes—in one-third the time. The interior of the product is baked by microwave energy, and the exterior is browned and crusted by conventional heat. Thiamin and moisture losses are also less for microwave-assisted conventional baking than for conventional baking alone. Combining the two heating methods could yield high-quality products at better production rates, in standard metal bake pans.

Microwaves can also be used in doughnut processing. This application involves microwave proofing of the dough and microwave-assisted conventional frying. Only the portion of the doughnut riding above the hot fat is exposed to the microwaves. The cooking fat is not heated by the microwaves since the surface is covered with doughnuts. This method reduces frying time by 20% and fat absorption by 25%. It also improves doughnut quality and extends shelf life.

Advantages

- Can reduce baking time and energy use by as much as 50%
- Produces high-quality products
- Can be carried out in standard metal baking pans
- Allows greater process control
- Potentially be used to control microorganisms in packaged breads and biscuits

Disadvantages

- Leaves a yeasty flavor in breads
- Has a high capital cost

Commercial Status

Use of this baking method was first reported in 1966. Known as "microwave proof-baking," it involved proofing the dough to 50% of normal and then finishing proofing and baking in one operation in a microwave oven. This method is ideal for producing partially baked products to be finished and browned by the consumer before serving. While U.S. bakeries have experimented with microwave baking, the technology is not yet widely adopted.

Microwave Baking System Characteristics

Dimensions	Length: 10'–40' Width: 5'–10' Height: 5'–10'
Power Rating	1–300 kW
Energy Consumption	41,600 kWh annually*
Key Inputs	
Power	Electricity
Other	Oscillator tube replacement
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Installed	$2,000–$750,000
Other Supplies	$200–$10,000

*Assuming a 40-kW unit used 4 hours/day, 5 days/wk, 52 wk/yr.

Cost and Electrical Requirements

To its disadvantage, microwave baking requires a relatively large investment of capital. Most microwave systems cost $2000–$4000 per kW, depending on whether it is for batch or continuous operation. A 40-kW batch unit might only cost $50,000, while the same size continuous unit would typically cost $100,000–$160,000. The increase in price is primarily due to the material handling system and more complex controls required by the continuous system.

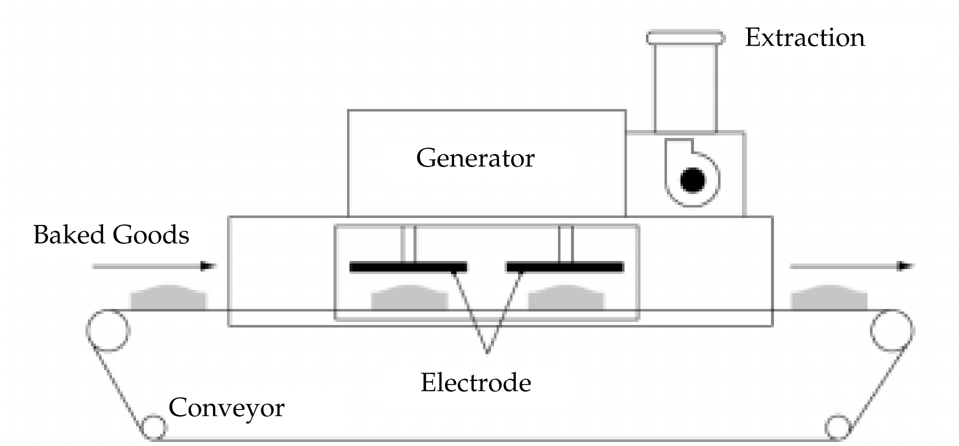
In general, microwave baking requires 1 kW per hour for every 2.5 pounds of water removed. Thus, for a 4000-pound bread-baking operation with a moisture content of 23%, a microwave system removing 10% of the moisture would require about 160 kW.

Radio-Frequency Drying/Heating

Basic Principle

Radio-frequency (RF) drying and heating uses RF waves to electrically heat non-conductive materials (e.g., food products) that contain polar molecules, such as water. When the direction of the electric field is alternated rapidly, the polar molecules constantly reverse their alignment. This molecular motion generates heat, evaporating water within the product, resulting in uniform drying.

