A small-business guide

Printers

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REPORT SUMMARY

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

Background

Members of the Small-business community historically have had little contact with their energy providers. These guides were developed to facilitate communities.

Objective

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

Approach

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

Results

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

Volume 1: Wholesale Bakeries

Volume 2: Auto Body Shops

Volume 3: Lodging

Volume 4: Medical Clinics

Volume 5: Drycleaners and Launderers

Volume 6: Metal Finishers

Volume 7: Shopping Centers

Volume 8: Convenience and Grocery Stores

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

EPRI Perspective

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

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

TR-106676, Volume 9

Interest Categories

Commercial building systems and analysis tools:

Commercial appliances

Product and Service design

Marketing

Key Words

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Lighting

Appliances

Building systems

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

ABOUT THIS GUIDE

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

The *Printers* guide is intended to familiarize readers with the business of owning and/or operating a commercial print shop by providing descriptions of basic processes and practices and summaries of the issues and challenges faced by printers. It focuses on delineating how electric equipment can address the needs and interests of print shop owners and managers.

This business guide is one of a series of publications produced by EPRI abut small businesses. The *Printers* 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 printing industry of the 1990s bears the hallmarks of its fifteenth-century beginning and the trademarks of the present computer age. The influence of the computer is mixed: some new electronic technologies significantly improve the efficiency and quality of conventional printing practices; others replace several applications of conventional printing.

Given the information-dependent, service-dominated U.S. economy, however, conventional printing is far obsolete. Despite the advent of CD-ROM and the Internet, the industry's value of shipments grew 23% from 1987 to 1993, and the Department of Commerce expects the printing industry to continue to expand, projecting an average 3.8-5.3% annual growth through 2000.

While printers may enjoy an eager market, they face increasing market demands for faster procedures, lower prices, smaller print runs, and higher-quality reproductions. Environmental regulations pose a separate and significant set of challenges because the printing process can generate volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions, heavy metal-bearing wastewater, and solvent-and metal-containing waste inks.

To keep pace with the current business world and comply with new environmental regulations, print shop owners and operators are seeking tools and procedures that will allow them to reduce operating costs; improve productivity, flexibility, and product quality; reduce VOC and HAP emissions; and control hazardous waste generation and disposal. The accompanying table identifies electrotechnologies that address these print shop concerns. These electrotechnologies and other high-efficiency electric technologies are described in the *Printers* guide (EPRI TR-106676-V9), copies of which are available from the EPRI Distribution Center. To order this publication or other guides in the series, call the Center at (510) 934-4212.

Electrotechnologies for Printers

	Ultraviolet Curing	**Electric IR Drying & Curing**	**Electrolytic Recovery of Silver**	**Membrane Filtration**	**Electric Desiccant Dehumidification**	**Outdoor Lighting**
Description	Ultraviolet (UV) light emitted from a bank of lamps triggers a chemical reaction that nearly instantly dries radiation-curable inks.	Quartz lamps and reflectors direct infrared (IR) radiation at an inked surface; heat is generated within the ink, providing extremely quick, non-blister drying.	Electrolysis strips film processing and/or platemaking wastewater of dissolved silver (or other heavy metal) ions by passing an electric current through the wastewater, causing the ions to deposit on cathodes as a solid metal.	Electric pumps force wastewater through a permeable barrier that filters contaminants; ultrafiltration filters out particles that are larger than 0.001 micron but smaller than 0.1 micron.	Desiccants are compounds that adsorb or adsorb water from the air; to dehumidify indoor air; a humid air-stream is passed through a desiccant, returning dry air to the facility and venting moist air to the rooftop.	Six types of lighting technolo-gies are available. Each offers different characteris-tics in wattage, brightness light tone, efficiency, and life span; they can be combined to meet site-specific needs.
Printer Need	Solvent-based inks emit contaminating VOCs and HAPs during the drying process; methods for drying alternative, solvent-free inks are needed.	Easy-to-operate technologies are needed for drying low- and no-solvent inks.	Printers in some locations need to recover silver and/or other heavy metals from wastewater prior to discharge to reduce contamination and disposal costs; the material can potentially be sold to a metal reclaimer.	Printers need to reduce operating costs, including those related to the purchase of chemicals and water and the disposal of wastewater.	Dehumidification is needed because high indoor humidity and high moisture content in paper tends to retard ink penetration and lengthen the drying time of printed materials.	Lighting improves the visibility and attractive-ness of a facility, reduces the potential for crime, increasees employee safety.

Electrotechnologies for Printers (Cont.)

	Ultraviolet Curing	**Electric IR Drying & Curing**	**Electrolytic Recovery of Silver**	**Membrane Filtration**	**Electric Desiccant Dehumidification**	**Outdoor Lighting**
Application	UV light can dry UV-curable inks on all types of substrates. UV systems are most commonly used in conjunction with gravure printing of packaging and labels.	IR drying works with both oil-based and water-based inks. IR systems are most commonly used in conjunction with wed press printing of packaging and labels.	Electrolysis is effective for reclaiming dissolved silver from the image-processing step of printing and for recovering heavy metals from platemaking wastewater.	Recovers the wastewater generated when using light-sensitive photopoly-mer coating to make plates for lithographic, flexographic, or letterpress printing.	Dehumidifies the press room and other humidity-sensitive areas, such as the paper storage area.	Lighting on signs on or near a facility; in parking lots, walkways, and delivery areas; and on the building façade and in the landscape.
Benefits	Eliminates hazardous emissions, increases productivity through faster drying, requires minimal floor space, and provides exceptional performance in terms of color density and gloss.	Provides consistently high quality results in 50-80% less time than natural gas drying ovens; reduces requirements for ventilation and floor space.	Recovers heavy metals in a reusable form, reduces the volume of hazardous waste, improves rinse quality and life, and reduces overall process water use.	Produces treated water that is clean enough for reuse on-site or for discharge; recovered polymers also can be reused.	Desiccant systems remove ambient moisture without overcooling, improving the efficiency of printing operations without causing discomfort for employees.	Increased public perception of quality, goodwill, and success from general and facade lighting; reduced accidents, injuries, and crime from area lighting.
Cost	A typical small system costs $1000-$5500 and consumes 120-600 watts per inch of process line; a fully automatic system costs $8000-$60,000 and consumes 200-800 watts per inch.	A small panel heater costs $1000-$2500; a large, custom-designed oven, $10,000-$250,000. Units use 8-15 kW per square foot.	Systems costs $1300-$60,000, depending on size and manual versus automatic operation; the energy consumption is 0.01-0.6 kWh per troy ounce.	For systems processing 0.1-10.0 gallons per minute, the purchase cost is $5000-$130,000; the operating cosst is $0.05-$0.40 per 100 gallons.	The capital cost for a desiccant dehumidification system is $4-$7 per cubic foot per minute of airflow rate; the operating cost is $0.23-$0.40 per hour, plus an additional cost for desiccant regeneration energy.	Systems are custom-designed to meet a facility's needs and budget.

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1

INTRODUCTION TO THE PRINTING INDUSTRY

Modern printing methods had their genesis in the early 1400s when a German publisher invented movable metal type based on alphabetic characters. The printing process has evolved significantly since then: cylinders replaced flat printing plates in the early 1800s, rotary technology vastly improved the speed of printing in the 1860s, and photographic typesetting improved image resolution in the 1940s.

Business Overview

Today, computers are revolutionizing the printing industry. They have enhanced printing speed and efficiency and reduced waste by allowing printers to complete many prepress activities electronically (e.g., using desktop publishing software and digital scanners), and by allowing the direct digital transfer of documents from image to printing plate, or from image to press. On the other hand, computers also present a competitive threat by offering customers alternative formats for publishing documents (e.g., CD-ROM, Internet), formats that do not involve printing at all and that enable updating of information quickly, easily, and often at lower cost.

Changes in the market for printed material are also influencing the printing industry. "Just-in-time" inventory systems, the greater precision with which companies can now target their advertising, and the evolution of graphic design have increased requests for shorter, more numerous press runs, and more colorful, eye-catching final products. To compete effectively in this demanding market, the printing industry is striving to reduce setup times and increase press speeds, as well as improve color reproduction to ensure unsurpassable quality.

In addition, printers face the challenge of complying with environmental regulations. The printing process typically generates volatile organic compounds (regulated by the Clean Air Act Amendments), silver-containing wastewater (regulated by the Clean Water Act), and waste inks that may contain solvents and heavy metals (regulated as hazardous waste by the Resource Conservation and Recovery Act).

Commercial printers (Standard Industrial Classification [SIC] code 275) are engaged in printing a variety of products—bags, catalogs, currency, labels, stationery, books, and magazines—for other businesses. (Other printing establishments in the broader classification of SIC 27 publish and print their own products.) The commercial printing segment is composed of three categories of printers: lithographic printers (SIC 2752), gravure printers (SIC 2754), and other types of commercial printers, not elsewhere classified (SIC 2759). Lithographic printers photographically create images on zinc, aluminum, or paper plates using a medium that accepts ink and repels water; gravure printers etch images into plates, creating tiny depressions that hold ink. The third category of printers includes flexographic, letterpress, and screen printers, as well as engravers and thermographers. Photocopying and duplicating services (SIC 7334) are considered retail services and are not included in this classification.

According to the U.S. Department of Commerce, there were nearly 37,000 commercial print shop establishments in 1993, employing more than 570,000 people and shipping goods valued at more than $58 billion (see Table 1). (These statistics do not include packaging, textile, and electronics manufacturing companies that perform printing as secondary parts of their businesses.)

With 94% of the establishments employing fewer than 50 people and more than 97% employing fewer than 100 people, commercial printing represents the largest conglomeration of small businesses in the domestic manufacturing sector (see Table 2).

Table 1
Profile of the Commercial Printing Industry (1993)

Segment	No. of Establishments	No. of Employees	Value of Shipments ($billion)
Commercial Printing, Lithographic (SIC 2752)	27,996	437,600	44.7
Commercial Printing, Gravure (SIC 2754)	440	21,500	3.5
Commercial Printing, NEC (SIC 2759)	8,527	112,700	10.0
TOTAL	36,963	571,800	58.2

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns 1992—United States*, (CD-CBP-92), 1994, and *County Business Patterns 1993—United States*, (CD-CBP-93), 1995; and Gale Research, *Manufacturing U.S.A.:A Ward's Business Directory, Fourth Edition*, 1994.

The commercial printing industry grew just 2% in the period 1987–1993, from 36,100 establishments to 36,963 establishments. Although industry employment rose in the late 1980s, it is now just 3% higher than it was in 1987. The industry value of shipments, on the other hand, has increased significantly to $58 billion, a 23% increase over the 1987 level. According to the Department of Commerce, the printing industry is expected to grow an average of 3.8–5.3% annually through 2000; particularly strong growth is expected in advertising (8–9%), free circulation newspapers (8–9%), and direct-mail products (5–6%).

Because printing is fundamental to so many industries and services, printing establishments can be found in virtually every city and county throughout the United States. Most printers serve local and regional markets, although some have national and even international clientele. In 1993, the largest concentrations of commercial print shops were in California and New York, which host 13% and 7% of the industry, respectively. Texas, Florida, Illinois, Ohio, Pennsylvania, and New Jersey each represented approximately 4–6% of the industry. Rounding out the top 10 states were Michigan and Georgia, each with approximately 3% of the commercial printing business.

Table 2
Distribution of Commercial Printers by Size (1993)

Segment	Printers by Number of Employees						
	Small (0-49)		Medium (50-99)		Large (100+)		
	No.	% of Total	No.	% of Total	No.	% of Total	Total
Commercial Printing, Lithographers (SIC 2752)	26,321	94	930	3	745	3	27,996
Commercial Printing, Gravure (SIC 2754)	375	85	21	5	44	10	440
Commercial Printing, NEC (SIC 2759)	8,078	95	295	3	154	2	8,527
TOTAL	34,774	94	1,246	3	943	3	36,963

Source: U.S. Department of Commerce, Bureau of the Census, *County Business Patterns 1993—United States*, (CD-CBP-93), September 1995.

Commercial printers typically use one or more of five basic types of printing processes: lithography, gravure, flexography, letterpress, and screen printing. These processes differ in the way they carry an image (e.g., via plate, cylinder, or screen) and the way they transfer an image to a substrate (e.g., directly or indirectly). Indirect (offset) printing, such as lithography, transfers the image from an image carrier to a blanket cylinder and then to the substrate. Direct printing transfers the image directly from the image carrier to the substrate. Substrates include paper and plastic.

Commercial printing processes are also categorized by the type of press and form of paper or other substrate they use in the press. Web presses print images on a continuous roll or "web" of paper. After printing, the roll is cut and trimmed to the required size. This type of press is generally used for larger print runs. Sheet-fed presses print images on individual sheets of paper or other substrates.

