Industrial Sectors Market Characterization

Plastics Industry

Prepared for Southern California Edison Company

Oakland, California, February 2012

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Acronyms and Abbreviations

AB 32	Assembly Bill 32, the Global Warming Solutions Act
ACEEE	American Council for an Energy Efficiency Economy
AMO	Advanced Manufacturing Office
ANSI	American National Standards Institute
ARB	California Air Resources Board
ARRA	American Recovery and Reinvestment Act
Btu	British thermal unit
CAA	Clean Air Act
DOE	U.S. Department of Energy
CAD	computer-aided design
CEI	continual energy improvement
CHP	combined heat and power
CO_2	carbon dioxide
CO_2e	carbon-dioxide equivalent
CPUC	California Public Utilities Commission
CWA	Clean Water Act
EEPS	energy efficiency portfolio standards
EPI	energy performance indicator
ESA	Endangered Species Act
F	Fahrenheit
GHG	greenhouse gas
GWh	gigawatt-hour
HDPE	high-density polyethylene
HSWA	Hazardous and Solid Waste Amendments
IAC	Industrial Assessment Center
IOU	investor-owned utility
ISO	International Standards Organization
ITP	Industrial Technologies Program
kWh	kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory
MBtu	million British thermal unit
MECS	Manufacturing Energy Consumption Survey
MW	Megawatt
NAICS	North American Industry Classification System

O&M	operations and maintenance
OEM	original equipment manufacturers
OSHA	Occupational Health and Safety Administration
PET	polyethylene terephthalate
PVC	polyvinyl chloride
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RPS	renewable portfolio standard
SCE	Southern California Edison Company
SEP	Superior Energy Performance
SPI	Society of Plastics Industry
TBtu	trillion British thermal unit
tpy	tons per year
U.S. DOE	U.S. Department of Energy
U.S. EPA	U.S. Environmental Protection Agency
UK	United Kingdom
VSD	variable speed drive

Summary of Findings

The plastics industry (North American Industry Classification System [NAICS] prefixes 32521 and 3261) combines petroleum products and chemicals to produce the raw plastics material called resin. This resin is heated, pressurized, shaped and molded into numerous products used in everyday life. Southern California Edison Company (SCE) territory customers in this sector manufacture specialized products (NAICS 326199), bottles (NAICS 326160), bags (NAICS 326111), packaging film and sheets (NAICS 326112), polystyrene foam (NAICS 326140), and raw material resin. The largest energy-consuming sector in SCE territory is specialized products, a diverse group of many small manufacturers producing specialty products.

The plastics industry is highly fragmented. In SCE's territory, the electric usage of the top five manufacturer customers combined represents less than 20 percent of the total plastics sector consumption. Other NAICS sectors producing commodity products (resin, bottles, bags, film) are more concentrated and have far fewer manufacturers.

Industry Landscape and Operational Models

California is one of five major U.S. centers for plastics components production due to its proximity to ocean shipping and transportation hubs and industrial end-use customers. While Texas is the major resin production center, due to its proximity to industry raw inputs of oil and natural gas, SCE territory contains several large resin producers that supply plastics' product manufacturers in-state and export through the Port of Long Beach, California.

Two primary business models dominate the plastics industry: commodity products and specialty products. Commodity products manufacturers are typically large, multinational players, led by chemical and oil and gas exploration firms that use crude oil and chemical additives to produce raw plastics. Many of these companies have just a few large accounts signed under long-term contracts. In SCE's territory, the typical specialty-products manufacturer is a private company, has a single plant and employs fewer than 100 people. Most manufacturers specialize in a few product lines as the equipment and tooling needed to engineer products to customer specifications can be expensive.

The cost structure is similar for both the commodity and specialty business models. Raw materials are the major manufacturing expense, often costing up to 50 percent or more of revenues. Crude oil or natural gas is the primary inputs used to manufacture resin. Plastics product manufacturers use resin or recycled plastics as the key input. Some but not all plastics can be recycled (e.g., polyethylene terephthalate [PET] used for bottles and sheets), and this recycled plastic can be used instead of resin to decrease input costs. Employee wages are the second highest cost at approximately 10–20 percent. Imports from lower wage cost countries such as China and other Asian countries represent an increasingly greater competitive threat.

Energy Use

Machinery of all types comprises about two-thirds of total energy usage, primarily in the form of electricity. The remainder is attributable to space heating, cooling, compressors, and lighting.

The high concentration of electric-powered motors and drives makes the industry a good target for standard energy efficiency projects.

Electricity-driven machines handle many factory tasks such as melting raw materials; cooling molds, and driving peripheral equipment such as grinders, compressors, pumps, pre-driers, and mixers; and forming semi-manufactured products. Energy use can be a critical hidden factor in the industry's profitability, and good potential exists to save energy and money at almost every stage of the plastic processing chain.

Drivers for Energy Decision Making

Standard industrial efficiency measures for motors and drives and other basic processes, as well as lighting, are primary options to reduce plastics industry energy consumption. Options such as high-efficiency motors and variable-speed drives have excellent payback for both new and replacement purchases. Product mix changes frequently, according to the short to medium term contracts, and can necessitate new industrial equipment. This is an optimal time to replace existing equipment with higher efficiency.

The most energy intensive industry sector, resin manufacturing, involves costly equipment, and production is detailed and complicated, like most other chemical processes. Improving this process to increase energy efficiency can be costly and presents a significant barrier. However, energy efficiency opportunities can be found in support equipment such as boilers, thermal oil heaters, thermal oxidizers, motors applications and cooling towers.

Overall Findings

SCE territory contains a mix of large plastics product manufacturers and many small niche plastics firms as well as a few very large resin producers. The following findings regarding improving the adoption of energy efficiency measures in the plastics industry are based on the primary and secondary research presented in this report. Managing energy costs typically ranks behind other business priorities such as raw material sourcing and labor management. Energy efficiency projects undertaken tend to be standard measures, such as higher efficiency motors, variable speed drives (VSDs), and behavioral changes, rather than more innovative solutions.

- Knowledge gaps identified in program understanding appear to inhibit broader participation among customers interviewed. Increased use of electronic communications, such as email check-ins or newsletters, may increase sector participation in this large, diffuse customer base
- Large products firms may be the most receptive to energy efficiency since their business model is based on producing large quantities of standardized products, and profitability depends on production efficiency and product mix.
- Small manufacturers comprise the largest energy use sector in SCE territory. These individual customers also have similar energy efficiency needs opportunities as larger product manufacturers, but have less access to capital and credit and require more sales time to target each company individually.
- Only a few resin manufacturers operate in SCE territory. These firms are large energy users but have costly, specialized equipment that is not likely to be upgraded frequently.
- Customers that have recently signed multiyear product sales contracts will be more receptive to longer-term projects than customers that face uncertain sales.
- Three major industry priorities compete with energy efficiency goals: cutting production costs, competing with low-cost imports, and effectively managing environmental concerns of its products such as contributing to pollution and waste and health concerns. Energy efficiency measures that contribute to these identified industry concerns will be more likely to move forward.

1. Project Background

The industrial sector consumes over 30 percent of the nation's energy,[1] presenting enormous opportunities for energy efficiency.[2] Many market forces beyond simple energy cost drive industrial customer decision making. Attaining a better understanding of the customer's world will assist Southern California Edison (SCE) in its design and implementation of industrial energy efficiency programs. Following upon a potential study developed in 2009 for Pacific Gas & Electric, SCE engaged energy-consulting firm KEMA, Inc. for a next phase to prepare market intelligence on specific energy-intensive subsectors.

The research objective is give SCE staff study results to facilitate improved marketing of energy efficiency products and support face-to-face engagement of customers with those products. To address the objective of this study, the work was organized into r key elements. These include:

- Perspectives about broad trends affecting California and the nation's industrial sectors (section 2)
- Detailed in-depth, industry-specific analysis of business and process drivers developed from secondary research (section 3)
- Energy usage, target technologies and process, and energy efficiency opportunities (section 4)
- Real-time perspectives and intelligence gained from key industry insiders through interviews and Webinar/Forum group discussions (section 5)
- Recommendations (section 6)
- Utility-specific appendices containing proprietary data and customer information (appendices).

In practice, these report elements are built stepwise—broad national trends inform industry-specific secondary research and industry-specific analysis informs the primary interviews and roundtable discussions. The outcome is a thorough research report intended to provide SCE staff members the breadth necessary to position their industrial energy efficiency products optimally and the depth necessary to knowledgeably engage their customers.

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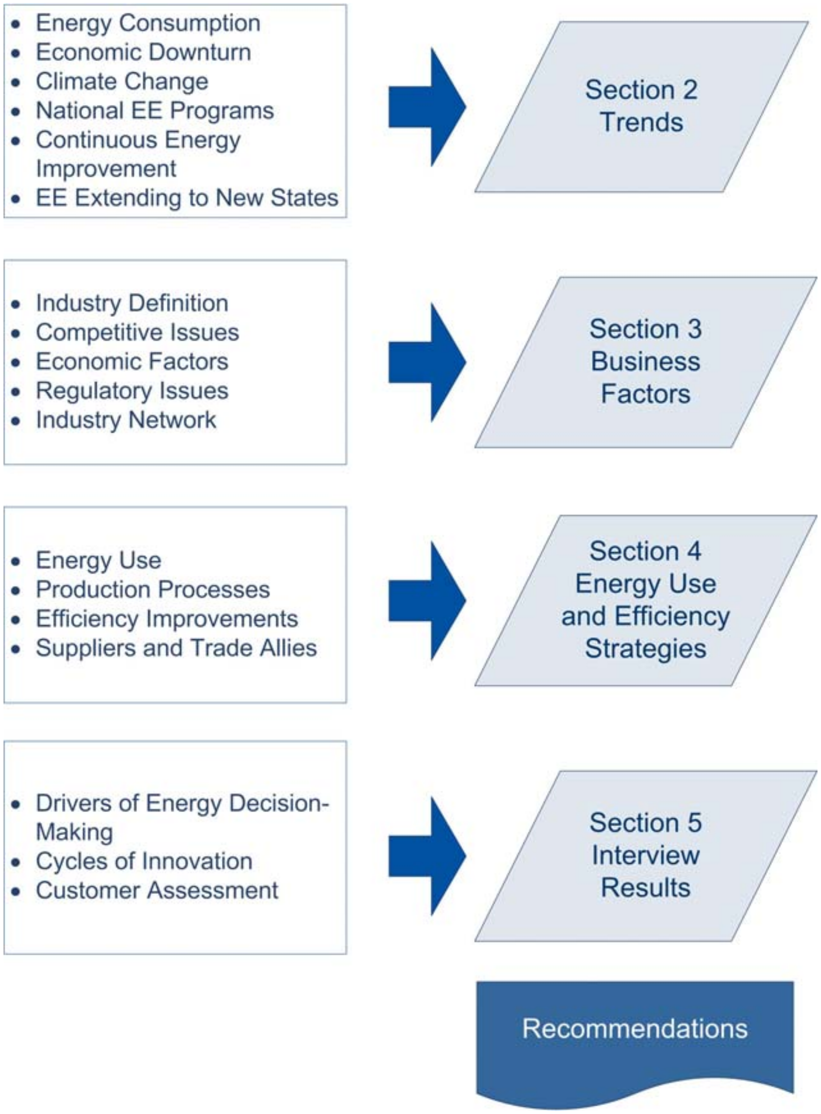
[1] Quinn, Jim. 2009. *Introduction to the Industrial Technologies Program*. Save Energy Now Series Webinar. January 15.
http://www1.eere.energy.gov/industry/pdfs/webcast_2009-0115_introtoitp.PDF

[2] U.S. Census Bureau, 2008.
http://www.census.gov/compendia/statab/2010/tables/10s0892.xls

Figure 1 provides a graphic overview of the report.

Figure 1: Graphic Overview of Report



2. Trends in Industrial Energy Efficiency

The industrial sector consumes an immense amount of energy, nearly 32 percent of total U.S. consumption in 2008,[3] to produce goods and materials for wholesale and retail sales. In the past three decades, the overall energy efficiency of the industrial sector in the United States has increased dramatically. Energy efficiency potential savings have been estimated at 20 percent or more by 2020, both nationally[4] and in California.[5] It has thus been an attractive target sector for utilities and government looking to reach new levels of energy savings through efficiency.