A typical RF heating unit consists of a power supply, oscillators, and an electrode system. The power supply provides the high voltages needed for the oscillator to generate high- frequency energy (2–100 MHz). Because the same frequencies are used for radio communication, RF heaters must be shielded to avoid radio interference. The electrode system receives the high-frequency energy and converts the power to RF waves.



Radio Frequency Drying Unit

System Description

In general, there are two methods of combining RF and conventional natural-gas-fired heating: (1) combining RF and conventional heat in the same oven and (2) applying RF heating after the product has passed through a conventional oven. In baking, the latter method has proven to be the most effective. RF equipment that operates in the high-temperature environment of the conventional oven may suffer early insulation breakdown and eventual failure.

In the postdrying RF method, baked goods pass through a continuous RF heating unit on a conveyor belt, or are processed in a batch system (similar to home ovens) where the operator must remove the product from the exposure area when processing is complete. Using RF heating to postdry baked goods dries products without additional browning. This selective removal of moisture allows for a high degree of product uniformity and is ideal for cookie and cracker production.

Advantages

- Combining RF and conventional heating reduces baking time by as much as 50% and energy use by as much as 40%.
- RF heating rapidly lowers the moisture level in baked products and allows close control of final moisture content while minimizing the formation of moisture gradients.
- RF heating can increase output by 18% for hard cookies and by over 50% for wire-cut cookies.

Disadvantages

- RF heating has not proven to be economical in the baking industry.
- The impact of RF heating on product quality in the baking industry has not been fully perfected.
- RF heating cannot be used for browning.

Commercial Status

RF drying and heating technology has been used in bakery applications since the late 1950s. This method is well established in the cookie and cracker industries, accounting for 80–90% of overall production in Europe. Application of this electrotechnology lags in the United States. However, continuous (conveyors) and batch (oven-like) systems are available from a number of U.S. vendors.

Radio Frequency Drying and Heating System Characteristics

Dimensions	Length: 15'–40' Width: 5'–10' Height: 5'–10'
Power Rating	1.5–200.0 kW
Energy Consumption	52,000 kWh annually*
Key Inputs	
Power	Electricity
Other	Oscillator tube replacement
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Installed	$2,500–$800,000
Other Supplies	$200–$10,000

*Assuming a 50-kW unit used 4 hours/day, 5 days/wk, 52 wk/yr.

Cost and Electrical Requirements

One of the major disadvantages of a RF system is the high initial capital cost, determined primarily by size, controls, and type of application. Capital costs may vary from $1000–$3500 per kW of power output, with smaller systems (1–200 kW) ranging from $2500–$3500 per kW, and larger systems (300–1000 kW) ranging from $1000–$2500 per kW. For example, a 210-kW system would cost approximately $570,000.

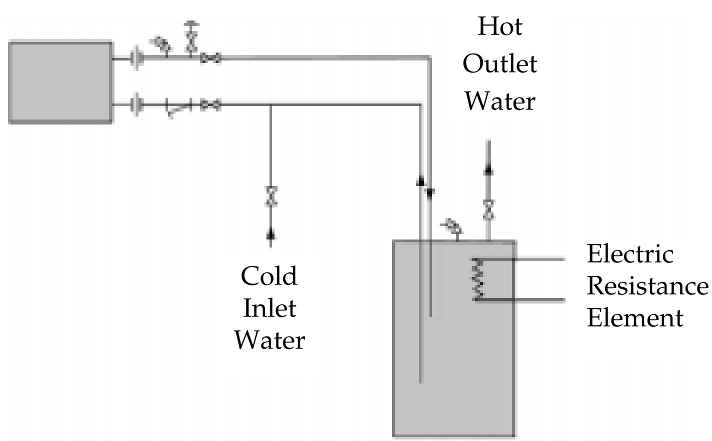
In general, a RF heating system requires 1 kW per hour for every kilogram of water removed. Thus, for a dough product weighing 1.3 kilograms and initially holding 23% moisture, a RF system removing 20% of the moisture would require about 0.26 kW per hour for each piece of dough. At a production rate of 500 dough pieces per hour, the power rating would be 130 kW.