Lithography. Originally developed in the late 1700s, lithography—or offset printing—is the dominant printing process today, capturing nearly 50% of the market for printing (see Figure 2). Offset printing is favored because the presses are relatively fast and inexpensive compared to other types of presses. Lithographic plates are referred to as planographic; the image and nonimage areas are on the same plane, neither raised nor depressed. Most lithographic printing is done on a rotary press, either sheet-fed or web-fed. Due to an increase in press speeds and improved image resolution achieved throughout the twentieth century, offset rotary web presses are available that can produce up to 40,000 impressions per hour. More than 90% of lithographic presses are sheet-fed; these are used for books, posters, labels, packaging, advertising flyers, brochures, and periodicals. The remaining 10% are web presses and are used for periodicals, newspapers, advertising, books, catalogues, and business forms. Estimates of the U.S. Environmental Protection Agency (EPA) suggest that lithography's share of the printing market will drop to 35% by 2025 due to competition from flexography and plateless printing, which are less expensive processes.

States	Facilities
CA	4891
TX	2410
OH	1627
MI	1210
IL	2125
NY	2595
PA	1527
FL	2153
NJ	1455
GA	1008

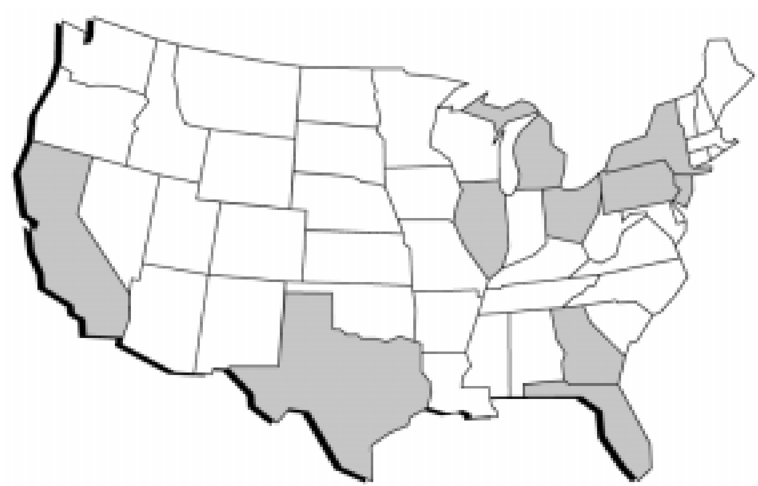


Figure 1
Top 10 States for Print Shops (1993)

Gravure. Gravure is an intaglio process in which the image area is recessed and the non-printing area is at a consistent surface level. This type of printing was developed in the fifteenth century when images were carved or engraved in stone or metal. Gravure printing currently holds 19% of the commercial printing market. It is typically used for large-volume, high-speed runs of high-quality color publications, such as magazines, catalogs, and advertising. It is also used to print large volumes of flexible packaging, paperboard boxes, and labels. Gravure printing can produce millions of impressions without image deterioration and can print glossy ink effectively. Its disadvantages include higher plate and/or cylinder cost and longer press setup times. Due to the size and complexity of gravure presses, they are also more expensive than lithographic presses; a gravure press costs $10 million, compared to $1 million for a lithographic press. By 2025, gravure's share of the printing market is expected to decline slightly to 16%.

Flexography. Flexographic printing—which holds 17% of the industry market share—is a relief printing process in which the image is raised above the nonimage areas. This process uses a flexible plastic or rubber plate in a rotary web press; it is used primarily for printing packaging or decorative items, such as plastic wrappers, corrugated boxes, milk cartons, shower curtains, foil, and paper bags. Other products include directories, newspaper inserts, and catalogs. Flexography works well for printing a large, solid surface area, and can achieve a glossy surface on many substrates. Due to the increasing volume of packaged products and directories, and the fact that the process is less expensive than many other printing processes, flexography is being used more and is expected to hold 21% of the market by 2025.

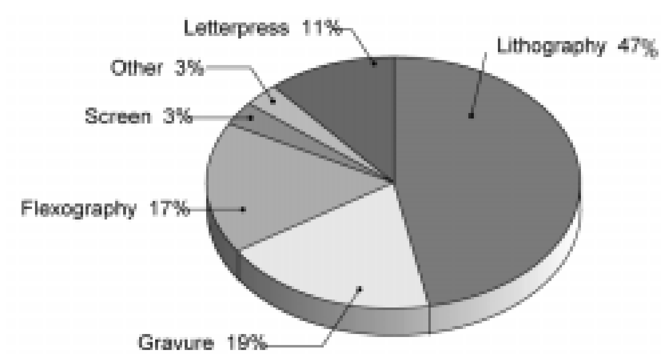


Figure 2
Market Use of Printing Processes

Letterpress. Like flexography, the letterpress process is also a relief (raised impression) process, but the plates are metal instead of rubber or plastic. Prior to the development of lithography in the late 1700s, letterpress was the most common printing process. Sheet-fed letterpress is currently used for books, stationery, announcements, business cards, and advertising brochures. It is especially useful for printing price lists, parts lists, and directories since changes can be made to a section of a plate without having to redo the entire plate. Web letterpress is also commonly used to print newspapers and magazines. Letterpress held just 11% of the market in 1992 and is continuing to lose market share to gravure and flexography, printing processes that are faster and less expensive, respectively. Letterpress printing is expected to maintain only 4% of the market by 2025.

Screen. In the screen printing process, ink is applied to a porous screen (sometimes silk) that carries a resistive image. The technique works on almost any substrate and is used primarily for specialty printing, such as T-shirts, posters, billboards, banners, decals, and wallpaper. It is also used to print patterns on electronic circuit boards before etching. This process now represents just 3% of the market, and its use is expected to show little or no growth by 2025.

Other. The other common types of commercial printing include thermography (primarily used for business cards and stationery), engraving, embossing, and plateless or non-impact printing.

Printing Operations

The printing process transfers ink impressions to a substrate, either paper, wood, fabric, plastic, glass, or metal. As shown in Figure 3, the process has three major phases (prepress, press, and postpress) and five steps (image processing, platemaking, makeready, printing, and finishing). During the prepress phase, an image is created photographically (image processing), and the image is transferred to an image carrier (plate, cylinder, or screen) using photoprocessing chemicals and solutions (platemaking). In the press phase, inks and organic solvents are used in transferring images from the plate, cylinder, or screen onto the substrate. The postpress phase includes the binding and finishing operations necessary to assemble the printed materials into a final product (e.g., an advertising brochure).

Image Processing. The first step in the printing process is to arrange and photograph the artwork, text, or copy to produce negatives. The negatives are then developed using developers, fixers, and rinses, just like photographic film; chemical reducers and intensifiers can also be used to change the image contrast on the film. The lithographic and letterpress processes use the negative to transfer the image to the plate. Gravure, screen printing, and some lithographic processes use the positive, which requires development of the film. Once the film is developed, a proof is made and compared with the original material; if necessary, the film is adjusted.

Platemaking. In platemaking, the image is transferred to an image carrier. In the actual printing process, the image carrier (plate, cylinder, or screen) accepts ink from a roller and transfers the image to a rubber blanket (which then transfers it to the substrate), or transfers it directly to the substrate. The image carrier determines the type of press used, the type of ink used, the number of impressions that can be printed, the speed with which they are printed, and the characteristics of the image. Each printing type uses a different image carrier.

- Lithographic Plates. Lithographic plates are produced photomechanically; light-sensitive coatings are exposed to light to create an image on a plate after processing and exposure to light. Both the image (ink-receptive) and nonimage (ink-resistant) areas are on the same plane.

- Gravure Cylinders. Rather than using plates, gravure printing uses steel cylinders plated with copper. The cylinders are either engraved with a diamond stylus or chemically etched using ferric chloride in an operation analogous to the manufacture of printed circuit boards.
- Letterpress and Flexographic Relief Plates. Letterpress and flexographic relief plates are typically made of zinc; a light-sensitive coating of polyvinyl alcohol captures the image. The images are raised from the plate surface, and only the raised portions come into contact with the ink rollers.
- Screen Printing Image Carrier. Screen printing uses a tightly woven fabric screen to carry an image. The image—a stencil or mask—is adhered to the screen and resists the ink. The image areas are handmade or manufactured from photographic film.

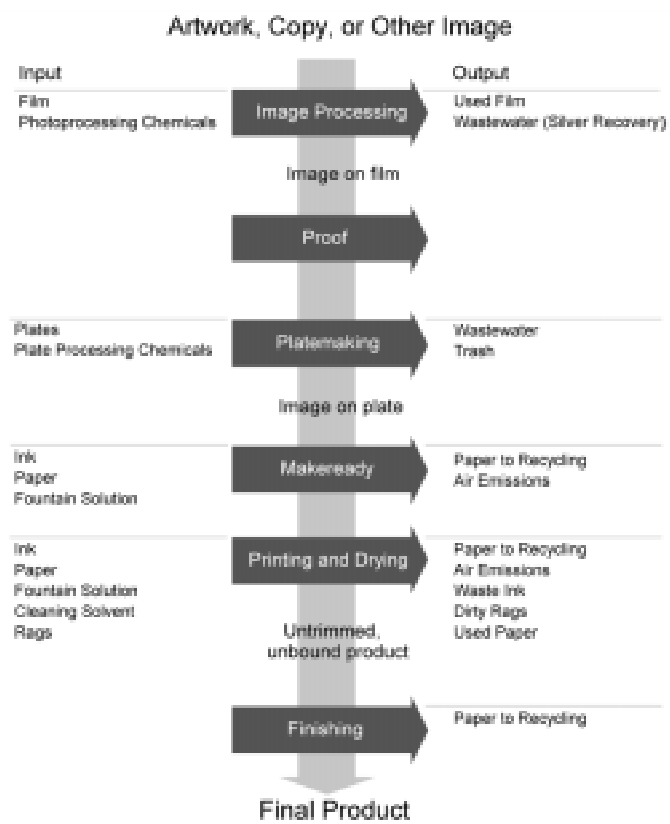


Figure 3
The Lithographic Printing Process

M akeready. Makeready involves printing a test product and making adjustments to the press and to the ink density to achieve the best possible reproduction. A print shop's objective in this step is to minimize the time involved and the amount of waste paper coming off the press.

Printing. Once the press has been adjusted, the actual printing can begin. The initial step is to attach the plate to the plate cylinder of the press; virtually all presses print from a plate cylinder. Ink is then applied to the plate, transferred to a rubber blanket, then to the substrate. The substrate, fed through the process by rollers, accepts the ink, thereby reproducing the image. The printing operation is generally the same for all major types of printing, except screen printing. Sheet-fed presses can print up to 10,800 impressions per hour; web presses can print up to 40,000 impressions per hour. A printing press has separate units for each color it prints. To print in full color, four separate units are required (magenta, cyan, yellow, and black), or what is known as a "four-color press."

In lithographic printing, a water-based dampening solution (known as a "fountain solution"), followed by an oil-based ink, is transferred to a plate's image area as the cylinder rotates. The image repels the solution and accepts the ink, while the nonimage areas accept the solution and repel the ink. The cylinder continues to rotate until the inked image is transferred to a blanket and then onto a substrate. Some inks need drying after printing; in lithography, both heat-set and non-heat-set inks are used. With heat-set inks, the substrate passes through a tunnel or floater dryer that uses hot air, direct flame, or a combination of both to dry the ink. With non-heat-set inks, the ink dries by adsorption.

In gravure printing, the cylinder is placed in the press and partially immersed in an ink bath or fountain. Solvent is added to the ink to maintain the proper viscosity level. As the cylinder rotates, the surface of the cylinder is coated with ink. A metal wiper ("doctor blade") moves along the surface of the cylinder to remove ink from the non-etched (non-image) areas. The substrate is then pressed against the rotating cylinder, and the ink is transferred. Gravure printing uses solvent-containing inks that dry by evaporation.

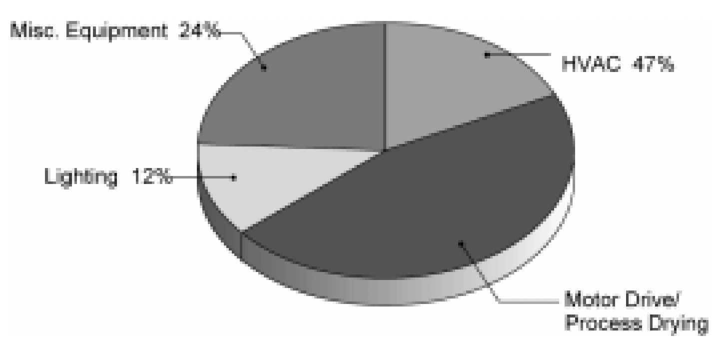


Figure 4
Typical Electricity Use in Print Shops

Finishing. The finishing step involves cutting, folding, collating, laminating, and/or binding to produce the final product. All finishing can be done by a print shop, although binding is typically done by a book binder (SIC 2789).

