Small Chemicals and Allied Products Manufacturers: A Profile of Motor Energy Efficiency Opportunities

Summary

- The chemicals industry is highly diversified and growing rapidly.
- It has a significant market presence within the State of California.
- The manufacturing of all types of chemicals requires a great deal of electricity, and the majority of that electricity is used to run motors.
- The industry does not appear to be aware of potential energy cost savings available through the use of efficient motors.

Across the United States, the chemicals industry (SIC 28) represents 30 different industries, 9,000 firms, 12,000 plants, and 70,000 products (ACEEE, 1997) (OIT, 1997)! Nationally, between 1992 and 1997, the industry as a whole grew substantially, in terms of overall establishments (367 new establishments between 1992 and 1997), and revenues (an increase of $94.6 billion or about 31 percent), especially in the areas of Plastics Materials and Resins (with a growth of 73 establishments and $12.9 billion or 40 percent in revenues) and Pharmaceutical Preparations (with a growth of 123 establishments and $16 billion or 32 percent in revenues) (US Census Bureau, 2000).

Within the State of California, $17.2 billion of chemical shipments were produced in 1996, the industry employed almost 73,000 people, and it contributed one percent to California's total gross state product (EIA, 11/22/00).

Of all the electricity used in manufacturing, motor use accounts for 59 percent. The chemicals industry is the largest user of motor systems energy, accounting for 20 percent of the total industrial motor system energy use (DOE, 1998). Machine drive within the chemicals industry has increased by approximately 16 percent from 1991 through 1994 (MECS, 1994).

1 INDUSTRY DESCRIPTION

Chemicals and Allied Products manufacturers, by definition of the U.S. Census, are establishments producing basic chemicals, and establishments manufacturing products by predominantly chemical processes. Chemicals are considered the largest exporting segment of the U.S. economy (Business.com, 11/29/00). Goods produced by chemical plants account for over six percent of the total value of manufacturing in the United States (BLS, 11/29/00).

Three types of products are manufactured in this SIC group (28):

- Basic chemicals (acids, alkalies, salts, and organic chemicals);
- Chemical products to be used in further manufacturer (synthetic fibers, plastics materials, dry colors, and pigments); and
- Finished chemical products to be used for ultimate consumption (drugs, cosmetics, and soaps, as well as paints, fertilizers, and explosives).

Four segments of the industry overall consume about 85 percent of all the fuel and electricity used in the chemical industry in 1994 (OIT, 1997). These "basic chemicals" include:

- *Inorganics*—made from inanimate material from the earth's crust, usually salts, other minerals, and metal compounds. Represent about 25 percent of global chemical sales, excluding plastics (such as sulfuric acid, the top seller of all basic chemicals, and industrial gasses like oxygen, nitrogen, and helium),
- *Organics*—(petrochemicals) made from materials containing carbon, and primarily from petroleum and natural gas. Represent about 75 percent of global chemical sales, excluding plastics (such as ethylene, the largest volume produced of this segment),
- *Plastics*—the largest employer, and the only segment of the chemical industry in which much of the production is geared directly towards the consumer (such as best-sellers polyethylene and polyvinyl chloride), and
- *Fertilizer Materials*—the smallest employer, manufactures usable forms of the three elements all plants need to grow: nitrogen, phosphate, and potassium (including phosphate, nitrogen, and potash) (Hoover's, 11/29/00).

Drug manufacturing, the most profitable of all industries included in the chemical industry, includes establishments that make:

- *Medicinals and Botanicals*—items which are used in the making of finished drugs,
- *Pharmaceutical Preparations*—the largest employer of the drug industry, making finished drugs,
- *Diagnostic Substances*—items such as home testing kits for blood glucose, and
- *Biological Products*—includes serums and vaccines (BLS, 11/29/00).

Due to the complexity of the chemicals industry, this report will concentrate on one of the four segments of "basic chemicals," **Plastics Materials**, as well as one section of the most profitable industry of chemical manufacturing, **Pharmaceutical Preparations** (SICs 2821 and 2834, respectively). These two industries have experienced growth between 3-8 percent since 1974, and because of the high demand for the end-uses of these industries, continued growth is expected (Worrell, 2000).

The Manufacturing of Plastics and Pharmaceuticals in Southern California

In Southern California Edison's (SCE) service territory, consisting of 15 counties in Southern California, a total of 145 businesses are registered primarily as Plastics Materials and Resins manufacturers and Pharmaceutical Preparation manufacturers (small being defined as less than 100 employees, due to the correlation between employee size and energy usage) that receive their electricity (between 250-2,499 MWh) from SCE. All of the manufacturers operate only one facility of this size in the SCE service territory. These businesses employ a total of 2,276 persons, and have sales of $470.4 million. (Dun & Bradstreet, 2000). The breakdown of plastics and pharmaceutical preparation manufacturers is shown on the following table.

Within SCE's Service Territory:						
Number of Employees	SIC 2821-Plastics			SIC 2834-Pharmaceuticals		
	# Businesses	Total Sales (Millions)	% Total Sales	# Businesses	Total Sales (Millions)	% Total Sales
2-4	28	$ 19.7	32.0 %	0	$ 0	0 %
5-9	27	$ 18.6	30.2 %	10	$ 111.5	27.3 %
10-24	14	$ 23.3	37.8 %	34	$ 126.5	30.9 %
25-49	0	0	0 %	23	$ 131.1	32.1 %
50-99	0	0	0 %	9	$ 39.7	9.7 %
Total	*69*	*$ 61.6*	*100 %*	*76*	*$ 408.8*	*100 %*

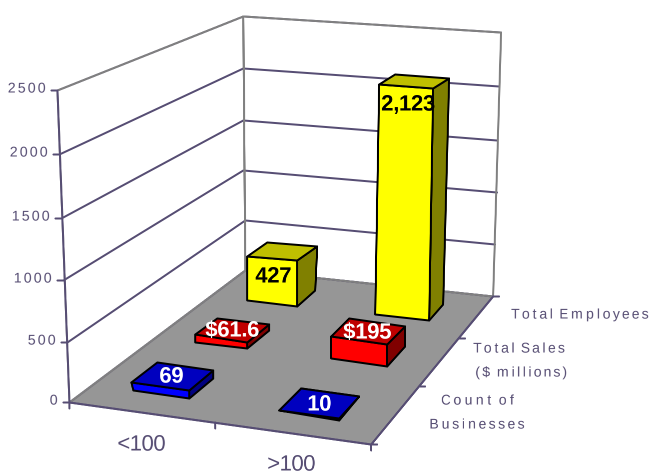
2 ENERGY USE

Of the 22.4 quads of manufacturing energy use in 1994, the chemical industry ranked second in terms of overall energy use, with 24.7 percent of the total (5.5 quads). Only the petroleum refining industry used a greater amount of energy, 26.4 percent of the total (OIT, 1997). The Energy Information Agency of the Department of Energy predicts that the industrial sector end-use energy consumption will grow to between 29.1 quads and 34.4 quads by the year 2015 (OIT, 1997).