Approximately 60% of the power input to a RF generator actually reaches the product. As a result, the power required is about 1.7 times the power reaching the product. Thus, a generator with an output of 210 kW would require about 350 kW of power input.

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 Process

Applications

HPWHs are ideally suited for kitchen, bakery, laundry, and pool facilities that have 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.

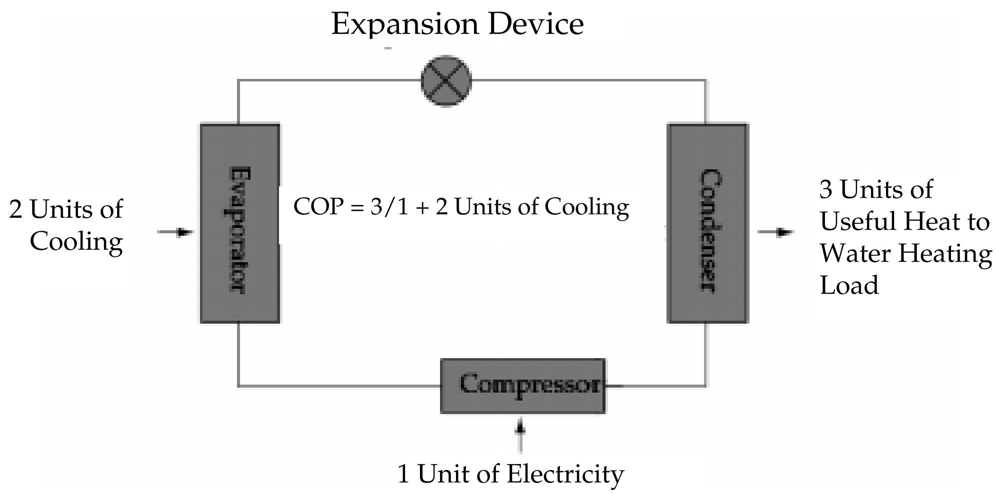
While HPWHs efficiently supply hot water, their most notable feature is free supply of space cooling. Assigning a quantitative value to the cooling is difficult, however, and is frequently subjective—a matter of the user's perspective. For example, the HPWH's free air conditioning may not result in a 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^{O}F, although some models can produce water temperatures of 180^{O}F. HPWH evaporators commonly operate over a wide range of temperatures, from 40–120^{O}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^{O}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%.



Heat Pump Water Heater Performance

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.

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

Cost and Electrical Requirements

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

Heat Pump Water Heater System Characteristics

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

EPRI Information

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

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

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

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

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

Dissolved Air Flotation

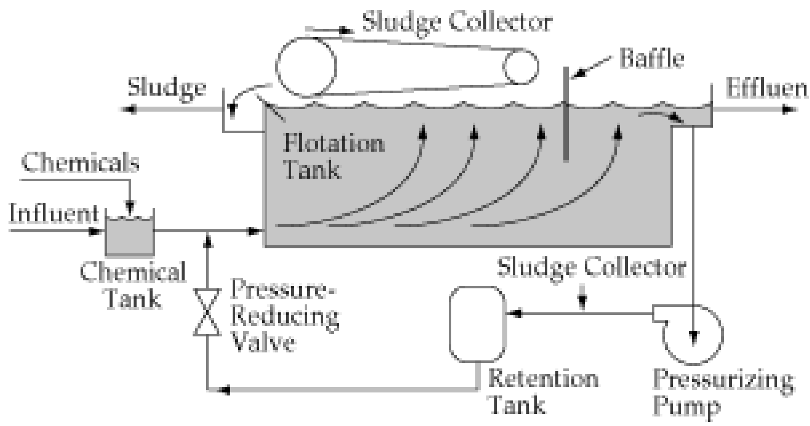
Basic Principle

The country is now on a trend toward increasingly stringent regulations on wastewater discharges. To help reduce the concentration of contaminants in the wastewater and thereby avoid additional sewer surcharges, bakeries can install various systems to pretreat wastewater prior to discharge. Dissolved air flotation (DAF) is one method of pretreatment. DAF is commonly used to control the strength of wastewater by removing emulsified waste solids within a specific gravity range, as well as by removing “light” suspended solids that have a tendency to float. A process such as DAF can separate a large amount of suspended solids and insoluble biochemical oxygen demand (BOD) prior to primary or secondary treatment.

