A small-business guide

Drycleaners and Launderers

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Wayne Krill manages the Electrotechnologies for Small Businesses project and directed development of this guide.

About This Guide

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

The *Drycleaners and Launderers* guide is intended to familiarize readers with the business of owning and/or operating a commercial fabric cleaning establishment by providing descriptions of basic processes and practices, and summaries of issues and challenges faced by members of the "fabricare" industry.

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

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

The commercial “fabricare” industry serves people in all walks of life, from professionals who need business suits drycleaned and pressed to equipment operators who need uniforms and shop towels washed and dried. Indeed, drycleaning shops handle largely professional apparel and fine household fabrics. Some commercial laundries supply clean linens for hospitals, hotels, restaurants, and other service-industry businesses; others supply clean uniforms and shop towels for manufacturing and the “dirtier” service industries such as gasoline stations. Commercial laundromats provide renters and others access to self-service washers and dryers.

While the day-to-day processes of drycleaners and laundries differ considerably, their economic drivers and the marketplace issues they confront are similar. Both are affected by changes in the American workplace and changes in American values. For example, the trend toward more casual attire in the workplace is dampening demand for drycleaning services—after a relatively recent boom when large numbers of women entered the professional ranks. At the same time, increasing public interest in health and environmental issues has prompted new regulations to control drycleaning emissions and reduce the volume of contaminated wastewater produced and discharged by laundries.

In this shifting marketplace, the primary concern of both drycleaners and launderers is competition. To maintain a clientele, a fabricare business must clean garments quickly and well—at a price acceptable to its target customers. Business operators therefore strive to strike a balance between customer-friendly service and the need to increase sales volume, boost productivity, and address environmental and health and safety issues. The accompanying table identifies specific electrotechnologies that can help drycleaners and/or launderers address these small-business concerns. These and other high-efficiency electric technologies are described in detail in the *Drycleaners and Launderers* guide (TR106676-V5), copies of which are available from the EPRI Distribution Center. To order this publication or other guides in this series, call the Center at (510) 934-4212.

Electrotechnologies for Drycleaners and Launderers

	Refrigerated Condenser	Wetcleaning	Ozonated Laundering	Microfiltration	Heat Pump Water Heater
Description	Reduces emissions of the cleaning solvent "perc" (a hazardous air pollutant) by condensing the solvent's vapors into liquid form for recovery and reuse.	An aqueous-based, nonchemical process that relies on the controlled application of heat, steam, and natural soaps to clean clothes that are normally drycleaned.	Ozonated water is used instead of fresh water in laundry wash and rinse cycles to quickly and effectively break down soils on fabrics with minimal or on use of detergents.	A membrane separation technique that circulates laundry waste-water under pressure in contract with a specially-constructed permeable membrane to filter out and reduce levels of oil, grease, heavy metals, and other suspended solids.	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.
Drycleaner/ Launderer Need	Addresses new federal regulations that require drycleaners to either eliminate perc, minimize its use, or control process emissions.	Addresses new federal regulations that require drycleaners to either eliminate the solvent perc, minimize its use, or control process emissions.	Laundries need options for reducing water use and reducing wastewater load while still cleaning clothing and other items effectively.	Water and wastewater treatment costs are an important component of operating costs; microfiltration enables laundries to treat and reuse water or simply pretreat water prior to disposal.	Technologies that decrease operating costs (for water heating and space cooling) help laundries maintain competitive prices.
Application	Refrigerated condensers are built into all new dry-to-dry machines (machines in which both cleaning and drying are performed) and can be retrofit to older dry-to-dry or transfer machines.	An alternative to drycleaning appropriate for almost any garment or fabric; however, the process operator must determine which among a variety of wetcleaning techniques is best for any given item	Apporiate for any commercial or industrial laundry.	Used primarily in industrial laundries that deal with "dirtier" wash items; microfiltration systems can be retrofit or built in to new facilities	Best suited to augment existing water heating and space cooling systems by serving a well-balanced water heating and space cooling load, vs. serving peak demand only.
Benefits	Requires little maintenance, has low operating costs, and minimizes wastewater generation (as compared to carbon adsorption).	Eliminates use of perc altogether, leaves less residual odor than perc-based drycleaning, minimizes shrinkage, and inhibits dry bleeding.	Laundries with ozone systems have faster wash and rinse cycles; use less water, less energy, and less or on detergents/ chemicals; generate less wastewater; and stress fabrics less.	Reduces water use through recycling and/or decreases the volume of wastewater leaving the facility; has low energy and maintenance requirements.	Provides efficient water heating and free space cooling and dehumidification for facilities that have hot water requirements and overheated work areas.
Cost	The cost to retrofit a dry-to-dry machine is roughly \$6000; the cost to purchase a dry-to-dry machine (35-lb capacity) with a built-in condenser is about \$50,000.	Wetcleaning machines capable of handling 50 to 100 pounds of clothing cost about \$10,000 to \$23,000.	System costs (ozone generator plus sidestream injector) range from \$6500 to \$143,000, depending on washer capacity (85 to 800 pounds).	Capital costs for crossflow and other types of microfiltration range from \$5000 to \$40,000 per unit; operating costs are \$0.5 to \$4.0 per thousand gallons of permeate.	Varies with the needs of the facility, ranging from \$125 per kBtu/h to \$210 per kBtu/h.

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INTRODUCTION TO DRYCLEANERS AND LAUNDERERS

The fabric cleaning industry is composed of two types of cleaning establishments: drycleaners and commercial and industrial launderers. While both provide what is known in the industry as “fabricare” services, they differ in the type of cleaning process used and their primary clientele. Drycleaners (SIC 7216) use solvents and clean garments for the general public. Commercial and industrial laundries use water and detergent and clean items for commercial and industrial service industries. Commercial laundries and linen suppliers (SICs 7211 and 7213) cater primarily to service-industry clientele such as restaurants, hotels, motels, and beauty parlors. Industrial laundries (SIC 7218) clean uniforms, mats, and shop towels for “dirtier” service and manufacturing customers such as gasoline stations, printers, and metal finishing shops. Commercial laundromats (SIC 7215) provide coin-operated self-service laundering to the public.

Drycleaning Business Statistics

Drycleaning establishments are primarily engaged in cleaning and pressing apparel and household fabrics (other than rugs). It is unclear exactly how many drycleaning establishments exist in the United States. According to the U.S. Department of Commerce (DOC), there were more than 22,500 drycleaning establishments (SIC 7216) in 1993 (see Table 1). The U.S. Environmental Protection Agency (EPA), in the process of developing drycleaning regulations, estimated a population of nearly 30,000 drycleaners in 1992.

Regardless of the actual number of establishments, DOC data indicate that most are small, single-owner facilities that employ five or six people and gross less than $200,000 per year.

The commercial garment cleaning industry developed in the United States in the mid-1880s as the population migrated to urban areas for work and people no longer had the time or space to wash and dry their clothing and other household linens. These early drycleaners used highly flammable solvents, such as gasoline, to remove stains, making drycleaning a dangerous business. In 1926, the first solvent specifically manufactured for drycleaning was introduced. A safer and effective cleaning solvent, perchloroethylene (perc), was first introduced in the late 1930s and is still used today by more than 90% of all drycleaners.

The drycleaning industry benefited immensely from the rise in the number of women entering the workplace as professionals in the 1960s and 1970s because their new roles generally necessitated dry-clean-only formal business attire. In addition, the Care Labeling Rule, instituted by the Federal Trade Commission in 1972, helped to increase the demand for drycleaning. This rule requires apparel manufacturers to specify at least one suitable method of fabric cleaning on a clothing label, making it easier for consumers, drycleaners, and launderers to determine how best to care for clothing. The method most commonly specified for adult career clothing is drycleaning.

Table 1
Distribution of Drycleaners by Size (1993)

Size	No. of Establishments	Percent of Total
Small (0-50 employees)	22,379	99.1
Medium (51-100 employees)	152	0.6
Large (100+employees)	41	0.2
TOTAL	**22,572**	**100.0**

Source: U.S. Department of Commerce, Bureau of the Census, *Country Business Patterns, 1993—United States,* CBP-93-1, 1996.

Today, drycleaning is considered a mature industry. According to DOC data, from 1987 to 1993 the number of drycleaning establishments in the United States increased just 6%. In the same period, the industry workforce grew just 2%, to reach a total of 167,346 in 1993. Annual receipts, on the other hand, increased by more than 30%, from $4.2 billion in 1987 to more than $5.5 billion in 1993. This growth in receipts is likely the result of higher prices for services, as opposed to higher demand. In general, demand for drycleaning services is declining due to a combination of factors, including a leveling off in the number of women entering the workforce and an increasing trend toward more casual work clothing.

In the late 1990s, all but the smallest drycleaners face a range of environmental challenges. The most pressing of these are regulations on the use of perc, the most popular drycleaning solvent. The regulations were developed by the EPA in response to the Clean Air Act Amendments of 1990 (CAAA) and were finalized in 1993. The regulations require many perc-using drycleaners to retrofit their machines with emissions control equipment and to adopt additional monitoring, record keeping, and other pollution prevention measures. The costs associated with meeting these regulations may be difficult for some small drycleaners to absorb, although the EPA estimates that less than 1% of U.S. drycleaners will go out of business as a result of the regulations.

California has the most drycleaning establishments (more than 2500), while New York and Texas follow closely with 1900 and 1700 establishments, respectively (see Figure 1). Other states with a significant number of drycleaning establishments include Florida, Illinois, New Jersey, Ohio, Pennsylvania, Georgia, and Michigan.

State	Drycleaners
CA	2577
NY	1991
TX	1776
FL	1388
IL	1014
NJ	936
OH	873
PA	864
GA	851
MI	700

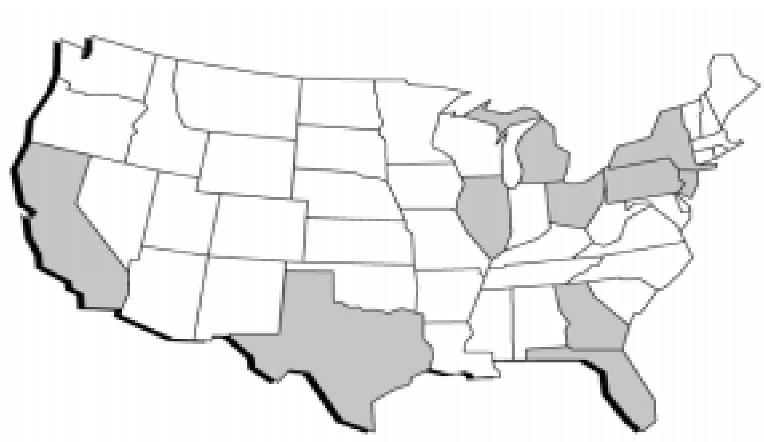


Figure 1
Top 10 States for Drycleaners

The Drycleaning Process

The goal of drycleaning is to remove dirt, grease, and other soils safely from fabric without damaging the fabric or garment. This goal is accomplished through the use of detergent and an organic solvent, perc. While perc is used in a variety of other commercial and industrial applications, including degreasing operations in manufacturing and the production of paints and adhesives, its principal use is in the drycleaning industry.

Perc is the most popular solvent for several reasons: it is nonflammable and relatively inexpensive, and it has a high vapor density and favorable cleaning properties. Although classified by the EPA as a possible carcinogen, perc is used by nearly 90% of all drycleaning facilities. Because of concerns about the flammability of other petroleum-based solvents, only 7% of drycleaners use them. The remaining 3% use CFC-113 or 1,1,1-trichloroethane (methyl chloroform). However, production of these two compounds is being phased out due to the contribution of their volatile organic by-products to the destruction of the stratospheric ozone layer; thus, more drycleaners are likely to switch to perc.

In drycleaning, insoluble soils are removed by mechanical action and then suspended in the solvent by a detergent. Solvent-soluble soils such as oils and fats dissolve in the solvent. During the washing cycle, the solvent is extracted from the drum and sent to filtration and distillation units that remove impurities in the solvent so it can be reused. Similarly, solvent vapors are reclaimed in the drying and aeration portion of the cycle.

The drycleaning process has four main steps.

Cleaning. In the cleaning cycle, clothes are deposited into a washer and solvent and detergent are introduced into the drum with the clothes and tumbled. Moisture (water) in the detergent removes the water-soluble soils such as salt and sugars; solvent removes the solvent-soluble soils such as oils and grease; and the detergent, in combination with the mechanical action of tumbling, removes the insoluble soils such as lint and dust. The soils, which are suspended by the solvent and detergent, are then flushed to the filter. Continuous filtration removes contaminants from the solvent during the cleaning cycle.