Energy Use

According to the U.S. Department of Energy, the printing industry (SIC 27) consumed 108 trillion Btu of energy in 1991. This represents a decrease of 8 trillion Btu since 1988 (even though industry shipments were increasing), presumably due to adoption of energy-efficient processes and technologies. SIC 27 includes commercial printers (SIC 275) as well as eight other categories of printers, such as manufacturer-publishers of newspapers, books, periodicals, business forms, and greeting cards. Roughly 50% of the energy used in 1991 was provided by electricity. Industry natural gas use totaled 48 trillion Btu, or 44% of total energy use, and was used primarily for process steam, space heating, and drying and curing of inks. The remaining 6% of the energy consumed was generated from other fuels, such as fuel oil, liquefied petroleum gas, and waste fuels (mostly paper products).

Data from the U.S. Department of Commerce (DOC) indicate that more than 46% of the 15.6 billion kWh of electricity used in the printing industry in 1991 was used in the printing process itself—primarily for driving the platemaking, printing, and finishing equipment, and for process drying. Miscellaneous equipment, such as wastewater treatment and solvent recovery equipment, represented about 24% of all electricity used by printers. Heating, ventilation, and air conditioning (HVAC) accounted for 18% of electricity use; lighting accounted for the remaining 12%.

Of the total 15.6 billion kWh, commercial print shops (SIC 275) consumed more than 9 billion kWh, at a cost of over $500 million in 1991, making it the largest consumer of electricity in SIC 27.

Overall, however, in comparison to other manufacturing sectors, the printing industry as a whole is not a heavy energy user, in terms of both energy consumption and net electricity consumption (purchases plus generation minus quantities sold). DOC data show that in 1992, electricity represented only 2.3% of total material costs for the printing industry. As a result, printers tend to be concerned with energy costs and efficiency improvements only if such improvements can also affect shop productivity, product quality, or help comply with environmental regulations.

2

BUSINESS CHALLENGES AND NEEDS

The magnitude of a community's need for printing services is determined by a number of factors, including economic activity, population growth, and the population's level of educational attainment. The local economic activity determines the number of business formations and transactions, advertising expenditures, financial market activity, disposable personal income, and the availability of leisure time. From 1987 to 1991, the industry as a whole experienced lower profit margins and heightened competition as a result of the general economic slowdown. Economic recovery in 1993 and 1994 reversed this trend. The continued favorable performance of the U.S. economy, combined with an increase in the number of households and school-age children, suggests industry growth in the near future.

Competition

While the country's recent economic recovery and positive demographic situation provide promise for the printing industry's future, there are also strong countervailing trends—fueled by intra-industry competition as well as competition from electronic media and high-quality copying—that pose potential obstacles. For example, many information providers are beginning to offer diskette and CD-ROM versions of previously print-only materials, such as directories and manuals. Although the printed versions of these materials have not been eliminated completely, they are printed less frequently, with the majority of updates provided electronically.

Printers also face competition from non-conventional types of printing. Convenience or "quick printers" are exerting a growing influence on commercial printers. The distinguishing feature of a quick printer is not use of a certain technology, but commitment to a quick turnaround time. Quick printers traditionally use xerographic reproduction, although some also employ small sheet-fed lithographic presses. While small- to medium-size commercial printers typically utilize high-quality equipment and offer higher-quality service, cost-conscious consumers and the desire for quick turnaround have helped to increase the market for quick printing services, especially for low-end color printing. The development of color copiers has placed convenience printers in direct competition with sheet-fed, offset printers for small runs of up to 5000 copies. As a result, it is a business priority for most commercial printers to achieve faster presses, shorter setup times, improved color rendition, and better materials handling procedures. Printers want to reduce operating costs and improve productivity, flexibility, and product quality.

One important aspect of operating costs is environmental regulations. From issues of paper recycling and emissions of volatile organic compounds (VOCs) to wastewater discharge and hazardous waste generation, the printing industry is closely scrutinized by environmental agencies. Environmental regulations established during the 1970s and 1980s have already dramatically altered the cost structure of many print shops. In 1991, businesses in SIC 27, the printing industry, spent over $265 million on pollution abatement. As environmental regulations continue to mount—new federal hazardous air pollutant regulations were finalized by the EPA in May 1996—printers must find innovative and cost-effective solutions to their environmental dilemmas or run the risk of increased operating costs.

Need

Reduce Operating Costs

Reducing raw material purchases, labor, and waste disposal costs can help a print shop reduce its overall operating costs. This, in turn, can help a shop compete more effectively with rival printers and against other media. There are opportunities to reduce operating costs in most areas of the printing process, from image processing to finishing. For example, recycling waste ink to make black ink can reduce raw material purchases and waste disposal costs.

Technology Solutions

One way to reduce operating costs is to reduce electricity use. Technologies such as adjustable speed drives and energy-efficient electric motors, HVAC, and indoor and outdoor lighting technologies, can help a print shop accomplish this. Other technologies can help reduce other operating costs. For example, centrifugal extraction of solvent from shop rags is helping very large print shops to reduce the costs associated with shop rag disposal and solvent purchase. Ultrafiltration of platemaking wastewater, on the other hand, can allow printers to recycle water, reducing water costs and the costs associated with wastewater disposal.

See pages 3-3, 3-5, 3-7

Need

Improve Productivity, Flexibility, and Product Quality

Commercial printers are finding that their business customers are now holding a smaller inventory of goods in their businesses and have the ability to target advertising with greater precision. This has resulted in a demand for shorter, more numerous press runs to produce multiple versions of catalogs and demographically customized editions of magazines. This trend has reduced gravure printing's long-held dominance in printing of catalogs and directories, and has increased competition from other types of commercial printers.

Automation has also become important as press speeds have increased. Industry advances include automatic feeding of paper into a press; automatic removal of printed materials from a press; and automatic monitoring and adjusting of plate registration (how separate colors of a multicolor job are aligned), web tension, and color integrity throughout a press run. In combination, these advances allow a printer to achieve optimal product quality at a faster rate. The industry is also moving toward the use of more color. By upgrading from four-color to six- and eight-color presses, printers can better match distinctive colors and take advantage of special effects such as metallic inks.

Technology Solutions

Printers can further improve productivity, flexibility, and product quality through the use of ultraviolet (UV) curing and infrared (IR) drying. Both technologies significantly reduce ink drying time and save space when compared to air drying or conventional drying in a natural gas oven. Electron-beam curing is an emerging electrotechnology that is currently used by only the largest printers due to its high initial cost. Energy-efficient indoor lighting can improve brightness and reduce glare, and potentially improve employee productivity by reducing headaches and eye fatigue. Closer control of humidity levels by using humidification, dehumidification, or desiccant dehumidification equipment can also significantly improve the quality of printed products and potentially speed the ink drying process.

See pages 3-4, 3-5, 3-9, 3-10

Environmental Regulations

Environmental concerns have fueled numerous changes within the printing industry. The printing process generates not only solid wastes, but hazardous solid and liquid wastes and air pollutants. The printing industry is regulated by the Clean Air Act Amendments (CAAA), the Clean Water Act (CWA), and the Resource Conservation and Recovery Act (RCRA). Compliance with national, state, and local environmental regulations poses a costly challenge. By reducing air emissions and wastewater and hazardous waste, however, a print shop can reduce its disposal fees and related expenses for environmental compliance, create a safer workplace, and improve its corporate image.

Need

Reduce VOC Emissions

Title I of the CAAA of 1990 regulates emission of VOCs. Printers use many solvent-containing materials that evaporate as VOCs, which can be toxic and endanger worker health and safety. Inks are typically 25–45% solvents. Most of the solvent evaporates when an ink is heated while passing through a dryer, producing VOCs that are either captured and incinerated, recovered and recycled, or emitted to the air. Depending on its location (i.e., depending on local air quality control regulations), a print shop may be required to control and reduce its VOC emissions.

CAAA regulations requiring a reduction in VOC emissions have led to the use of several new compounds.

- Alternative Fountain Solutions and Press Cleaners. Some fountain solutions (used to dampen the nonprinting areas of the plate in offset lithography) contain the VOC isopropyl alcohol (IPA). In areas with strict regulations on VOC emissions, printers using IPA-containing solutions can be required to install air pollution control equipment. As a result, many printers are switching to fountain solutions that contain no or low concentrations of IPA. Conventional press-cleaning solvents (blanket washes) also contain VOCs, and no- and low-VOC blanket washes are becoming popular. Environmentally sound blanket washes are a focal point of the Environmental Protection Agency's Design for Environment Printing Project.
- Water-Based Inks. Water-based inks are composed of film-formers and pigments suspended in water. These inks are widely used in flexographic printing on paper and in gravure printing. Water-based inks are less expensive than solvent-based inks, do not require controls for air emissions, are less toxic to employees, and reduce waste ink disposal costs because they are usually classified as non hazardous. To their disadvantage, water-based inks require more energy to dry than solvent-based inks and can adhere to and dry out on the press, thus necessitating more frequent equipment cleaning. Other problems include low gloss and a relative tendency to make paper curl.
- Ultraviolet Inks. Inks curable by UV light consist of one or more monomers (simple molecules that can be combined to form a polymer) and a photosynthesizer that selectively absorbs energy. The inks contain no solvent and therefore generate no VOCs. UV-curable inks dry more quickly than conventional inks—but cure only upon exposure to UV light, not on the press or in the ink fountain overnight. In addition, UV curing does not heat the paper substrate above 932°F, forestalling shrinkage and/or curling.

Technology Solutions

UV curing and IR drying both speed the drying process while allowing the use of VOC-reduced or VOC-free inks. Electron-beam curing, an emerging electrotechnology, offers the same benefits, but its use is currently limited due to its high initial cost.

See page 3-5

Design for Environment Printing Project

The EPA's Design for Environment (DfE) program is helping a number of industries reduce the cost of hazardous waste disposal and the expense associated with regulatory compliance. The DfE Printing Project is a cooperative EPA-industry project information for small-and medium-sized print shops that do not have the time or resources to investigate technology options. The project makes available comparative printing methods. More specifically, the project focuses on three areas of environmental concern:

- Blanket washes in lithography
- Screen reclamation in screen printing
- Inks in flexography

For more information on the program, call the EPA's Pollution Prevention Clearinghouse at (703) 821-4800.

Need

Reduce Emissions of Hazardous Air Pollutants

Title III of the CAAA regulates the emission of 189 hazardous air pollutants (HAPs). In May 1996, the EPA finalized federal regulations that require print shops using wide-web (>18 inches in width) flexographic and gravure processes and that qualify as major sources of HAPs to control HAPs emitted from their presses. (Major sources of HAPs are shops that have the potential to emit more than 10 tons per year of any one HAP, or 25 tons per year of any combination of HAPs.) The organic HAPs typically found in printing inks and cleaning solvents include toluene, xylene, ethylene glycol, and hexane. All are regulated under Title III because they have the potential to cause reversible and irreversible adverse health effects.

The regulations are designed to reduce HAP emissions from gravure printers of publications by 30%, and emissions from gravure and wide-web flexographic printers of packaged products by 40%. This rule is expected to affect approximately 200 printing facilities nationwide, costing them $40 million on an annual basis and increasing product prices by an average of 1.5%. Most of these facilities are larger printing establishments rather than commercial print shops; the EPA has determined that the regulations will not force the closure of any small firms and will not have a significant economic impact on a substantial number of small firms.

The 1996 rule regulates HAP emissions from solvent storage tanks, ink-mixing operations, printing operations, press- and parts-cleaning operations, proof and production presses, and solvent recovery systems. Rather than promoting the use of “end-of-pipe” control technologies such as carbon adsorbers or catalytic oxidizers, the regulations instead encourage pollution prevention via the substitution of nontoxic chemicals for toxic ones. The print shops affected must reduce their HAP emissions to the regulated level by May 30, 1999. New sources must comply with the regulations upon startup.

Technology Solutions

Since most HAPs used by printers are also VOCs, most low-VOC products are also low-HAP products. As a result, technologies such as UV curing and IR drying will benefit print shops that want to reduce HAPs by switching to low-HAP inks (e.g., waterborne inks). Both UV and IR technologies have the added benefit of allowing printers to maintain or improve productivity because they dry low-HAP inks quickly.

See page 3-4

Need

Reduce the Silver Content of Wastewater

The CWA regulates the direct discharge of wastewater to waterways, and the indirect discharge to publicly owned treatment works (POTWs). Most print shops discharge to a POTW. In the image-processing step of the printing process, photoprocessing chemicals (such as the developer, fixer, and rinse water) become contaminated with silver, a toxic heavy metal, from photographic film and paper. Because print shop wastewater can contain silver or solvents, printers in some locations are required to pretreat their wastewater on-site before discharging it to a POTW. (In California, for example, silver-bearing wastewater is classified as hazardous if it contains more than 5 mg/l of silver.) If photographic process baths are discharged to the sewer, a permit from the local POTW is usually required. Regardless of location, every print shop must ensure that the concentration of silver in its wastewater is consistently below the limit established by its POTW.