Changing energy markets and climate change policies are driving greater interest in energy efficiency technologies. Key trends discussed are energy consumption patterns; effect of the economic downturn on manufacturing; climate change and energy legislation; the rise of continuous energy improvement; energy efficiency adoption outside California and national energy efficiency programs. These trends are discussed in more detail below.

2.1 Energy Consumption Trends

California ranked first in the nation in gross domestic product, at $1891.4 billion in 2009. Table 1 shows the industrial energy consumption. California ranks only third in the nation for energy use, reflecting higher efficiency levels in the industrial sector.[6]

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[3] U.S. Census Bureau, 2008. *Energy Consumption, by End-Use Sector*. http://www.census.gov/compendia/statab/2010/tables/10s0892.xls

[4] McKinsey & Co. 2009. *Unlocking Energy Efficiency in the U.S. Economy.* July. http://www.mckinsey.com/clientservice/electricpowernaturalgas/downloads/_energy_efficiency_exc_summary.PDF

[5] KEMA. 2008. *Strategic Industrial Report for PG&E.*

[6] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State and Regional Partnerships. 2011. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=CA

Table 1: Industrial Energy Consumption, California

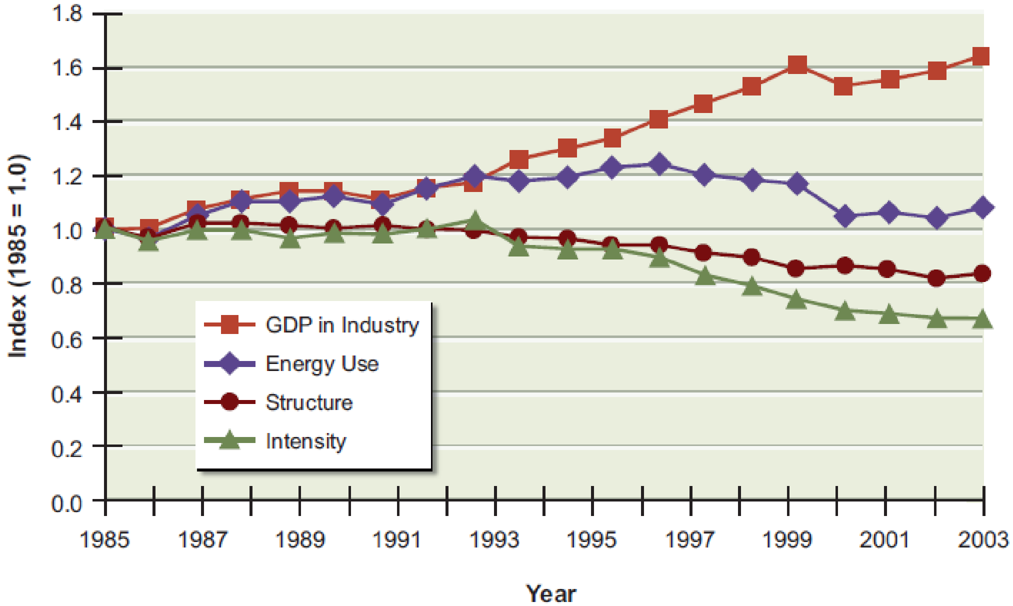
Year	California Industrial Energy Consumption (Trillion Btu)
2009	1,770
2008	1,955
2007	1,958
2006	1,979
2005	2,001
2004	2,053
2003	1,986
2002	1,999
2001	2,137
2000	2,132

Source: Energy Information Administration[7]

Figure 2 shows U.S. trends in industrial energy intensity over time. This figure shows that there has been a general trend since 1993 toward stable or slightly decreasing energy use, even while the economy prospered. More significantly, the energy intensity, or energy per unit of production, has been steadily increasing. Thus, the industrial sector has shown consistent improvement in reducing the amount of energy required to produce manufactured goods.

[7] U.S.DOE. 2011. *State Energy Consumption Estimates 1960 through 2009*. DOE/EIA-0214(2009). June 2011. http://205.254.135.7/state/seds/sep_use/notes/use_print2009.PDF

Figure 2: U.S. Trends in Industrial Energy Intensity Delivered Energy, 1985–2004



Source: National Academy of Sciences[8]

2.2 Economic Downturn Effects on Industrial Production

Most U.S. industries experienced a sharp drop in production as demand for manufactured goods declined, starting in the last quarter of 2008. The plastics industry experienced a reduced demand for its products, especially from the automotive, consumer goods, and construction industries.

A method of observing the economic downturn's effect in California is to consider trends in carbon emissions. Although multiple factors affect emissions, including energy efficiency and carbon reduction, dramatic short term changes do indicate likely reductions in production. According to analysis by research firm Thomson Reuters Point Carbon, an overall reduction of carbon emissions of 11 percent from 2008 to 2010 was observed among the 343 California facilities that must comply with California's cap-and-trade program. Table 2 displays the carbon-dioxide (CO_2) emission changes by industrial sector. Facility closures was the major driver for cement, glass, pulp and paper industries' decline while chemicals sector emissions increased

[8] National Academy of Sciences. 2010. *Real Prospects for Energy Efficiency in the United States*. National Academies Press.

largely from a new hydrogen plant in SCE's territory. While not identified in the table, the plastics industry has also experienced a cyclical downturn.[9]

Table 2: Percent Change in CO2 Emissions among Largest Calif. Industrial Sectors, 2008-2010

CO2 Emissions 2008 vs. 2010	California Industrial Sector	Notes
+21%	Chemicals	Driven by new $80MM hydrogen facility in SCE territory
+5%	Metals	Increase in production
-34%	Cement, lime and glass	Driven by facility closures
-35%	Pulp, paper and wood	Driven by facility closures

Source: Thomson Reuters Point Carbon[10]

The economic recession is forcing businesses and governments to take a close look at initiatives that save money and do not require capital investments, such as the best practices developed by the United States (U.S.) Department of Energy's (DOE) Advance Manufacturing Office and through increased energy management systems, as discussed in the following sections.

2.3 Climate Change and Energy Legislation

Industry's energy-related CO_2 emissions have decreased in the last decade, while rising more dramatically in other sectors, as shown in Figure 3. This reduction is largely attributable to U.S. industry's net decrease in energy consumption, according to the American Council for an Energy Efficient Economy[11] that resulted from a decrease in manufacturing activity as well as energy efficiency gains. Still, industry accounts for approximately 27.4 percent of total energy-related CO_2 emissions in the United States.

Greater energy efficiency will almost certainly be an important component in comprehensive national—and global—strategies for managing energy resources and climate change in the

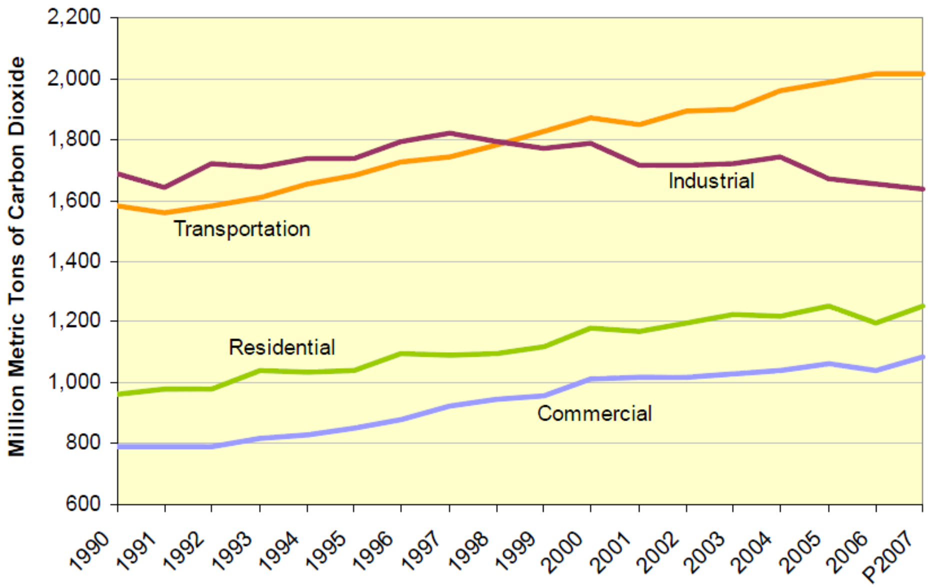
[9] High Beam Business. Industry Report. http://business.highbeam.com/industry-reports/chemicals/plastics-materials-synthetic-resins-nonvulcanizable-elastomers

[10] Thomson Reuters Point Carbon. 2011. *California Emissions in 2010 Down by 11%.* August http://www.pointcarbon.com/aboutus/pressroom/1.1564622

[11] Chittum, A., R. Elliott, and N. Kaufman. 2009. *Trends in Industrial Energy Efficiency Programs: Today's Leaders and Directions for the Future*. American Council for an Energy Efficient Economy, Report IE091. September 2009.

future. Energy efficiency is generally acknowledged to be the lowest-cost and fastest-to-deploy resource to slow the growth of CO_2 emissions, and it also results in positive economic impacts. Congress is not expected to approve any policy mechanisms to reduce CO_2 emissions in the short term although legislation encouraging greater energy efficiency in the U.S. manufacturing sector is possible.

Figure 3: U.S. Energy-Related CO_2 Emissions by End-Use Sector, 1990-2007



Source: ACEEE[12]

2.4 National Programs

Typical utility programs address only a subset of the energy efficiency improvement opportunities, focusing primarily on retrofits and capital improvements. Less attention is given to behavior or maintenance. Federal, regional, and state government agencies, utilities, and others have developed a range of programs to improve industrial energy efficiency. These include providing incentives, audits and technical assistance, and continuous improvement programs.

Many of SCE's customers participate in these programs which can yield insights and best practices to inform utility programs, such as energy assessments offered by the U.S. DOE's

[12] Chittum, A., R. Elliott, and N. Kaufman. 2009. *Trends in Industrial Energy Efficiency Programs: Today's Leaders and Directions for the Future*. American Council for an Energy Efficient Economy, Report IE091. September 2009.

Advance Manufacturing Office (AMO), formerly the Industrial Technologies Program (ITP). In California, 49 assessments were completed for small and medium facilities in 2009 through 2011 and 38 assessments for large facilities between 2006 and 2011.[13] For example, Epic Plastics of Lodi and Orion Plastics of Compton were audit participants.

The U.S. DOE's AMO has been the primary federal entity supporting manufacturing research and development (R&D) in partnership with industrial stakeholders. For example, the DOE supported a project to use recovered plastics in durable goods manufacturing in California.

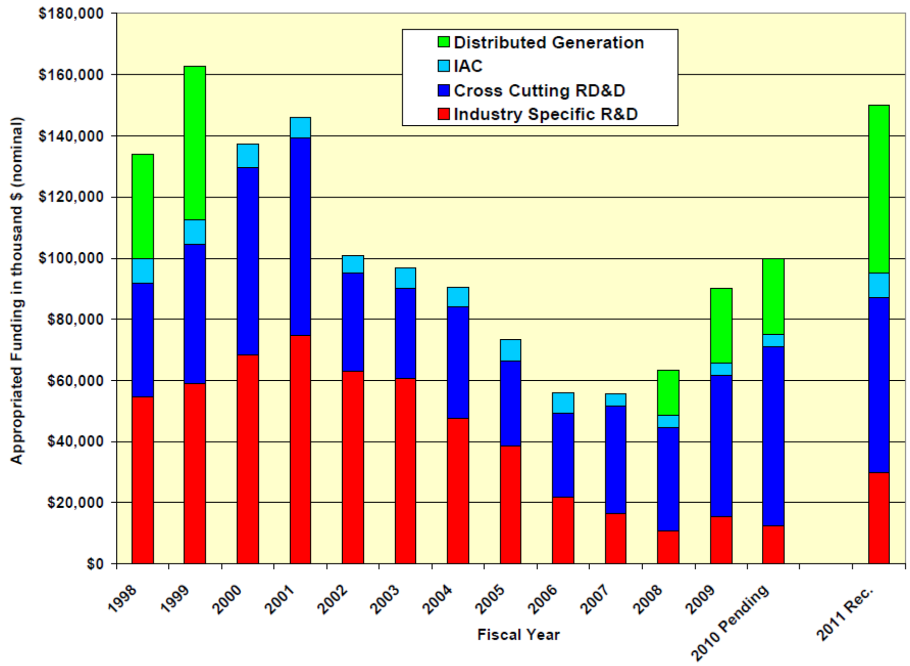
The AMO R&D program has been recognized as one of the most successful federal R&D efforts operating today. However, in recent years support for the program's R&D funding has faltered, particularly for the industry-specific R&D funding. This has been the most effectual initiative, considering its track record of commercializing products useful to industry. A U.S. DOE peer review report called the manufacturing R&D pipeline "largely empty."[14] This is challenging for the transformation of manufacturing because even though AMO's industry-specific R&D reaches commercialization faster than most other federal R&D, it can still take seven to ten years for results from R&D to reach a plant floor.