Extracting. In this step, the drum is spun at high speeds to extract additional solvent from the wet garments. When this cycle is completed, a filtration or distillation system removes nonvolatile residues or impurities from the solvent so it can be reused. The solids (residues known as "muck") filtered or distilled out of the solvent are collected. Because this muck may contain as much as 50% solvent, it is reduced in quantity in a muck cooker and disposed of as a solid waste. Most drycleaners use a subsequent distillation step to remove dissolved oils and fats from the solvent.

The Difference Between Drycleaning and Laundering

The primary difference between drycleaners and launderers is the solvents they use to clean fabric. Drycleaners use petroleum-based (organic) solvents and detergents, while launderers use water and detergents. Drycleaning is the cleaning method of choice for more sensitive fabrics, such as silk and wool. These fabrics would likely shrink or be otherwise damaged in the conventional laundering process.

Drying. After solvent extraction, the clothes are moved to a dryer and tumbled dry in a warm airstream to remove any remaining solvents. The normal drying time is 18 to 20 minutes. Fresh air is drawn in from outside the machine, circulated through the tumbling garments, and then passed out of the machine. Since the hot air leaving the dryer contains significant amounts of solvent vapors, it is typically routed through a lint trap and a solvent recovery system such as a carbon adsorber or a refrigerated condenser. The clean airstream is then routed back to the dryer, reheated, and reused. The recovered solvent is sent to a solvent storage tank for later reuse in the cleaning process.

Aeration. Following the drying cycle, the dryer and clothes are aerated. In this step, fresh air is circulated through the dryer for about 5 minutes to cool the clothes and remove any residual solvent. These solvent vapors are also passed through a carbon adsorber or a refrigerated condenser. Solvent recovered at this stage is also reused in the cleaning process.

Drycleaning machines are available in capacities suited to handle loads ranging from 18 to 70 pounds. A small local drycleaner typically has one 25- to 35-pound unit. A large contract cleaner is more likely to have several large-capacity machines. There are also two types of drycleaning machines: transfer machines and dry-to-dry machines. In the older, less sophisticated transfer machines, cleaning/extraction and drying/aeration are done in separate units, requiring manual transfer of the clothes from one machine to the other (see Figure 2). This transfer step increases both perc emissions to the atmosphere and worker exposure to perc. Transfer machines currently account for slightly more than 30% of all commercial perc drycleaning machines.

In the newer, more sophisticated dry-to-dry machines, all four steps are conducted in the same machine. Compared to transfer machines, these combination units greatly reduce the emissions that occur in the process of drycleaning (process emissions). Two types of dry-to-dry machines have been developed: vented and no-vent. Vented machines release residual solvent vapors to the atmosphere or to a vapor recovery unit during the aeration step. This vapor stream, however, can contain a significant amount of solvent, possibly increasing process emissions to the atmosphere and the potential for worker exposure to dangerous levels of perc. No-vent machines are closed systems that do not include the aeration step and contain built-in emissions control equipment. These units increase solvent mileage by recovering perc and reducing the level of process emissions vented to the air outside the facility.

In addition to process emissions, both dry-to-dry and transfer machines allow fugitive emissions of solvent. Fugitive emissions include evaporation of solvents as a result of equipment leaks, solvent transfer, and handling and disposal of spent filters and distillation wastes.

The exhaust gas from the washing and drying processes is routed to a vapor recovery unit, which can employ a carbon adsorber or refrigerated condenser. The solvent recovery process results in the generation of “contact water,” wastewater with small quantities of solvent. This contact or separator water is sent to a hazardous waste company for proper disposal. Machines with refrigerated condensers produce much less solvent-contaminated wastewater than machines with carbon adsorbers (about 50 gallons per year compared to 500–700 gallons per year, respectively).

Older transfer machines may have been purchased without a solvent recovery system; these units are referred to as “uncontrolled” machines. The majority of machines in place today are controlled: they were either purchased with carbon adsorbers or refrigerated condensers, or one of these control devices was retrofitted later. The machines sold today are all dry-to-dry with refrigerated condensers. Refrigerated condensers are also sold separately for retrofitting older machines.

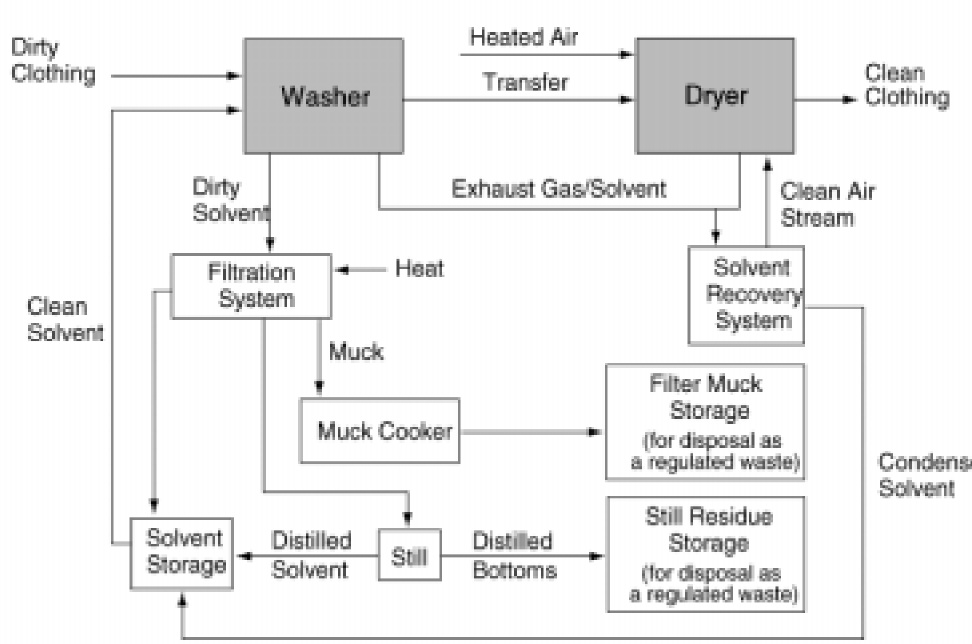


Figure 2
The Drycleaning Process, Transfer Method

Laundry Business Statistics

According to the DOC, there were approximately 17,400 establishments engaged in laundering services in 1993, employing nearly 200,000 people and generating annual receipts of more than $10 billion (see Table 2). There are four types of laundering establishments, each with different functions and clientele:

- Commercial Laundries (SIC 7211). These establishments, also called "power laundries," clean clothing and other fabric items for the general public.

- Linen Supply (SIC 7213). These establishments launder items such as uniforms, gowns, table and bed linens, and towels for commercial establishments such as hospitals, beauty salons, and restaurants.

- Coin-Operated Laundries (SIC 7215). Coin-operated laundries are self-service laundromats, also known as "coin-ops." This industry subsegment is primarily composed of individual owner/operators; a small percentage are operated by chains. They are unique in that they have no inventory or receivables and few employees.

- Industrial Laundries (SIC 7218). These establishments supply laundered or dry-cleaned industrial work uniforms, shop mats and rugs, dust control items, wiping towels, and other items to industrial and commercial customers such as manufacturers, food processors, printers, gasoline stations, and auto body shops.

As indicated in Table 3, 94% of all laundries have fewer than 50 employees and only 2% employ more than 100 people.

In the early 1900s, commercial launderers picked up, processed, and delivered laundry to millions of households and businesses. With the advent of home-sized washer and dryer appliances in the early 1950s, wash-and-wear fabrics in the 1960s, and the installation of in-house laundries in many hotels, motels, and institutions, the demand for commercial laundry services leveled off.

Table 2
Profile of the Laundry Industry (1993)

Type of Laundry	No. of Establishments	No. of Employees	Annual Receipts ($ million)
Commercial Laundries (SIC 7211)	1,788	29,609	896
Linen Supply (SIC 7213)	1,313	52,360	2,614
Coin-Operated Laundries (SIC 7215)	12,873	47,640	2,886
Industrial Laundries (SIC 7218)	1,401	67,772	3,763
TOTAL	**17,375**	**197,331**	**10,159**

Source: U.S. Department of Commerce, Bureau of the Census, Annual Survey of Service Industry, 1993; and County Business Patterns, 1993—United States, CBP-93-1, 1996

Table 3
Distribution of Laundry Establishments by Size (1993)

Subsegment	Laundries by Number of Employees						
	Small (0-49)		Medium (50-99)		Large (100+)		
	No.	% of Total	No.	% of Total	No.	% of Total	Total
Commercial Laundries (SIC 7211)	1,674	94	74	4	40	2	1,788
Linen Supply (SIC 7213)	944	72	213	16	156	12	1,313
Coin-Operated Laundries (SIC 7215)	12,841	> 99	23	< 1	9	< 1	12,873
Industrial Laundries (SIC 7218)	911	65	308	22	182	13	1,401
TOTAL	**16,370**	**94**	**618**	**4**	**387**	**2**	**17,375**

Souce: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns, 1993—United States*, CB-93-1, 1996.

Today the industry is growing once again, due in part to the recession of the early 1990s, which decreased home ownership and, therefore, the viability of home laundering. (The rental market is currently the fastest growing segment of the real estate market.) In addition, many hotels, correctional facilities, and other institutions have closed their in-house laundries in an effort to cut costs. Both of these trends have increased demand for the services of commercial and coin-operated laundries.

New York, California, and Texas are the states with the most laundry establishments (1800, 1700, and 1200, respectively; see Figure 3). Other states with significant numbers of laundry establishments include Florida, Illinois, Ohio, Michigan, New Jersey, Pennsylvania, and North Carolina.

State	Laundries
NY	1792
CA	1728
TX	1265
FL	1093
IL	910
OH	700
MI	656
NJ	644
PA	543
NC	508

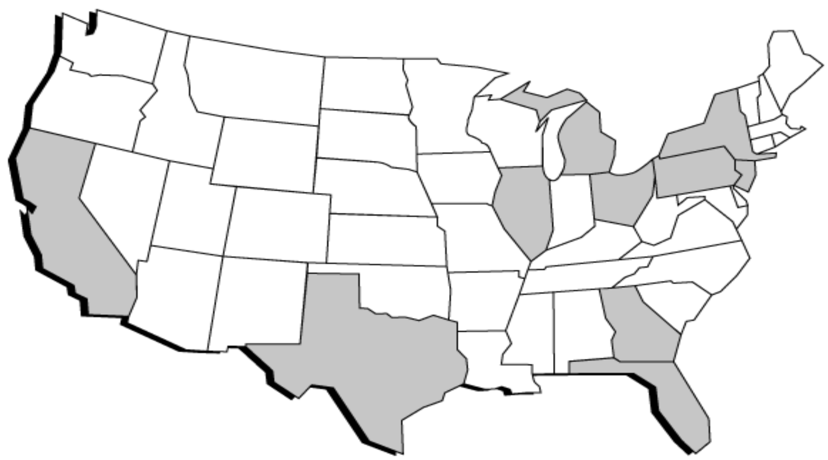


Figure 3
Top 10 States for Laundries

The Laundering Process

Commercial and industrial laundering are similar multistep processes that involve sorting, prewashing, washing, rinsing, drying, pressing, and redistributing clothing and linens. In a typical industrial laundry, 200–700 pounds of laundry are loaded into a double-cylinder washing machine—similar in construction to a residential washing machine—that performs the prewash, wash, and rinse cycles. Conventional washers typically use 4 to 6 gallons of water per pound of laundry, while water-efficient washers may use less than 2 gallons per pound. A perforated inner cylinder spins to agitate the garments, helping to free dirt from the fabric. The perforations allow water, detergents, and other cleaning agents into the cylinder at the beginning of the wash cycle and soil-containing water out at the end. Laundry chemicals can be either manually or automatically fed to the machines during the wash and rinse cycles. Detergents remove dirt and other organics from fabric by lowering the surface tension, which facilitates “wetting” of the fabric. Alkalis are then added, which allow the detergents to react with the organics more effectively.

In most laundries, clothing is manually transferred to dryers, which are usually gas- or steam-heated. For every pound of wet clothing that goes into a dryer, about 0.4 pounds of water must be removed. Most laundries today use conventional tumble dryers to vaporize the water; the entering air temperature in these dryers is about 350°F. Wet clothes are placed inside the heated dryer drum and tumbled in arcs. The high temperature of the air in the dryer transfers heat to the fabric, evaporating the water in the clothing.