CWA regulations have led to the use of technologies that minimize the amount of water used and discharged in printing and/or that can recover silver from wastewater.

- Waterless Lithographic Plates. In traditional lithography, water is used to dampen the plate and keep ink away from nonimage areas; however, dry lithography uses waterless lithographic plates that do not require dampening systems. While dry systems have achieved a higher product quality and can be operated more efficiently than conventional systems, they require special inks and plate materials that repel ink from non-image areas. They also require chilling of rollers on the press to remove the excess heat that is traditionally removed by water.
- Direct-to-Plate Technologies. These technologies, also known as computer-to-plate technologies, eliminate the film-making stage from the platemaking process. They transfer data directly from the computer to the plate, saving time and production costs by eliminating the generation of films, the processing of metal plates, and most important, the use of hazardous chemicals. In addition, higher product quality is achieved because the plate is a first-generation image. Examples of direct-to-plate technologies include laser platemakers, imagesetters, and platesetters. A laser platemaker can image paper, plastic, and polyester plates. Imagesetters and platesetters can image metal, paper, and polyester plates. The biggest drawback to a paper or polyester plate is limitation to a shorter print run (i.e., less than one million impressions); but given the trend toward shorter, more frequent press runs, this may soon cease to be a disadvantage. However, the technologies for laser platemaking and electronic imaging are costly.
- Plateless Printing Technologies. Advances in computer and laser technology have led to the development of various types of plateless printing processes, including xerography, laser printing, ink jet printing, magneto-graphy, thermal printing, ion deposition printing, and direct-charge deposition printing. These alternative printing methods are becoming an important force in the industry due to their ease of use and growing application in computer-controlled printing. The EPA estimated that these technologies had 3% of the market in 1991 and expects their use to grow quickly such that they will command a 21% market share by 2025.
- Silver Recovery from Photographic Wastewater. In some areas of the country, print shops are required to pretreat silver-bearing wastewater prior to release to a POTW. Because silver is also a valuable heavy metal, many printers reclaim and sell silver from their wastewater.

Technology Solutions

Printers can use electrolysis to remove silver from image processing wastewater. Electrolysis units can be installed on the fix bath of a photoprocessor to recover silver and extend the life of the fix bath, or on the first-rinse and developer waste stream to recover silver from the solution and reduce the toxicity of the wastewater.

Ultrafiltration can also be used to treat platemaking wastewater and recover water for reuse. This technology reduces the amount of water being used and the contaminant concentration in wastewater discharged to a POTW.

See page 3-6

Need

Reduce Hazardous Waste Generation

RCRA regulates the generation, storage, and disposal of hazardous and solid wastes. Printers use many hazardous chemicals and must dispose properly of waste inks and ink sludges that contain solvents or toxic heavy metal pigments. Other hazardous wastes include spent photographic developers and fixers, and cleaning solvents. Sludges and wastewater that contain heavy metal, silver, ink, and solvent are generally banned from municipal landfills.

RCRA regulations have led to the practice of recycling waste inks instead of discharging them to the sewer or having them picked up by a contractor licensed to dispose of hazardous waste. Ink recycling basically means blending inks of different colors to make black ink, as this is more practical than trying to regain the original color. However, the recycled black ink is relatively low quality, and consequently its use is commonly limited to newspaper printing. Small printers may find off-site recycling—by a large printer or an ink manufacturer—more economical. This practice enables a small printer to avoid the high cost of ink disposal. Larger printers can more easily recycle waste ink on-site, eliminating the expense of disposal and/or the purchase of new black ink.

Technology Solutions

Centrifugal extraction of solvent from rags allows printers to send otherwise toxic rags to the laundry and to recover solvent for later use in the printing process. While the initial cost of this procedure is too high for commercial printers at this time, the potential long-term savings can be extremely attractive to larger businesses with more capital.

See page 3-7

3

TECHNOLOGY SOLUTIONS

This section describes each of the technology solutions identified in the previous section. Each technology is summarized, linked by end-use application to a business need, and categorized as an “electrotechnology” or “efficiency technology.” Electrotechnologies are selected new or alternative electric equipment options. In many print shop applications, they can improve productivity, flexibility, and product quality; or control pollution; and may couple increased energy costs with an overall decrease in operating costs. Efficiency technologies, in contrast, offer opportunities to decrease energy use but have little or no direct impact on production. Also discussed are “emerging electrotechnologies,” electrotechnologies that are not currently in use in the industry but have the potential to meet a business need.

Each electrotechnology is more completely described in Section 4, Electrotechnology Profiles. Vendors of electrotechnologies, sources of information on efficiency technologies, and trade associations are listed in Section 5, Resources.

Technologies are grouped and discussed in this section by end use, beginning with “Process Equipment,” the end use that represents the greatest percentage of total printing industry electricity consumption. Table 3 summarizes the technology solutions.

Table 3
Technology Solutions to Commercial Print Shop Needs

			Business Needs		
End Use	**Solution Type**	**Technology Type**	**Reduce Operating Costs**	**Improve Productivity/ Flexibility/ Product Quality**	**Reduce VOC Emissions/ Control Waste Generation**
Process	Efficiency Technology	Energy-Efficient Electric Motors	■		
Process	Efficiency Technology	Adjustable Speed Drives	■	■	
Process	Electrotechnology	Ultraviolet Curing		■	■
Process	Electrotechnology	Electric IR Drying & Curing	■	■	■
Process	Emerging Electrotechnology	Electron-Beam Curing		■	■
Miscellaneous/ Waste Handling	Electrotechnology	Electrolytic Recovery of Silver	■		■
Miscellaneous/ Waste Handling	Electrotechnology	Membrane Filtration	■		■
Miscellaneous/ Waste Handling	Emerging Electrotechnology	Centrifugal Extraction of Solvent from Shop Rags	■		■
HVAC	Efficiency Technology	Humidification		■	
HVAC	Efficiency Technology	Dehumidification		■	
HVAC	Electrotechnology	Electric Desiccant Dehumidification		■	
Lighting	Efficiency Technology	Energy-Efficiency Indoor Lighting	■	■	
Lighting	Electrotechnology	Energy-Efficient Outdoor Lighting	■		

Process Equipment

Nearly half of the electricity used in the printing industry is consumed by motors that drive printing presses and other process equipment, and by process drying equipment. A number of electric-based technologies can help printers reduce the amount of electricity used by this equipment, thereby reducing operating costs while simultaneously improving productivity and product quality.

Printing Presses

Since motor-driven printing presses are the dominant electricity users in a print shop, motor efficiency significantly influences the overall energy efficiency of a facility. For this reason, printers should consider using energy-efficient electric motors and adjustable speed drives (ASDs) on presses and material handling equipment; ASDs can also improve process control.

Efficiency Technology Solution
Energy-Efficient Electric Motors

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

Efficiency Technology Solution
Adjustable Speed Drives

ASDs, also known as variable-speed drives, use solid-state electronics to vary the frequency of electricity applied to a motor. By reducing the frequency below the nominal 60 hertz, ASDs can efficiently reduce the speed or output of a motor, thereby eliminating energy use that otherwise would have been wasted. Prior to ASDs, operators used valves and dampers to throttle back the output of the motor. Today, ASDs can improve the control and energy efficiency of printing presses by, for example, reducing the amount of electrical energy going to the motor. ASDs can also be used on conveyors, compressors, pumps, fans, mailers, inserters, trimmers, HVAC equipment, chillers, recycling equipment, and finishing equipment. ASDs have been demonstrated to result in energy savings of 15–40% in such applications.

Process Drying

Once a print run leaves the printing press, the printed materials must be dried or cured. This is typically accomplished by allowing them to air dry, or by passing them through a natural-gas-fired convection oven. Air drying requires a large amount of space, takes a long time, and potentially allows airborne particles to settle into ink before it is dry. Natural-gas-fired convection ovens speed up the drying process compared to air drying, but they generate emissions of VOCs and combustion by-products such as carbon dioxide and nitrogen oxides.

The alternatives to conventional drying processes include UV, IR, and electron-beam curing of specialized inks. All three methods significantly speed the drying process compared to gas-fired convection ovens and allow the use of VOC-reduced or VOC-free inks. Given that the productivity of a print shop is highly dependent on the rate at which press runs can be completed, a decreased drying time can increase a print shop's productivity and enable it to improve its competitiveness. IR drying can reduce drying time from what would take minutes with a natural gas dryer to seconds with IR. UV curing solidifies ink almost instantly, providing even speedier drying time.

Electrotechnology Solution
Ultraviolet Curing

Oil-based printing inks are 25–45% ink oils, plus pigments, resins, and film-formers. The ink oils evaporate as VOCs when the printed material passes through a drying oven. The VOCs can be incinerated, recovered and recycled, or emitted to the air. UV-curable inks contain no solvents and emit no VOCs.

Instead, UV-curable inks contain photoinitiators. When UV radiation produced by a UV lamp strikes the ink, the photoinitiators absorb the light energy and become unstable, reacting with monomers in the ink and triggering polymer chain formation. The result is an almost instantaneous cure without the need for heat. UV curing of ink has a number of other advantages, such as no premature drying, exceptional performance in terms of color density and gloss, and compact equipment that allows economical use of floor space.

UV curing was introduced in the 1960s and until recently has been used by only a small percentage of print shops. Use of the technology is growing as its advantages become better recognized. The technology is applicable to all types of printing presses, including screen printing. It is most often used with web-fed presses and for high-quality sheet-fed package printing. The instantaneous curing allows the web to be further processed (e.g., printed with additional colors, stacked, cut, and folded) at press speeds without compromising product quality.

It is important to note, however, that the use of UV-curable inks alone may not bring a print shop into compliance with VOC regulations. Cleanup solvents and blanket washes also contribute to potential VOC emissions and must be handled appropriately.

Electrotechnology Solution
Electric IR Drying & Curing

Electric IR radiation is produced by heating an emitter of IR radiation. The system requires no special airflow for heat transfer because energy radiates directly to the inked surface without heating the air. IR drying is used for quick drying of either oil-based or water-based inks; it has a higher heat transfer rate than conventional gas ovens. The technology is appropriate for both multicolor offset and sheet-fed presses. By allowing the use of reduced- or non-solvent inks (which typically dry more slowly than solvent- or oil-based inks), the technology enables print shops to reduce or eliminate VOC emissions significantly. In addition, by localizing the origin of emissions, electric IR drying makes any VOC emissions relatively easy to capture.

The advantages of IR over conventional gas-fired ovens include improved energy efficiency, higher production rates, space savings, precise control, low maintenance, improved product quality with lower costs, and reduced environmental impact. As is true with UV curing, the use of IR technology is growing.

Emerging Electrotechnology Solution
Electron-Beam Curing

Similar to UV-curable inks, inks curable by electron beams require no solvents and use little energy—even less than UV curing systems. In electron-beam curing, electrons are generated by a hot filament and cathode and then accelerated by a high-voltage charge to produce a surge of high-energy electrons. These electrons are concentrated into a beam that is focused on the ink surface. Similar to UV curing, once the electrons strike the ink, they cause cross-linking reactions that immediately polymerize the ink. Electron-beam curing is typically used for opaque inks because the high-energy beam can penetrate the surface of the coating.

Electron-beam systems are enclosed to maintain an inert nitrogen atmosphere; they are shielded to protect the operator from potentially hazardous radiation. Due to the presently high capital cost of an electron-beam system, the technology is used in only high-volume web printing applications. The most common application is printing of food packaging, since electron-beam curable inks have minimal odor and transfer no odd flavors to the package contents.

Miscellaneous/Waste Handling

Nearly one-fourth of the electricity used in a print shop goes to the miscellaneous equipment used in wastewater treatment, space heating, and solvent recovery; emergency and computer power supply systems; plant indication and control equipment; and power supply systems for communication and instrumentation.

Wastewater Treatment

Two steps in the printing process—image processing and platemaking—generate wastewater. Because this wastewater typically contains solvents and heavy metals, some print shops must treat their wastewater prior to discharge, depending on the requirements of their local POTW. Even if a POTW will accept untreated wastewater, surcharges may be levied based on the strength of the wastewater, making it increasingly economical in some areas to perform treatment on-site. Two electrotechnologies are available to treat print shop wastewater: electrolysis (for photo-processing and/or platemaking wastewater) and membrane filtration (for platemaking wastewater).

Electrotechnology Solution
Electrolytic Recovery of Silver

The image processing step in printing uses photochemical processes similar to those used in photofinishing, such that film development generates silver-bearing wastewater. Silver is a toxic heavy metal, and if its concentration in wastewater is regulated by a printer's POTW, the shop's image processing wastewater may need to be treated prior to disposal. The platemaking step of the printing process also generates heavy metal-bearing wastewater. Photomechanical platemaking is a relatively common method of making plates for lithographic, flexographic, and letterpress printing. The two most popular types of light-sensitive coatings are diazo and photopolymer coatings. Photopolymer coatings are applied to plates intended for longer print runs since they are abrasion resistant and relatively insensitive to changes in temperature and humidity. Both image processing and platemaking wastewater can be treated with electrolysis.