System Description

DAF is a gravity separation system that bubbles air through a wastewater holding tank to help float insoluble materials to the surface so they can be removed. These materials either adhere to or are entrapped by the air bubbles pumped into the wastewater and float to the surface. Some materials that are heavier than water can also be removed if a chemical flocculent is used. The flocculent causes these materials to join together in clusters that are lighter than water and therefore float. The solids can then be skimmed off and removed. If oils are emulsified in the wastewater, chemical coagulants must be added before separation can be performed. Emulsion-breaking chemicals include organic polyelectrolyte, iron and aluminum salts, and sulfuric and nitric acids.

Two types of DAF systems are commonly used: full-flow pressurization systems and recycle-flow pressurization systems. Both systems contain three components: a tank (rectangular or circular), a float recovery and collection system, and a pressurization pump and tank. Variations in the commercially available systems include features such as tank design (including compact systems) and skimmer design. DAF systems are designed on the basis of the peak flow rate expected, unless the concentration of insoluble solids exceeds 3000 milligrams per liter (mg/l). The flow usually ranges from about 1–6 gallons per minute (gal/min) per square footof surface area.



Dissolved Air Flotation Filtration Process

Advantages

- DAF reduces fats, oils, and grease by 97%.
- DAF reduces emulsified oils by 60–80%, and with the addition of chemical additives, the reduction level increases to 80–90%.
- DAF reduces suspended solids by 60%, and with the addition of flocculent, the reduction level increases to 85–90%.
- DAF systems do not require excessive maintenance and/or management.
- DAF systems can potentially to reduce sewer surcharges.

Disadvantages

- Soluble contaminants such as sugar are not usually removed by a DAF system, although they are occasionally trapped in the float along with other particles.
- DAF can impede settlement of heavy solids. Materials such as dough pieces, bits of fruit, nuts, etc., settle because they are heavier than water; a DAF system can negate the settling of these materials.
- Waste disposal is often required since DAF concentrates the pollutants; the float must then be disposed of properly.
- For smaller bakeries, DAF systems can be expensive to buy and operate, rarely costing less than surcharges. High chemical use can also increase operational costs.

Commercial Status

Currently, there is limited experience with using DAF systems in bakeries. However, many food processing plants, such as poultry and meat processors, use DAF systems as a method of pretreatment. The experience of these facilities may be useful for bakery managers considering methods of pretreatment.

Several bakeries are currently using DAF as a pretreatment system. These systems often have removal efficiencies similar to those noted under Advantages. These DAF efficiencies were obtained from multiproduct bakeries. Bread bakeries have substantially less biochemical oxygen demand and fats, oils, and grease content. Therefore, opportunities for DAF in bread plants are more limited.

Cost and Electrical Requirements

The installation cost of a DAF system varies greatly ($20,000–$6,000,000), depending on the nature and concentration of the wastewater and the flow rate. Most small bakeries would need a system able to handle near the low gal/min wastewater limit. These units cost approximately $20,000–$75,000 and have a power rating of 1–6 kW. In comparison, a large industrial-sized DAF system may cost $1–$6 million.

Dissolved Air Flotation System Characteristics

Capacity	15-60 gal/min
Approximate Size	Width: 2.5 ft Length: 4 ft^2 – 50 ft^2
Power Rating	1–6 kW
Energy Consumption	0.01 kWh/gal
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	Sludge that must be disposed of properly
Air Emissions	None
Water Effluent	Wastewater that may need secondary treatment
Cost	
Installed	$20,000–$75,000

Ultrafiltration

Basic Principle

Ultrafiltration is a membrane separation technique that uses permeable membranes to filter selected components from wastewater. Molecules are separated by the membrane on the basis of their shape or size. This process can be used to reduce the levels of dissolved solids and biological oxygen demand in bakery wastewater, allowing the bakery to reduce its surcharge payments.

Ultrafiltration falls between reverse osmosis and microfiltration, two other methods of membrane separation. It allows molecules between the size of 0.001 and 0.1 microns to pass through, and retains compounds with molecular weights higher than 500 microns.