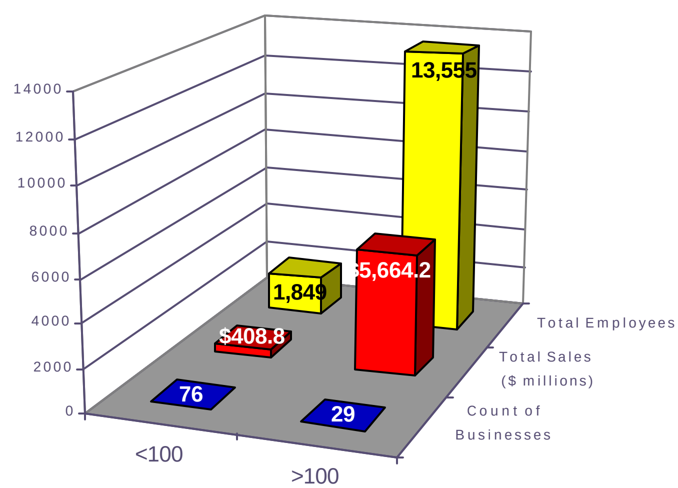
The chemical industry spent nearly $104 billion on energy in 1993, with 96 percent of that

Small vs. Large Employers Within SCE's Service Territory

SIC 2821: Plastics Materials and Resins



SIC 2834: Pharmaceutical Preparations



money purchasing electricity, petroleum products, and natural gas (OIT, 1997). Almost 53 percent of the chemical industry energy use is for fuel and power, with the remainder being for feedstocks (OIT, 1997).

In 1997, California ranked third in the U.S. for industrial sector energy use, with a share of 6.5 percent of the U.S. total energy use—the state consumed about 2,322 Trillion Btus of energy. Natural gas provided the most energy, 35.6 percent of the California industrial use total. The next greatest provider was petroleum, which contributed 19.8 percent (EIA, 11/27/00).

Largest Expected Growth of Energy Consumption

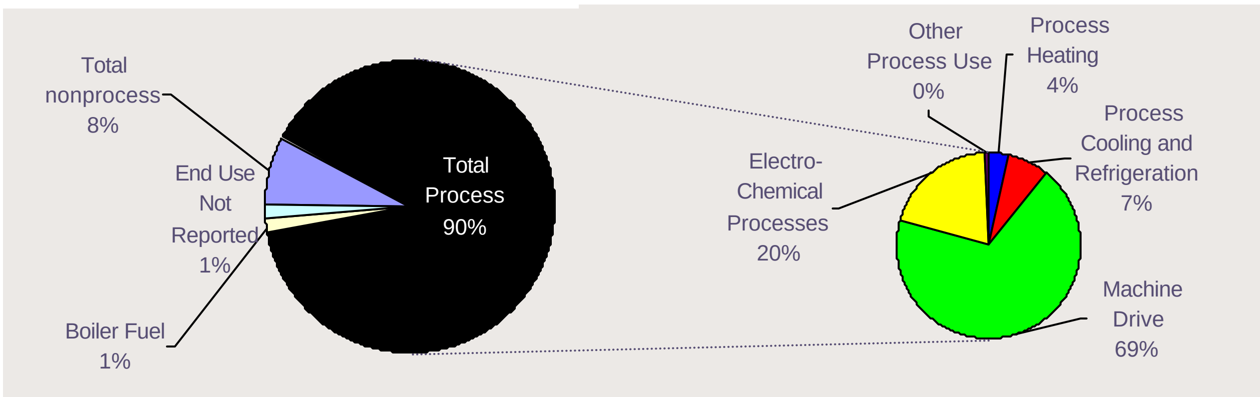
Four of the counties in California with the largest expected growth in *electricity* and four with the largest expected growth of *natural gas* are located within SCE's service territory, and are expected to grow by 11.27 percent and 6.22 percent by 2007, respectively.

Source: CEC, 1998 Baseline Energy Outlook

Energy use in any industry can be separated into two distinct categories:

- Process uses, such as machine drive, process heating, cooling, and refrigeration, and
- Non-process uses, such as facility lighting, heating, ventilating, and air conditioning (MECS, 1994).

SIC 28: Breakdown of Net Demand for Electricity



Source: MECS, 1994

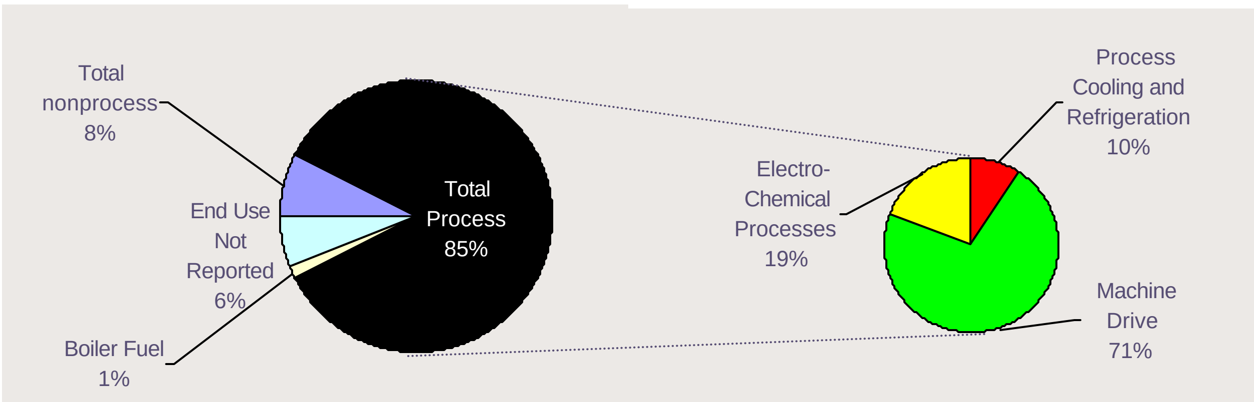
As shown in the figure above, for the U.S. Chemicals and Allied Products Industry as a whole, machine drive (motors) represents 69 percent of the total process use; this represents 62 percent of the total demand for electricity in the industry. All process uses have increased their net demand for electricity since 1991, with machine drive increasing by approximately 16 percent (MECS, 1994).