The electrolytic process strips wastewater of its dissolved silver ions (or other heavy metal) by passing an electric current through the wastewater, causing the silver ions to deposit as a solid metal onto a series of cathodes. Once a cathode is full, it is removed, and the high-grade silver can be sold for its metal value.

Electrolytic units are cost-effective in recovering most forms of silver and are available in sizes that can meet the needs of even very small print shops. Units can be used alone or in combination with other wastewater treatment technologies. The process has the advantage of producing no toxic sludge, thereby reducing the cost and potential liability associated with sludge disposal. In addition, units operate efficiently at both high and low silver concentrations, and maintenance is limited to routine cathode replacement.

Electrotechnology Solution
Membrane Filtration

Ultrafiltration is one of three commercially available membrane filtration techniques; the others are microfiltration and reverse osmosis. All three systems use electricity-driven pumps to force wastewater through a permeable barrier to filter out pollutants or valuable raw materials. Water and dissolved matter—depending on the type of membrane—pass through, while other contaminants do not. Ultrafiltration is typically used to filter out particles that are larger than 0.001 micron but smaller than 0.1 micron, which is appropriate to the needs of most print shops.

In some sophisticated platemaking processes, a photographic negative is mounted on a piece of water-soluble, light-reactive polymer and exposed to light. The exposed areas of the polymer cure and become inert, while unexposed areas remain water-soluble. The plate is then rinsed with detergent and water; this polymer-containing wastewater can be reclaimed for reuse by using ultrafiltration to remove the photopolymers from the soapy water.

Ultrafiltration is an attractive wastewater treatment option because it can produce treated water that is clean enough for reuse on-site or for discharge well within the limits of a typical POTW. Reuse of reclaimed rinse water can reduce operating costs by cutting the volume of fresh water used in platemaking as well as the volume of wastewater discharged from a facility.

Solvent Recovery

Cleaning solvents are used in the printing step of the overall printing process. Rags leased from a commercial laundry are moistened with solvent and used to clean the presses after each run. Used rags contain spent solvents and inks, and can pose environmental problems if returned to a laundry or sent to a landfill. Rags sent to a commercial or industrial laundry can contaminate the laundry’s wastewater, creating discharge issues for the laundry and/or for the local POTW; contaminants in rags sent to a landfill can leach into the groundwater, creating a potential liability for the print shop.

Emerging Electrotechnology Solution
Centrifugal Extraction of Solvent from Shop Rags

An explosion-proof centrifugal extractor can remove the majority of ink and solvent from soaked rags; thus, the solvent can be reused, and the rags can be safely sent to a laundry. The centrifugal extractor removes solvent by spinning the rags in a drum, similar to the spin-cycle action of a residential washing machine. An extractor can remove 2.5–3.5 gallons of spent solvent for every rag load (in a unit handling approximately 220 rags per load). The recovered solvent can be used again to clean ink from the press between press runs and at the end of the day. The primary disadvantage of this technology for small printers is the high initial capital cost: a unit can cost $20,000–$30,000. As a result, centrifugal extraction is used primarily by large printers. In one instance, a centrifugal extractor saved a large print shop $34,000 in its first year of use, producing a short, six-month payback on a $15,000 centrifuge. According to one vendor, 60–70% of large printers have adopted this technology.

Heating, Ventilation, and Air Conditioning

HVAC accounts for 18% of the electricity used in the printing industry and has an important influence on the overall productivity of a print shop. Paper is one of the key materials in the printing process. Whether coated stock or simple newsprint, the size of a piece of paper and its ability to carry print in sharp definition is largely dependent on the environmental conditions of the press room and the moisture content of the paper. In addition, ink drying time depends on temperature and humidity. High indoor humidity and high moisture content in paper tends to retard ink penetration and lengthen drying time, a concern with all drying processes except UV. Dehumidification as part of an HVAC system can address these issues. Other conditions to consider in designing a press room HVAC system are the particles of paper and ink in the air, and the emission of VOCs from solvents used in press cleanup procedures.

For most printing processes, the press room temperature should be 75–80°F with a relative humidity of 43–47%. Maintaining the correct temperature and/or humidity level is important because paper is very hygroscopic: a 2% change in moisture content causes a 0.15% change in the dimensions of paper.

In addition to normal building envelope heat gain and loss, careful attention must be paid to internal heat gains from printing presses and drying systems. The moisture content of the paper stock entering the press room must also be considered since the paper may either add to or absorb moisture from the air.

Large printing operations with high-speed presses usually have sophisticated HVAC systems that are able to control temperature and relative humidity to exact standards. A newspaper facility or book printer in a medium-size city could be expected to have multiple centrifugal chillers with a total capacity of over 100 tons, air-handling equipment capable of dehumidification control (possibly with adsorption equipment), and winter humidification equipment.

In spite of the stringent temperature and humidity standards necessary for quality printing, many small print shops and newspaper press rooms get by with considerably less rigorous control. Mechanical cooling is usually supplied by packaged air-cooled rooftop units or by air-cooled split systems, with no attempt to dehumidify the space in the summer or to humidify it in the winter. Ventilation and exhaust may be provided integrally with the equipment or by separate exhaust fans. Typically, paper stock is stored in the press room long enough to bring it up to the temperature and moisture levels necessary for consistent product quality.

Some print shops have patchwork HVAC systems that have evolved to cope with additions and/or changes to production equipment. Retrofitting to add a modern, well-controlled chilled-water system could produce energy cost savings and improve temperature regulation. Given the sensitivity of print quality to ambient moisture, the addition of humidity control equipment can also represent a practical investment. Evaporative humidifiers and humidistats are relatively inexpensive and would benefit print shops in dry climates and shops that experience dry conditions during the winter season. Similarly, facilities burdened with large latent heat loads—either externally from weather conditions or internally from people and production equipment—can utilize dehumidifiers to control relative humidity levels.

Efficiency Technology Solution
Humidification

The market for humidifiers is relatively large; consequently, many types are available at a range of costs. Selecting the humidification equipment appropriate for a given facility depends on the water available (specifically, its mineral content), the HVAC system design, and the site-specific humidification needs. Alternatives include atomizing nozzles that can be piped directly into the supply air duct; stand-alone units that can independently deliver a water mist; and steam, injected into the environment, that can provide both heating and humidification.

Efficiency Technology Solution
Dehumidification

Dehumidifiers are more complicated and expensive than humidifiers because the vapor pressure of water at standard room conditions tends to maintain a high relative humidity. Pulling water out of the air requires either lowering the energy level of the air through refrigeration, which causes moisture to condense, or exposing comparatively humid air to a desiccating material that absorbs or adsorbs moisture. In either case, energy is required to cool the air or heat the desiccant. Selection of the bestsuited system is a function of the facility's climate, its internal heating and cooling loads, and its existing HVAC system. Conventional dehumidification uses the cooling system to lower the dew point of the conditioned air (also known as the "process air") to condense out a sufficient amount of moisture. Since the dew point necessary to achieve the right moisture level is often too cold for comfort, reheating the process air is frequently necessary. In some states, however, energy-efficiency codes preclude the reheat step, unless it is performed with a heat recovery heat exchanger, a heat pump, or a similar energy-conserving device. A heat recovery heat exchanger transfers energy from the hot, high-moisture return air to the cool, dry supply air and is the least expensive retrofit. A heat pump uses the refrigeration cycle to remove heat from the facility and to reject it to the supply air. This option is energy-efficient and quite suitable for print shops with high internal heat loads.

Electrotechnology Solution
Desiccant Dehumidification

Desiccant dehumidification is an alternative technology now widely used in industrial applications; it is increasingly gaining recognition as an appropriate technology for commercial facilities. Exploiting the affinity of certain compounds for moisture, this technology dries air without overcooling it. After pulling moisture from the process airstream, however, energy is needed to dry (regenerate) the desiccant. The heat required for regeneration can be provided by gas, electric resistance, or heat pump equipment. For print shops with high cooling load, the heat pump offers an energy-efficient option that can address both cooling and dehumidification needs.

Lighting

Lighting accounts for approximately 12% of the printing industry's total electricity consumption. Since quality work and reasonable turnaround times are essential attributes for a successful printer, lighting systems are needed that provide sufficient illumination in terms of quantity and quality of light. Adequate lighting is not only critical to the timely completion of jobs that require attention to detail, it also helps to ensure that colors are printed properly. Due to the nature of the work, both the prepress and press areas require high levels of lighting with good color rendition. Proper lighting levels—brightness without glare—contribute to product quality and also to employee health, morale, and productivity.

Three types of lighting systems are used in print shops. The most common system is a fluorescent lamp (tube) with magnetic ballast. Fluorescent lamps are available in a variety of shapes and sizes. Some of the most commonly used are 4-foot-long tubes used in two-, three-, and four-tube fixtures; larger facilities also use 8-foot-long tubes.

The second most common lighting source is the incandescent lamp. These fixtures are relatively inexpensive and easy to install but are the least efficient lighting source available. They are typically used in office, hallway, and common areas; but not for lighting the prepress and press areas. They are also used for signs, displays, and exit lighting.

Another type of lighting system used in larger print shops is the high-intensity discharge (HID) lamp. The HID family of lamps includes mercury vapor, metal halide, and high-pressure sodium lamps. All of these lamps are more energy-efficient than fluorescent lamps and have significantly longer lives; however, their color rendition index may not be as good. Although these lamps are most commonly used in parking lots and driveways, they can be used in large warehouse-style facilities. Mercury vapor is the least efficient HID lamp and can be replaced with either metal halide or high-pressure sodium lamps with a relatively short payback.

Efficiency Technology Solution
Energy-Efficient Indoor Lighting

The most efficient form of fluorescent lighting available today is the T-8 fluorescent lamp with an electronic ballast. Conversion from a magnetic (T-12, 40-watt) ballast to an electronic (T-8, 32-watt) ballast can be accomplished by either retrofitting the existing fixture or installing a new fixture designed for T-8 lamps, at a cost of roughly $40 and $100, respectively. Ceiling-mounted incandescent lamps can be successfully replaced with compact fluorescent lamps when the ceiling height is less than 12 feet, such as in hallways.

Electrotechnology Solution
Energy-Efficient Outdoor Lighting

Outdoor lighting can also be a part of a print shop’s energy bill. Existing applications range from incandescent lights on building signs to mercury vapor lights in parking lots and driveways. These lighting systems normally represent only a small portion of a facility’s energy bill because they are on for limited periods of time; however, they can be cost-effectively upgraded to more energy-efficient systems. In addition, other important benefits can be realized by increasing outdoor lighting levels. Better lighting can reduce the potential for crime, increase employee safety, and improve the visibility and attractiveness of a building’s exterior and grounds.

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. Turn to Section 5 for a list of equipment vendors that can provide further information as needed.

Ultraviolet Curing

Basic Principle

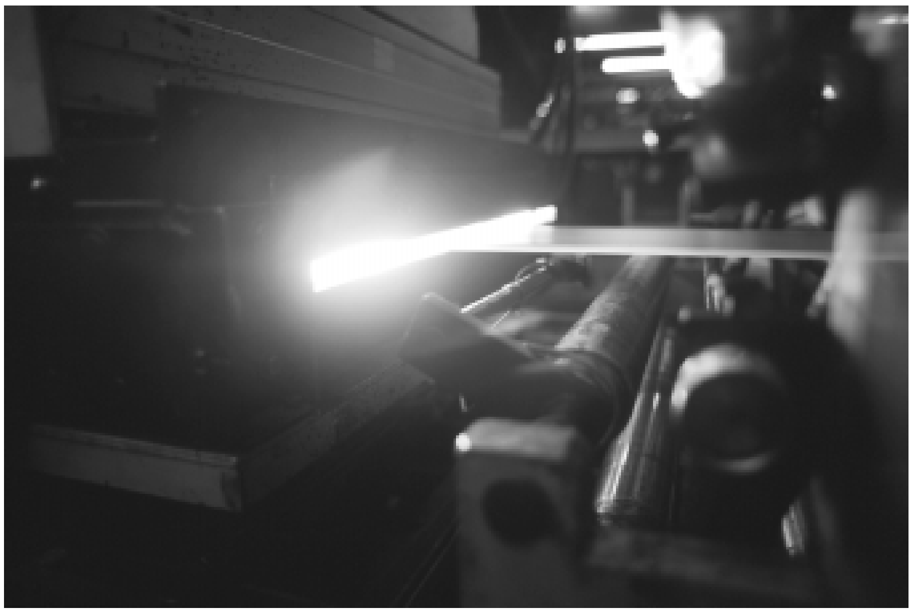
Ultraviolet (UV) radiation has a wavelength range of 4–400 nanometers. UV radiation can be used to cure inks or coatings containing polymers that cross-link when subjected to radiation. The cross-linking transforms the coating from a liquid to a solid. Radiation-curable coatings provide a clear or pigmented finish that protects, decorates, and provides other functional properties.