Tunnel washers are also used by some laundries. As the name implies, these washers are tunnel-shaped and are composed of several dedicated segments that perform the washing, rinsing, and drying functions. Washing is accomplished through the action of chemicals, rather than the action of agitation. These tunnel washers are extremely water-efficient compared to conventional washers, using as little as 1 gallon of water per pound of laundry.

Energy Use

The average electric intensity for all drycleaners and laundries was 6.3 kWh per square foot in 1991 (see Table 4). This intensity is generally less than that of other commercial establishments. On a regional level, the electric intensity, on average, is much higher in the West. High real estate costs in the West lead to smaller-than-average drycleaning and laundry facilities in terms of total floor space.

Drycleaners and laundries typically operate six days per week, one to one-and-a-half shifts per day. According to the Department of Energy (DOE), drycleaners and laundries consumed approximately 3.3 trillion Btu of energy in 1992. Natural gas and electricity are the two primary energy sources for cleaners, accounting for 46% and 44% of the total, respectively. Although these amounts are almost equal, electricity represents over 73% of the total energy cost. Fuel oil and district heating make up the remaining 10%.

As illustrated in Figure 4, the majority of electricity in the cleaning industry (55%) is for process uses and miscellaneous plug loads, such as sewing machines and portable fans. Lighting, another major end use, accounts for 31% of total electricity use. The remaining electricity use (14%) is for heating, ventilation, and air conditioning (HVAC).

Table 4
Electricity Consumption in the Fabricare Industry in 1991

Census Region and Division[1]	Total Electricity Consumption (thousand kWh)	Total Floor Space (thousand sq ft)	Total Electric Intensity (kWh/sq ft)
Northeast	**41,564**	**13,340**	**3.1**
New England	7,298	1,838	4.0
Middle Atlantic	34,266	11,502	3.0
Midwest	**269,130**	**43,797**	**6.1**
East North Central	205,559	31,567	6.5
West North Central	63,571	12,230	5.2
South	**141,988**	**19,337**	**7.3**
South Atlantic	56,956	5,822	9.8
East South Central	34,596	6,919	5.0
West South Central	50,437	6,596	7.6
West	**54,600**	**4,594**	**11.9**
Mountain	4,284	546	7.8
Pacific[2]	50,316	4,048	12.4
TOTAL	**507,283**	**81,068**	**6.3**

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

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

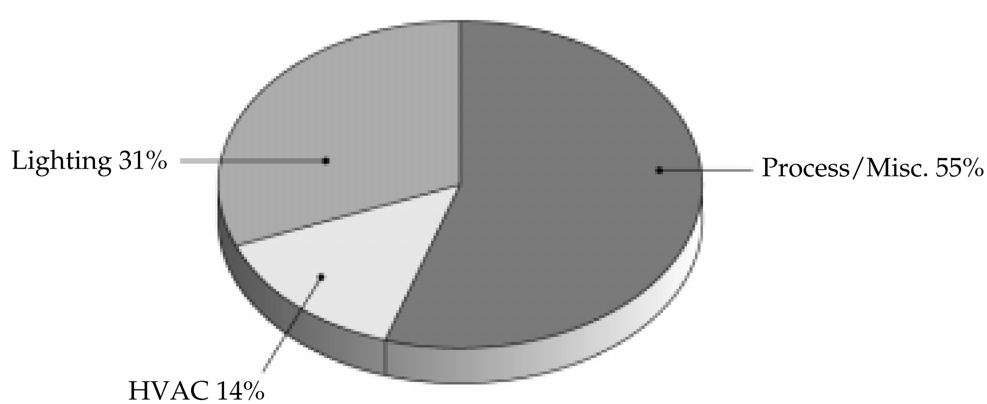


Figure 4
Typical Electricity Use in Drycleaning and Laundry Establishments

2

BUSINESS CHALLENGES AND NEEDS

Although their operations differ significantly, drycleaners and launderers have similar business interests and needs. Both strive to increase sales volume and improve productivity while reducing operating expenses, and both must address environmental, health, and safety issues.

Competition

The primary concern of a drycleaner or launderer is competition. To compete effectively in the marketplace, a fabricare business must clean garments quickly and well, keep operating costs low, and attract new customers. Energy costs themselves consume only 4–5% of total industry revenue. As a result, business owners are usually interested in energy-related improvements only if they also enhance productivity or product quality, or help the facility reduce operating expenses. Achieving compliance with environmental, health, and safety regulations is also an important business issue, which—if not addressed—can result in large fines and even jail time for the business owner.

In a competitive marketplace, a drycleaner or launderer can be successful only if he or she can provide a high-quality service quickly and at an acceptable price. By increasing productivity and reducing operating costs, a fabricare operator can potentially retain current customers and attract new ones.

Need

Increase Productivity/Reduce Operating Costs

Increasing productivity and reducing operating costs are common goals of all manufacturing and service-industry businesses, often going hand in hand. An increase in productivity typically reduces operating hours and/or labor costs, both of which are important components of total operating cost.

Drycleaners

Aside from federal and state environmental regulations (discussed later in this section), economic incentives have persuaded many drycleaners to voluntarily install emissions control devices and/or to switch to more efficient process technologies such as the dry-to-dry machine. The solvent perc is a significant factor in a drycleaner's total operating costs. By upgrading from a transfer machine to a dry-to-dry machine, a drycleaner can reduce the amount of perc needed to clean a load or, in the vernacular, can "increase solvent mileage." Perc use can also be reduced by adding a refrigerated condenser for emissions control. A new dry-to-dry machine with a refrigerated condenser can also reduce operating costs by reducing the cost of maintenance.

Technology Solutions

Drycleaners can reduce perc consumption and therefore operating costs by employing a dry-to-dry machine outfitted with a refrigerated condenser. Ultrasonic cleaning and microwave drying, emerging electrotechnologies, may be available in the future to clean and dry clothing in a fast, energy-efficient manner. Drycleaners could also potentially reduce their energy bill by installing energy-efficient indoor lighting and air-to-air heat recovery.

See pages 3-4, 3-6, 3-8, 3-12, 3-13

Commercial and Industrial Launderers

Automation of the laundry process has altered the way clothing is laundered, dried, and finished by increasing the speed, efficiency, and productivity of laundry operations. This automation reduces labor requirements by decreasing the number of tasks performed manually. By linking washers, dryers, and finishing machines with automated laundry handling equipment, a launderer can eliminate much or all of the manual handling of loads between laundry phases. Automation also improves employee health and safety by reducing or eliminating heavy lifting and dermatological conditions associated with direct contact with detergents and other chemicals. In addition, laundries are beginning to use computers to ease the task of load tracking. Industry experts say that by adding automation and computer tracking, a laundry facility with a process workforce of 100 people operating two shifts per day could cut back to 70 people operating one shift. As this example suggests, at this time, this type of productivity improvement is most likely to be implemented by the larger laundries.

Water, energy, and other utility costs can make up a substantial portion of total operating costs for a commercial or industrial laundry. Twenty years ago, electricity, gas, oil, and water were quite inexpensive. Today, water and energy costs vary dramatically across the country and have been rising rapidly in many areas. At today's rates, these costs can have a significant impact on the profitability of a laundry. One way to reduce both water and energy use is by purchasing water- and energy-efficient equipment when designing or retrofitting a laundry.

Water costs are incurred three ways: purchase cost, heating cost, and disposal cost. A water-efficient washer uses 1.2 to 2 gallons of water per pound of laundry, while conventional machines use up to 4 gallons per pound. If the washing unit is water-efficient, a laundry can decrease the amount of water purchased, the amount of water heated, and the amount of water needing disposal. (The latter can be the most significant, as sewer costs in some areas of the country have risen to eight times the cost of water purchase.)

Laundries can also save energy by making procedural changes. The key elements in the washing equation are time, temperature, chemicals, water, and mechanical action. Detergent/chemical formulas are available that work well in lower temperatures; by reducing wash temperatures as little as 5°F, a laundry can save approximately 2% of its total fuel costs. In addition, scheduling so that loads are full and equipment works continuously, rather than leaving downtime between loads, can help save energy. In facility locations where electric demand charges are levied during utility peak-load hours, laundry managers should also consider the advantages of night production, as well as heat recovery systems. Heat recovery and heat pump systems effectively recover waste heat from the air and water, thereby reducing the amount of energy required to preheat water for washing and air for drying.

Technology Solutions

Ozonated laundering, microfiltration of laundry wastewater, heat recovery water heaters, heat pump water heaters, and air-to-air heat recovery can help commercial laundries reduce operating costs by reducing detergent use, water use, and/or energy use to heat wash water. Energy-efficient lighting can also reduce energy consumption. Finally, two emerging electrotechnologies—ultrasonic cleaning and microwave drying—can be used to speed washing and drying times.

See pages 3-6, 3-8, 3-9, 3-10, 3-11, 3-13

Coin-Operated Laundries

In coin-operated laundromats, water and energy costs are determined by the efficiency of the equipment—toploaders, frontloaders, dryers, overhead lighting fixtures, and water heaters—and the cost of sewer services. The average utility cost for a laundromat was 18.1% of annual gross operating costs in 1982. By 1993, the figure had risen to 25%. As water and energy costs continue to increase, with little room for laundromats to increase prices, the only alternative is to reduce expenses.

Technology Solutions

Frontloading or horizontal-axis washers are designed to save electricity, water, and chemicals. The utility savings can often pay for a good portion of the new equipment; annual water, energy, and disposal savings on the order of $50–$120 per machine are possible. Since the cost of a machine ranges from $175–$250, payback could be achieved in 1.5–5.0 years, depending on actual savings and the machine purchased. By increasing efficiency and getting clothing cleaner, the washers can reduce operating costs and increase customer satisfaction, making the laundromat less vulnerable to competition. Laundromats can also reduce their energy consumption for lighting by installing energy-efficient lamps. Microwave dryers, an emerging electrotechnology, may also be available in the future to speed the drying process.

See pages 3-8, 3-10, 3-11

Need

Increase Sales

The business performance of a drycleaning or laundry facility depends on a variety of factors, including location, demographics, services offered, design and condition of the facility, equipment selection, prices, hours of operation, and competition. To attract new customers or increase sales volume from existing customers, drycleaners and laundries must be aware of all these factors.

In general, most customers want convenient drop off/pick up services (good hours, location, parking, easy access to the shop from the parking area); quick turnaround, high-quality cleaning; and a friendly, knowledgeable staff. Although the majority of customers want low prices, industry experience shows that some are willing to pay extra for an environmentally conscious facility. In coin-operated laundromats, customers spend considerable amounts of time in the facility and are attracted to those with a comfortable atmosphere.

Over the longer term, the demand for commercial and industrial laundry services may increase as more institutions, such as hospitals, elect to close their in-house laundries in an effort to cut costs. Drycleaners, on the other hand, may face continued declining demand due to the leveling off of the number of women entering the workforce and the trend toward more casual dress at the office.

Technology Solutions

Drycleaners and launderers can take advantage of the trend toward casual clothes and consumers' increasing awareness of environmental issues by employing wetcleaning, a nonchemical process, as an alternative to drycleaning clothing with perc. Ultrasonic cleaning, an emerging electrotechnology, may also offer businesses an energy-efficient, perc-free method of cleaning clothes—both fine fabrics that are traditionally drycleaned and common items, such as socks and towels, that are traditionally washed at home.

See page 3-6

Environmental, Health, and Safety Regulations

The need to comply with environmental and worker safety regulations is just as important as the need to increase sales and productivity and reduce operating costs. Failure to comply with regulations can result in stiff fines or even jail time for a business owner. This section presents the regulations that apply to drycleaners and commercial and industrial laundries. Coin-operated laundromats are not subject to any environmental regulations.

The majority of environmental, health, and safety problems in the drycleaning industry relate to the use of organic solvents in the drycleaning process. These solvents are hazardous and can result in air emissions that endanger workers and the public and contaminate wastewater and solid wastes. If not disposed of properly, solvents can also contaminate groundwater. The cost of meeting new and existing regulations for solvent emissions and wastes can be high and is expected to put a small number of drycleaners out of business.

Of most immediate concern among environmental issues for laundries are water use and wastewater treatment and disposal. Water and sewer charges are rising in many parts of the country, and savings on these costs add directly to a laundry's bottom line. In addition, federal EPA regulations on industrial laundry wastewater are under development.