SIC 28: CHEMICALS and ALLIED PRODUCTS	**Net Demand for Electricity (million kWh)**		**% Change 1991-1994**
	1991	**1994**	
TOTAL INPUTS	170,520	199,284	14%
Indirect Uses-Boiler Fuel	1,150	2,646	57%
Direct Uses-Total Process	151,906	178,483	15%
Process Heating	4,756	6,565	28%
Process Cooling and Refrigeration	9,921	12,698	22%
Machine Drive	103,402	122,820	16%
Electro-Chemical Processes	33,485	35,644	6%
Other Process Use	342	756	55%
Direct Uses-Total Nonprocess	14,251	15,232	6%
Facility Heating, Ventilation, and Air Conditioning (e)	7,253	7,538	4%
Facility Lighting	5,284	5,750	8%
Facility Support	1,386	1,614	14%
Onsite Transportation	98	65	-51%
Conventional Electricity Generation	--	--	
Other Nonprocess Use	230	265	13%
End Use Not Reported	3,213	2,923	-10%

2.1 Energy Use in Plastics and Resins Manufacturing

The Plastics Materials and Resins industry has roughly the same breakdown in terms of net demand for energy, with process uses using slightly less of the total demand, and machine drive using slightly more of the demand than the for the chemicals industry as a whole (see figure below).

SIC 2821: Breakdown of Net Demand for Electricity



Source: MECS, 1994

For the Plastics Materials and Resins industry, the increase in demand for electricity has largely been concentrated in electro-chemical processes, though machine drive has also increased, as shown in the following table (MECS, 1994).

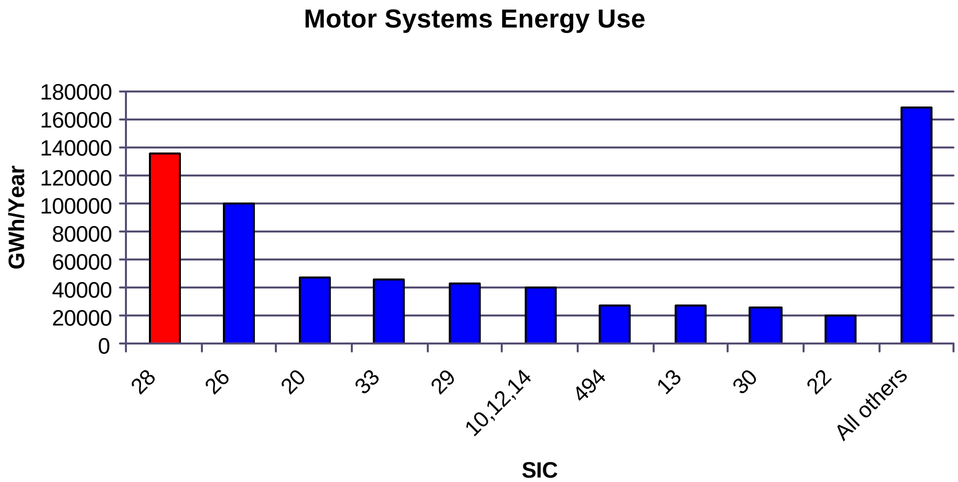
SIC 2821: PLASTICS MATERIALS AND RESINS	Net Demand for Electricity (million kWh)		% Change 1991-1994
	1991	1994	
TOTAL INPUTS	17,408	21,060	17%
Indirect Uses-Boiler Fuel	218	306	29%
Direct Uses-Total Process	15,382	17,859	14%
Process Heating	W	W	
Process Cooling and Refrigeration	1,759	1,617	-9%
Machine Drive	11,197	12,050	7%
Electro-Chemical Processes	1,975	3,279	40%
Other Process Use	W	W	
Direct Uses-Total Nonprocess	1,535	1,606	4%
Facility Heating, Ventilation, and Air Conditioning (e)	756	768	2%
Facility Lighting	594	626	5%
Facility Support	174	204	15%
Onsite Transportation	10	W	
Conventional Electricity Generation	--	--	
Other Nonprocess Use	1	W	
End Use Not Reported	273	1,289	79%

2.2 Energy Use in Pharmaceutical Preparations Manufacturing

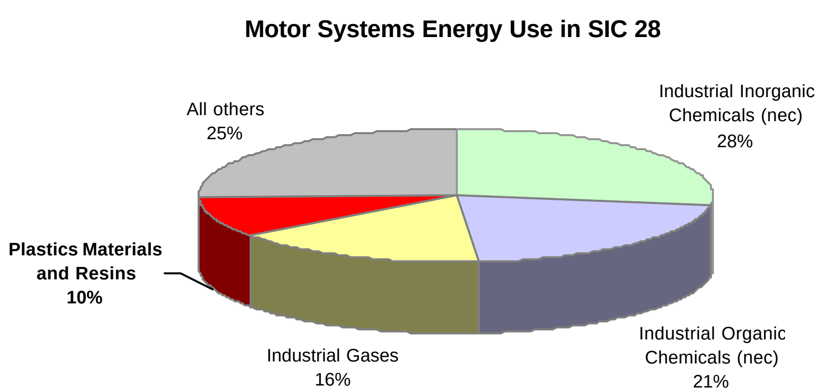
In California's PG&E service territory, energy use for all Pharmaceutical Preparations plants (with no controls put on size) has increased by approximately 37 percent, from 156 GWh of energy consumed in 1993 to 247 GWh consumed in 1998 (XENERGY, 2000).

3 MOTOR USE

Nationally, motor use accounts for 59 percent of all electricity used in manufacturing (DOE, 1998). The Chemicals and Allied Products Industry (SIC 28) is the largest user of motor systems energy, accounting for 20 percent of the total industrial motor system energy use.