In addition to R&D activities (both the industry specific mentioned above and cross cutting), ITP has two technology and best practices programs: Better Plants (formerly Save Energy Now) and the Industrial Assessment Centers.

[13] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State and Regional Partnerships. 2011. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=CA

[14] Savitz, et al.2009. *DOE Industrial Technologies Program 2008 Peer Review*. http://www1.eere.energy.gov/industry/about/pdfs/itp_peerreview_report2008.PDF

Figure 4: Industrial Technologies Program Funding, 1998–2010



Source: ACEEE[15]

Better Plants works with large industrial energy consumers to help reduce their energy intensity using audits, software tools, and best practices. The other program, Industrial Assessment Center (IAC), serves a similar function for small- and mid-sized industrial facilities, and also trains the next generation of industrial energy engineers. Twenty-six centers at U.S. engineering universities train students to identify energy savings opportunities and perform no-cost assessments for small and medium industrial customers. In California, San Francisco State University and San Diego State University run IAC programs. The IAC program has a public database of recommendations dating back to 1981, a resource for customers on industrial energy efficiency improvements.

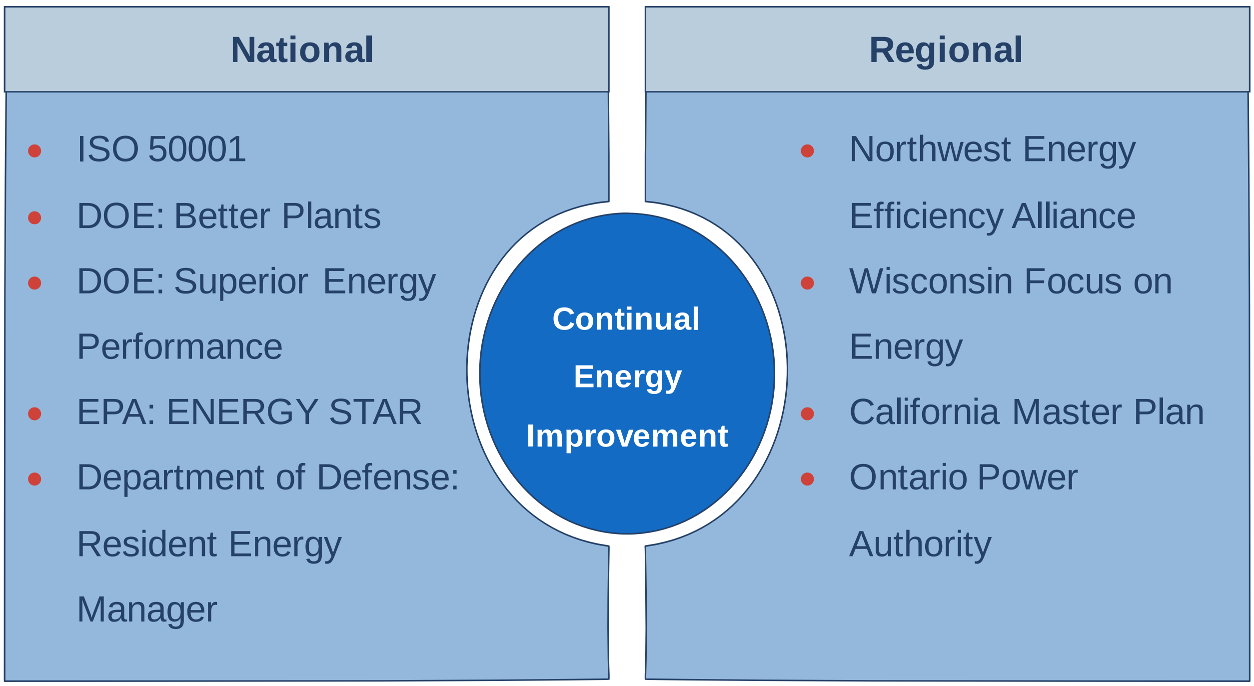
2.5 Rise of Continual Energy Improvement

Utilities, and private organizations, and governments around the world have developed programs in the last few years that focus on setting goals and targets to achieve continual

[15] American Council for an Energy Efficient Economy. 2009. *Barriers to energy efficiency investments and energy management in the U.S. industrial sector*. October 20, 2009.

energy improvement (CEI) in industry. National programs in the United States have been developed by the DOE (Better Plants and Superior Energy Performance) and U.S. Environmental Protection Agency (EPA) (ENERGY STAR). Figure 5 displays some examples of national and regional continual energy programs. From a business perspective, interest in energy management is increasing, as shown by the increasing number of participants in these programs.

Figure 5: Examples of National and Regional Continual Energy Improvement Programs



Two important developments in 2011 are expected to heighten interest and activity around energy management: the release of ISO 50001, a global energy management standard, and the launch of Superior Energy Performance, a national program to support energy intensity reductions for industrial plants and commercial buildings.[16]

[16] McKane, Aimee. 2011. "Achieving Superior Energy Performance[cm]: through Energy Management." (Presentation, ACEEE 2011 National Symposium on Market Transformation, Washington DC, April 10–12, 2011). http://www.aceee.org/files/pdf/conferences/mt/2011/I1%20-%20Aimee%20McKane.PDF

The recent work on U.S. and international energy management standards will have a significant impact on how energy is used in the industrial sector. The International Standards Organization (ISO) released an international energy management standard, ISO-50001 in June 2011.

The U.S. DOE is in the process of launching the Superior Energy Performance (SEP) program to promote industrial energy management and increased energy efficiency. This voluntary program will focus on fostering an organizational culture of energy efficiency improvement in U.S. manufacturing facilities, targeting mid- to large-sized plants.

Participants establish an energy management system that complies with ISO 50001 and meets other SEP program requirements, including robust measurement and verification of energy savings. Pilot programs have been launched in Texas and the Pacific Northwest, and the full SEP program is expected to begin in 2013. A California pilot is also planned within the next two years. The American National Standards Institute (ANSI) is developing companion standards to support SEP. ANSI MSE 50021 will provide the additional energy performance and management system requirements for SEP certification that goes beyond basic conformance with ISO 5000; and ANSI 50028 will provide the requirements for verification bodies for use in accreditation or other forms of recognition.[17]

Regional CEI programs have been developed under the Northwest Energy Efficiency Alliance,[18] working with the Bonneville Power Administration and the Energy Trust of Oregon. California has identified CEI as an important aspect of its strategic plan.[19] Similarly, Wisconsin's Focus on Energy employs an internally developed tool called Practical Energy Management©.[20] CEI is still in its infancy, with few CEI programs beyond the pilot stage.

2.6 Additional States Adopt Industrial Energy Efficiency

California has long been perceived as a leader in energy efficiency programs. Historically, energy efficiency trends and best practices tended to spread from California to other states

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[17] U. S. Council for Energy-Efficient Manufacturing. 2010. Superior Energy Performance. http://www.superiorenergyperformance.net/pdfs/SEP_Cert_Framework.PDF

[18] Northwest Energy Efficiency Alliance. Continuous Improvement for Industry website. http://www.energyimprovement.org/index.html

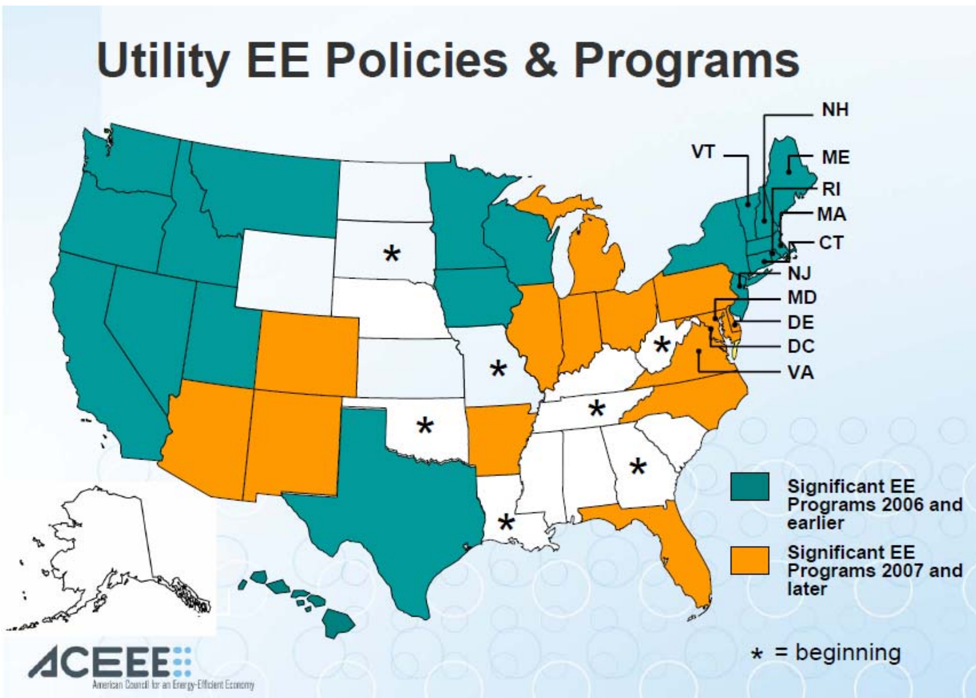
[19] California Public Utilities Commission. 2011. *CA Energy Efficiency Strategic Plan, January 2011 Update*. http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.PDF

[20] Wisconsin Focus on Energy, Industrial Program. Practical Energy Management tool. http://www.wifocusonenergy.com/page.jsp?pageId=368

involved in industrial energy efficiency. More recently, a sizable contingent of states have made significant commitments to energy efficiency programming as shown in Figure 6. The flow of information is changing as energy efficiency programs spread to locations in the Midwest and South that typically had provided modest or little ratepayer funding for energy efficiency. Program development efforts in many of the aforementioned states are in their early stages compared to California.

These states have signaled their commitment to energy efficiency by adopting aggressive Energy Efficiency Portfolio Standards[21] (EEPS) policies[22] that exceed those in California. As shown in Figure 6, California ranks number 14 for cumulative electricity savings targets by 2020, below states primarily in the Northeast and Midwest.

Figure 6: Utility Energy Efficiency Policies and Programs, 2006 vs. 2007+



Source: ACEEE[23]

[21] Covers all sectors including residential, commercial and industrial efficiency.

[22] These include: Illinois, Maryland, Michigan, New Mexico, Ohio, Pennsylvania, and Virginia (provisionally).

[23], Nadel, Steven. 2011. *Program Introduction*. (Presentation, ACEEE 2011 National Symposium on Market Transformation, Washington DC, April 10–12, 2011).
http://www.aceee.org/files/pdf/conferences/mt/2011/Introduction%20-%20Steve%20Nadel.PDF

The electric EEPS targets in most of these states rise from 1 to 2 percent of retail sales per year within the first 5–10 years of the standard, rivaling the annual savings levels currently being achieved in only a handful of leading states. For example, North Carolina has until recently been relatively inactive in energy efficiency, but has enacted a renewable portfolio standard (RPS). Under this RPS, energy efficiency can meet up to 40 percent of the total requirements of the state's investor-owned utilities (IOUs) and an unlimited amount of the publicly owned utilities' requirements.

The rise of energy efficiency policies and programs indicates that California utilities can increasingly draw on program experience in other states to inform their own experiences.