Need

Control Perc Emissions in Drycleaning

Title III of the 1990 CAAA substantially expanded the regulation of air toxics by adding 181 hazardous air pollutants (HAPs), including perc and 1,1,1-trichloroethane to the original list of 8 regulated by the Clean Air Act of 1970. The CAAA requires the EPA to issue National Emission Standards for Hazardous Air Pollutants for all 189 HAP source categories. The CAAA divides HAP emission sources into two categories: major sources and area sources. Major sources are those that have the potential to emit 10 tons or more per year of a single HAP. The law requires these sources to control their emissions to the level of the Maximum Achievable Control Technology (MACT). Area sources are defined as all other sources of a HAP not already defined as a major source. These sources are required to control their emissions to a less stringent control level of a Generally Available Control Technology (GACT).

Perc emission standards were proposed by the EPA in December 1991 and promulgated in their final form in September 1993. The annual perc consumption of a drycleaning facility determines its EPA-designated source category. There are three source categories: small-area source, large-area source, and major source. Table 5 relates perc consumption to source category. Based on formal and informal surveys of drycleaners conducted by state environmental protection agencies it appears that the majority of drycleaners are large-area sources. This distinction determines the type of process vent and fugitive emissions control requirements a drycleaner must meet.

In general, the regulations call for most drycleaners who use perc to install a solvent recovery technology—specifically, a refrigerated condenser—by September 1996. Although the regulations do not require the phaseout of old transfer machines, they do prohibit the installation of new transfer machines.

The specific control technology requirements depend on the source or category (annual perc consumption) of the facility, the type of drycleaning machine used, and whether the facility is a new or existing facility. The smallest drycleaners, those with annual receipts of less than $75,000, are exempt from the perc emission control requirements. An existing shop that falls into the large-area source category, however, is required to add refrigerated condensers (considered GACT) to its machines if they are uncontrolled. If the machines already have carbon adsorbers installed, however, replacement is not required. The EPA reasoned that the additional cost of purchasing a refrigerated condenser to replace an adsorber would not be worthwhile, considering the relatively small difference in solvent recovery effectiveness. Existing small-area sources are exempt from these process vent control requirements. New small- and large-area sources, however, must purchase dry-to-dry machines that incorporate refrigerated condensers. New major sources are subject to the strictest regulations: they can install only dry-to-dry machines with both refrigerated condensers and small carbon adsorbers.

Regardless of size, all drycleaners are required to adopt fugitive emissions control measures designed to prevent leaks from emissions control devices, pumps, and filters. Drycleaners must also maintain a program of weekly leak detection and repair, as well as a monitoring and record-keeping program.

Perc is toxic to the liver, kidneys, and central nervous system, and may be a human carcinogen. As a result, drycleaners are also subject to Occupational Safety and Health Act (OSHA) regulations on worker exposure to hazardous air contaminants in the work place. OSHA prescribes a permissible exposure level (PEL)—a time-weighted average (TWA) that allows higher periods of exposure during an 8-hour day, provided there is a sufficient period of low exposure so that the 8-hour TWA does not exceed the PEL of

100 ppm. The most common type of worker exposure is the inhalation of solvent vapors.

The OSHA regulations were updated in January 1989, dramatically affecting drycleaners using perc. The PEL was lowered to 25 ppm at that time, but was later changed back to the 100 ppm level following an unfavorable court decision. Despite this action, the International Fabricare Institute—the primary drycleaning industry association—has recommended that, if possible, drycleaners attempt to achieve the 25 ppm level.

Technology Solutions

According to federal drycleaning regulations, the use of a refrigerated condenser is required for certain drycleaners. This technology not only controls perc emissions by preventing their release to the atmosphere but allows the perc to be recycled and reused, resulting in significant chemical savings for the drycleaner. Photocatalytic oxidation, an emerging electrotechnology, may eventually allow the treatment of perc-contaminated water and wastewater and even perc-laden air. In addition, wetcleaning and, in the near future, ultrasonic cleaning, offer drycleaners perc-free alternative cleaning methods.

See pages 3-5, 3-6

The Trend Toward Casual Dress

According to a 1996 survey by Levi Strauss and The Society for Human Resource Management, more than 90% of companies have some form of casual dress code for office workers (the survey sample was weighted to bring it into alignment with Dun & Bradstreet industrial profiles). One-third of the roughly 500 companies surveyed allow casual dress every day. While traditional business wear typically requires drycleaning, most casual clothing can be washed at home. As casual office dress becomes the norm rather than the exception, drycleaners may face a decreased demand for their services. This reduced demand may force some drycleaners to adopt wetcleaning or conventional laundering in an effort to retain customers who now have the option of home laundering.

Table 5
Perc Consumption Source Categories

Type of Machine(s) Used	Small Area Source*	Large Area Source*	Major Source*
Only Dry-to-Dry	< 140 gal/yr	140-2100 gal/yr	>2100 gal/yr
Only Transfer	<200 gal/yr	200-1800 gal/yr	>1800 gal/yr
Both	<140 gal/yr	140-1800 gal/yr	>1800 gal/yr

*Based on gallons of perc consumed at a facility during the last 12-month period.

Need

Pretreat Laundry Wastewater

The regulations affecting commercial and industrial laundries are primarily those of the Clean Water Act (CWA). Laundries generate a significant volume of wastewater that is contaminated with a variety of chemicals. Powder and liquid chemicals—alkaline detergents, bacteriostats, chlorine bleach, sour (phosphoric acid), and fabric softener—are used in both the wash and rinse cycles. In addition, the soils on the laundry articles themselves often contaminate the water with oil and grease; hydrocarbons; toxic heavy metals such as zinc, chromium, copper, nickel, cadmium, and lead; various organic chemicals; and suspended solids. The contaminants found in the wastewater depend in large part on the type of customers a laundry services. For example, a laundry that services automotive maintenance facilities typically has a high concentration of petroleum-based solvents in its wastewater. All of these contaminants contribute to creating a laundry wastewater with high biochemical oxygen demand, a factor subject to regulation.

Although not currently regulated by federal standards, the EPA is planning to issue a draft of proposed standards for laundries by December 1996. Once public comments have been reviewed, a final effluent standard will be issued in 1998. The new effluent guideline will focus on the regulation of heavy soils and other pollutants that may be harmful to the environment. Linen supply companies (SIC 7213) and industrial laundries (SIC 7218) will be most affected by the standard. Although the standard will not specify the use of a particular technology, it will establish "reasonable performance standards" that must be met by all regulated facilities.

New standards for sewage sludge disposal, finalized in 1994, may also affect industrial laundries that discharge wastewater with a high level of heavy metals. These standards established restrictions for publicly operated treatment works (POTWs) on the level of heavy metals in their sewage sludge. Sludge with high levels of metals may not be disposed of through low-cost means such as land application, but instead may require disposal in a licensed hazardous waste landfill, a more expensive alternative. As a result, POTWs may be forced to limit the discharge of heavy metal-bearing wastewater to their facility. For example, a POTW having trouble meeting the sludge regulations may ultimately require industrial laundries that discharge to it to pretreat their wastewater prior to disposal. The impact of the CWA on laundries, then, is as yet unknown.

Technology Solutions

Microfiltration offers laundries a method for treating wastewater; ozonated laundering eliminates the need for wastewater treatment altogether.

See pages 3-9, 3-10

Need

Reduce Laundry Water Use

In addition to the costs associated with wastewater disposal, many commercial and industrial laundries are concerned with the increasing cost of water itself. The cost of water to an industrial laundry has two main components: the availability of water and the amount of treatment it requires. In arid areas such as the Southwest, water is more expensive because it must be imported or simply because supply is low. In addition, as water treatment facilities face the challenge of complying with strict environmental regulations of their own, their compliance costs and requirements are generally passed on to their customers.

Technology Solutions

Microfiltration and ozonated laundering allow commercial and industrial laundries to recycle and/or reuse wash water. In addition, by using less water overall, horizontal-axis washers offer coin-operated laundromats an opportunity to reduce water use while getting clothes cleaner than possible with traditional top-loading washers.

See pages 3-9, 3-10

3

TECHNOLOGY SOLUTIONS

This section describes each of the technology solutions identified in the previous sections. Each technology is summarized, linked by end-use application to a business need, and categorized as an “electrotechnology” or “efficiency technology.” Electrotechnologies are selected new or alternative electric equipment. In many dry cleaning and/or laundry applications, the electrotechnologies can increase productivity, improve product quality, or control pollution, and may couple increased energy costs with an overall decrease in operating costs. Efficiency technologies offer opportunities to decrease energy use, but have little or no direct impact on operations.

Also discussed are “emerging electrotechnologies,” electrotechnologies that are not currently in use in the industry but have the potential to meet business needs in the future. Each electrotechnology is more completely described in Section 4, Electrotechnology Profiles. Vendors of these electrotechnologies, sources of information on efficiency technologies, and trade associations are listed in Section 5, Resources.

In this section, technologies are grouped and discussed by end use, beginning with “Process and Miscellaneous Equipment,” the end use that represents the greatest percentage of total fabricare industry electricity use. Table 6 summarizes the technology solutions.

Table 6
Technology Solutions to Fabricare Industry Needs

			Business Needs		
End Use	**Solution Type**	**Technology Type**	**Increase Productivity/ Reduce Costs**	**Increase Sales**	**Reduce Emissions & Water Use/ Pretreat Wastewater**
Process/Misc. Drycleaning	Electrotechnology	Refrigerated Condenser	■		■
Process/Misc. Drycleaning	Emerging Electrotechnology	Photocatalytic Oxidation			■
Process/Misc. Drycleaning	Electrotechnology	Wetcleaning		■	■
Process/Misc. Drycleaning	Emerging Electrotechnology	Ultrasonic Cleaning	■	■	■
Process/Misc. Drycleaning	Emerging Electrotechnology	Microwave Drying	■		
Process/Misc. Laundering	Electrotechnology	Ozonated Laundering	■		■
Process/Misc. Laundering	Efficiency Technology	Horizontal-Axis Washer	■		■
Process/Misc. Laundering	Electrotechnology	Microfiltration	■		■
Process/Misc. Laundering	Electrotechnology	Heat Pump Water Heater	■		
Process/Misc. Laundering	Efficiency Technology	Heat Recovery Water Heater	■		
Lighting	Efficiency Technology	Energy-Efficient Indoor Lighting	■		
HVAC	Efficiency Technology	Air-to-Air Heat Recovery	■		

Process and Miscellaneous Equipment

More than half of all the electricity used in the fabricare industry is consumed by process-related equipment and miscellaneous plug loads. Electricity is used to operate the drycleaning machines in the drycleaning industry and the washers, tunnel washers, and dryers in the laundry industry. It is used to operate pumps that circulate water, solvent, and/or detergent; to rotate drums that agitate items during cleaning; and to drive dryer fans that take in fresh air and expel solvent-bearing or moist air. The efficiency of the process equipment used in a drycleaning or laundering facility therefore significantly influences the overall energy efficiency of the facility. Any drycleaning or laundry shop facility is likely to have numerous plug loads, such as sewing machines, portable fans, and/or coffee machines; these loads are small and rarely present opportunities for significant energy savings.

Drycleaning Technologies

Electric technology solutions to drycleaning business needs can be divided into two groups: perc emission control technologies, including the dry-to-dry machine, refrigerated condenser, and photocatalytic oxidation; and alternatives to conventional drycleaning such as wetcleaning, ultrasonic cleaning, and microwave drying.

Perc Emission Control Technologies

In 1992, roughly 66% of all drycleaners had dry-to-dry machines and 60% of drycleaners had additional perc emission control equipment—either a carbon adsorber or a refrigerated condenser, as indicated in Table 7.

Table 7
Status of Drycleaning Machine Vapour Controls

	No. of Machines			
Type of Machine	**Uncontrolled**	**Carbon Adsorber**	**Refrigerated Condenser**	**Total**
Dry-to-Dry	6,890	4,260	9,980	21,130
Transfer	5,250	2,530	2,530	10,310
TOTAL	**12,140**	**6,790**	**12,510**	**31,440**

Source: Center for Emissions Control, *Dry Cleaning: An Assessment of Emission Control Options,* September 1992.