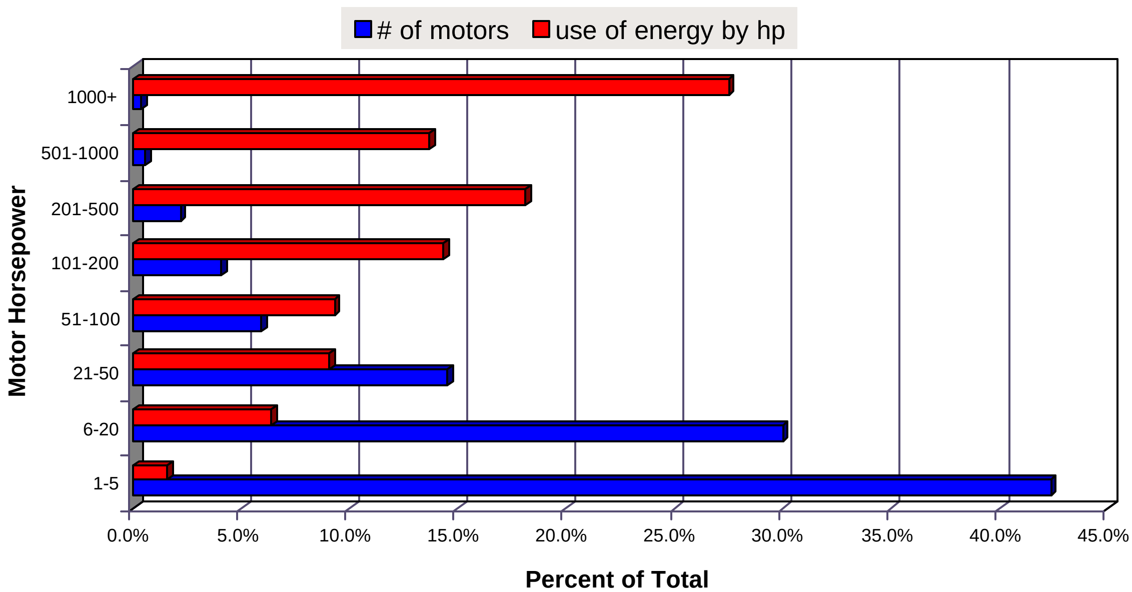


Within the chemicals and allied products industry group, the breakdown for motor system energy is even more pronounced, with four of the industries within this group comprising more than 75 percent of the total motor system energy use.



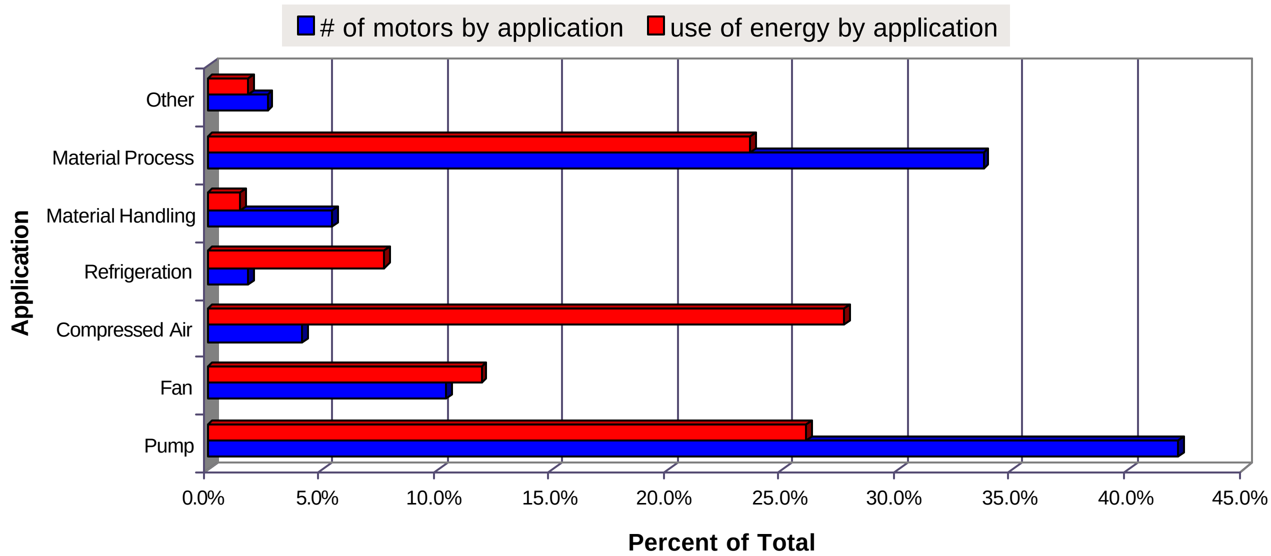
The distribution of motors within this industry group is also telling of the potential for increased motor efficiency, as the largest number of motors in the chemicals and allied products industry are those with horsepower levels between 1-5 (see figure below) and the vast majority of all the motors in this industry are less than 50 horsepower.

SIC 28: Distribution of Motor Population and Energy by Horsepower



As is shown in the following figure, the largest applications of motor use (in terms of numbers of motors) within the chemicals and allied products industry are used in pumps and material processing. However, the application that uses the greatest amount of energy is compressed air, followed closely by pumps and material processing. These areas represent the greatest potential sources of efficiency upgrades.