Table 3: 2020 Cumulative Electricity Savings Targets, by State[24]

State	2020 EE Target	State	2020 EE Target
Vermont	30%	Indiana	14%
New York	26%	Rhode Island	14%
Massachusetts	26%	Hawaii	14%
Maryland	25%	**California**	**13%**
Delaware	25%	Ohio	12%
Illinois	18%	Colorado	12%
Connecticut	18%	Utah	11%
Minnesota	17%	Michigan	11%
Iowa	16%	Pennsylvania	10%
Arizona	15%	Washington	10%

Source: ACEEE[25]

[24] Includes extensions to 2020 at savings rates that have been established.

25 Nadel, Steven. 2011. *Program Introduction*. (Presentation, ACEEE 2011 National Symposium on Market Transformation, Washington DC, April 10–12, 2011). http://www.aceee.org/files/pdf/conferences/mt/2011/Introduction%20-%20Steve%20Nadel.PDF

3. Industry Characterization

The following sections describe the plastics industry, including industry definition (section 3.1), description of primary energy uses (section 3.2), industry landscape in California (section 3.3), competitive issues (section 3.4), economic issues (section 3.5), regulatory issues (section 3.6), and the industry network (section 3.7).

3.1 Industry Definition

Plastic manufacturers use raw inputs of oil or natural gas, mixed with chemicals, to produce more than 60 different types of resin in the form of pellets, granules, powders, sheets or fluids. These materials are the basic input that plastics manufacturers heat, shape and mold into numerous products used in products that touch nearly every aspect of everyday life. Widespread synthetic plastic use emerged primarily after the 1940s.

Plastic is a type of synthetic or man-made polymer that has similar properties to natural resins found in trees and plants. Properties such as lightness and ability to be heated, cooled and molded into many different shapes and sizes account for widespread use in nearly every industry. Plastic material is used in clothing, housing, aircraft, electronics, medical devices and implants, packaging, containers, and many other applications.

The plastics industry is described by two major U.S. Census Bureau's NAICS codes:

- Plastics material and resin manufacturing (NAICS 325211)
- Plastics (and rubber) products manufacturing (NAICS 326)

NAICS classifies rubber with plastic because resin is increasingly substituted for natural rubber. Rubber manufacturing accounts for less than 8 percent of the SCE's total plastic subsector energy usage. As a result, this report focuses on resin and plastics products manufacturers, the latter of which are the largest SCE territory energy users in this industry.

Table 4 displays the range of NAICS codes under resin and plastics manufacturing. NAICS subsector 326 is restricted primarily to products made entirely of plastic. Other products that incorporate plastic components, such as footwear and furniture manufacturing, are covered under other NAICS codes, and not included in this report.

Table 4: Plastics Manufacturing NAICS Codes 325–326

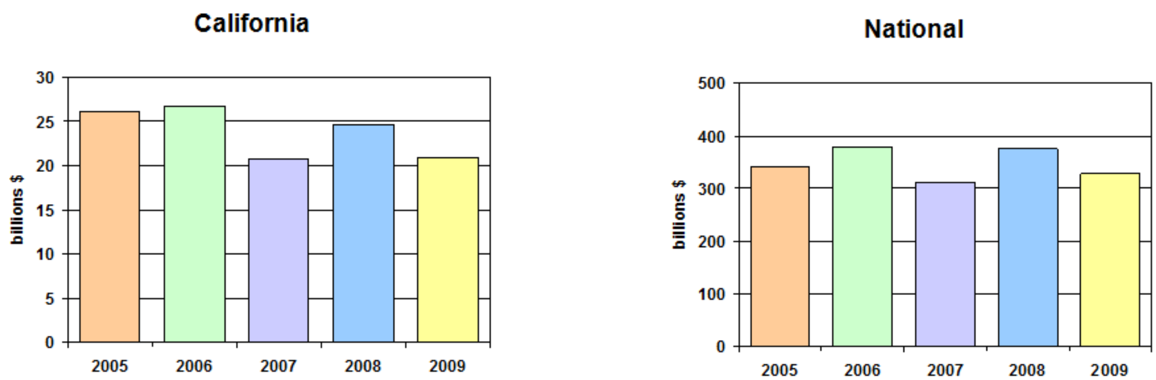
32521	Resin (and Synthetic Rubber) Manufacturing
326111	Plastics Bag Manufacturing
326112	Plastics Packaging Film and Sheet (including Laminated) Manufacturing
326113	Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing
326121	Unlaminated Plastics Profile Shape Manufacturing
326122	Plastics Pipe and Pipe Fitting Manufacturing
326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing
326140	Polystyrene Foam Product Manufacturing
326150	Urethane and Other Foam Product (except Polystyrene) Manufacturing
326160	Plastics Bottle Manufacturing
326191	Plastics Plumbing Fixture Manufacturing
326199	Other Plastics Product Manufacturing

California's plastics industry shipments totaled close to $21 billion in 2009, and comprised 6.4 percent of total $327 billion national shipments in 2009.[26] These totals are down from a high in 2006 of $379 billion nationally. Figure 7 shows the relationship of California and national production trends (see Figure 7). Nationally, California is ranked third in total plastics industry shipments, according to industry group The Society of Plastics Industry. Seven states account for the majority of plastic manufacturing jobs: California, Ohio, Texas, Michigan, New York, Pennsylvania, and New Jersey.[27] Plastic resin manufacturers are often located close to the sources of oil and natural gas raw materials, such as in Texas, or close to concentrations of industrial customers, such as in California, Illinois, Ohio, Pennsylvania, and North Carolina.

[26] The Society of the Plastics Industry. 2011. *Plastics in California*. Fact Sheet http://spi.files.cms-plus.com/images/public/CA%20Fact%20Sheet.PDF

[27] The Society of the Plastics Industry. 2009. *Plastics Industry Facts*. Fact Sheet. http://spi.cms-plus.com/files/industry/plastics_industry_facts.PDF

Figure 7: California vs. National Total Industry Shipments, 2005–2009 ($ billions)



Source: The Society of the Plastics Industry, Inc. [28]

The U.S. plastic (and rubber) products manufacturing industry comprises approximately 16,000 facilities. The synthetic plastic industry started in the early 1900s and has grown to over 50 families of plastics such as polyester, nylon, polystyrene, polypropylene, silicone, and styrene. Plastics have been increasingly substituted for other materials such as steel, wood and glass due to their ability to offer similar properties at a sharply lower price.

Plastics have increasingly come under greater scrutiny over perceived environmental and health threats. Plastic bags and Styrofoam have been banned or limited in sectors such as food preparation and retail shopping sites, while other plastics materials (such as bisphenol-A used in plastic bottles) have raised health concerns. Resin manufacturing is a commodity business (e.g., little differentiation among products), while the highly fragmented plastics product manufacturing industry has hundreds of niches, determined by material type, manufacturing process, and end use.

The recession that started in 2008 has impacted nearly every U.S. industry, and therefore reduced demand for the plastic components and products used by consumers. For example, total U.S. durable goods manufacturers' shipments, an indicator of demand for plastic used in manufactured products, fell nearly 19 percent in the first eight months of 2009 compared to the same period in 2008, according to research firm First Research. Figure 7, above, shows a

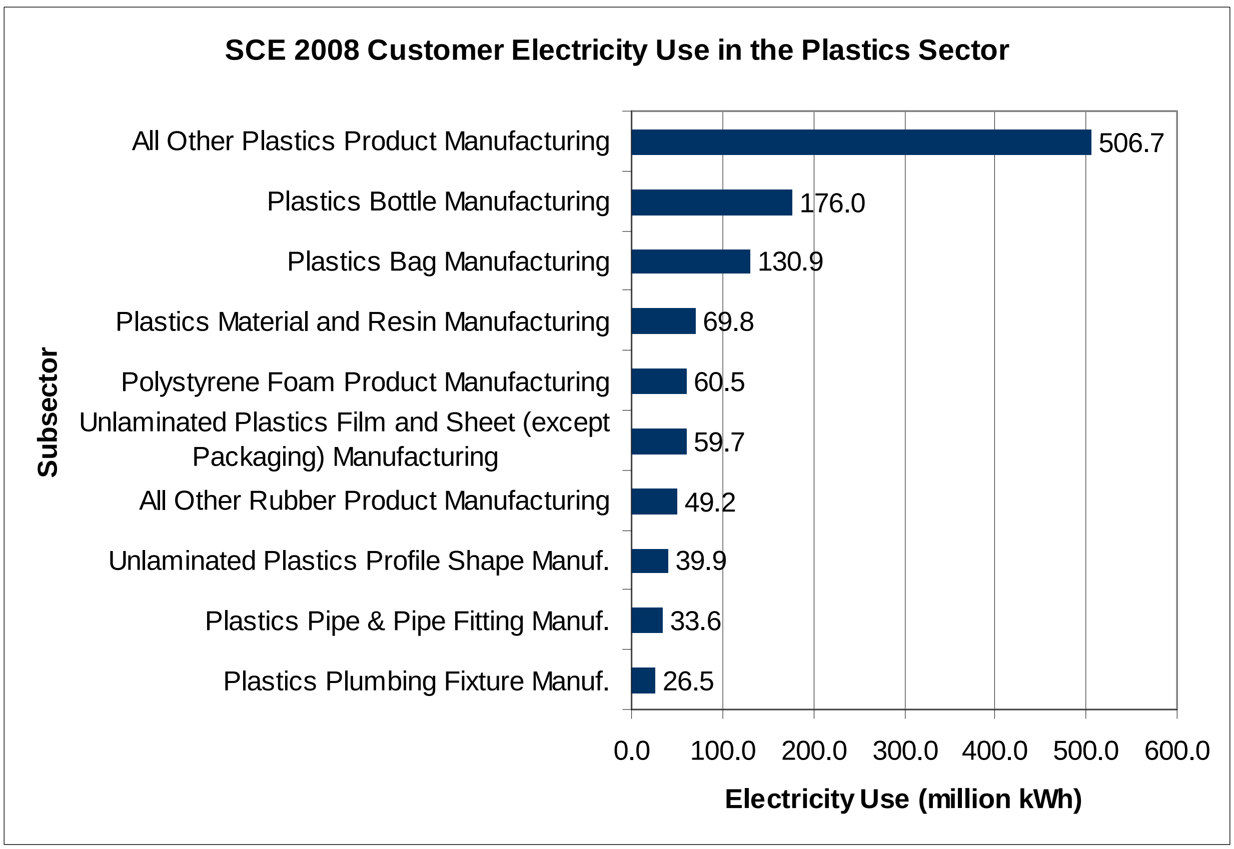
[28] The Society of the Plastics Industry. 2011. *Plastics in California*. Fact Sheet http://spi.files.cms-plus.com/images/public/CA%20Fact%20Sheet.PDF

decrease in plastic production nationally of 16 percent from 2008 to 2009, with a slightly larger reduction in California of 19 percent.

3.2 Energy Use

Figure 8 shows the subsector breakdown by 6-digit NAICS code of electricity usage in SCE's territory. In the resin and plastics products industries, SCE sells the most electricity to a diverse group of firms producing specialized products, a few extremely large resin manufacturers, and numerous large manufacturers producing plastic bags, bottles, film, pipes and polystyrene foam.

Figure 8: Plastics Subsector Electricity Purchases from SCE in 2008



Source: KEMA, Inc.[29]

[29] Based on SCE data

In SCE's territory, companies under the NAICS 326199: All Other Plastics Manufacturing comprise 41 percent energy use among the plastic and rubber industry. This is followed by plastics bottle manufacturing (14 percent), plastics bags (11 percent), plastics material and resin (6 percent), polystyrene foam (5 percent) and unlaminated film and sheet (5 percent). *All other plastics manufacturing* is a broad sector, encompassing numerous plastics products not otherwise classified, such as auto components, plastic dinnerware, trash containers, swimming rafts and plastic siding as well as customized shapes and applications. Southern California is particularly important to the plastics industry due to the availability of foreign shipping facilities in Long Beach, California.

3.3 Industry Landscape

The plastics manufacturing industry consists of hundreds of niche firms, as well as a handful of very large multinational corporations. Resin manufacturers tend to be large, often multinational, companies, while plastics product manufacturers are a mix of small to large firms. The larger product manufacturers produce standard shapes of bags, bottles, and film, while smaller firms specialize in one or two custom or specialized shape products. Many resin manufacturers have roots in the oil, gas and chemical industries since raw plastics manufacturing starts from fossil fuels and additive chemicals. California manufacturers Dow Chemical and Union Carbide are examples of this type. Most firms that manufacture plastics products tend to be smaller and cover a smaller sales territory than resin manufacturers.