Drycleaners currently using carbon adsorbers are not required by EPA regulations to retrofit their machines with refrigerated condensers, despite the EPA preference for refrigerated condensers. The advantage of carbon adsorption is its ability to handle high volumes of air with relatively low solvent concentrations and still maintain high removal efficiencies. However, the technology needs frequent desorbing (cleaning of the carbon filter), a process that generates large volumes of solvent-contaminated wastewater. Furthermore, if desorption is not performed frequently enough, the saturated carbon filter adsorbs no more solvent and the control technology fails entirely. As a result, EPA's perc regulations now require drycleaners operating uncontrolled machines to install refrigerated condensers; those purchasing new equipment must buy dry-to-dry machines that incorporate refrigerated condensers.

Drycleaning machines have evolved technically over the years such that each new generation of equipment is able to control emissions to a greater degree (see Table 8). Original transfer machines (first-generation machines) evolved into dry-to-dry vented machines (second-generation machines) and finally to the current dry-to-dry machines with refrigerated condensers (third-generation machines). According to federal CAAA regulations, all machines purchased after September 15, 1996, must be third-generation machines—dry-to-dry machines with refrigerated condensers—or later models.

Table 8
Generations of Drycleaning Machines

First Generation	Transfer machines
Second Generation	Dry-to-dry machines
Third Generation	Dry-to-dry machines w/refrigerated condensers
Fourth Generation	Dry-to-dry machines w/refrigerated condensers and small carbon adsorber
Fifth Generation	Dry-to-dry machines w/refrigerated condensers, small carbon adsorber, and lockout device

Carbon Adsorption: How It Works

Carbon adsorption is used in approximately 35% of emission-controlled machines to recover 95–99% of airborne perc. In the process known as adsorption, airborne perc is attracted to an activated carbon bed so that solvent-free air vents to the atmosphere. After a period of use, the carbon—specially treated or "activated" to increase its surface area-to-volume ratio—eventually reaches a point where it can no longer adsorb more perc and must be desorbed.

While U.S. environmental regulations currently require at least third-generation machines, equipment manufacturers also offer fourth- and fifth-generation machines. Fourth generation machines add a small carbon adsorber that is intended to capture the perc vapors that remain in the cleaning/drying chamber before the door is opened. Fifth-generation machines (currently required by German environmental regulations) include a lockout device to prevent the equipment from being opened until a specified perc concentration has been achieved in the chamber.

Increasingly stringent environmental regulations and the rising cost of perc have persuaded many drycleaners with transfer machines to go beyond current federal regulations and upgrade to fourth-generation machines. According to one manufacturer, the new dry-to-dry machines can reduce perc consumption from 140 gallons to 40 gallons per year (cleaning the same volume of clothing), thereby reducing operating costs. By also reducing emissions, the fourth-generation equipment increases employee and customer safety.

Electrotechnology Solution
Refrigerated Condenser

Refrigerated condensation is currently used in 65% of controlled machines. The technology is based on the principle that the amount of solvent held in the air in a vapor state is a function of temperature: as temperature is reduced, air holds less vapor. The refrigerated condenser chills the perc vapor stream, causing the solvent and water vapor to condense; the solvent can then be collected and reused. A condenser requires little maintenance and minimizes wastewater generation since steam regeneration is not required. The device does, however, require higher solvent concentrations than a carbon adsorber and cannot be used to control low-concentration fugitive emissions, an important attribute of the carbon adsorber.

No-vent, dry-to-dry third-generation machines have built-in refrigerated condensers. Refrigerated condensers can also be retrofit to both transfer machines and vented, dry-to-dry machines. The process can achieve 30–85% vapor control in transfer machines and 95% in dry-to-dry machines. In transfer machines, the solvent-laden vapor passes through the condenser only once during cleaning, making that step of the process significantly less efficient.

Emerging Electrotechnology Solution
Photocatalytic Oxidation

Photocatalytic oxidation, a technology being developed in cooperation with the U.S. Department of Energy, uses ultraviolet (UV) light, supplied by sunlight or electric UV lamps, and a titanium dioxide photocatalyst to destroy organic contaminants in air and water. The technology is particularly well-suited to low-concentration, low flow-rate contaminated airstreams, such as those found in drycleaning facilities.

Photocatalytic oxidation is currently being used in remediation efforts to destroy perc in soil and water and can potentially be adapted within 5 years to treat perc vapors inside drycleaning facilities. This process would eliminate the need for vapor barriers in facilities currently located in residential buildings—part of proposed drycleaning regulations in the state of New York. Laboratory tests indicate that the process can successfully treat a thin film of water with traces of perc. With further development, photocatalytic oxidation may be practical for destroying perc in drycleaning separator water and even in air.

Alternatives to Conventional Drycleaning

In 1993, the EPA's Design for the Environment project undertook a Cleaning Technologies Substitute Assessment (CTSA) to search for alternatives to perc drycleaning. The first process investigated was wetcleaning; future CTSA technology demonstrations will include ultrasonic cleaning and microwave drying. Demonstration shops have been established in Chicago, Indianapolis, and Los Angeles to test the technical and financial viability of alternatives under normal field conditions.

Electrotechnology Solution Wetcleaning

Wetcleaning is an aqueous-based cleaning process that relies on heat, steam, pressing, and natural soap to clean clothes that are traditionally drycleaned. In conjunction with the Neighborhood Cleaners Association (NCA), the EPA undertook testing at the NCA's New York School of Dry Cleaning, as well as field demonstrations in Chicago, Indianapolis, and Los Angeles. The demonstrations have shown that wetcleaning may be a viable alternative to drycleaning for most fabrics. Costs are similar to perc drycleaning; capital costs are lower, but labor costs are higher. Consumer evaluations found no real difference in the finished garments, except that the clothing that went through the wetcleaning process smelled better. The actual cleaning ability of the process is still being assessed.

Proponents argue that adoption of wetcleaning will reduce the volume of clothing being drycleaned, therefore reducing the amount of perc emissions and the size and cost of emissions control equipment. The lack of emissions in the wetcleaning process also improves worker and customer comfort and safety, and enables wetcleaning facilities to locate next to food establishments or in apartment buildings or shopping malls—sites that are not available to perc-using drycleaners. In addition, the wetcleaning process generates no hazardous waste, and the wastewater is easily treated at the POTW.

Drycleaners now using wetcleaning machines believe that wetcleaning does a superior job on difficult-to-clean items such as beaded bridal gowns, brightly colored silks, and leather-trimmed items. Some drycleaners believe the trend toward more casual work dress and stiffened environmental regulations will make wetcleaning an integral part of garment care. Most, however, do not accept wetcleaning as a complete replacement, but rather as an important complement to solvent cleaning.

Skeptics are concerned about the possibility of shrinkage and problems associated with care labeling. Many drycleaners are not willing to wetclean garments labeled "dryclean only" due to possible liability for damaged garments. Concerns have also been expressed about the amount of water consumed in the process, and whether wastewater disposal will be a problem in some areas. It takes 2.5 gallons of water, on average, to wetclean one pound of clothing. This level of water usage may not be acceptable in drought-prone areas, such as the southwestern United States. Another major point of contention is what percentage of garments currently drycleaned can realistically be wetcleaned.

Emerging Electrotechnology Solution
Ultrasonic Cleaning

Ultrasonic cleaning uses sound waves to create microscopic bubbles that mechanically scrub items clean. While still under development for use in the fabricare industry, ultrasonic cleaning has been used for years in industrial parts cleaning. The developer of the fabricare technology believes the water-based process will prove to be more energy-efficient and environmentally sound than drycleaning, since it eliminates organic solvents.

In a theoretical ultrasonic cleaning unit, incoming clothes are loaded onto a flat conveyor belt and secured between sheets of mesh fabric. The mesh eliminates shrinkage and reduces the need for pressing the garments, while also allowing a wider variety of laundry items (such as socks and towels) to be cleaned. The conveyor passes through a brief, cool, aqueous wash. Ultrasonic waves are used to create microscopic bubbles in a process known as "cavitation." The bubbles agitate the surface of the clothing, loosening particulate matter through their scrubbing action. The conveyor belt then carries the clothes through a rinse trough. The rinse trough uses continuous water filtration and circulation to keep the bath chemistry fresh and rinse water clean, and to minimize water use. After the rinse phase, the conveyor passes through a set of semi-soft rollers, similar to those on an old ringer washing machine, to eliminate excess moisture. Automatic chemical misting is signaled for pieces of clothing that need special finishes such as starch or waterproofing. In the drying chamber, garments are subjected to large amounts of cool, high-speed, dehumidified air.

The ultrasonic cleaning system has advantages over both drycleaning and traditional laundering. Continuous loading eliminates the time-consuming sorting and batching of incoming loads. The high degree of agitation enables efficient cleaning in lower-temperature water, thereby reducing electricity use and thermal stress on clothing. Ultrasonic cleaning requires less detergent and water and allows for recovery and reuse of a large amount of the water, reducing both the volume and strength of the wastewater. In addition, the system dries the clothing with less heat. In combination, these characteristics can save a considerable amount of water and energy, lowering operating costs. Still in question is what percentage of clothes currently drycleaned can be cleaned with this alternative technology.

Microwave Dryer Efficiency

Microwave dryers, recently developed and not yet commercially available, are capable of operating in three modes:

- **Cool Drying**. This mode uses microwaves and ambient air to dry wool and other delicate fabrics without shrinkage or damage. This type of drying has the lowest energy efficiency.

- **Maximum-Efficiency Drying**. This mode uses microwaves and air preheated with waste heat from the microwave generators (magnetrons). It can reach efficiencies of 80%.
- **High-Speed Drying.** This mode uses microwave power and air heated with electric resistance. Moderate levels of efficiency are achievable.

Emerging Electrotechnology Solution *Microwave Drying*

In the conventional drying process, clothes tumble inside a drum as heated air evaporates the water and carries it away as vapor. While high-temperature air shortens the drying time, it can damage wools and other delicate fabrics, shrink and yellow fabric, break down natural oils in fabric, and shorten fabric life span.

In the same way that a microwave acts on food in an oven, a microwave dryer causes rapid movement of water molecules in clothing, resulting in heat and evaporation. Airflow through the microwave dryer transports water vapor out of the drum. Because microwaves preferentially heat water molecules in the clothing, the clothes dry 35–50% faster and the dryer consumes 15–25% less electricity than conventional electric dryers.

Both the absence of heated air and the evaporation of water from clothing help keep microwave dryer temperatures near 110°F—much cooler than the 180°F environment of a conventional dryer. Microwave dryers also offer the additional advantage of reduced fabric wear due to shorter drying times. As a result, microwave drying can lengthen the life of many fabrics and potentially eliminate the need for drycleaning of delicate fabrics such as wool and silk.

The technology appears appropriate for commercial, industrial, and coin-operated laundries, and as a complement to wetcleaning in the drycleaning industry. Current development efforts are focused on residential-sized dryers (7- to 12-pound loads) for use in residences, apartments, and coin-operated laundromats. Researchers believe, however, that the dryers can be scaled up to the larger sizes needed by on-site laundries at hotels and hospitals (50- to 150-pound loads) and full-sized commercial and industrial laundries (up to 400-pound loads). A payback of several years is estimated in all settings.

Although microwave dryers cost more than conventional dryers—$2900 (uninstalled) for a 30-pound commercial microwave dryer, compared to $1900 and $2400 (uninstalled) for a similar conventional unit—this cost is somewhat offset by energy savings and an increase in fabric life. According to the International Fabricare Institute, an increase in fabric life of 10% could produce a two-year payback when drying high-value items such as uniforms. For common items such as towels and sheets, a 30% increase in fabric life would be required to achieve payback in 2 years.

Laundering Technologies

Electrotechnology solutions to laundry industry needs can be divided into two groups: alternative laundering technologies such as ozonated laundering and horizontal-axis washers, and water and heat reclamation technologies such as microfiltration and heat recovery water heaters.

Alternative Laundering Technologies

Several alternative technologies can help laundries reduce both water use and wastewater load while cleaning clothing and other fabric items more effectively. Ozonated laundering and horizontal-axis washers provide new options to reduce total operating costs and comply with environmental regulations.

Electrotechnology Solution
Ozonated Laundering

Ozonated laundering systems substitute ozone for other cleaning agents so that dirt and other organic soils are removed with less detergent and cooler water. Ozone—a powerful oxidizing agent that breaks down organic molecules—can be produced by passing an airstream between high-voltage electrodes (the corona discharge method) or by passing an airstream through a path irradiated with UV light. Most applications, including industrial laundries, use the corona discharge method.