SIC 28: Distribution Motor Population by Application and Energy Use



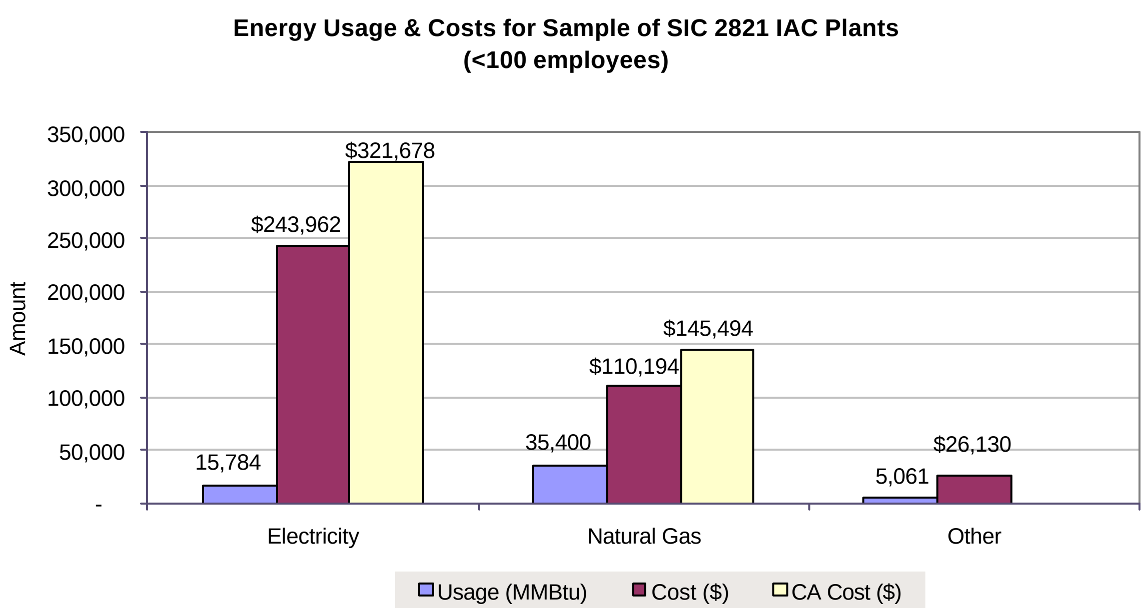
Motor use within the Plastics and Resins manufacturing and the Pharmaceutical Preparations manufacturing is similar in many ways:

- First, almost 80 percent of all motor use is used to stir/agitate, compress, pump liquids around, and lift (with hydraulic lifts) (Kidorski, 2000 and Rodgers, 2000).
- Second, both of these industries use gravity to help move the base materials around the plants, where raw materials enter via the top of the plant, and the finished product exits at the bottom of the plant.
- Third, both of these industries tend to use specialty motors (motors designed for a specific task).
- Fourth, reducing energy costs associated with motor use is not high on the industry priority lists, because for many of these manufacturers, energy cost is not a substantial component of the costs of goods sold. At the two-digit SIC level, motor system energy costs accounted for a little less than two percent of the total energy costs for the Chemicals and Allied Products Industry, which explains why little attention is paid to this operating cost (DOE, 1998).

Major differences are also present between these two industries. The Pharmaceutical Preparations manufacturers have much more stringent regulations (by the FDA) for plant management than do the Plastics and Resins manufacturers, as pharmaceutical products are produced for human consumption. Thus, Pharmaceutical Preparations manufacturers tend to require cleanrooms—rooms that are supplied with a constant volume of makeup air circulating frequently (often 400-600 times per hour) through high efficiency particulate air filters to maintain low particle concentrations (Chen, 1997 and PG&E, 1997). These cleanroom facilities offer tremendous energy savings potential, through the measures detailed in the Genentech profile below. In addition, Pharmaceutical Preparations are primarily processed in batches, while plastics are produced continuously. The following provides a detailed breakdown of energy consumption and costs in these industries.

3.1 Motor Energy Use in SIC 2821 — Plastics and Resins

Of the assessments performed on the 34 small- to medium-sized Plastics and Resins (SIC 2821) manufacturing firms in the Department of Energy's Industrial Assessment Center (IAC) Database, 17 meet our criteria as being small (that is, having less than 100 employees).[1] These 17 plants were in operation for 6,114 hours annually, on average (76 percent of maximum 24-hours-a-day operation). Their average annual energy consumption costs of $380,286 is broken down in the following chart:



MECS has also developed an estimate of the annual consumption of energy per employee for the Chemicals and Allied Products industry and the Plastics Materials and Resins industry — 4,087 million btus and 5,934 million btus, respectively. Extrapolating this information out for the two chemicals industries focused on in this report, it can be estimated that the 69 Plastics Materials and Resins manufacturers in the SCE service territory use 2.53 trillion btus of energy total (or roughly 37 billion btus per business) and the 76 Pharmaceutical Preparations manufacturers use 7.5 trillion btus of energy total (or roughly 99 billion btus per business) (MECS, 1994). These numbers are a bit higher than those estimates gleaned from the Industrial Assessment Database, and as the numbers for electricity and natural gas consumption are for those plants with less than 100 employees, they tend to represent a more accurate picture of energy use in the target industries.

[1] Only one of these 17 manufacturers is located in California, but the average of the 17 plants provides a representative picture of small-sized Plastics and Resins manufacturing plants.

3.2 Motor Energy Use in SIC 2834 — Pharmaceutical Preparations

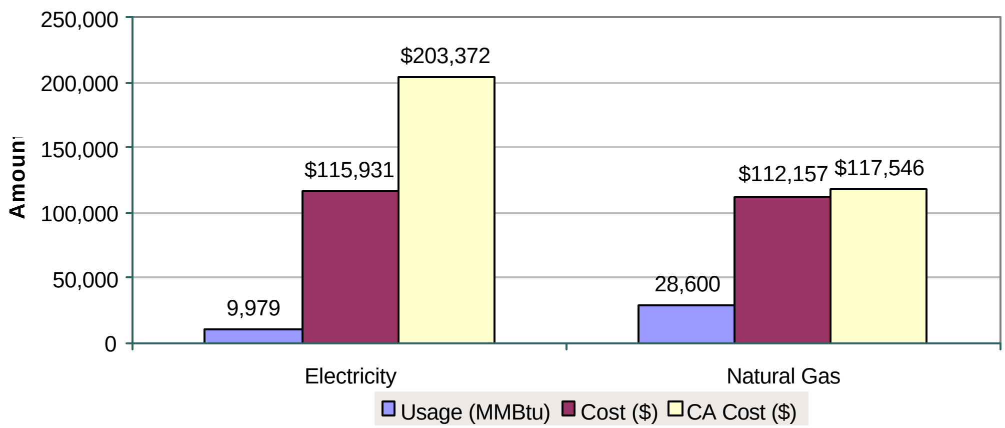
Of the assessments performed on the 36 small- to medium-sized Pharmaceutical Preparations (SIC 2834) manufacturing firms in the Department of Energy's Industrial Assessment Database, 7 meet our criteria as being small facilities (less than 100 employees). These 7 plants were in operation for 5,711 hours annually, on average (71 percent of maximum possible). Their average annual energy consumption costs of $228,088 ($320,918 if extrapolated into 1997 California industrial sector energy prices (EIA, 1998)) can be broken down as shown in the following chart:

Variable Speed Drives (VSDs) at Genentech

Genentech, a leading pharmaceutical manufacturing company located in Vacaville, CA, replaced the inlet vanes of its six variable volume air handlers (including one serving the cleanroom) with VSDs, which reduced the fan's horsepower to reduce the flow of air. To reduce airflow with the inlet vanes, the pressure drop was increased while the fans were running at full speed. The cost savings of these VSDs equal about $23,000 per year, and have resulted in a reduction in peak load of approximately 40 kW.