Curing differs from drying in that drying is accomplished by driving off a solvent, usually through evaporation, leaving the pigment or coating material on the surface of the product. Only solvent-containing inks or coatings can be dried. Curing, on the other hand, changes the molecular structure of the coating material to solidify it. Radiation-curable coatings, therefore, do not need to contain organic solvents and eliminate the problem of volatile organic compound (VOC) emissions.

System Description

Two basic types of lamps are commonly used to produce UV light: medium-pressure mercury vapor lamps (arc lamps) and medium-pressure mercury microwave-powered lamps (microwave-powered or electrodeless lamps). In both cases, the UV energy produced by the lamp bulb is focused by reflectors onto the coated materials as they move down a process line. The UV energy striking the materials causes a photoinitiator (a chemical in the coating) to trigger the cross-linking reaction, curing the coating. The UV light must be enclosed to prevent worker exposure.

Most UV systems are custom-made for use with conveyor-driven process lines. By using multiple lamps, the width of the treatment area can be extended as needed. Lamp length determines the number of lamps needed to achieve a specific treatment-area width. The system price varies with the type, number, and length of lamps; type of shielding; and cooling method. The capital cost of a conventional curing system such as a gas-fired curing oven can be nearly four times greater than that of an equivalent UV curing system. Also, although radiation-curable inks or coatings are twice as expensive per pound as conventional solvent-based coatings, less coating material is used per unit. The process is also easy to control; so there is less loss of product due to poor quality, and costs become comparable.



Ultraviolet Curing

Ultraviolet Curing System Characteristics

Dimensions	Length: 11-86″ Width: 9-55″ Height: 18-86″
Power Rating	120-800 watts per inch
Energy Consumption	9600-64,000 kWh per year*
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	None
Air Emissions	Ozone
Water Effluent	None
Cost	
Purchase	$1000-$60,000
Installation	Minimal
Other Supplies	None

*Assuming system with four 10-inch lamps operated 2000 h/yr.

Advantages

- Radiation-curable inks and coatings dry quickly, thereby increasing the production rate.
- UV systems work with non-solvent coatings, thus eliminating VOC emission concerns.
- Since no VOC emissions occur, UV curing eliminates the need for VOC incinerators.
- UV curing equipment takes 10–50% less space than conventional fuel-fired curing ovens.
- Radiation-curable coatings are available in an array of colors and provide a high-gloss finish with improved wear- and scratch-resistance.

Disadvantages

- Ozone can form if the UV light reacts with available oxygen.
- Operating personnel must avoid the hazards of exposure to UV light.

Commercial Status

UV curing is currently used in a variety of industrial applications where a clean or very thin coating is required and where acceptable radiation-curable coatings are available. Examples include printing labels, decorating metal, hardening polymers on non-wax flooring materials, and coating printed circuit boards with protective insulation.

UV systems are readily available for a range of applications. Small systems with one or two lamps are frequently used in laboratories and in manufacturing plants for testing ink coatings and adhesives before application to film, foil, or paper substrates. Medium-sized systems with multiple lamps are used to cure finishes on metal, glass, and plastic products. Large multichambered ovens with rows of lamps are used to cure finishes on floor tiles and on textured coatings on large substrates such as paper, board, or glass. More complex UV systems are used in curing coatings on products that are not flat, such as wires, tubes, furniture, packaging, and electronic assemblies.

Cost and Electrical Requirements

The cost of UV curing systems varies significantly with size and system complexity. A single-lamp system may cost a few hundred dollars, while a complex multilamp system may cost hundreds of thousands of dollars. The majority of UV curing systems are custom-made multilamp systems; their price depends on the type and number of lamps, type of shielding, and cooling method.

An arm-mounted UV system for new installation or retrofit to an existing system usually costs $1000–$5500 and consumes 120–600 watts per inch, depending on the number of lamps and lamp length. A fully automatic UV lamp conveyor system costs $8000–$60,000 and consumes 200–800 watts per inch, depending on the complexity of controls and lamp lengths.

Electric IR Drying & Curing

Basic Principle

Infrared (IR) is part of the electromagnetic spectrum, occurring between visible light and radio waves (0.75–1000 microns). Electric IR radiation is produced by heating an emitter of IR radiation. The radiation emitted is then absorbed by the substance at which it is directed, causing the molecules of the substance to vibrate and generate heat. The heat thus generated dries a coating from the inside out. IR systems require no special airflow for heat transfer because energy radiates directly to the coated surface without heating the air. By localizing the origin of the emissions, and allowing the use of reduced- or non-solvent paints, inks, and coatings, the technology enables facilities to significantly reduce or eliminate VOC emissions.

IR wavelengths are separated into three ranges: short, medium, and long. Short-wave IR provides fast, intense bursts of energy and, depending on the material, can penetrate the deepest. Short-wave IR is most useful when short cycle times are required, such as in drying inks in the printing industry and curing powder coatings in the metal finishing industry. Medium-wave IR is less intense than short-wave, thus it is more useful for heat-sensitive materials such as textiles. Medium-wave IR is also more readily absorbed by plastics and glass, and is typically used to dry water-based inks, coatings, and adhesives. Long-wave IR has the shallowest penetration and therefore heats more by convection; it is well-suited to slower, more even heating, such as is required for drying paper products and film. Long-wave IR is also less sensitive to color differences, making it the wavelength of choice for drying or curing multicolored products.

Many factors must be considered in selecting the appropriate type of IR equipment (i.e., short-, medium-, or long-wave emitters) for a given application. These factors include the absorption factor and color of the product as well as the depth of penetration and processing speed required. The absorption factor is determined by the temperature, humidity, thickness, color, and surface condition of the material being dried or cured. Each material best absorbs energy of a specific wavelength. Peak efficiencies are typically achieved by matching the wavelength of the IR emitter to the absorption wavelength of the product. For example, water has a maximum absorption of 2.6–3.2 microns, making medium-wave IR best for drying water-based materials.

System Description

A typical electric IR system includes quartz lamps and reflectors. Systems are typically configured as a tunnel or bank of lamps on a process line; smaller applications use moveable arch or portable arm-mounted lamps. An IR system reaches full power in less than 1 second and can be accurately regulated with simple controls. Electric IR systems are also highly energy-efficient, especially in comparison to gas IR systems. In an electric IR system, more than 85–90% of the energy used is converted to radiation, and 50–70% of the energy used is absorbed by the substance that needs drying. A gas IR system transfers only 20–25% of the energy used to the drying substance and produces emissions of its own.

Panel IR Unit for Process Line Drying

Advantages

- Quick, effective drying or curing. Reduces process time 50–80% in comparison to convective drying ovens. Curing takes place almost instantly.
- Markedly increases production potential.
- Quick startup and shutdown eliminates costly preheating, thereby increasing overall efficiency.
- Relatively insensitive to changing conditions (i.e., temperature, humidity).

- Modular design and small size of IR panels allow flexibility; they are easily incorporated into existing production lines and require minimal floor space.
- Reduced need for air circulation since IR heats products directly.
- Long lifespan, minimal routine maintenance.
- Relatively short payback period, depending on the application.

Electric IR Drying Curing System Characteristics

Dimensions	Length: 6-90″ Width: 10-60″ Height: 10-90″
Power Rating	8-15 kW per square foot
Energy Consumption	4160 kWh annually*
Key Inputs	
Power	Electricity
Other	None
Key Outputs	
Solid Waste	None
Air Emission	None
Water Effluent	None
Cost	
Purchase	Panel: $1000-$2500 Custom oven: $10,000-$250,000
Installation	10-20% of purchase cost
Other Supplies	None

* Assuming an 8-kW unit used 2 h/d, 5d/wk, 52 wk/yr.

Disadvantages

- Initial capital cost can be high.
- Has difficulty uniformly heating geometrically complex shapes.

Commercial Status

Long- and medium-wave IR are well-known and have been used to dry materials and/or cure coatings since the 1930s. A variety of IR source systems are available from numerous vendors. Systems can be obtained with heating element temperatures of 600–4000°F, thereby producing radiation in the 1.0–6.0-micron wavelength. However, as the industry makes increased use of low- and non-solvent paints, inks, and coatings, short-wave technology (0.75–2.3-micron wavelength) is becoming more prevalent. As evidenced by the large number of IR equipment manufacturers active in this market, many manufacturing facilities are already using short-wave IR equipment.

Cost and Electrical Requirements

A basic electric IR spot heater or panel heater with two or three quartz emitters costs \$1000–\$2500. Custom-designed ovens or tunnels cost \$10,000– \$250,000.

Electric IR ovens typically cost 10–20% less than gas convection ovens for the same application and features. This is primarily because fewer control systems are required (e.g., air-handling equipment and gas-related safety features).

Electrolytic Recovery of Silver

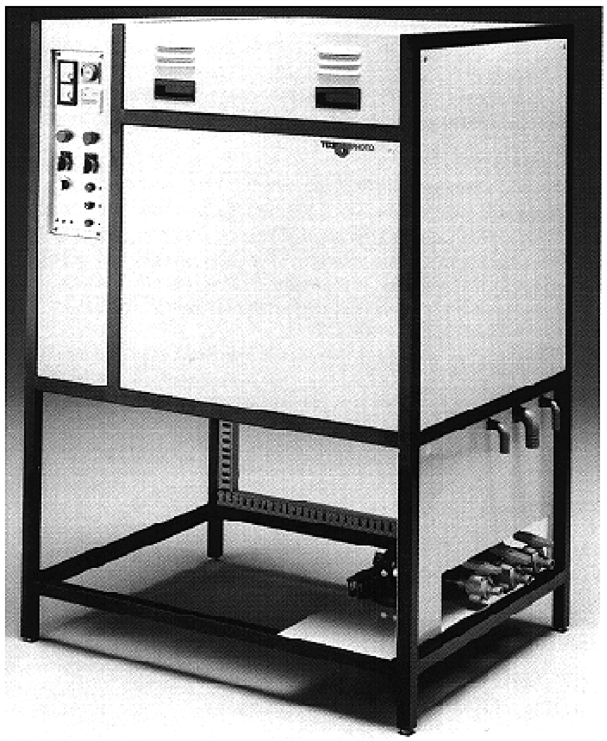
Basic Principle

Electrolysis uses an electric current to cause a chemical change in a substance in solution. In one type of electrolysis, metal ions in solution are reduced to metals plated onto a series of cathodes. Loaded cathodes can be sold to a metal reclaimer. The process (sometimes referred to as "electrowinning") is generally used to treat spent process or rinse water prior to subsequent treatment or discharge to a publicly owned treatment works (POTW).

Most facilities remove metal from wastewater through chemical precipitation and sedimentation, producing a toxic sludge that requires proper disposal as a hazardous waste. Electrolysis produces no sludge, thereby eliminating the cost and the potential liability associated with hazardous sludge disposal. Electrolysis is an efficient process at both high metal concentrations (process streams) and low metal concentrations (rinse streams). The only maintenance task is routine replacement of the cathodes. Electrolysis can recover precious metals, such as gold and silver, and other metals, such as copper, brass, nickel, zinc, and cadmium. The imagemaking film used in photoprocessing and printing contains silver; film development generates silver-bearing wastewater. The platemaking step of the printing process can also generate heavy metal-bearing wastewater.

System Description

There are two types of electrolytic silver recovery systems: terminal (or tailing) and closed loop. The terminal system usually is connected to the spent-fixer overflow pipe of a photoprocessor. Spent fixer trickles into the terminal system at the same rate as fresh fixer is introduced into the processor; it flows out of the terminal system at the same rate at which it was introduced. Any silver present in the spent fixer plates out at the rate of 4 grams per amp per hour. The main disadvantage of a terminal system is that it does not manage the substantial volume of silver that is transported from the processor's fixers into the wash tank as film is moved from one tank to the next. This can result in nonrecovery of approximately 30% of the silver released from the film. Another disadvantage is that spent fixer is generally introduced into a terminal system faster than the system can plate out the silver content. Consequently, the spent fixer that is released for sewage disposal still contains silver. This not only results in a further loss of recoverable silver but may not ensure compliance with pollution control regulations.



Electrolytic Silver Recovery System

Courtesy of R.J. Brimo

A closed-loop electrolytic system is attached to a processor's fixer tank and acts as a continuous electronic filter. As the fixer solution is pumped through the system, the silver is removed through electrolysis and the desilvered fixer is returned to the fixer tank. This type of system can recover significantly more silver than a terminal system and reduce the tank carryover losses to negligible levels. Maintaining a low silver concentration in the fixer tank (less than 1 gram per liter) minimizes silver carryover to the wash tank. A closed-loop unit recovers up to 15% more silver than a conventional system and reduces overall fixer consumption by as much as 75%. It is considered to be the most effective system for silver pollution control for facilities that utilize photoprocessors. The only drawback is that improper operation of the system can cause problems in overall production.