This technology is appropriate for and is being used by commercial laundries, linen supply companies, and industrial laundries. Industrial laundries, which use large volumes of water and generate large volumes of wastewater, have the greatest incentive to investigate this technology because of upcoming wastewater regulations. Industrial laundry wastewater typically has high biochemical oxygen demand—two to five times greater than domestic sewage. The wastewater can contain toxic heavy metals, volatile organic compounds (VOCs), oils and grease, phosphates (from detergents), and colors that can interfere with the operation of local POTWs. The EPA is expected to propose federal standards for industrial laundries in December 1996. Final effluent standards are scheduled to be issued in 1998. While it is unclear what technology controls will be evaluated, ozonated laundering—which saves energy, cuts detergent costs, and allows wastewater reuse—presents an attractive compliance option for industrial laundries.

Filtration of Laundry Wastewater

A San Francisco laundry operation that processes 8000–10,000 pounds of laundry per day is saving $40,000 per year as a result of installing a water reuse filtration system. The system separates soils and other contaminants from the water and returns the cleaned water to the hot water tank. Approximately 65% of the 27,000 gallons of water used per day is treated and reused. The treatment also maintains the heat of the wastewater, reducing the cost of heating the water to wash temperatures. Water efficiency is especially important in San Francisco, where water and sewer rates have increased more than 60% since 1990 to the current high of more than $7.50 per 1000 gallons consumed. Most laundries use millions of gallons of water each year. As a result, savings add up quickly through reuse of heated water.

Efficiency Technology Solution
Horizontal-Axis Washers

Coin-operated laundromats that replace top-loading washers with horizontal-axis washers will reduce both energy and water use. Horizontal-axis washers use one-third less water than conventional washers because clothes tumble through a partially filled, horizontally oriented wash tub instead of a completely filled, vertically oriented tub.

Compared to a top-loading washer, a horizontal-axis washer typically uses 50–60% less energy. Eighty to ninety percent of the energy used in a vertical-axis washer is for water heating; the reduction in the amount of water needed in a horizontal-axis washer can reduce energy use significantly. These washers also have a high-speed spin cycle (up to 1000 rpm) that extracts more water from clothes than does a conventional washer, thereby speeding drying times and further reducing energy requirements. In addition, studies have shown that these washers clean more effectively. The vertical tumbling action agitates the clothing more, forcing water through the clothing and thereby helping to remove dirt and other soils.

Although these washers have been popular in Europe for some time, in the United States they have not yet been produced by major manufacturers or launched commercially. In 1995, EPRI established a Laundry Products Initiative to commercialize both the horizontal-axis washer and the microwave dryer and to produce performance data for use in encouraging further market acceptance of the technology.

Water and Heat Reclamation Technologies

New institutional laundry facilities are incorporating energy-efficient features such as water and heat reclamation systems in their original designs; these systems can also be retrofit to existing facilities. Microfiltration, heat recovery water heaters, and heat pump water heaters are technologies available to help laundries achieve these efficiencies.

Electrotechnology Solution
Microfiltration

Water conservation is a focal point of many newly designed laundries. Some laundries reuse as much as 65% of their water. For example, laundries can treat rinse water (which is basically clean) and then reuse it to wet soiled goods in future washes. Laundry wastewater filtered by microfiltration can also be reused; alternatively, microfiltration can simply pretreat wastewater prior to discharge to the POTW.

In microfiltration, which is a membrane filtration system, electrically driven pumps force laundry wastewater through a permeable barrier to filter out pollutants. Water and some dissolved matter (depending on the type of membrane) pass through, while other contaminants do not. Microfiltration is typically used to filter out particles 10 microns in diameter or larger, such as suspended solids. Substances such as clay can be added to absorb oil and grease, thereby creating solids that can be collected by filtration.

Microfiltration and other membrane systems are attractive wastewater treatment options because they produce treated water (permeate) that is clean enough for reuse on-site or for sewer discharge below POTW standards. Water recycling can also significantly reduce a facility's total water use, as well as minimize the amount of wastewater that requires treatment and/or discharge.

Electrotechnology Solution
Heat Pump Water Heater

Heat pump water heaters (HPWHs) provide water heating and coincident space cooling by transferring energy from warm air regions to hot water storage tanks. This technology can be particularly useful for facilities such as laundries that use large amounts of hot water and need the concurrent cooling to condition over-heated work areas. They can be installed in new-construction or retrofit situations and are best applied to augment existing water heating and space-cooling systems. HPWHs represent a highly competitive alternative to fossil-fuel-fired water heating systems. In addition, because HPWHs have a by-product of cool air, they provide "free" air conditioning.

Efficiency Technology Solution
Heat Recovery for Water Heating

Heat recovery for water heating is similar to air-to-air heat recovery. Heat recovered from laundry wastewater ("gray water") can be used to preheat makeup water. Use of a simple heat exchanger to transfer energy from the outgoing wastewater to the incoming fresh water is inexpensive, effective, and provides a short payback period. A coaxial tube-in-tube heat exchanger, which has minimal clogging risk and maintenance requirements, is generally recommended for this application.

Lighting

Lighting systems account for more than 30% of the electricity used in drycleaning and laundry facilities, the second largest electricity use. Fluorescent lamps (also known as tubes or bulbs) with magnetic ballasts are the system used by more than 90% of all facilities, typically to illuminate more than three-quarters of a facility. Fluorescent fixtures come in a variety of shapes and sizes. Some of the most common are 4-foot-long tubes used in two-, three-, or four-tube fixtures. The basic components of a fluorescent lighting system are fixture, reflector, switch, lamp, ballast, and lense. Compact fluorescent lamps are only used by 3% of all facilities.

The second most common lighting source is incandescent lighting; 40% of facilities use incandescent lamps. Incandescent fixtures are relatively inexpensive and easy to install, but are the least efficient lighting source available. Due to their inefficiency, incandescent lamps are typically used to light only a small portion of a facility and/or for decorative lighting (e.g., signs and displays) and exit lights.

Another type of lighting used in larger drycleaning and laundry facilities is high-intensity discharge (HID) lighting. The HID family of lamps includes mercury vapor, metal halide, and high-pressure sodium lamps. Although these lamps are most commonly used in parking lots and driveways, they can be used in large warehouse-style facilities such as large wholesale drycleaners or industrial launderers. All of the HID lamps have significantly longer lives than incandescent lamps and many fluorescent lamps.

Efficiency Technology Solution
Energy-Efficient Indoor Lighting

The most efficient form of fluorescent lighting available today is a 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 customer areas and hallways. Mercury vapor lamps can be replaced with either metal halide or high-pressure sodium lamps with relatively short payback.

Heating, Ventilation, and Air Conditioning

A typical drycleaning facility has a customer area in the front of the store and work rooms in the rear. The work areas are literally steam rooms due to the large amounts of heat and water vapor generated by irons and steam presses. In laundry facilities, hot water heaters and steam converters (steam-to-water heat exchangers) continually add heat to the environment while large volumes of air are exhausted during dryer operation. In addition, drycleaning and laundry facilities are burdened with heat loads from operating dryers, motors, water heaters, and frequent air exchanges as customers and delivery personnel open and shut doors. As a result, providing a comfortable atmosphere for customers and workers can be a complicated endeavor.

The HVAC systems used in drycleaning and laundry facilities are similar to those of retail stores. However, because drycleaning and laundry facilities have more heat-intensive equipment and greater ventilation needs, they typically have HVAC systems with larger capacities and more operating units.

In most drycleaning and laundry facilities, neither the work areas nor customer counter areas are air conditioned. Work areas where clothes dryers are in constant use exhaust large volumes of air, approximately 400–600 cfm per dryer. Although new, well-designed facilities have makeup air units to supply the necessary outside air, older establishments often rely on open windows and doors for ventilation. Exhaust and floor fans are used to bring a small degree of relief from the heat; roof ventilators, side-wall exhausters, and window-mounted fans are common. Placement of exhaust fans directly over or behind major heat generators (such as a steam press) aids employee comfort. During cool weather, steam heaters or wall radiation units are often employed to heat the customer area and provide heat for morning startup in the work area.

A laundromat operator has a similarly multi-faceted situation to deal with. In this case, providing air conditioning and heating for customer comfort is essential to remain competitive in the marketplace.

Facilities with HVAC systems that currently provide inadequate worker and customer comfort can justify reasonable investments in new or upgraded HVAC equipment in terms of the competitive advantages offered by increased worker productivity and friendlier customer environments.

Efficiency Technology Solution
Air-to-Air Heat Recovery Units

During the heating season, the transfer of heat from warm exhaust air to cool makeup air can significantly reduce energy consumption in an HVAC system. Air-to-air heat recovery units use a heat exchanger to perform this energy exchange. Unfortunately, warm moisture-laden exhaust air cannot be cooled very many degrees before reaching its dew-point temperature (the point at which water vapor begins to condense out in the heat exchanger). For example, water vapor in exhaust air at 90°F and 80% relative humidity will start to condense out when cooled to only 82°F. As a result, heat recovery makeup air units must be selected carefully. Heat pipe exchangers perform well in this type of application, and packaged makeup air units with heat pipe exchangers are available.

4

ELECTROTECHNOLOGY PROFILES

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

Refrigerated Condenser

Basic Principle

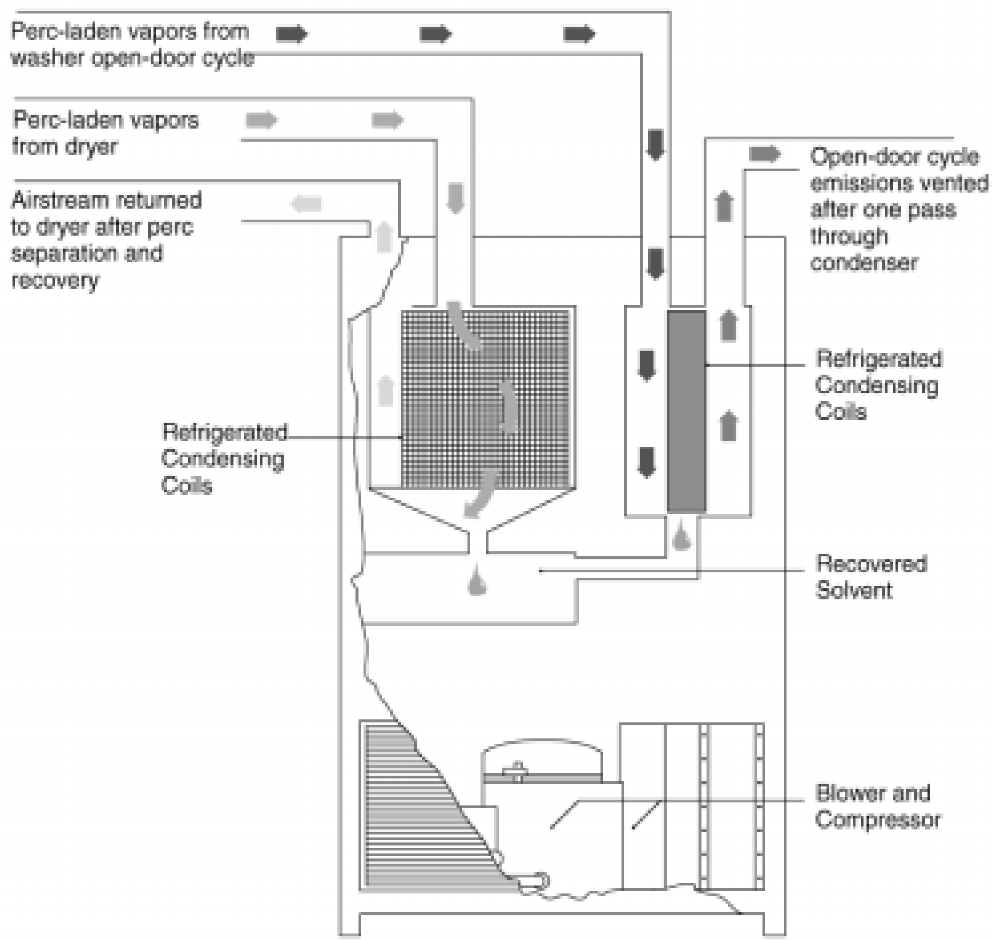
Perchloroethylene (perc) is an organic solvent used by 90% of the drycleaning industry to remove dirt, grease, and other soils from apparel and household fabrics. Since 1993, perc has been classified by the U.S. Environmental Protection Agency (EPA) as a hazardous air pollutant (HAP) and a possible carcinogen. When drycleaning machines are opened, perc vapors generated during the cleaning process are released, along with steam. To comply with new EPA regulations, drycleaners must find alternatives to perc in the form of new cleaning solvents or additional process controls that can reduce perc emissions. Refrigerated condensers are the most commonly used device in the drycleaning industry for reducing perc emissions. A refrigerated condenser reduces emissions by lowering the ambient air temperature below the dew point of the solvent, thus condensing the vapor into liquid form. The recovered solvent can be recycled and reused, saving both material and money. Depending on the type of machine, a refrigerated condenser can recover as much as 95% of the solvent.