System Description

In the system, wastewater is circulated under pressure, in contact with a polymeric film. Water and some dissolved matter pass through this membrane while other contaminants 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 20–100 pounds per square inch.

There are four basic configurations:

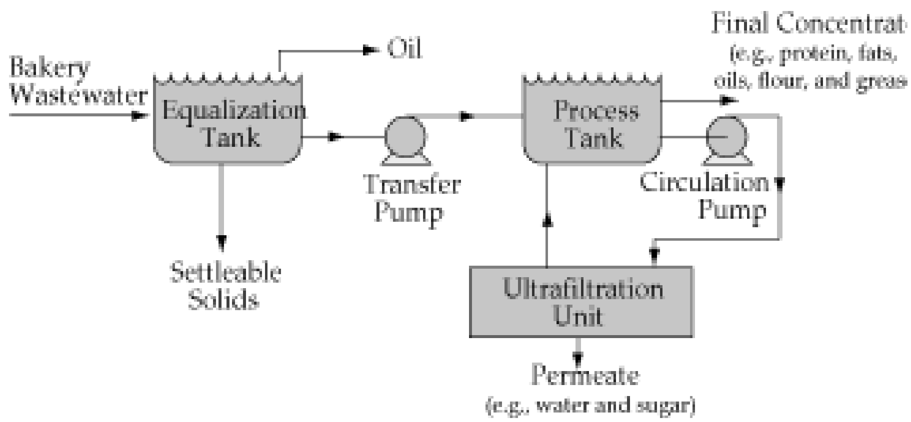
1. Tubular—the least susceptible to fouling, but the most expensive
2. Flat plate—compact and less costly, but poses maintenance problems
3. Spiral wound—compact, low capital cost per unit, but requires more prefiltration and makes leak detection difficult
4. Hollow fiber—relatively low capital cost, but requires prefiltration and faces operating pressure limitations

These systems use energy only to pump the wastewater through the system; they have no moving parts, no emissions, and operate near room temperature. This process is an energy-efficient alternative to evaporation and distillation.

Advantages

- There is no need for flocculents to assist in the breakup of emulsified oils since ultrafil-tration separates emulsified oils from water.
- With ultrafiltration, proteins, fats, and oils are recovered as by-products.
- The fats, oil, and grease content of the effluent is consistent and will not change with a change in wastewater composition.
- Membrane separation processes such as ultrafiltration require substantially less energy than conventional phase-change processes.
- Reliability is high. The ultrafiltration membrane modules have no moving parts or electrical pumps. Because the process operates at room temperature, corrosion is also minimized.

- By removing suspended solids, the ultrafiltration system allows for the recycling and reuse of the permeate.
- Ultrafiltration membrane systems require less space than evaporation or distillation processes. They can also be easily added to existing wastewater treatment processes.
- In general, cost is a fraction of in-phase-change technology.
- Savings in labor costs are possible due to reductions in material handling and process control requirements.



Utrafiltration Process

Disadvantages

- Ultrafiltration membranes can be damaged by organic and inorganic compounds.
- Fouling can occur when particles collect on the membrane surface for extended periods of time.

Commercial Status

The most common use of ultrafiltration is the treatment of industrial effluents to recover valuable materials and allow water recycling. Ultrafiltration is used commercially in food processing applications such as bakeries, as well as in industrial applications such as chemical processing, seawater desalination, and pulp and paper processing. The development of new ceramic, metallic, and synthetic polymer membranes is opening up a variety of new applications in wastewater treatment.

Cost and Electrical Requirements

For a large plant processing 5–10 million gallons of wastewater per year, a system would cost $150,000–$300,000. A small system generally costs less than $10,000. The electrical requirement for units processing 0.1–5 gal/min is between 4–10 kW. Electricity is required primarily for pumping the wastewater through the system.

Ultrafiltration System Characteristics

Capacity	0.1–5.0 gal/min
Approximate Size	Length: 30"–80" Width: 25"–40" Height: 55"–70"
Approximate Weight	125–450 lb
Power Rating	4–10 kW
Energy Consumption	1–6.0 kWh/100 gal of permeate
Key Inputs	
Power	Electricity
Other	Membrane replacement (once every 1–3 years)
Key Outputs	
Solid Waste	Oil, grease, solids
Air Emissions	None
Water Effluent	Treated water discharged to the POTW
Cost	
Purchase	$5,000–$40,000
Installed	10% of purchase cost
Other Supplies	$0.50–$3.00/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) bakery 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.