Electrolytic Recovery of Silver System Characteristics

Dimensions	Length: 8-40″ Width: 10-40″ Height: 10-70″
Cathode Size	10-100 sq ft
Energy Consumption	0.01-0.6 kWh per troy ounce
Key Inputs	
Power	Electricity
Other	Cathodes and anodes
Key Outputs	
Solid Waste	Cathodes loaded with silver
Air Emissions	Venting required in most applications
Water Effluent	Treated or desilvered fixers are returned to the image-processing or film-development step
Cost	
Purchase	\$1300-\$60,000
Installation	Minimal
Other Supplies	\$0.003-\$0.085 per troy ounce of recovered silver

Advantages

- Reduces the volume of hazardous waste, thereby minimizing the need for chemical waste treatment
- Reduces or eliminates the costs associated with hazardous waste disposal
- Improves rinse quality and life
- Reduces water use
- Efficient operation at both high and low silver concentrations
- Reduces the costs of chemicals and labor
- Permits the recovery of silver

Disadvantages

- Trailing system: The fixer released to the sewer contains some silver.
- Closed-loop system: Improper operation can result in production problems.

Commercial Status

Electrolytic silver recovery is common among printers and photofinishers. Units are available from vendors nationwide in sizes of 1–100 square feet (or more) of cathode surface area. Larger custom units are also available.

Cost and Electrical Requirements

The installed cost for a standard flat-plate cathode unit depends on the cathode surface area, which is itself dependent on the amount of metal to be recovered. For small, bench-top batch systems requiring manual wastewater input, the cost range is $1300–$3300. This type of system can recover 0.4–2.0 troy ounces of silver per hour utilizing a cathode surface area of 1–2 square feet. Larger units with automatic controls and a cathode surface area of 3–10 square feet can recover 3.2–10 troy ounces of silver per hour; these systems cost $13,000–$20,000. Very large systems with 100 square feet of cathode surface can cost $60,000. These costs can be partially offset by annual savings from recycling bleach-fix, reduced need for wastewater treatment chemicals, and a reduced volume of hazardous sludge, as well as the value of the recovered silver. The electrical requirements for a particular application are difficult to predict due to variables including, but not limited to, conductivity, required voltage, and rectifier and current efficiency.

Membrane Filtration

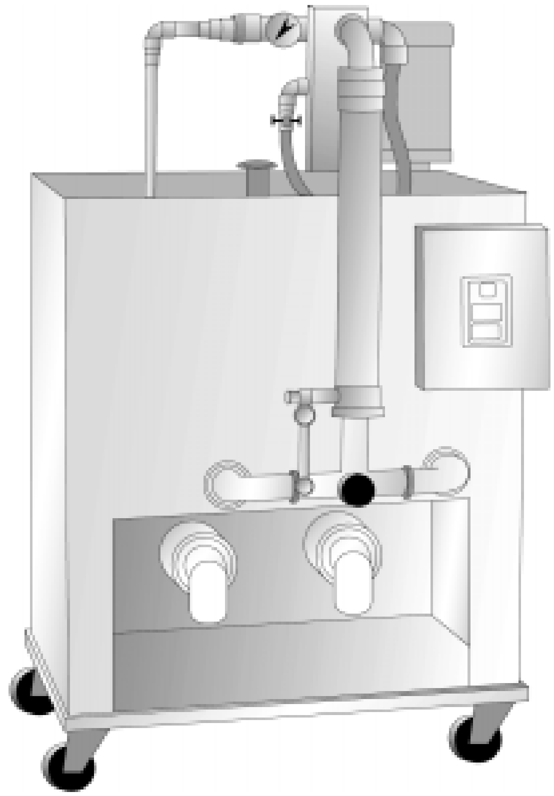
Basic Principle

Membrane filtration is used by various industries to recover materials and reduce hazardous wastes and contaminants in discharge water. In this process, electrically driven pumps force wastewater through a permeable barrier that filters out selected pollutant components depending on their particle size.

Membrane separation processes include microfiltration, ultrafiltration, and reverse osmosis, and are distinguishable on the basis of the particle size filtered. Microfiltration systems have the largest pore size and capture particles from 1000–10,000 angstroms (i.e., suspended solids). Ultrafiltration systems capture particles larger than 10 angstroms—with greatest efficiency up to 1000 angstroms—which includes emulsified oil and grease, detergents, and precipitated metal hydroxides. The smallest membrane filtration systems are reverse osmosis systems, which act as a barrier to everything larger than 5–20 angstroms, including heavy metals and salts. As membrane pore size decreases, additional pressure is needed to force the wastewater through.

System Description

In membrane filtration systems, wastewater is circulated under pressure in contact with a specially constructed membrane. Water and some dissolved matter (depending on the type of membrane) passes through, while other contaminants do not. The systems are generally modular, designed as self-contained pressure vessels; microfiltration typically operates at pressures of 1–25 psi; ultrafiltration, at 10–100 psi; and reverse osmosis, at 400–800 psi. Continuous pressure is maintained by an electrically driven pump.



Ultrafiltration Unit

Courtesy of Koch Membrane Systems, Inc.

Membrane Filtration System Characteristics

	Microfiltration	Ultrafiltration	Reverse Osmosis
Energy Consumption	1.0-3.0kWh/100 gal of permeate	1.0-6.0kWh/100 gal of permeate	1.0-7.0kWh/100 gal of permeate
Capacity	0.1-10.0gal/min	0.1-10.0gal/min	0.1-10.0gal/min
Key Inputs			
Power	Electricity	Electricity	Electricity
Other	Membrane	Membrane	Membrane
Key Outputs			
Solid Waste	Organics, metals	Oil, grease, solids	Heavy metal, salts
Air Emissions	None	None	None
Water Effluent	None	None	None
Cost			
Capital	$5000-$100,000	$5000-$100,000	$10,000-$130,000
Installation	10-30%of purchase price	10-30%of purchase price	10-30% of purchase price
Operating	$0.05-$0.40/100 gal	$0.05-$0.30/100 gal	$0.10-$0.30/100 gal

Advantages

- Pollution control: Membrane filtration systems decrease the waste load, thereby reducing the amount of treatment required prior to discharge.
- Low energy requirements: Membrane filtration systems require less energy than conventional phase-change processes.
- Limited maintenance requirements: No moving parts reduces the need for maintenance.
- Limited water use: Membrane filtration systems allow for recycling and reuse of the permeate by removing suspended solids.
- Modular, compact systems: The systems require less space than either evaporation or distillation processes and can be added to an existing wastewater treatment process.
- Cost savings: In general, membrane filtration systems cost a fraction of phase-change systems.
- Labor savings: Fewer person-hours are required due to reductions in materials handling and process control requirements (compared to chemical precipitation).

Disadvantages

- Membrane filtration systems are susceptible to damage by a variety of inorganic and organic compounds.
- Fouling can occur when particles collect on membrane surfaces.

Commercial Status

Membranes have been used for over a decade to remove toxic metals and organics from wastewater. Membrane separation processes are currently used in such industries as wood preserving, electroplating, metal finishing, food processing, chemical processing, printing, and pulp and paper processing. Membrane filtration units are available from a large number of vendors nationwide; unit capacities range from 0.1 to more than 500 gallons per minute.

Cost and Electrical Requirements

Capital and operating costs depend primarily on the type of membrane and its specific application. The purchase cost for either an ultrafiltration system or a microfiltration system for a plant processing 5 gallons per minute is about $34,000, and the operating cost is about $0.40 per 100 gallons. A reverse osmosis system processing the same amount would cost $30,000–$35,000, and have an operating cost of about $0.30 per 100 gallons.

Electrical requirements depend on the type of application, unit size, membrane type (pore size), waste stream temperature, pressure, and flow rates. Electricity is required for pumping water through the system. Units for small operations range in size from 0.1–10.0 gallons per minute and require 4–10 kilowatts of electricity, respectively. In this range, the electricity usage of a microfiltration unit is 1.0–3.0 kWh per 100 gallons of filtered water (permeate), the usage of an ultrafiltration unit is 1.0–6.0 kWh per 100 gallons of permeate, and the usage of a reverse osmosis unit is 1.0–7.0 kWh per 100 gallons of permeate.

Electric Desiccant Dehumidification

Basic Principle

In many facilities, desiccant dehumidification provides an attractive opportunity to improve operations and/or decrease cooling system operating costs while increasing indoor comfort. Desiccant dehumidification relies on the moisture-absorbing qualities of specific compounds to either adsorb or absorb water from the air. There are many different types of desiccants with a range of chemical and physical behaviors. Desiccants that absorb moisture chemically bond to water molecules; those that adsorb moisture use low-vapor-pressure surface properties to pull water molecules from high-vapor-pressure areas, such as humid airstreams. Both absorption- and adsorption-based desiccants release their moisture in a heat-based process known as reactivation or regeneration.

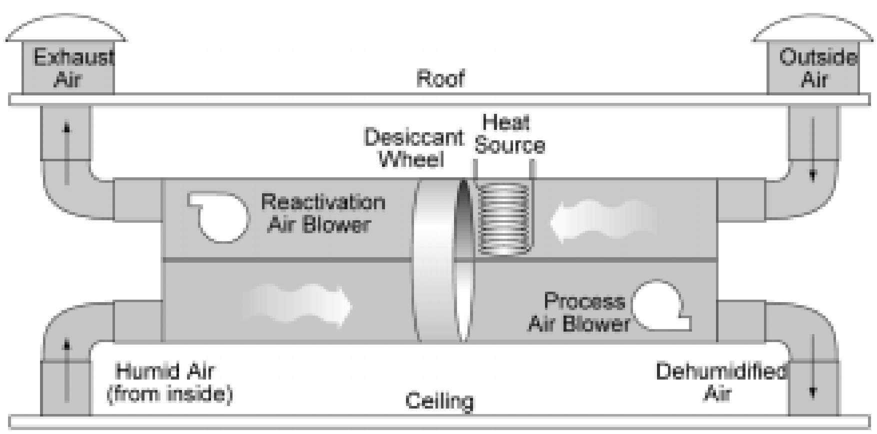
Interest in dehumidification technologies is driven by two principal trends. First, an increasing awareness of “sick building” syndrome is motivating building engineers and owners to increase outside air ventilation rates. Current industry ventilation standards set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) call for an outside airflow of 20 cubic feet per minute (cfm) per person—15 cfm per person higher than 10 years ago. In existing facilities, the increased ventilation rate can exceed the design capacity of the current HVAC systems; rather than replacing existing equipment to gain capacity, a dehumidification system can augment an existing HVAC system.

The second trend driving dehumidification is energy efficiency. Conventional dehumidification overcools the air to condense out the proper amount of moisture. Although this air can be reheated prior to returning it to the conditioned space, this practice is discouraged by many state codes that promote energy efficiency in commercial applications. To comply with this energy efficiency restriction frequently requires the use of reheat energy provided by a heat recovery heat exchanger. Desiccant dehumidification offers an alternative.

An environment with a relative humidity of 40–60% is attractive in terms of human comfort, facility maintenance, and refrigeration efficiency. Indoor air with a relative humidity of more than 60% encourages the growth of bacteria and mold spores and creates a musty environment. Additionally, high relative humidity increases a building's maintenance burden by promoting glue separation in wallpaper, oxidation of steel surfaces, and condensation on windows; in a grocery store, it decreases refrigeration system efficiency; in a print shop, it affects paper size and drying time.

System Description

In a desiccant dehumidification system, the desiccant is typically contained in a wheel that has two zones. In one zone, a high-humidity airstream is pulled from the indoor environment, passed through the desiccant, and returned to the indoor space. Concurrently, a hot, regenerating airstream is sent through the other zone of the wheel. As the hot regeneration air warms the desiccant, the desiccant releases its moisture and the warm, moisture-laden airstream exhausts to the roof. The desiccant wheel then rotates to expose the regenerated zone to the conditioned airstream.



Electric Desiccant Dehumidification System

Desiccant dehumidification lessens the burden on a cooling system in two ways.

1. Since the latent heat fraction has been substantially reduced, the energy absorbed by the cooling system is largely sensible heat. Consequently, the temperature drop across the system evaporator increases, and the cooling unit can achieve a lower airstream temperature with less compressor power.

2. Air at a low relative humidity feels cooler than moist air at the same temperature. Without sacrificing comfort, the demand on the cooling system can be reduced by setting the thermostat higher.

The largest load on a typical desiccant dehumidification unit, and consequently the key determinant of its operating cost, is the energy required to heat the regeneration air. Desiccants can be regenerated over a wide range of temperatures; however, regeneration effectiveness and the subsequent ability of the desiccant to dry the process air during the next cycle increases as the regeneration temperature increases. Regeneration temperatures of 200°F offer moisture removal rates of 55–75%, while lower temperatures (around 140°F) bring the drying rate down to 30–40%.