The resin manufacturing industry is highly concentrated, where a small number of firms hold the vast majority of the market share. Research firm First Research estimates the top 50 companies command more than 80 percent of the market. Some of these are household names such as Dow Chemical, DuPont and General Electric.[30] Concentration in the product manufacturing industry is low since many firms specialize by product type, industry or application.

No overlap exists among market leaders in the top five manufacturing niche sectors in SCE territory (see Table 5). Plastics material and resin manufacturing is the raw material for other plastics products industries listed, such as plastics (other), bottles, bags, sheets and film. Few market leaders overlap categories since the equipment and processing is particular to each plastics products application. Thus, the plastics manufacturing industry has niche market share leaders rather than an overall set of global or national players.

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[30] First Research. 2012. *Plastic Resin & Synthetic Fiber Manufacturing Industry Profile*. Quarterly Update, January 23, 2012.

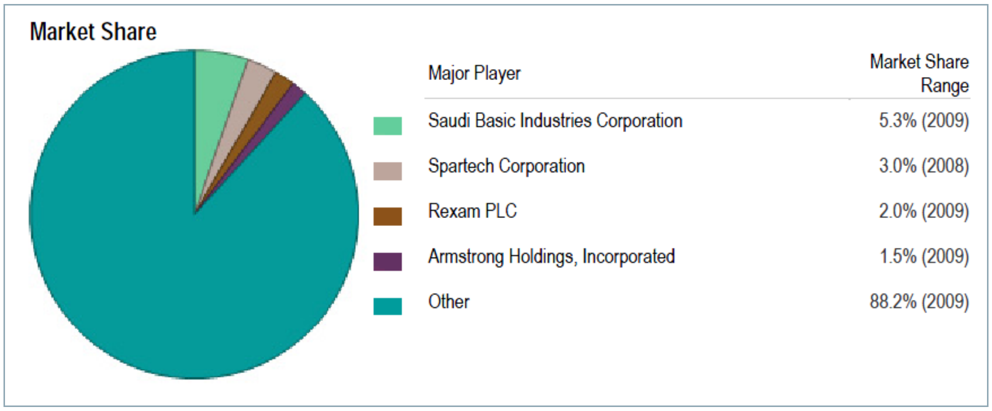
Table 5: Market Share Leaders, Plastics Products Manufacturing—National and SCE's Territory

Product Category	NAICS 6-digit Code	Leaders—National	Leaders—SCE
Resin/Raw Plastics Material	325211	Lyondell Basell North America	Dow Chemical
		Dow Chemical	Union Carbide
		Approx. 50 players hold 80% market share	
Plastics Manufacturing—Other	326199	Saudi Basic Industries	INEOS Polypropylene
		Spartech Corp.	Cambro Manufacturing
		Others: 88% players hold <2% share each	Peninsula Packaging
			Leading Industry Inc.
Plastic Bottles	326160	Blackstone Group	Amcor Pet Packaging USA Inc.
		Dean Foods	Western Container Corp.
		Constar International	Plaxicon Company
		Rexam PLC	Consolidated Container Company
		Ball Corp.	
		PlastiPak Corp.	
		Others: 41% players hold <5% each	
Plastic Bags, Film, Sheets	326111	Bemis Company	AEP Industries
		Alcan Company	Omega Plastics Corp.
		Sealed Air Corp.	Heritage Bag
		Pactiv	Mercury Plastics Inc.
		Printpack Inc.	TRM Manufacturing
		AEP Industries	
		The Clorox Company	
Polystyrene Foam	326140	Dart Container Corp.	Dart Container Corp. of CA
		Pactiv Corp.	Solo Cup Company
		Solo Cup Company	

Source: KEMA In, based on IBISWorld Industry Reports and SCE data

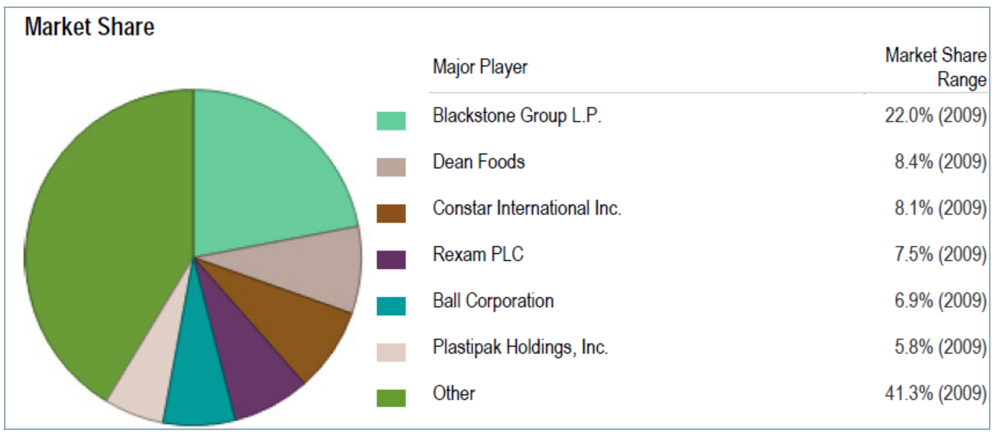
Because there are no clear industry leaders across all plastics manufacturing, the following market leaders are profiled according to major products category. All subsectors are well represented in SCE territory. Figure 9 to **Error! Reference source not found.** display national market shares for major plastics and rubber product manufacturing segments, by 5-digit NAICS code.

Figure 9: Market Share of Plastics Products—Miscellaneous (NAICS 326199)



Source: IBISWorld[31]

Figure 10: Market Share of Plastics Bottle and Container Manufacturing (NAICS 32616)

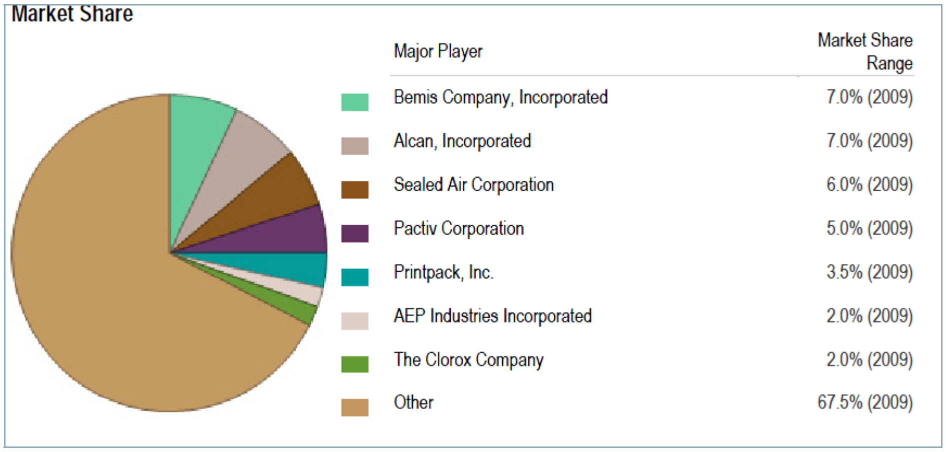


Source: IBISWorld[32]

[31] IBISWorld. 2009. *IBISWorld Industry Report, Plastic Products Miscellaneous Manufacturing in the US: 32619*. June 09 2009.

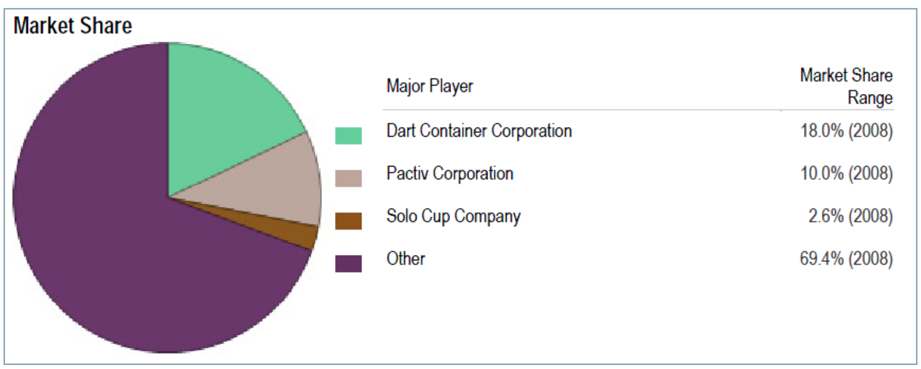
[32] IBISWorld. 2009. *IBISWorld Industry Report, Plastic Bottle & Container Manufacturing in the US: 32616*. August 13, 2009

Figure 11: Market Share of Plastic Film, Sheet & Bag Manufacturing (NAICS 32611)



Source: IBISWorld[33]

Figure 12: Market Share of Polystyrene Foam Product Manufacturing (NAICS 32614)

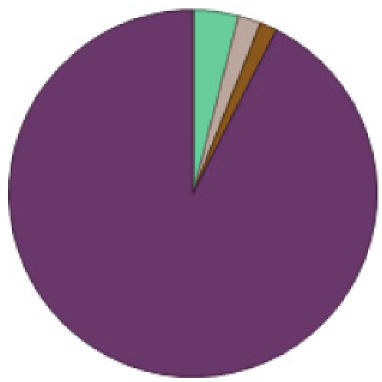


Source: IBISWorld[34]*,*

[33] IBISWorld. 2009. *IBISWorld Industry Report, Plastic Film, Sheet & Bag Manufacturing in the US: 32611.* May 28, 2009.

[34] IBISWorld. 2009. *IBISWorld Industry Report*, Polystyrene Foam Product Manufacturing in the US: 32614. August 28, 2009.

Figure 13: Market Share of Plastic, Resin & Rubber Manufacturing (NAICS 32521)



Major Player	Market Share Range
The Dow Chemical Company	4.0% (2009)
Exxon Mobil Corporation	2.0% (2008)
Apollo Global Management, LLC	1.5% (2008)
Other	92.5% (2008)

Source: IBISWorld[35]

The figures above demonstrate that although some large players exist in U.S. markets, these manufacturing niche sectors are highly fragmented, and no company has more than 22 percent share of any sector. Additionally, only a few companies such as Pactiv operate across multiple subsectors and hold market share above 5 percent.

3.3.1 Summaries of Major Manufacturers

3.3.1.1 Global Leaders in SCE Territory

The following sections focus primarily on market leaders in the SCE territory to limit to the most relevant profiles among the fragmented field comprised of many global and national players. The source of the following information is the company websites of these organizations.

INEOS Olefins & Polymers USA is one of the four main businesses of INEOS, the third largest chemical company in the world. Its UK-based parent company INEOS Group was formed in 1998 after CEO Jim Ratcliffe, who controls the group, led a management buyout. It now operates more than 60 manufacturing facilities in two dozen countries worldwide. The company manufactures polymers or resins including olefins, high-density polyethylene and polypropylene. Headquartered in League City, Texas, INEOS has manufacturing facilities in Carson, California and Texas. The Carson plant produces the resin material polypropylene and is the second

[35] IBISWorld. 2009. *IBISWorld Industry Report*, *Plastic, Resin & Rubber Manufacturing in the US: 32521.* April 27, 2009.

largest plastics exporter in the United States. Product ships from the Long Beach, California docks, within 30 miles of the Carson facility. The company sells approximately $2.5 billion raw material annually to chemical and plastics products manufacturers. Products are transported to customers by pipeline (feedstocks and olefins); and bulk truck, box, bag and dedicated rail fleet (polymers) and ocean shipping from the port of Long Beach, California, less than 10 miles from the Carson facility.

Amcor PET Packaging manufactures containers for food and beverage companies out of the resin polyethylene terephthalate (PET). Operating through five divisions, Amcor runs some 220 plants in 30-plus countries. About 30 percent of total sales are driven by PET Packaging, Amcor's biggest division. Amcor has over 300 sites in 43 countries with sales of $14 billion Australian dollars.

Products primarily include PET plastic containers for beverage applications, flexible packaging for the food and healthcare markets, tobacco packaging, corrugated boxes and a North American distribution business. Amcor PET Packaging is part of Amcor Rigid Plastics, a business unit of Amcor. Parent company Amcor, based in Victoria, Australia, makes a slate of corrugated boxes, cartons, aluminum and steel cans, flexible and film packaging, PET and glass bottles, metal and plastic closures, and multiwall sacks. Customers in food and beverage, healthcare, and tobacco account for more than 80 percent of sales.