Outdoor Lighting

Equipment Suppliers

Bairno Corp.
2251 Lucien Way , No. 300, Maitland, FL 32751, (407) 875-2222

Bieber Lighting Corp.
970 W. Manchester Blvd., Inglewood, CA 90301 (213) 776-4744
fax: (213) 776-0235

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
(708) 956-8400

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.
4700 Crestview Court, Famington Hills, MI 48335
(800) 521-9330, (313) 477-2700, fax: (313) 477-0742

Fisher-Haynes Corp.
P.O. Box 100055, Atlanta, GA 30348
(404) 525-5501

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) 438-2527

Hapco Division of Kearney-National Inc.
P.O. Box 547, Abington, VA 24210
(703) 628-7171

ITT Outdoor Lighting
A Unit of the Lighting Fixture Division, Southaven, MS 38671
(601) 342-1545

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

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

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
(612) 485-2141, fax: (800) 328-3635

Sylvania Lighting Equipment
Lighting Special Production
465 Devon Park Dr., P.O. Box 500, Devon, PA 19333
(508) 678-3911

Unique Solution/ Manville
515 McKineley Ave., Newark, OH 43055
(614) 349-4194

Microwave Baking

Equipment Suppliers

Microdry, Inc.
7450 Highway 329, Crestwood, KY 40014
(502) 241-8933, fax: (502) 241-8648

Nemeth Engineering Associates, Inc.
5901 W. Highway 22, Crestwood, KY 40014
(502) 241-1502, fax: (502) 241-5907

PSC
21761 Tungsten Rd., Cleveland, OH 44117
(216) 531-3375, fax: (216) 531-6751

Radio Frequency Company, Inc.
P.O. Box 158, 152 Dover Rd., Millis, MA 02054
(617) 762-4900, fax: (617) 762-4952

Thermex Thermatron, Inc.
60 Spence St., Bay Shore, NY 11706
(516) 231-7800, fax: (516) 231-5399

Radio-Frequency Drying/Heating

Equipment Suppliers

Microdry, Inc.
7450 Highway 329, Crestwood, KY 40014
(502) 241-8933, fax: (502) 241-8648

Nemeth Engineering Associates, Inc.
5901 W. Highway 22, Crestwood, KY 40014
(502) 241-1502, fax: (502) 241-5907

PSC
21761 Tungsten Rd., Cleveland, OH 44117
(216) 531-3375, fax: (216) 531-6751

Proctor Strayfield
251 Gibraltar Rd., Horsham, PA 19044
(215) 443-5200, fax: (215) 443-0154

Radio Frequency Company, Inc.
P.O. Box 158, 150 Dover Rd., Millis, MA 02054
(617) 762-4900, fax: (617) 762-4952

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

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

Dissolved Air Flotation

Equipment Suppliers

Hi-Tech Inc.
P.O. Box 360597, Birmingham, AL 35236
(205) 987-8976, fax: (205) 987-8996

Memtek Corporation
28 Cook St., Billerica, MA 01821
(508) 667-2828, fax: (508) 667-1731

Mercer International, Inc.
P.O. Box 540 , Mendham, NJ 07945
(201) 543-9000, fax: (201) 543-4343

Pollution Control Engineering
6 Autry, #B, Irvine, CA 92718
(714) 830-8373, fax: (714) 830-3738

Precision Environmental Systems
3300 E. Pythian, P.O. Box 668, Springfield, MO 65801
(417) 865-2240, fax: (417) 865-0906

Smith and Loveless, Inc.
14040 W. Santa Fe Trail Dr., Lenexa, KS 66215
(913) 888-5201, fax: (913) 888-1017

WesTech
P.O. Box 65068, 3605 South West Temple, Salt Lake City, UT 84165
(801) 265-1000, fax: (801) 265-1080