Most electric desiccant dehumidification systems use electric resistance heating to achieve high regeneration temperatures. The most efficient electric desiccant dehumidification systems use heat pumps to augment the cooling system and provide regeneration energy. The hot gas discharge from heat pump compressors can reach temperatures of 140°F, which can be employed for desiccant regeneration. This technology offers significant advantages in that the entire heat pump cycle contributes to cooling and dehumidification. The low regeneration temperature requires a higher airflow rate across the desiccant, but with proper equipment sizing, this system provides a competitive alternative to gas technologies.

Advantages

- Good energy efficiency: By removing ambient moisture without overcooling, this technology provides an energy-efficient opportunity to improve a facility's environment.
- Increased cooling system capacity: Desiccant dehumidification units can augment existing cooling systems to accommodate increases in outside air intake rates. By removing latent heat, desiccant dehumidification systems in effect add to the capacity of existing cooling systems.
- Lowered cost of system upgrades: Desiccant dehumidification lowers material and installation costs by reducing the capacity required of an expanded cooling system. Lower-capacity equipment requires smaller ductwork and support structures, which reduces the amount of material and labor required for installation.

Disadvantages

- High initial cost: If used solely to enhance indoor comfort, these systems are relatively expensive. However, desiccant dehumidification systems are comparatively feasible investments when evaluated against cooling system upgrades. The payback period is heavily dependent on the quantitative/qualitative value assigned to a lower ambient relative humidity by the facility owner.

- Supplemental energy required: Using the hot gas discharge line from a heat pump compressor offers a limited amount of regeneration. Systems larger than 2000 cfm must supplement the energy rejected from a heat pump with other energy sources, such as gas.

Electric Desiccant Dehumidification System Characteristics

Dimensions	Height: 25-60″ Width: 50-120″ Depth: 25-50″
Power Rating	Single-or 2-phase, 60 Hz, 120 or 220 V, 10-20 A 2-4 kW for air-handling needs Regeneration energy requirements are not included; they depend on fuel type and facility needs.
Key Inputs	
Power	Electricity
Regeneration energy	Hot water, hot gas refrigerant, electric resistance heat, or natural gas
Key Outputs	Dry process air Wet reactivation air
Cost	
Capital	$ 4-$7/cfm
Operating	$0.23-$0.40/h, plus the cost of heat for regeneration

Commercial Status

Desiccant dehumidification is a mature technology that has been used for decades in industrial applications such as battery manufacturing, and in pharmaceutical processes requiring dry conditions. Electric resistance desiccant dehumidifiers are used widely in industry to preserve large equipment and holding tanks. Due to limitations on heat exchanger effectiveness and ice formation problems, any facility requiring dew-point temperatures below 40°F must use some type of absorption dehumidification system. Commercial systems are receiving more attention as a result of increased ventilation rate requirements and energy efficiency concerns. Common commercial system sizes range from 150 cfm for small electric resistance units to 20,000 cfm units for large facilities. Although gas-fired desiccant dehumidification systems have been around longer, heat pump-regenerated units offer improved energy efficiency.

Cost and Electrical Requirements

Desiccant dehumidification systems cost approximately $4–$7 per cfm. For example, the capital cost of small system with a capacity of 150 cfm is $600–$1050. A large system with a capacity of 20,000 cfm costs $80,000–$140,000. Equipment specifications and support system requirements are typically defined by the manufacturer; installation is handled by local HVAC contractors.

The largest energy input is the heat required for regeneration, which is a function of the necessary airflow rate and the expected moisture level. Unfortunately, the broad range of regeneration heat sources complicates any estimate of system installation and operating costs. These heat sources include waste heat from heat pumps and refrigeration systems, electric resistance heat, and gas-fired heat, all of which can be used individually or in combination, depending on the application. Since installation costs are significantly affected by the type of regeneration heat source, and subsequent operating expenses are largely driven by the cost of regeneration heat, without a site-specific cost estimate the best cost estimate is a range. In addition, the process air and regeneration air blowers also draw significant quantities of electricity (2–4 kW).

Outdoor Lighting

Basic Principle

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

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

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

1. Signage on the exterior of the building or illuminated signs near the building to generate attention for the building or the small business

2. General lighting in parking lots, driveways, parking garages, and walkways

3. Facade lighting to increase the visibility of the structure and surrounding architectural features and landscaping

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

Typical Outdoor Lighting Applications

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

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

System Description

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

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

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

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

Typical Lamp Characteristics for Outdoor Applications

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

Note: Initial lumens/watt includes ballast losses.

Advantages

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

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

Disadvantages

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

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

Commercial Status

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

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

EPRI Information

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

5

RESOURCES

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

Ultraviolet Curing

Equipment Suppliers

American Ultraviolet Company
562 Central Ave., Murray Hill, NJ 07974
(908) 665-2211, fax: (908) 665-9523

Argus International
424 Route 31 North, Imgoes, NJ 08551
(609) 466-1677, fax: (609) 466-4111

Canrad Hanovia, Inc.
100 Chestnut St., Newark, NJ 07105
(201) 589-4300, fax: (201) 589-4430

Fusion Systems Corporation
910 Clopper Rd., Gaithersburg, MD 20878
(301) 527-2660, fax: (301) 527-2661

Industrial Heating & Finishing Company
P.O. Box 129, Pelham, AL 35124
(205) 663-9595, fax: (205) 663-9608

UV III Systems, Inc.
21 Governor Ave., Bellingham, MA 02019
(800) 398-5456, (508) 883-4881, fax: (508) 376-4748

Werner Lemnermann
Specialty Coating Systems, 5707 West Minnesota St., Indianapolis, IN 46241
(800) 356-8260, fax: (317) 240-2073

XENON Corporation
20 Commerce Way, Woburn, MA 01801
(617) 938-3594, fax: (617) 933-8804

Electric IR Drying & Curing

Equipment Suppliers

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

Americure, Inc.
2353 W. Lincoln St., Phoenix, AZ 85009
(602) 253-3130

Argus International
P.O. Box 38-M, Hopewell, NJ 08525
(609) 466-1677, fax: (609) 466-4111

BGK
4131 Pheasant Ridge Dr., N.E., Minneapolis, MN 55449
(612) 784-0466, fax: (612) 784-1362

Cleveland Process Corporation
127 S.W. Fifth Ave., Homestead, FL 33030
(800) 241-0412, fax: (305) 248-4371

Dry-Clime Corporation
P.O. Box 146, State Rd. 46 W., Greensburg, IN 47240
(812) 663-4141, fax: (812) 663-4202

Edwin Trisk Systems
670 New York Street, Memphis, TN 38104
(800) 261-7976, fax: (901) 274-8355

Eraser Company, Inc.
Olivia Drive, P.O. Box 4961, Syracuse, NY 13221
(315) 454-3237, fax: (315) 454-3090

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

Future Cure
29313 Clemins, Westlake, OH 44145
(800) 722-4664, fax: (216) 835-1578

Glenro, Inc.
39 McBride Ave., Paterson, NJ 07501
(800) 922-0106, fax: (201) 279-9103

Infratech Corporation
1634 Industrial Park St., Covina, CA 91722
(818) 331-9400

Infratrol Manufacturing Corporation
646 S. 29th St., Milwaukee, WI 53234
(414) 671-7140, fax: (414) 671-5088

IRT Systems
89 Connie Crescent, Concord, Ontario, L4K 1L3, Canada
(800) 387-3639, fax: (905) 669-1171

Prime Heat
1946 John Towers, El Cajon, CA 92020
(619) 449-6623, fax: (619) 449-9844

Process Thermal Dynamics
304 G 50th Ave., Alexandria, MN 56308
(612) 762-2077, fax: (612) 762-1319

Radiant Energy Systems
458 Hamburg Turnpike, Wayne, NJ 07470
(201) 942-7767, fax: (201) 942-5581

Solaronics
704 Woodward, Rochester, MI 48307
(810) 651-5333, fax: (810) 651-0357

Tech Systems
1030 N. Lincoln St., Greensburg, IN 47240
(812) 663-4720, fax: (812) 663-4799

Watlow Electric Manufacturing Company
12001 Lackland Rd., St. Louis, MO 63146
(314) 878-4600, fax: (314) 878-6814

Electrolytic Recovery of Silver

Equipment Suppliers

Andco Environmental Processes, Inc.
595 Commerce Dr. Buffalo, NY 14228
(716) 691-2100, fax: (716) 691-2880

Electrosynthesis Company
72 Ward Rd., Lancaster, NY 14086
(716) 684-0513, fax: (716) 684-0511

Hallmark Refining Corporation
1743 Cedardale Rd., P.O. Box 1446, Mt. Vernon, WA 98273
(800) 255-1895, fax: (360) 424-8118

Kinetico Engineered Systems, Inc.
10845 Kinsman Rd., Newbury, OH 44065
(800) 633-5530, fax: (216) 564-1988

Manchester Corporation
280 Ayers Rd., P.O. Box 317, Harvard, MA 01451
(508) 772-2900, fax: (508) 772-7731

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

Safety-Kleen/Drew Products
1717 Fourth St., Berkeley, CA 9471
(510) 527-7100, fax: (510) 525-5294

Membrane Filtration

Equipment Suppliers

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

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

Infinitex
P.O. Box 409, Clarence Center, NY 14032
(716) 741-8381, fax: (716) 741-9649

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

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

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

Membrex, Inc.
155 Route 46 West Fairfield, NJ 07004
(201) 575-8388, fax: (201) 575-7011

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

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

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

Sanborn
9 Industrial Park Rd., Midway, MA 02053
(508) 533-8800, fax: (508) 533-1440

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

Electric Desiccant Dehumidification

Equipment Suppliers

Air Technology Systems, Inc.
1922 Tilco Dr. Frederick, MD 21701
(301) 620-2033, fax: (301) 622-6421

Engelhard/ICC
441 N. 5th St., Philadelphia, PA 19123
(215) 625-0700, fax: (215) 592-8299

Munters Corporation
Dry Cool Division, 16900 Jordan Dr. Selma, TX 78154
(210) 651-5018, fax: (210) 651-9085

New Thermal Technologies
12900 Automobile Blvd., Clearwater, FL 34622
(813) 571-1888, fax: (813) 571-2242

Outdoor Lighting

Equipment Suppliers

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Information on Efficiency Technologies

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

Adjustable Speed Drives

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

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

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

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

Dehumidification and/or Refrigeration

Dehumidification Performance of Unitary Rooftop Air Conditioning Systems: Kmart Demonstration, TR-106066, May 1996.

Dehumidification Performance of Air Conditioning Systems in Supermarkets: Field Demonstration With Heat Pipe Heat Exchangers in Delchamps Supermarket, Gulf Breeze, Florida, TR-106065, May 1996.

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

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

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

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

Energy-Efficient HVAC

Electric Chiller Handbook, TR-105951, February 1996.

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

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

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

Energy-Efficient Lighting

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

Electronic Ballasts, BR-101886, May 1993.

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

Advanced Lighting Technologies Applications 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.

Trade Associations

Flexographic Technical Association
900 Marconi Avenue, Ronkonkoma, NY 11779-7212
(516) 737-6026, fax: (516) 737-6813

Members are flexographic printers and suppliers to the flexographic process.

Graphic Arts Technical Foundation
4615 Forbes Avenue, Pittsburgh, PA 15213-3796
(800) 910-GATF, (412) 621-6941, fax: (412) 621-3049

GATF is a nonprofit, member-supported and directed educational, research, and technical organization that serves the graphic communications industry.

Graphic Communications Association
100 Dangerfield Rd., Alexandria, VA 22314-2888
(703) 519-8160, fax: (703) 548-2867

Members are printers, publishers, and other related organizations.

Gravure Association of America
1200-A Scottsville Road, Rochester, NY 14624
(716) 436-2150, fax: (716) 436-7689

Members are gravure printers and suppliers.

International Prepress Association
7200 France Ave., Suite 327, Edina, MN 55435
(612) 896-1908, fax: (612) 896-0181

Members produce prepress material (e.g., plates) for the graphics industry.

National Association of Printers and Lithographers
780 Palisade Avenue, Teaneck, NJ 07666-3196, (800) 642-NAPL (6275)
(201) 342-0700, fax: (201) 692-0286

NAPL works toward increasing printers' profitability.

Printing Industries of America, Inc.
100 Dangerfield Road, Alexandria, VA 22314
(703) 519-8100, fax: (703) 548-3227

The umbrella organization of the graphic arts industry.

Screen Printing and Graphic Imaging Association International
10015 Main Street, Fairfax, VA 22031-3489
(703) 385-1335, fax: (703) 273-0456

Conducts research, tests, and studies on-screen printing, digital imaging, and related processes.