System Description

Two types of drycleaning machines are available: transfer machines and dry-to-dry machines. In the older transfer machines, washing and drying are performed in separate units, requiring the manual transfer of solvent-laden clothes from one unit to another. In this case, refrigerated condensers must be retrofit onto each of the machines. In the washing machine, only 30% efficiency is achievable because the airstream passes through the condenser only once. In the dryer, vapors are routed back to the condenser several times until the drying cycle ends. The recovery efficiency for the drying process is about 85%.

In newer dry-to-dry machines, both washing and drying are performed in one unit, which reduces process emissions by 95%. Currently, 65% of all controlled machines use refrigerated condensers. A refrigerated condenser can be built into a dry-to-dry machine or can be retrofit to both dry-to-dry and transfer machines.

A refrigerated condenser usually consists of a blower, a cooler, and a device to collect the condensate and water. The blower is a centrifugal unit that operates at very low pressure. The cooler may be a water chiller or an air-cooled heat exchanger, although compact vapor compression refrigeration systems are most common in dry-to-dry machines today.



Refrigerated Condenser

Advantages

- Little maintenance is required.
- Less wastewater is generated than with carbon adsorption.
- Operating costs are low.

Disadvantages

- Requires relatively high solvent concentrations for effectiveness.
- Cannot be used to control fugitive emissions.
- Low air temperature may increase the drying time.

Commercial Status

Nearly 65% of the industry uses machines with refrigerated condensers built into or retrofit onto cleaning units. EPA regulations require all new dry-to-dry machines to be built with refrigerated condensers, but separate units are commercially available for retrofit addition.

Refrigerated Condenser System Characteristics

Capacity	30-50 lb of wet clothing
Dimensions	Width: 8′ Depth: 5′ Height: 8′
Power Rating	6-10 kW
Energy Consumption	5 kW/30-min wash-and-dry cycle
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effluent	None
Cost	
Purchase	Retrofit: $6000-$8500 Built-in: $35,000-$50,000
Installation	Minimal
Operating	$90-$200/year

Cost and Electrical Requirements

Capital costs for a refrigerated condenser are $6300 if retrofitting a dry-to-dry machine (sized for less than 50-lb loads) or $8400 if retrofitting a transfer machine of the same size. The capital cost of a carbon adsorber unit is $6800–$7000. However, operating costs of the two alternatives differ greatly. For drycleaners or launderers with annual revenues between $75,000–$100,000, operating costs for a carbon adsorber dry-to-dry machine are $2686 per year versus $93 a year for a refrigerated condenser dry-to-dry machine. Likewise, operating costs for a carbon adsorber transfer machine are $2695 per year versus $179 per year for a refrigerated condenser transfer machine. Purchasing a 35-lb load-capacity dry-to-dry machine with a built-in refrigerated condenser generally costs $35,000–$50,000.

The electrical requirement for a 35-lb-load dry-to-dry machine is roughly 10 kW; of this, 7 kW is used by the refrigerated condenser, and 3 kW is used to operate fans, pumps, filters, and drive units. The average energy use for a 30-minute wash and dry cycle is 5 kWh.

Wetcleaning

Basic Principle

Perchloroethylene (perc) is an organic solvent used by 90% of the drycleaning industry to remove dirt, grease, and other soils from apparel and household fabrics. Since 1993, perc has been classified by the U.S. Environmental Protection Agency (EPA) as a hazardous air pollutant (HAP) and a possible carcinogen. This classification has led the EPA and the drycleaning industry to combine efforts to find alternative chemicals or methods to reduce or eliminate the use of perc. One new method currently under evaluation is wetcleaning. This nonchemical process is a potentially viable, environmentally safe method of cleaning delicate fabrics and removing spot stains, something previously possible only through drycleaning. Wetcleaning relies on the controlled application of heat, steam, and natural soaps to clean clothes that are normally drycleaned.

System Description

Research has confirmed that, in most cases, water will not harm fine textiles. Excessive heating, rapid changes in temperature, and rough mechanical agitation, however, can cause damage. Therefore, almost any garment can be wetcleaned through a variety of different techniques if the fabric is properly cared for. Because a wetcleaning process operator must identify which cleaning technique is appropriate for the fabric, wetcleaning is very labor-intensive. Depending on the type of fabric and soil, the cleaning process can involve steam cleaning, spot removing, hand washing, machine washing, tumbling dry, and/or vacuum cleaning.

Under guidance from the EPA's Design for the Environment Program, a Clean Technologies Substitute Assessment project examined trade-offs of multiprocess wetcleaning in terms of risk, performance, cost, energy impact, and resource conservation. Although more research is needed, the project demonstrated that wetcleaning is an economically and technically viable alternative to drycleaning. While wetcleaning proved more labor-intensive than drycleaning, the extra labor cost was offset by lower costs for equipment, hazardous waste disposal, electricity, and other supplies. In terms of performance, most consumers participating in the project rated their satisfaction with the wetcleaned items equal to or higher than their satisfaction with the drycleaned items.

Advantages

- Does not require use of hazardous solvents such as perc
- Cleans a wide range of fabrics safely
- Leaves less residual odor in the cleaned garment
- Minimizes shrinkage
- Inhibits dry bleeding

Disadvantages

- More labor-intensive since the operator must identify the best cleaning process for the garment

Commercial Status

Although wetcleaning machines are on the market, the effectiveness of the units is still being proven. A short-term, high-volume test, conducted between November and December 1992, compared the cost and performance of conventional drycleaning and the wetcleaning process. Nearly 1500 garments, separated into lots of 50, were collected from government agency employees in Washington, D.C. and New York City. The clothes were sent to the Neighborhood Cleaners' Association New York School of Dry Cleaning in Manhattan, where, depending on a random flip of the coin, the lots were separated into those to be drycleaned and those to be wetcleaned. Overall, 712 articles were wetcleaned and 787 were drycleaned. After cleaning, the clothes were pressed on the same machine and returned to the customers with a questionnaire. The customers were not told which cleaning process was used for their garment(s). The questionnaire asked them to evaluate the quality of the cleaning process for appearance, odor, and overall acceptability. Out of 900 cards, 350 were returned and showed a statistical preference for clothes that were wetcleaned, especially with regard to lack of odor.

Wetcleaning System Characteristics

Dimensions	Lenght: 42-64″ Height: 59-76″ Width: 31-52″
Capacity	30-600 lb of clothing
Power Rating	2-15 kW
Key Inputs	
Power	Electricity
Other	Water, detergent
Key Outputs	
Solid Waste	None
Air Emissions	None
Water Effuent	None
Cost	
Purchase	$6000-$33,000
Installation	Minimal
Other Supplies	Detergent cost, water cost

Cost and Electrical Requirements

The cost of a wetcleaning system can vary significantly with size and system complexity. A small wetcleaning system that can handle 30 pounds of clothing costs approximately $6000 and draws 2 kW of electricity. A large unit with a capacity of 600 pounds costs $33,000 and uses about 15 kW of electricity. Most small drycleaners would want wetcleaning machines that could handle 50–100 pounds of clothing. These units cost $10,000–$23,000; they have a power requirement of 3–5 kW.

Assuming that a small drycleaner operates 4 hours per day (1040 hours per year), a wet-cleaning machine with a 60-lb capacity and a power input of 4 kW will use an average of 4160 kWh per year.

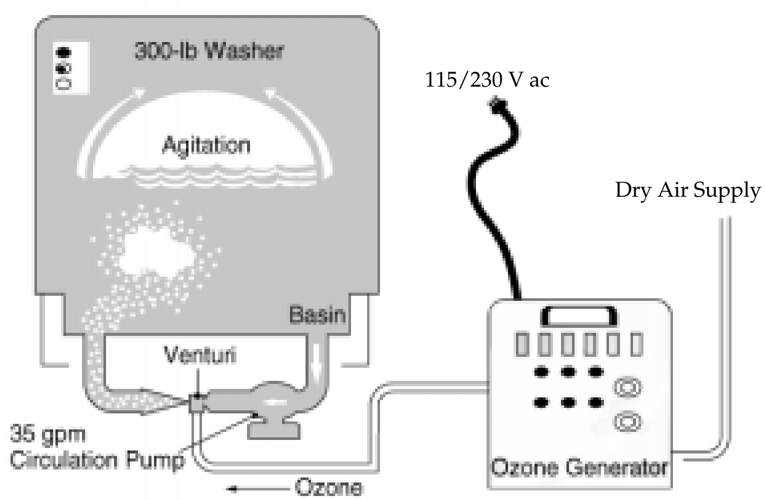
EPA Information

Additional information on the EPA's Design for the Environment Program can be obtained through the Pollution Prevention Information Clearinghouse, (202) 260-1023.

Ozonated Laundering

Basic Principle

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



Ozone Laundering System

System Description

Because ozone is highly reactive, it must be generated on-site as needed. Ozone can be generated by corona discharge or by ultraviolet (UV) excitation. In the corona discharge method, air or oxygen is passed between two electrodes, and a corona discharge is generated by applying high voltage to the electrodes. In the UV excitation method, ozone is generated photochemically by passing air through a path irradiated with UV light. In both methods, a portion of the air dissociates and recombines to form ozone.

The most commonly used ozone generation method is corona discharge. The UV excitation method has limited use because of its high energy requirements (20 kWh per pound of ozone produced) and relatively low ozone production rate.

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

Advantages

- Ozone is more powerful than chlorine in water: Ozone can vastly enhance cleaning capabilities of detergents and chemicals, sometimes even making them unnecessary. A correction facility was able to reduce chemical costs by 65%.

- Wash and rinse times are reduced: Oxidation of organics and hydrocarbons loosen the soils from the textile surface, making the mechanical agitation and use of detergent more effective.

- Water usage reduced: Cutting down on detergent means the rinse cycle can be reduced by an average of two cycles. In a closed-loop system where the wastewater is recycled, water usage can be reduced another 70–75%.

- Reduced energy consumption: Shorter operating time requires less electricity. In addition, since ozone lasts longer and works better in colder temperatures, there is less demand for hot water. A correction facility, for example, cut hot water demand by 78%.

- Extended textile life: Less mechanical agitation, lower alkalinity, lower wash temperature, and shorter wash time all contribute to longer-lasting fabric.

- BOD and COD reduced: In an open-loop system, effluent concentrations of BOD and COD can be reduced by 50%.

- Low operating cost: Less water, less detergent, less energy consumption, and less water treatment all contribute to lower bills.

Disadvantages

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

Ozone-Generating/Pumping System Characteristics

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

Commercial Status

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

Cost and Electrical Requirements

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

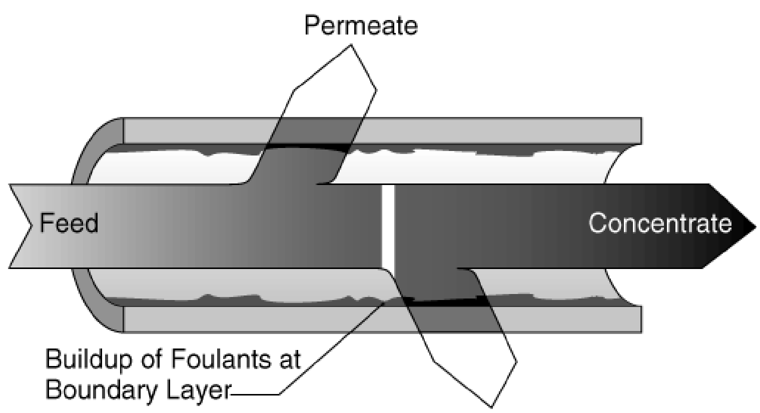
An ozone-generating/pumping unit suitable for use with a 200- to 450-lb load-capacity washer (typically used by industrial laundries) would consume about 27.5 kWh per day and draw 4.9 kW. A typical laundry might own six such washers and operate them 8 hours per day. This would result in an electricity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

Microfiltration

Basic Principle

Microfiltration is a membrane separation technique that utilizes permeable membranes to filter selected components from industrial laundry wastewater. The membrane separates the molecules on the basis of shape and size, allowing particles smaller than 10 microns to pass through. This process can be used to reduce the levels of oil, grease, heavy metals, chlorinated solvents, and suspended solids in industrial laundry wastewater, allowing the facility to comply with restrictions of the local publicly operated treatment works.