Source: Southern Exposure Engineering, 1997

Energy Usage & Costs for Sample of SIC 2834 IAC Plants (<100 employees)



4 MOTOR EFFICIENCY MEASURES

This section introduces some of the measures for improving the energy efficiency of motor systems, and provides some efficiency and cost data on sample motors, along with calculations to illustrate the financial costs and benefits of premium efficiency motors. However, motor applications vary between different facilities and motor costs and performance specifications change over time. Any site-specific or detailed analysis should be based on updated information from sources listed in section 6, "Tools and Sources of Additional Information," including:

- DOE's Best Practices (www.oit.doe.gov/bestpractices/motors/) and
- Consortium for Energy Efficiency (www.ceeformt.org/ind/mot-sys/mot-sys-main.php3 or www.ceeformt.org).

4.1 Types of Motor Efficiency Measures

The majority of the implemented measures recommended to chemicals manufacturers listed in the Industrial Assessment Database were:

- Replacing standard-efficiency motors greater than 1.5 horsepower that run more than 6,000 hours per year with energy-efficient motors (with savings averaging 2-5 percent for a motor replacement);
- Adjusting the sheave and speed of the impeller components of the device attached to the motor (e.g., the stirrer and pump) to better match the desired outflow;
- Installing Variable Frequency Drives (VFDs) on pumps to better optimize the flow of the liquid being pumped with the system needs, rather than using valves to control the flow;
- Installing VFDs on fans that were previous controlled by dampers to control the air flow more efficiently;
- Adding sensors (such as a differential static pressure sensor) to control systems to control the level of ventilation to a certain area in the plant (such as a clean room).

Many other motor efficiency measures that would be suitable for small chemical and pharmaceutical plants are cited in the sources identified below.

4.2 Financial Analysis of Motor Efficiency Decisions

[insert to be provided soon]

5 MARKETING MOTOR EFFICIENCY TO THE INDUSTRY

This section provides recommendations for utility representatives or other energy efficiency professionals when contacting or visiting small chemical or pharmaceutical manufacturing plants.

5.1 Key Contacts and Decisionmakers to Target

The Plant Manager is generally the best person to engage about motor efficiency at most small chemical and pharmaceutical facilities. Other personnel to approach would include the Facilities Manager, Maintenance Manager, Operations Manager or General Manager. If it is not possible to reach the manager with authority over motors and other manufacturing systems, it may be necessary to start with a Plant Electrician, a Control System Engineer, or lower-level engineering, operations, manufacturing or technical personnel.

For facilities that are owned by multi-plant corporations with headquarters out of state, it may be necessary for most on-site managers to go through a centralized or formalized review and approval process. Likewise, it may be necessary for utility representatives to treat such customers as they would other "national accounts." At headquarters there may be a Facilities Manager with responsibility for technical decisions across many plants. Also, the decision may be made or directed by a specialized Energy Manger or by a Procurement or Purchasing Manager.

In contrast, for single-plant, privately-owned or other facilities where operational and investment decisions are made on-site, it is somewhat more likely that the decision will be made or reviewed at the general plant management level or by a corporate officer. At the same time, for small manufacturing plants with fewer than 100 employees, it is less likely that there will be an energy specialist available to guide the analysis, and there may not be an engineering department on-site with an interest in improving the efficiency of their process. Therefore, the information provided by the utility or motor efficiency professional will have a greater influence on the outcome than would be the case for larger or multi-plant facilities.

When dealing initially with operational personnel, basic information can be collected on the existing condition of motors. Before identifying particular motor opportunities, it will be helpful to determine the context in which these motors operate, including not only the types of processes but also other information to assess the nature of the opportunities likely to be available. For example, the age of the facility may provide an indication of the extent to which recent construction or expansion was subject to motor efficiency standards or the extent to which motor replacement may have already taken place (e.g., the oldest plants may already have replaced many of their oldest motors).

As discussion proceed with operational personnel, it will be useful to emphasize the technical characteristics and advantages of energy efficient motor systems – for example:

> *Motor energy efficiency can increase the productivity of the plant by reducing downtime for machine repairs, as high-efficiency motors tend to have less wear and tear on the motor workings because they are able to maintain their peak efficiency levels over a broader range of loads than do standard-efficiency motors* (PG&E, 12/21/00).

For small single-plant manufacturing companies, it may also be possible to contact someone in the accounting or finance department who would be knowledgeable about the bottom-line impact of energy costs and investments, and who would be concerned about cutting energy costs or who would approve spending money on new high-efficiency motors in the plant. It may be possible to identify such a financial decisionmaker by starting with the clerk who pays the electric bill and ask for a referral to the Controller or another financial manager.

At many separately-owned plants, the on-site manager with responsibility for motor procurement decisions will also be aware of the costs of energy and may be in a position to make financial decisions. While the scarcity of capital funds in the short-term may be a greater concern than energy prices in the long term, these decisionmakers will be very aware of current electricity prices and supply concerns. Energy costs are significant for both chemical and pharmaceutical industries, as noted above, and as energy prices continue to rise, these manufacturers are going to start paying more attention to their energy costs and look for ways to control them. When dealing with financial or general business management personnel, it will be appropriate to emphasize the financial advantages of energy efficient motor systems – for example:

> *Motor efficiency will save money on electric bills, as energy costs for a standard efficiency motor over the course of a year can be up to five times the cost of a new motor, and even greater if the motor is oversized* (PG&E, 12/21/00).
>
> *While energy cost may not be a substantial component of the costs of goods sold, energy represents a much higher proportion of the variable costs over which a manufacturing plant can exercise some control, and while energy cost-cutting does not increase top-line revenue, it can have a significant bottom-line impact.*

With management or financial personnel, it may be appropriate to encourage the manufacturer to develop a <u>company policy</u> to reduce costs and waste or to improve the impact on the environment. Such a policy could emphasize increasing the overall efficiency of operations, or could focus on energy efficiency in general and motor efficiency in particular. It is unlikely that most small facilities in California have done this, since a 1998 survey indicates that only one-third of all U.S. small manufacturers had any efficiency policy, and only 7 percent of sampled industrial facilities in the United States had written specifications for motor purchases that included efficiency guidelines (US DOE, 1998e). Such a policy may address opportunities for both system-wide retrofit and replacement of failed motors, as discussed in the next two sections.