Dow Chemical produces plastics, chemicals, hydrocarbons, and agrochemicals and is the largest chemical company in the United States, according to Hoovers Inc., and is number 2 worldwide (ahead of ExxonMobil and behind BASF).[36] Dow also makes performance plastics (engineering plastics, polyurethanes, and materials for Dow Automotive). Other products include materials for packaging (such as its Styrofoam brand insulation), fibers, and films, as well as performance chemicals like acrylic acid. The company also manufactures commodity chemicals (chlor-alkalies and glycols), olefins, aromatics and agrochemicals. Dow also owns half of silicone-products maker Dow Corning.

Saudi Basic Industries Corp (SABIC), based in Saudi Arabia, produces chemicals, plastics, fertilizers, and metals (mostly steel and some aluminum). One of the world's largest makers of polyethylene and polypropylene (with LyondellBasell and Ineos), it is majority owned (70 percent) by the Saudi government. In 2007, SABIC bought the former GE Plastics (now the

[36] Hoovers. 2011. Industry research for *The Dow Chemical Company*.
http://www.hoovers.com/company/The_Dow_Chemical_Company/rfckri-1-1njht4-1njfaq.html

Innovative Plastics unit) for $11 billion, taking over General Electric's laminated profile shape manufacturing facility in Michigan and expanding its U.S. operations. The former GE Plastics manufactured high-performance plastics used by compounders, molders and major original equipment manufacturers for use in a variety of applications, including fabrication of automotive parts, computer enclosures, compact disks and optical-quality media, major appliance parts, telecommunications equipment and construction materials. The company holds a 5.3 percent market share in *plastics manufacturing: other* category, according to research firm IBISWorld.

3.3.1.2 Domestic Leaders

Dart Container Corporation (Dart), based in Michigan, is a private company that manufactures a broad range of single-use products for the food-service, retail, and food-packaging industries, and claims to be the world's largest manufacturer of foam cups. It has four recycling centers in the United States and Canada. Dart accounts for around 45 percent of the U.S. foam cup and container market. Dart states that it designs and manufactures most of its own production equipment and produces much its own raw materials. The company also operates a fleet of trucks used for distribution. The roots of the Dart business date back to 1937. The company's president is currently Kenneth Dart. Dart also operates subsidiaries in Argentina, Australia, Canada, Mexico and the United Kingdom (UK). Self-sufficient, Dart builds its own molding machinery, and uses Dart trucks to deliver products from plants in the United States, Canada, Mexico, Argentina, the UK, and Australia. Dart generated revenues of around $1.5 billion in 2006 (up 8.8 percent on 2005) and employed 5,640 people.

AEP Industries Incorporated, based in New Jersey, manufactures plastic packaging films—more than 15,000 types—including stretch wrap for industrial pallets, packaging for foods and beverages, and films for agricultural uses, such as wrap for hay bales. AEP also makes dispenser-boxed plastic wraps, which are sold to consumers as well as institutions, from schools to hospitals. Other industries courted by AEP are packaging, transportation, food, autos, chemicals, textiles, and electronics. The company underwent a multiyear restructuring program that drove divestiture of non-core businesses and consolidation of operations in Europe, Australia, and Asia. AEP's sales are concentrated in North America.

JM Eagle (J-M Manufacturing) produces polyvinyl chloride (PVC) and high-density polyethylene (HDPE) pipes, fittings, and tubing products. Pipe diameters range from half an inch to 63 inches; the lineup's applications include sewer as well as water main construction, and electric and communication line projects. In mid-2007 J-M acquired PW Eagle, creating a heavyweight in the global plastic-pipe-manufacturing arena. JM Eagle operates 23 manufacturing facilities across the United States, catering to the demands of utility, plumbing, irrigation, and electrical industries. The company is based in Los Angeles.

Spartech Corporation, based in Missouri, compounds basic plastic resins from other suppliers into sheet and rollstock, plastic alloys, calendered vinyl film, and finished molded products (extruded and injection-molded), among other items. Spartech's customers include equipment manufacturers in industries such as auto parts, building materials, electronics, medical equipment, and toys. It operates just about 30 plants, most of which are located in North America, where it achieves more than three-quarters of its sales. Spartech is a top North American producer of rigid plastic sheet and rollstock, as well as color and specialty compounds.

3.3.1.3 Regional/Local Leaders

Cambro Manufacturing Company, based in Huntington Beach, California, manufactures products for the foodservice industry such as trays, display items, shelving, table service, storage, merchandising, catering, and warewashing products. The company also offers products for draining tomatoes or washed produce, thawing frozen meat or poultry, or holding fresh fish on ice; wall shelving and extenders, which convert empty wall space in a functional wall space; and products that are used to drain liquids and oils. It offers its products through its sales and distribution network. Founded in 1951, the company is privately owned

Peninsula Packaging Company, based in Exeter, California, is an integrated manufacturer of PET packaging for fruits and vegetables, bakery, and deli food and industrial packaging products. Peninsula's vertical manufacturing systems; state-of-the-art sheet extrusion, thermoforming and decorating machining centers; and product development capabilities are business strengths. Its extrusion and thermoforming facility in Exeter, California has a 1.1 megawatt (MW) photovoltaic sun farm.

Omega Plastics Corporation, based in Elkhart, Indiana, is a privately owned and family-owned organization that has been in operation for over 26 years. Omega delivers custom plastics components from conception to production. The company serves a wide array of industries by designing and building custom solutions for original equipment manufacturers (OEM) and proprietary products, such as agriculture, building products, fencing and railing, packaging, medical and textile.

Western Container Corp. manufactures PET containers for the Coca-Cola Bottling System. The company was established in 1979 by a group of Coca-Cola Bottlers who acted on the long-term need to offer a central distribution point and a reliable source of high-quality, low-cost plastic bottles. The company operates bottle plants in Rancho Cucamonga and Benicia, California as well as plants in Texas, Arizona, Mississippi, Arizona and Washington. The company utilizes 38 injection-molding machines and 28 blow-molding machines at these seven facilities, and has 661 members between its seven manufacturing plants and the corporate headquarters in Midland, Texas. In 2008, Western Container produced over 4 billion bottles.

3.4 Competitive Issues

Competitive pressures vary by industry product: moderately competitive for commodity products (e.g., raw plastic or resin and plastic bottles, film, latex gloves, etc.); and less competitive for plastics products/specialty designed and manufactured according to customer needs.

Commodity products: Resin is sold as a commodity, based on the lowest price, and demand can vary based prices of the primary product input, crude oil. The resin-manufacturing sector is dominated by large, multinational companies, many of which explore and drill for natural gas and oil, the primary raw materials in resins. Long-term contracts are typical among these commodity producers, making it difficult for other firms to compete for business. This results in a moderate threat of increased competition from firms entering the industry. However, some products such as plastic bottles or latex gloves can be considered commodity items, and manufacturers compete aggressively based on price.

Plastics products/specialty: This highly fragmented segment covers hundreds of niches, determined by material type, manufacturing process, and end use, which keeps competitiveness lower. Producers primarily sell their ability to make a product according to the customer's specifications, with price a secondary consideration. Plastics product manufacturers typically have shorter contracts than commodity producers; one year is typical, according to research firm IBISWorld. Because products often have very specialized applications, or are made to customer specifications, most manufacturers remain small, partly because few economies of scale are gained by combining companies. Large companies have economies of scale in buying raw materials and in manufacturing commodity products such as bottles and plastic film. Small companies can compete effectively by specializing.

In an industry with hundreds of market niches, acquisitions are frequent as companies try to enter new markets and secure their position in existing ones. Companies also dispose of low-margin product lines after assessing their strategic importance. Increased raw material costs or geographic shifts in demand may also prompt companies to seek acquisitions or disposals.

Plastic product manufacturers are often located close to the sources of raw materials, such as in Texas, or close to concentrations of industrial customers, such as in California, Illinois, Ohio, Pennsylvania, and North Carolina. Manufacturing plants for bulky products, such as bottles, are often located close to customers because of high shipping costs.

Import/Export: Competitive threats from plastic imports are significant, primarily from China. In 2008, annual imports were around $30 billion, including $9 billion from China and $7 billion from Canada, according to resin manufacturers trade group The Society of the Plastics Industry Inc (SPI). Annual exports of about $20 billion go largely to Canada and Mexico.

3.4.1 Operational Models

In SCE's territory and nationally, the industry market leaders operate under two primary business models: commodity or specialty products. In more detail, these are:

Commodity Products. Commodity products are relatively uniform across competitors, and the primary distinguishing characteristic is price. This primarily comprises resin manufacturers, and may also include some typical shaped products, such as plastic bottles and film. Resin manufacturers are typically large, multinational players, led by chemical and oil and gas exploration firms that use their crude oil products to produce raw plastics. Many of these companies have just a few large accounts. Typical customers include original equipment manufacturers (OEMs), such as auto, aircraft, and medical device companies; consumer product companies, such as Procter & Gamble, or soft-drink bottlers that use bottles and containers; end-users such as hospitals and the construction industry; and makers of consumer products.

Plastics Products/Specialty. Most producers specialize in a few product lines, as the equipment and tooling needed to manufacture to customer specifications can be expensive. Because products often have very specialized applications, or are made to customer specifications, most manufacturers remain small, partly because few economies of scale are gained by combining companies. The typical manufacturer has a single plant and fewer than 100 employees.

Manufacturing plants for bulky products, such as bottles, are often located close to customers because of high shipping costs. Plastic product manufacturers are often located close to the sources of raw materials, such as in Texas, or close to concentrations of industrial customers, such as in California, Illinois, Ohio, Pennsylvania, and North Carolina.

3.4.2 Cost Structure

Raw materials are the major expense for both resin/commodity and specialty products, often costing up to 50 percent or more of total costs.[37] The primary input to manufacture resin is natural gas and/or crude oil. Plastics product manufacturers use resin or recycled plastics as the key input, and prices vary by the many types of polymers. Some plastics, such as PET, often used for bottles and sheets, can be recycled.

Employee wages are the second highest cost at approximately 10–20 percent. As a result, imports from lower wage-cost countries such as China and other Asian countries may represent a greater competitive threat. Other costs include freight, marketing and insurance expenditures.

Energy costs are significant, with utility costs at approximately 4% in the plastic, resin, and rubber manufacturing sector.[38]

3.4.3 Technology Change

Rapid technological innovation characterizes the industry due to the short product life cycle of many plastics intended for single use. This in turn allows manufacturers to continually reinvent their products and related manufacturing equipment. In addition, production equipment and new ways of producing plastics are constantly evolving as companies seek to find new uses for existing plastic and synthetic rubber materials. Most technical advances come from the suppliers of machinery and raw plastics materials, rather than from specialty plastics products manufacturers. Some exceptions do exist, such as Dart Container Corporation, which manufacturers most of its own production equipment for its foam cups, and operates in the SCE territory.

The molding and shaping process is energy intensive and uses industrial equipment, and has been the target of recent innovation. More technologically developed processes of molding plastics, such as reaction injection molding, use considerably less energy. Reaction injection molding injects liquids that chemically react to turn into plastic inside the mold. Because this method requires little heating, it uses considerably less energy. As historical background,

[37] First Research. 2012. *Plastic Resin & Synthetic Fiber Manufacturing Industry Profile*. Quarterly Update, January 23, 2012.
[38] IBISWorld. 2009. IBISWorld Industry Report, Plastic, Resin & Rubber Manufacturing in the US: 32521. April 27, 2009.

injection and compression molding are the principal methods of plastic processing. In the injection molding process, plastic material is put into a hopper that feeds into a heated injection unit. The heat softens the plastic into a fluid, which is injected into a cold mold. The plastic cools and hardens, then is ejected. Timing is essential to ensure that the plastic is in the correct state for softening and hardening.

Research and development within the industry has been focused upon expanding the use of recycled materials, improving product performance (i.e., increased strength, flexibility and durability) and expanding product applications. Most large chemical companies are exploring the development of and uses for bioplastics, which are derived from biomass such as vegetable oil or corn starch instead of petroleum. Plastic companies anticipate that bioplastics will eventually outpace traditional petro polymers, as bioplastics are competitive in terms of cost and performance and environmental attributes such as degrading faster in landfills.