Microfiltration systems are available in four types: polymer, metal membrane discs, pleated cartridge filters, or crossflow configurations. Crossflow microfiltration is the most commonly used method of filtering industrial laundry wastewater.

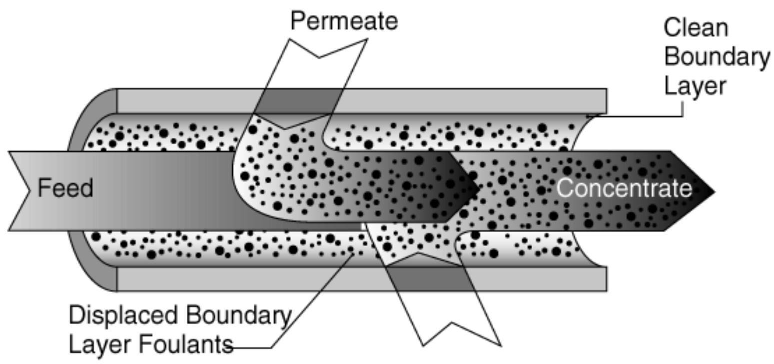


Principle of Crossflow Microfiltration

System Description

In the crossflow microfiltration system, wastewater is circulated, under pressure, in contact with a specially constructed polymeric film. Typically, clay is added to industrial laundry wastewater to absorb oil and grease, creating particles large enough to be captured by the filter. The wastewater is then separated into two effluent streams, permeate and concentrate (see figure). The permeate passes through the membrane, while the concentrate retains particles rejected by the membrane. The feed and concentrate flow parallel to the membrane instead of perpendicular; thus the process is called "crossflow."

At relatively low operating pressures and high recirculation flow rates, turbulent flow is produced at the membrane. This condition allows a thin layer of particles to form on the membrane, causing fouling. By backpulsing, or reversing the flow of the clean permeate, the system periodically cleans the membrane surface (see figure). Backpulsing keeps the membrane clean over extended periods of time; chemical cleaning is required only occasionally.



Backpulse Principle

Advantages

- Self-cleaning: Particles are swept away with the concentrate stream, eliminating frequent filter media changes or resin regeneration.
- Controls pollution: Decreases the waste load leaving the facility, reducing the amount of treatment required prior to discharge.
- Limited maintenance: There are no moving parts, reducing the need for maintenance.
- Reduces water use: Allows for recycling and reuse of permeate by removing suspended solids.
- Compact in size: Requires less space than a dissolved-air flotation system.
- Modular for easy retrofitting: Can be added onto existing wastewater treatment processes.

- Saves labor: Fewer worker-hours are required due to reductions in material handling and process control requirements.

Disadvantages

- Potential for equipment damage: Microfiltration systems are susceptible to damage by a variety of organic and inorganic compounds.

- Potential for fouling: Fouling can occur when particles collect on the membrane surface.

Commercial Status

The most common use of microfiltration is for treatment of industrial effluents to ensure compliance with discharge regulations and allow water recycling. Microfiltration is used in industrial laundries, and in food, chemical, and pulp and paper processing. The development of new ceramic, metallic, and synthetic polymer membranes is enabling a variety of new applications, especially in the area of wastewater treatment.

Microfiltration System Characteristics

Capacity	0.1-0.5 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	1.2-3.0 kWh/100 gallons of permeate
Key Inputs	
Power	Electricity
Other	Membrane, clay
Key Outputs	
Solid Waste	Oil, grease, solids
Air Emissions	None
Water Effluent	Treated water discharged to POTW
Cost	
Purchase	$5000-$40,000
Instllation	10% of purchase cost
Other Supplies	$1-$6/1000 gallons of feed rate

Cost and Electrical Requirements

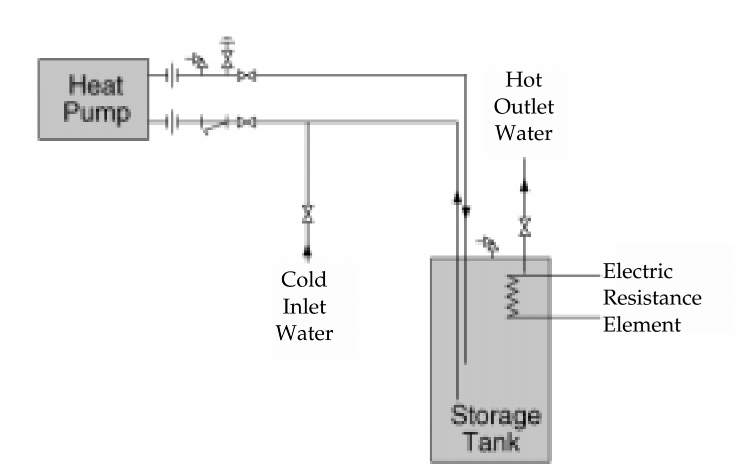
Capital and operating costs depend primarily on the type of membrane and its specific application. Capital costs for all types of microfiltration are $5000–$40,000 per unit, while operating costs are $0.5–$4 per thousand gallons of permeate.

Electrical requirements depend on the type of application, membrane, area, permeability, temperature, pressure, and feed flow rate. Electricity is required for pumping water through the system. Units ranging in size from 0.1–5.0 gallons per minute (gpm) require 4–10 kW of electricity. Therefore, the electrical requirement for a microfiltration unit would be 1.2–3.0 kWh per 100 gallons of permeate.

Heat Pump Water Heater

Basic Principle

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



Heat Pump Water Heater System Configuration

Applications

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

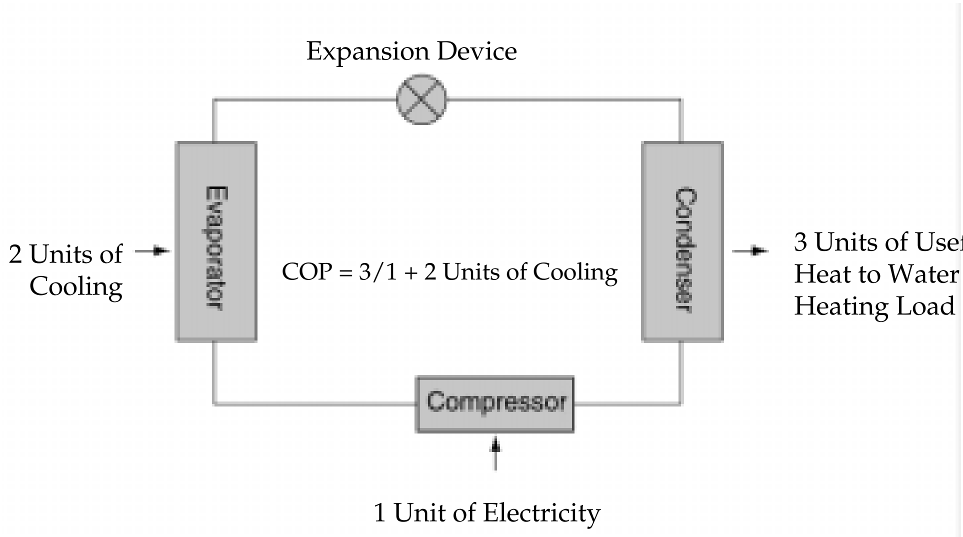
HPWHs are normally applied in conjunction with conventional water heating systems. In these applications, the HPWH is sized to serve the average water heating load and the conventional system augments the supply, as needed, during periods of greatest hot water demand. In contrast to conventional systems,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

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

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

System Description

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



Heat Pump Water Heater Performance Cycle

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

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

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.

Heat Pump Water Heater System Characteristics

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

Commercial Status

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

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.

EPRI Information

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

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

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

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

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

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) fabricare 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.

Refrigerated Condensers

Equipment Suppliers

Doucette Industries, Inc.
Grantley & King Mill Rd., P.O. Box 2337, York, PA 17405-2337
(800) 382-3812, fax: (717) 845-2864

Flakice Corp.
60 Liberty St., Metuchen, NJ 08840
(908) 494-1070, fax: (908) 494-1079

Hercules Machinery Sales, Inc.
3188 Lawson Blvd., Oceanside, NY 11572
(516) 766-8400, fax: (516) 766-3230

Kleen-Rite, Inc.
4444 Gustine Ave., St. Louis, MO 63116
(314) 353-1712, fax: (314) 353-5340

Super Radiation Coils
6716 Walker St., Minneapolis, MN 55426
(800) 880-9317, fax: (800) 903-8324

Wetcleaning

Equipment Suppliers

Aero-Tech Direct
290 NE 68th St., Miami, FL 33138
(800) 746-4583, fax: (305) 751-8390

Aqua Clean Systems, Inc./Wascomat
469 Doughty Blvd., P.O. Box 960338, Inwood, NY 11096-4204
(516) 371-4513, fax: (516) 371-4204

IPSO USA, Inc.
7455A New Bridge Rd., Hanover, MD 21076
(800) 872-4776, fax: (410) 850-5959

J & B Enterprises
P.O. Box 671153, Dallas, TX 75367
(972) 231-9224, fax: (972) 238-1926

Marvel MFG. Co.
5922 San Pedro Ave., San Antonio, TX 78212
(210) 344-8551, fax: (210) 344-3004

Pellerin Milnor Corp.
P.O. Box 400, Kenner, LA 70063
(504) 467-9591, fax: (504) 468-3094

Royaltone Co., Inc.
P.O. Box 35949, Tulsa, OK 74153
(800) 331-5506, (918) 622-6677, fax: (918) 665-6017

Ozonated Laundering

Equipment Suppliers

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

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

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

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

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

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

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

Microfiltration

Equipment Suppliers

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

EPOC
3065 N. Sunnyside Fresno, CA 93727
(209) 291-8144, fax: (209) 291-4926

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

544 E. Eisenhower Parkway, Suite 150, Ann Arbor, MI 48108
(313) 761-3836, fax: (313) 761-3844

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

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

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

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

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

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

Heat Pump Water Heater

Equipment Suppliers

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

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

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

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

Econar Energy Systems Corporation
33 W. 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 St., Gainesville, GA 30501
(404) 534-5971, fax: (404) 534-3410

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

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.

Energy-Efficient Lighting

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

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

Electronic Ballasts, BR-101886, May 1993.

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

Lighting Fundamentals Handbook, TR-101710, March 1993.

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

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

Heat Recovery

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

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

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

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

Information on heat recovery for water heating and other water heating technologies is available from the EPRI Water Heating Information Office, (404) 874-9563.

Horizontal-Axis Washer

EPRI Tumble-Action Washer, VT-106517, 1996.

Horizontal-Axis Residential Washing Machine, TB-105962, December 1995.

Information on horizontal-axis washers can be obtained from John Kesselring, manager of the EPRI Laundry Products Initiative, (415) 855-2902.

Trade Associations

Cleaning Equipment Manufacturers Association
111 E. Wacker Dr. Suite 600, Chicago, IL 60601
(312) 644-6610

Members are manufacturers of powered cleaning systems and their components.

International Drycleaners Congress
Box I, Cupertino, CA 95015
(408) 252-1746, fax: (408) 252-5951

Members are fabricare industry leaders.

International Fabricare Institute
12251 Tech Rd., Silver Spring, MD 20904
(301) 622-1900, fax: (301) 236-9320

Members are drycleaners and launderers.

Multi-Housing Laundry Association
4101 Lake Boone Trail Suite 201, Raleigh, NC 27607
(919) 821-1435, fax: (919) 839-0633

Formerly the National Association of Coin Laundry Equipment Operators.

National Association of Institutional Linen Management
2130 Lexington Rd., Suite H, Richmond, KY 40475
(606) 624-0177

Members are linen service employees in hospitals, hotels/motels, correctional facilities, and nursing homes.

Neighborhood Cleaners Association
252 W. 29th St., 2nd Floor, New York, NY 10001-5201
(212) 967-3002, fax: (212) 967-2240

Members are drycleaners and launderers.

Uniform and Textile Service Association
1300 N. 17th St., Suite 750, Arlington, VA 22209
(202) 296-6744, fax: (202) 296-2309

Members are companies renting and cleaning work uniforms, gloves, mats, towels, etc. Formerly the Institute of Industrial Launderers.