5.2 System-Wide Retrofit Opportunities

A company-wide energy efficiency policy could call for a system-wide survey of opportunities to retrofit existing motors with new premium-efficiency motors or variable speed drives. The following is one approach[2] that has been used in the chemical industry to carry out a system-wide replacement policy. This approach has several key steps, several of which would be beneficial to the manufacturing plant even if no efficiency measures were implemented, because many small manufacturers are not aware of what machines are the big "energy hogs" within their plant, as they may not have separate meters for different sections of the plant (Rodgers, 2000). The approach includes:

1. Locating and identifying the key motors used within the manufacturing plant;
2. Documenting these motor systems, including the manufacturer, type of system, controls, operational requirements, and use (though field measurements);
3. Comparing the need versus the use of the system (is the motor oversized, etc.) and how much energy the motor system is using;
4. Developing options/alternatives for upgrading/replacing the motor, including the estimated savings, the cost to implement, and feasibility of the project (both financial and operational);
5. Preparing feasible recommendation strategy reports (describing the system and the opportunities for improvements/savings) and presenting them to the plant management for consideration;
6. Implementing the projects, as selected and as funding is made available, emphasizing the standard yearly maintenance shut-down to avoid interruption of operations at other times of the year; and
7. Monitoring the upgraded systems and comparing actual savings to calculated savings, and documenting these results.

Timing is critical for any significant motor retrofit activity because the financial savings could be wiped out by any reduction in revenue that could be associated with unplanned production downtime. Therefore, as noted above, a standard yearly maintenance shut-down period should be used to replace motors. Utility representatives should be aware of this timing issue and should inquire what the schedule may be at each facility for such opportunities. Many plants will schedule as much maintenance as possible into a week-long vacation period. SCE staff may be able to work back from such a maintenance schedule to determine the best time to approach facility personnel about motor efficiency retrofit strategies. Another opportune time for customer discussions is at year-end when maintenance and capital budgets are being prepared for the coming year.

[2] This approach was implemented by 3M in a 1995 Motor Challenge Showcase Demonstration Project, but could be streamlined to adapt to the realities of a smaller company. (Hydraulic Institute, 2000)

5.3 Procurement Policy for Replacement of Failed Motors

For small manufacturing companies where system-wide retrofits of energy efficient motors may be too expensive, a more practical option would be replacement of failed motors with energy efficient models. As demonstrated above in the section "Financial Analysis of Motor Efficiency Decisions," the incremental cost of efficiency is lower when a motor has already failed than in a retrofit situation.

Making sure that facilities have written specifications for motor replacements that feature efficiency guidelines will ensure that replacement motors are energy efficient even when the replacement decision must be made quickly to minimize downtime. A motor replacement purchase policy can build on an inventory such as that described in the first two or three steps of the system-wide retrofit approach outlined above, and can consist of the following two major additional elements:

- **specifications** of the high efficiency motor to be used to replace each existing motor when it fails (and where appropriate marking the replacement motor model on each such existing motor), and
- **advanced purchasing arrangements** with contractors or other motor suppliers of the high efficiency motor types, models and sizes which will be needed for in local dealer inventory to guarantee delivery for rapid replacement of failed motors in the future. CEE's Motor Systems Toolkit (www.ceeformt.org/ind/mot-sys/mot-sys-main.php3 or www.ceeformt.org) will include a leave-behind guide with a step-by-step approach to developing such a procurement policy, along with a draft policy that a small chemical company could adopt or adapt to its needs.[3]

5.4 Addressing the Availability of Premium Efficiency Motors

Distributors have a difficult time stocking energy efficient motors in general because of their higher initial cost and because motor manufacturers are more interested in price than efficiency. Maintaining an inventory of efficient motors is a greater problem for manufacturing plants with specialized motor needs than it is for users of more standardized motors. In these situations, availability can be a greater barrier than cost to energy efficient motor use.

Small manufacturers may not have sufficient volume to convince their motor suppliers to agree to the advanced purchasing arrangements described above. While they can attempt to convey their efficiency policies to their motor vendor(s) and maintain good relations with them, utility incentive programs[4] or other approaches may be necessary to ensure the availability of particular motors. For example, San Diego Gas and Electric developed a way to handle this situation by

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[3] See also Energy Star® Procurement Toolkit http://www.epa.gov/nrgystar/purchasing/.

[4] For example, utilities can encourage motor vendors to keep a supply of energy-efficient motors on hand by providing an incentive directly to the vendor for every efficient motor sold.

financing the return of several standard efficiency motors from large distributors back to the manufacturers, and replacing these motors with energy efficient models. Customers will generally purchase the motors in stock over a specially ordered motor (especially when acting quickly to replace a failed motor), so this was an effective method of ensuring the availability of energy efficient models to customers.

5.5 Technical Assistance for Motor System Improvements

A "systems approach" to motor efficiency may be of particular value to small manufacturing facilities. The systems approach looks at the big picture of efficiency—making an electric motor system more efficient in terms of total system performance, rather than focusing on the individual elements of the system. For example, rather than just emphasizing replacing motors themselves, attention should also be paid to the other elements that can reduce the energy used by motor systems in the plant, such as adjusting belts, sheaves and speeds of devices attached to motors or adding sensors to help optimize ventilation levels.

"Tuning up" motor systems may cost less, while achieving the same of better efficiency improvements, compared with replacement of the motors themselves, especially in manufacturing plants and other complex facilities. The applications in which motors are used may be subject to variation over time as new products are introduced and manufacturing processes are changed or refined. When such changes are introduced, motor systems may need to be adjusted to maintain efficiency.