Some plastics makers, such as of food packaging, use information management tools that link manufacturing operations to customers. These systems improve customer service by ensuring timely product distribution while reducing supply chain costs and improving productivity.

Some companies may also use computer-aided design (CAD) systems to design products, or use 3-D simulation software for computer modeling of various products or manufacturing processes. The extension of 3-D simulation to adding color and creating a 3-D print of the new product can eliminate the need to paint the plastic parts. Use of 3-D technology and printing has sped the pace of technology innovation, as processes and product characteristics are more easily redesigned. The timeline for moving products from concept to market has decreased from years to months.

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3.4.4 Supply Chain Management

The shortened product life cycle affects the entire supply chain of plastic products. Equipment manufacturers look to closer collaboration with plastics suppliers to cut production timetables, asking them to be responsible for specialized molded component design, development, and assembly. This requires plastic manufacturers to have more complex product design knowledge and capability, including more sophisticated machinery and better-educated employees. Quick and accurate turnaround on customer orders is critical for plastic companies to stay competitive.

3.4.5 Product Development and Roll-out

Drivers of product development in this industry are: (1) reduced consumption of fossil fuels and related, increased customer demand for more environmentally friendly products; and (2) new uses for existing products to replace other materials (e.g., steel, metal and glass) in varied applications.

Shortened product life cycles encourage sales executives to find other applications for existing products by selling plastics to replace other heavier and more expensive materials with lighter, cheaper plastics. In fact, demand for plastics has increased in many industries due to a preference for more lightweight components. High-temperature, high-performance plastics are replacing aluminum, brass, steel, and other metals historically used in manufacturing. Demand is also increasing in the packaging and container market, as plastic is preferred over glass and metal for containers, and in the medical supplies industry for tubing, containers, and instruments.

With changing technology, companies are reformulating products with new properties to make them suitable for new uses. Natural fibers are used as additives for thermoplastics for both the auto and building industries. Organic plastics, or bioplastics, use renewable sources to replace petroleum-based resins and currently form a tiny but growing fraction of overall plastic raw material. Companies are developing new ways to incorporate post-consumer, recycled plastic as feedstock for making new products. Plastics using post-consumer waste are a growing but tiny fraction of the overall industry, initially finding applications in the auto industry. By developing plastics that incorporate post-consumer waste, companies can market products as more 'environmentally friendly', with reduced CO_2 emissions, lower costs, and reduced consumption of crude oil.

All of these trends exist among SCE's customers. To illustrate, Dow Chemical has joined other American Chemical Council members that manufacture plastic bags to set recycling goals of 40 percent recycled content in all plastic bags by 2015, and 25 percent of that post-consumer content. The program is expected to cost these manufacturers a combined $50 million per year to update manufacturing processes, and will cut greenhouse gas emissions as well as eliminate use of 300 million pounds of raw plastics material per year.

3.4.6 Value Chain

Resin manufacturers produce products with little to differentiate, and value added depends on favorable sourcing of raw materials, primarily oil and gas, as well as chemicals to transform the raw material into plastic. Plastic product manufacturers add value primarily by conceiving, designing, and custom manufacturing products for individual customers. This can also create natural protection from potential competitors and imported products, which tend to be standard or commodity. Product transformation or value-add occurs during manufacturing, and process efficiencies will add value to the product by decreasing energy needs and speeding production.

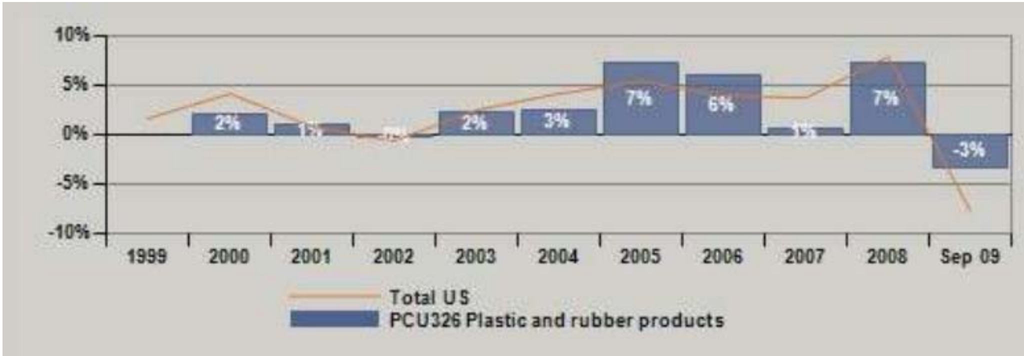
Firms that produce custom-made products require sales staff with technical expertise, internal knowledge of how materials can stretch, mold, shape and conform to customer specifications, and the necessary conditions to manufacture the product. These factors may include appropriate facility space and special types of equipment, which may be purchased specifically for a customer's product application.

In SCE's territory, numerous firms produce specialty, value-added products, although most of the major energy users manufacture standard products such as resin, bags and bottles. One exception is AEP Industries, Inc. This firm custom designs to meet the specific needs of its customers, as many as 20,000 separate and distinct products in any given year (although not all these products are produced at its California facility).

3.4.7 Pricing

Because resin and many plastic products are derived primarily from oil and natural gas, price and availability depend on the price of these raw materials. Thus, oil prices shape product demand and pricing during economic booms and periods of high oil prices (see Figure 14). Large companies may hedge against increased materials costs by investing in financial futures. While these are typically not made public, it can be assumed that some large, multinational firms in SCE territory engage in this practice. Local raw material prices and labor costs can affect competitiveness with imports, primarily for resin and plastic products sold as commodities, with little to differentiate except price.

Figure 14: Change in Producer Prices: Total U.S. and Plastic/Rubber Products



Source: First Research[39]

Pricing is also influenced by production costs. Manufacturers that can maximize production volumes and plant capacity can generate efficiency advantages that can be passed on in lower product prices.

Transport costs can be significant, particularly for bulky items such as plastic bottles. To hedge these costs, manufacturers seek to locate their facilities close to customer sites, typically within 100 miles, to minimize shipping costs. In SCE's territory, Western Container Corporation is well situated to manufacture plastic bottles for its only customer, Los Angeles area Coca Cola bottlers. Other firms, such as Dart Container, have found it more cost effective to vertically integrate. DART manufactures foam cups in its SCE-territory facility, then ships products using Dart trucks.

3.5 Economic Factors

3.5.1 Business Cycles

Plastic is highly dependent on business cycles. Demand for raw material and finished products is closely linked to the U.S. economy. Most resin and plastics products are intermediate components that go into final goods, and thus demand rises or falls in step with economic business cycles and manufacturing activity. Industries served by the plastics industry have been particularly hit hard by the current recession, such as automotive, consumer goods, and

[39] First Research. 2009. *Industry Profile, Plastic and Rubber Products Manufacturing*. Quarterly Update. November 16, 2009.

construction. As a result, demand for manufactured goods has decreased, affecting both resin and plastics products, as components in many goods.

3.5.2 Availability of Capital and Credit

In SCE's territory, the smaller players typically need new capital up front to establish operations and therefore can be saddled with debt from launch. During the recession, few new businesses began operations because little credit was available to pay for the sunken costs associated with startup. Venture capital is generally not available because the niche plastics markets are so specialized that they will unlikely ever achieve the rapid growth sought by venture capitalists. Many small businesses take collateralized loans to begin operations. Costs for such credit have gone up considerably, representing a higher barrier to entry for new entrants into the field. Another option for operations, which require specialized processing machines, is to obtain manufacturer-sponsored financing when they purchase equipment. For many small players in the highly fragmented plastics industry, this can be an attractive financing option.

In SCE's territory, there are a number of large multinational corporate players in the plastics industry. These firms can fund new projects and facility improvements from operating cash. They also have access to the corporate debt market and issue bonds, but they sport a range of credit ratings. Players with low-credit ratings are highly leveraged and carry higher levels of existing debt. A moderate amount of mergers and acquisitions exists among this industry for larger players but abruptly ended in 2008 when credit markets froze.

3.6 Regulatory Issues

Because of the chemicals used or added to some plastics, manufacturers are regulated to avoid air and water pollution and ground contamination. Industry operators are required to comply with existing and potential federal, state, and local air-emission and waste-discharge legislation. Fumes may also be released in the workplace during manufacturing.

Recycling legislation has been enacted in California, which requires that a certain specified minimum percentage of recycled plastic be included in certain new plastic containers.

The U.S. Environmental Protection Agency's (EPA) National Emission Standards for Hazardous Pollutants (NESHAP) has rules and guidelines for the manufacture of polymers and resins, cellulose, amino and phenolic resins, and plastic composites. The Occupational Health and Safety Administration (OSHA) has specific regulations to protect workers from potentially hazardous chemicals used in plastics manufacturing including acrylonitrile, methylene chloride, butadiene, as well as flammable and combustible liquids.

3.6.1 Environmental

According to research firm First Research, the industry has historical issues with air pollution and ground contamination, particularly with butadiene. An ongoing industry effort is to reduce emissions by curtailing releases from a variety of equipment, enhancing monitoring, and improving leak inspections. Some companies have installed fence-line monitors and infrared cameras to hunt down leaks, and submit more frequent reports about their emissions to applicable regulatory authorities.

The plastics industry must comply with the following environmental laws:

- **The Clean Air Act** (CAA) regulates air emissions from stationary and mobile sources. Key pollutants are defined as particle pollution (often referred to as particulate matter), ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Regulated sources are stationary sources or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants. Currently, the EPA is preparing to move forward with regulation of greenhouse gases under the Clean Air Act, as discussed in Section 3.5.2.
- **The Clean Water Act** (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA, the U.S. EPA has implemented pollution control programs such as setting wastewater standards for industry. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained.
- **The Resource Conservation and Recovery Act** (RCRA) gives the EPA the authority to control hazardous waste from the *cradle-to-grave*. This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled the EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. HSWA—the Federal Hazardous and Solid Waste Amendments—are the 1984 amendments to RCRA that focused on waste minimization and phasing out land disposal of hazardous waste as well as corrective action for releases.

- **The Comprehensive Environmental Response, Compensation, and Liability Act of 1980** is also known as the Superfund. Manufacturers incur the costs for rehabilitating plant sites contaminated by hazardous substances.
- **The California Beverage Container Recycling and Litter Reduction Act** (CA Beverage Container Recycling Program) require beverage manufacturers and distributors in California to apply a minimum cash redemption value associated with plastic bottles and other beverage containers. California's Department of Conservation is the agency that implements the Bottle and Can Recycling Law.
- **The National Emission Standards for Hazardous Pollutants** (NESHAP) has rules and guidelines for the manufacture of polymers and resins, cellulose, amino and phenolic resins, and plastic composites.
- **Occupational Safety and Health Administration** (OSHA) has specific regulations to protect workers from potentially hazardous chemicals used in plastics manufacturing including acrylonitrile, methylene chloride, butadiene, as well as flammable and combustible liquids.

Responsibility for enforcing environmental laws is distributed between the federal government (usually the EPA), state agencies, counties and municipalities. In California, regional air districts are charged with developing and enforcing air quality regulations that are more stringent than federal standards. In general, facilities in the plastics industry are long accustomed to complying with existing environmental regulations as part of their normal course of business.

In California, a law (AB 1319) passed in 2011 effectively bans the use of bisphenol-A in products for infants and toddlers.[40]

3.6.2 Climate

3.6.2.1 California Global Warming Solutions Act

In 2006, Assembly Bill 32, the Global Warming Solutions Act (AB 32) became the first legislation signed into law in the United States to establish mandatory limits on greenhouse gas emissions (GHG). The California Air Resources Board (ARB) was designated as the lead agency tasked

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[40] Molteni, Megan. 2011. "New California law will limit bisphenol A in products for infants and toddlers." Oakland North blog on SFGate.com. October 7, 2011. http://blog.sfgate.com/inoakland/2011/10/07/new-california-law-will-limit-bisphenol-a-in-products-for-infants-and-toddlers/

with developing the regulatory structure to achieve emissions reductions targets for CO_2 and other GHGs.[41] California facilities that emit more than 25,000 metric tons of CO_2 equivalents (CO_2e) must report their emissions to the ARB. This includes large plastics facilities, as well as other large industrial plants. All reporting entities must have their emissions reports verified by an accredited third-party auditor.