Ultrafiltration/Membrane Systems

Equipment Suppliers

A/G Technology Corporation
101 Hampton Ave., Needham, MA 02194
(617) 449-5774, fax: (617) 449-5786

Applied Membranes, Inc.
110 Bosstick Blvd., San Marcos, CA 92069
(619) 727-3711, fax: (619) 727-4427

Dedert Corporation
20000 Governors Dr., Olympia Fields, IL 60461
(708) 747-7000, fax: (708) 755-8815

EI du Pont de Nemours & Co., Inc./Permasep Products
Glasgow Site, Wilmington, DE 19898
(302) 451-3207, fax: (302) 451-3700

Ellis Corporation
1400 W. Bryn Mawr, Itasca, IL 60143
(708) 250-9222, fax: (708) 250-9241

Infinitex
P.O. Box 383, Clarence, NY 14031
(716) 759-6983, fax: (716) 759-2050

Ionics, Inc.
65 Grove St., Watertown, MA 02172
(617) 926-2500, fax: (617) 926-4304

Koch Membrane Systems, Inc.
10 State Ave., Suite 205, St. Charles, IL 60174
(708) 513-0550, fax: (708) 513-0551

850 Main St., Wilmington, MA 01887
(617) 935-7840, fax: (617) 657-5208

Komline-Sanderson
12 Holland Ave., Petack, NJ 07977
(908) 234-1000, fax: (908) 234-9487

LCI Corporation
P.O. Box 16348, Charlotte, NC 28297
(704) 394-8341, fax: (704) 392-8507

Membrane Technology & Research, Inc.
1360 Willow Rd., Menlo Park, CA 94025
(415) 328-2228, fax: (415) 328-6580

Memtek Corporation
28 Cook St., Billerica, MA 01821
(508) 667-2828, fax: (508) 667-1731

Niro Hudson, Inc.
1600 O'Keefe Rd., Hudson, WI 54016
(715) 386-9371, fax: (715) 386-9376

Osmonics, Inc.
59951 Clearwater Dr., Minetonka, MN 55343
(612) 933-2277, fax: (612) 933-0141

Prosys Corporation
187 Billerica Rd., Chelmsford, MA 01824
(508) 250-4940, fax: (508) 250-4977

Sanborn
25 Commercial Dr., Wrentham, MA 02093
(508) 389-3181, fax: (508) 389-5376

Scienco/Fast
3240 N. Broadway, St. Louis, MO 63147
(314) 621-2536, fax: (314) 621-1952

Sepracor, Inc.
33 Lockes Dr., Marlboro, MA 01752
(508) 481-6700, fax: (508) 485-6045

U.S. Filter
181 Thorn Hill Rd., Warrendale, PA 15086
(412) 772-0044
fax: (412) 772-1360

4669 Shepard Trail, Rockford, IL 61105
(815) 877-3041, fax (815) 877-0946

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.

Adjustable Speed Drives

Environmental Benefits of Adjustable Speed Drive Applications, TR-100200, July 1992.

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

Adjustable Speed Drive Directory, Third Edition, CU-7544, December 1992.

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

Proceedings: Advanced Motors and Drives R&D Planning Forum, TR-191288, December 1992.

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

Energy-Efficient HVAC

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

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

Electric Chiller Handbook, TR-105951, February 1996.

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

Energy-Efficient Lighting

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

Lighting Fundamentals Handbook, TR-101710, March 1993.

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

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

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

Electronic Ballasts, BR-101886, May 1993.

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

Energy-Efficient Motors

Electric Motors, TR-100423, June 1992.

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

Heat Recovery

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

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

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

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

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

Thermal Energy Storage

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

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

Proceedings: Electric Thermal Storage/Thermal Energy Storage 1990, CU-7430, July 1991.

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

Trade Associations

American Bakers Association

1350 I Street, NW, Suite 1290, Washington, DC 20005
(202) 789-0300, fax: (202) 898-1164

American Society of Bakery Engineers

2 North Riverside Plaza , Suite 1733, Chicago, IL 60606-6560
(312) 332-2246, fax: (312) 332-6560

Independent Bakers Association

1223 Potomac Street, NW , Washington, DC 20007
(202) 333-8190, fax: (202) 337-3809