Even where the basic financial performance of system improvements is not more attractive than that of motor replacement, these improvements may be an attractive starting point because they can often be implemented primarily with a commitment of engineering time, supported by technical assistance from utility or motor professionals, rather than a substantial capital investment. When savings are demonstrated from these operational measures, it may help convince a Plant Manager to make investments in new premium efficiency motors.

While some adjustments to "tune up" systems without purchase of new motor equipment may have little cost, some other systems level measures may require consultation with outside engineers and may require substantial capital investment. For example, because motors typically have highest efficiency at 70 to 90 percent of their maximum loads, effectively matching motors to loads will result in substantial energy savings (Qayoumi, 1995). An analysis of system efficiency may reveal opportunities to install variable frequency drives (VFDs). A VFD is an electronic control device that modulates the amount of power being delivered to a motor to allow for continuous matching of motor speed to the demands of varying flow and may be used to increase motor efficiency in water supply facilities. These devices accommodate fluctuating demand by running motors or pumps at lower speeds and requiring less energy while more accurately meeting pumping needs. They are efficient alternatives to standard throttling valves and cause far less stress and damage to mechanical equipment. While the initial costs are high, investments in VSDs are often cost-effective in the right applications. Where these opportunities exist, utility representatives can help by offering support for engineering and financial analysis.

6 TOOLS AND SOURCES OF ADDITIONAL INFORMATION

The best sources of motor management tools and information are:

- DOE's Best Practices: www.oit.doe.gov/bestpractices/motors/, and
- Consortium for Energy Efficiency: www.ceeformt.org/ind/mot-sys/mot-sys-main.php3 or www.ceeformt.org/.

These two web sites include the resources listed below.

6.1 Motor Management and Planning

Energy Management for Motor Driven Systems – DOE guidebook designed to help establish a facility energy-management program, to identify and evaluate energy conservation opportunities involving motor-driven equipment, and to design a motor improvement plan.

Energy Star® Procurement Toolkit: www.epa.gov/nrgystar/purchasing/

6.2 Motor Replacement

CEE Premium-Efficiency Specifications – utility-developed and supported efficiency recommendations for 114 classifications for motors.

Efficient Motors: Selection and Application Considerations **--** CEE brochure provides a brief guide to understanding and selecting efficient motors. It contains several examples to help determine when using a premium-efficiency motor is appropriate.

MotorMaster+3.0 – A DOE energy-efficient motor selection and management tool including a catalog of over 20,000 AC motors: http://mm3.energy.wsu.edu/mmplus/

6.3 Motor Repair

DOE-OIT's BestPractices Repair Tools for Motors

- **Motor Repair "Tech Brief" –** A general brochure explaining what is meant by quality repair and why it is important
- **A Shop Evaluation Guide –** to assist the customer in selecting a repair shop
- **A General Motor Repair Specification –** to request quality repair services
- **A Bibliography –**listing motor repair publications and materials.

Electrical Apparatus Service Association (EASA)

- **Tech. Note 16 –** Guidelines for Maintaining Motor Efficiency During Rebuilding
- **A Guide to AC Motor Repair and Replacement**
- **AR100-1998 Recommended Practice for the Repair of Rotating Electrical Apparatus.**

California Motors Initiative's Guidelines to a Good Motor Repair.

6.4 Key Associations

American Chemical Society 1155 16th Street NW Washington, DC (202) 872-4600 www.acs.org	Founded in 1876 and chartered by a 1937 Act of the U.S. Congress, the American Chemical Society (ACS) is the world 's largest scientific society, with more than 161,000 members. The ACS seeks to Promote the public's perceptions and understanding of chemistry and the chemical sciences through public outreach programs and public awareness campaigns.
American Chemistry Council 1300 Wilson Blvd. Arlington, VA (703) 741-5000 www.cmahq.com	The American Chemistry Council (ACC), formerly the Chemical Manufacturers Association, is the voice of the US Chemical Industry, with more than 300 members in the US and Canada. ACC represents the chemical industry on public policy issues, coordinates the industry's research and testing programs, and administers the industry's environmental, health, and safety performance improvement initiative, known as Responsible Care.
American Institute of Chemical Engineers 3 Park Ave. New York, NY (800) 242-4363 www.aiche.org	Founded in 1908, the American Institute of Chemical Engineers (AIChE) is a nonprofit organization providing leadership to the chemical engineering profession. Representing 57,000 members in industry, academia, and government, AIChE provides forums to advance the theory and practice of the profession, upholds high professional standards, and supports excellence in education.
Synthetic Organic Chemical Manufacturers Association 1850 M St N.W., Suite 700 Washington, DC (202) 721-4100 www.socma.com	The Synthetic Organic Chemical Manufacturers Association (SOCMA) represents the interests of over 300 member companies, encompassing every segment of the industry—from small specialty producers to large multinational corporations. SOCMA influences proposed and pending regulations by advocating sound science as the basis for regulation.
Drug, Chemical & Allied Trades Association 510 Route 130, East Windsor, NJ (609) 448-1000 www.dcat.org	Founded in 1890, the Drug, Chemical & Allied Trades Association provides educational programs, events, and business development opportunities to member companies (approximately 500 corporations operating in 30 countries) in the drug, chemical, and related industries.
Pharmaceutical Research and Manufacturers of America 1100 Fifteenth Street, NW Washington, DC (202) 835-3400 – www.phrma.org	The Pharmaceutical Research and Manufacturers of America (PhRMA) represents the country's leading research-based pharmaceutical and biotechnology companies (more than 200 member companies).
Society of the Plastics Industry 1801 K St., NW, Washington, DC (202) 974-5200 www.plasticsindustry.org	Founded in 1937, the Society of the Plastics Industry, Inc. is the trade association representing the fourth-largest manufacturing industry in the United States. SPI's 1,700 members represent the entire plastics industry supply chain, including processors, machinery and equipment manufacturers and raw material suppliers.
Society of Plastics Engineers PO Box 403, Brookfield, CT (203) 775-0471 – **www.4spe.org**	Started in 1942, the Society of Plastics Engineers is the recognized medium of communication amongst scientists and engineers engaged in the development, conversion and applications of plastics. The objective of the Society is to promote the scientific and engineering knowledge relating to plastics.

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