In January 2009, the ARB adopted a Scoping Plan that provides the blueprint for achieving the reductions through a mix of incentives, direct regulatory measures, and market-based compliance mechanisms.

Key elements of the Scoping Plan include:

- Expanding and strengthening existing energy efficiency programs, as well as building and appliance standards
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system
- Establishing targets for transportation-related emissions for regions throughout California, and pursuing policies and incentives to achieve those targets.

Most plastic resin manufacturers and potentially some plastics products manufacturers in California are likely to be affected in the proposed cap-and-trade program. Cap and trade requires large emission sources to surrender emissions permits equal to their actual emissions in any given year. The amount of total available permits declines over time, thereby making it more and more expensive to emit GHGs. Emissions permits are tradable among market actors and emissions reductions from non-capped sectors, known as offsets, can also be used for low-cost compliance purposes.

As California implements AB 32, affected plastics manufacturers can expect to be treated as capped sources. The implementation of the cap-and-trade under AB 32 has been delayed to 2013, although the state plans to develop the regulatory framework in 2012.

Starting in the first compliance period of 2013, all large industrial facilities that emit over 25,000 metric tons CO_2e per year will be required to acquire and hold emissions permits. Starting in the

[41]These gases include methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). Since each of these gases' unique physical properties causes them to have varying heat trapping effects, they are normalized into carbon dioxide equivalents. For example, one metric ton of methane is equivalent to 21 metric tons of CO_2 equivalents (CO_2e).

second compliance period of 2015, industrial fuel combustion at facilities with emissions at or below 25,000 metric tons CO_2e per year will be included. The ARB estimates that cap-and-trade will regulations will cover about 80 percent of GHG emissions in the state.[42]

For some energy-intensive industrial sources, stringent requirements in California, either through inclusion in a cap-and-trade program or through source specific regulation, have the potential to create a disadvantage for California facilities relative to out-of-state competitors unless those locations have similar requirements. Recent analysis by the California Legislative Analyst suggests that this effect will not be significant for the overall economy. Sectors most affected are likely those with high-energy intensity and significant trade-related activities where increased costs may not be able to be reflected in higher prices.[43]

3.6.2.2 EPA Mandatory Reporting

The U.S. EPA issued a rule for mandatory GHG reporting from large emissions sources in the United States. In general, the rule calls for facilities that emit 25,000 metric tons or more of GHG emissions per year to submit annual reports to the EPA. From 85–90 percent of total national U.S. GHG emissions, from approximately 13,000 facilities, are covered by the proposed rule. The EPA estimates the average cost of reporting under this proposed rule would be approximately $0.04 per metric ton.

Resin manufacturing plants have sizable emissions that they are required to monitor and report them to the EPA. This rule does not apply to most plastics product manufacturers.

3.6.2.3 EPA Regulation under the Clean Air Act

Greenhouse gas emissions are now regulated in the United States under the Clean Air Act. According to the Tailoring Rule,[44] GHG permitting requirements will cover for the first time new construction projects that emit GHG emissions of at least 100,000 tons per year (tpy). Modifications at existing facilities that increase GHG emissions by at least 75,000 tpy will be

[42] California Air Resources Board 2010. California Cap-and-Trade program, Resolution 10-42. Dec 16. http://www.arb.ca.gov/regact/2010/capandtrade10/res1042.PDF

[43] Taylor, Mac. 2011. *Letter to Honorable Dan Hogue*. California Legislative Analyst's Office. May 13, 2011. http://www.lao.ca.gov/reports/2010/rsrc/ab32_logue/ab32_logue_051310.PDF

[44] Federal Register. 2010. *Environmental Protection Agency: Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule*. Vol. 75, No. 106, June 3, 2010. http://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf#page=1

subject to permitting requirements, even if they do not significantly increase emissions of any other pollutant. By 2016, the EPA may lower the threshold to 50,000 tpy.

Under the EPA rulemaking for New Source Review proposed emissions sources will be required to install best available control technology. Typically, this means installing energy efficiency equipment. Large sources permitted through the Title V program may have emissions limits on GHG emissions in the future.

3.7 Industry Network

3.7.1 Trade Associations

The industry network for this sector provides a list of potential partners for energy efficiency with California utilities. The following organizations serve the resin and plastics products industry.

- **American Plastics Council** (APC) (http://plastics.americanchemistry.com/) is comprised of 23 of the leading resin manufacturers, plus one affiliated trade association representing the vinyl industry. APC's membership represents more than 80 percent of the U.S. monomer and polymer production and distribution capacity.
- **The International Association of Plastics Distribution** (http://www.iapd.org/), represents member companies that manufacture and distribute a range of plastics products. These include materials in semi-finished stock shapes: rod, tube, sheet, valves, and related products. These products serve the needs of a variety of high-performance and engineering applications.
- **Society of the Plastics Industry (SPI)** (http://www.plasticsindustry.org/)was founded in 1937, and is the major trade association representing the plastics industry. SPI's 1,500 members represent the entire plastics industry supply chain, including processors, machinery and equipment manufacturers and raw material suppliers. The U.S. plastics industry employs 1.5 million workers and provides more than $330 billion in annual shipments.

- **Association of Postconsumer Plastic Recyclers** relates to recycling and reuse of all types of manufactured plastic products and reuse of recycled plastic material. This association is outside the scope of the plastics industry but of increasing interest to plastic manufacturers.

- **Society of Plastics Engineers** (SPE) is a professional society focusing primarily on downstream applications than resin production.

3.7.2 Vendors

Vendors serving the plastics industry play an important role introducing energy efficiency technologies and products. The following firms are identified as serving plastics industry customers in the SCE territory.

- **Crown Machine uwp, Inc**. (http://www.crown-cdl.com/) designs, engineers and builds standard or custom precision equipment for the plastics industry, including pelletizers, extruders, screen changers, gear pumps, compactor densifiers, and rotary dryers. The company also produces systems spanning many facets of the plastics manufacturing industry such as compounding, recycling, pipe production, pipe coating, and sheet extrusion.
- **Engel** manufactures machinery for injection molding machinery. With eight facilities worldwide, w the company offers machines and provides a range of plastic processing technologies.
- **IMS Industrial Molding Supplies**, a Division of IMS Company, has served the industry since 1949. The company supplies plastics accessories, auxiliary equipment, parts, supplies, and technical advice. The IMS Industrial Molding Supplies' comprehensive catalog contains products serving the entire industry.
- **MGS Manufacturing Group** provides engineering and manufacturing solutions for the plastics industry. Their range of services include engineering and design of molds, parts, tooling, automation and custom applications. They also provide process and production support. MGS manufacturing sites are in Wisconsin, Illinois and Mexico.
- **RSW Technologies LLC** serves the plastics industry in industrial control repairs and reconditioning of electronic controls and systems RSW can repair over 250 brands of plastic-machine control systems and components. RSW also provides controls and retrofit options for older injection molding machines.

4. Target Technologies / Processes and Energy Efficiency

Energy use can be a critical hidden factor in the industry's profitability, and potential exists to save energy and money at almost every stage of the process chain. Major assets of plastics products are the combination of good heat and electrical insulation properties. Unfortunately for the manufacturing process, this also means that they transfer heat poorly and are difficult to heat and cool. The slow rate of heat transfer limits the speed of processing, making the process highly energy intensive.

4.1 Energy Use

Plastics processing uses energy, primarily in the form of electricity, to power machines that dry, heat, process, cool, cut and shape raw materials into manufactured products. Nationwide, the plastics industry (resin and product manufacturing combined) consumes 8.9 percent total energy used by U.S. manufacturing industries, or 1,884 trillion British thermal units (Btu) of energy, according to 2006 Manufacturing Energy Consumption Survey (MECS) data. This represents nearly 9 percent of the U.S. total in 2006, the most recent survey year. The plastics industry ranks far behind more energy-intensive industrial subsectors, but the high concentration of electricity use in manufacturing by motors and drives make this industry a good target for energy efficiency.

Table 6 shows total energy consumption by major plastics sectors (e.g., resin and manufactured products). Nationally, resin manufacturers use roughly 82 percent of the total industry energy, and product manufacturers use the remaining 18 percent. Resin manufacturers use natural gas and oil as raw material inputs. Product manufacturers primarily use electricity to shape resin into finished products. Both sectors use electricity to power machines at their factories.

Table 6: Energy Use in the Plastics Sector

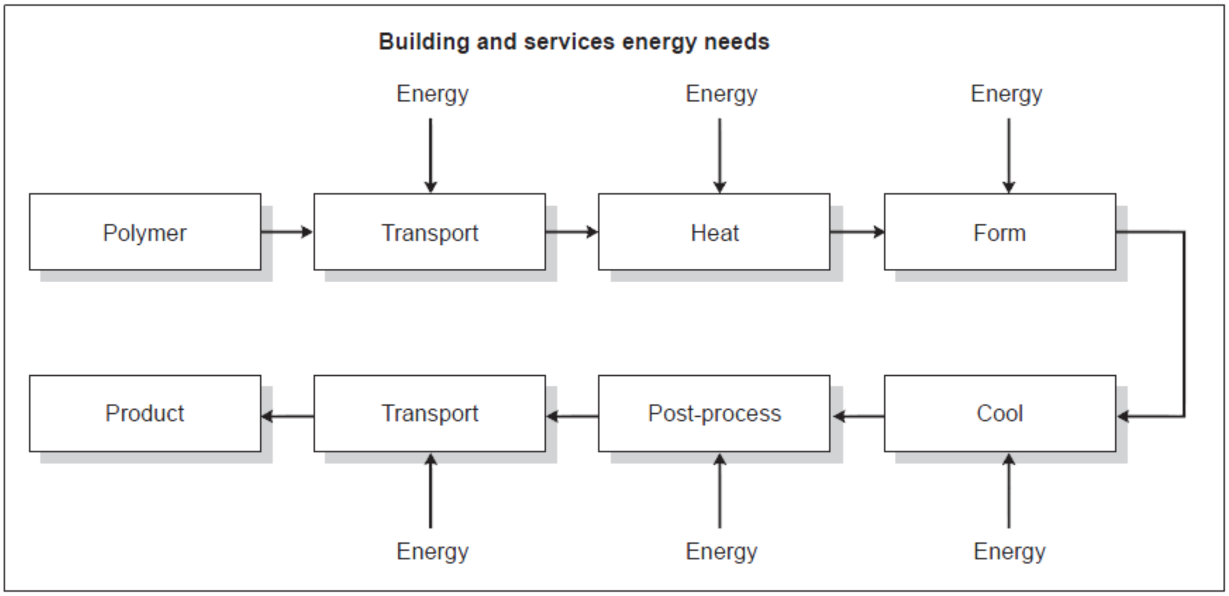
Category	Energy Use (Trillion Btu)	Electricity (Million kWh)
Plastics Materials and Resins	1,547	19,180
Plastics and Rubber Products	337	53,404
Total	1,884	72,584

Source: 2006 Manufacturing Energy Consumption Survey

Energy is used in every step of plastic processing, from resin production to transport of finished product (see Figure 15). The four major energy uses in resin processing are:

- Motors and drives (e.g., extruders, grinders, air compressors)
- Heaters (on extruder barrels, driers, etc.)
- Cooling systems and (on extrusion cooling troughs, injection molds, and drives)
- Lighting

Figure 15: Energy Used in the Plastics Industry, by Process



Source: Great Britain and British Plastics Federation[45]

Machines drives comprise the majority of energy use at plastic factories.[46,47] This energy, primarily electricity, powers the main processing equipment as well as compressors, pumps, and fans. Electricity-driven machines handle many factory tasks: melting and cooling raw and molded plastics materials; driving peripheral equipment such as grinders, compressors, pumps,

[45] Great Britain, Energy Technology Support Unit and British Plastics Federation. 1999. *Energy in plastics processing – a practical guide*. Good Practice Guide 292, October 1999. http://www.tangram.co.uk/TI-Energy_in_Plastics_Processing_(GPG292).PDF

[46] Leonardo Energy. 2009. *Power Quality and Utilization Guide, Plastics Industry*. January 2009. http://www.leonardo-energy.org/webfm_send/8

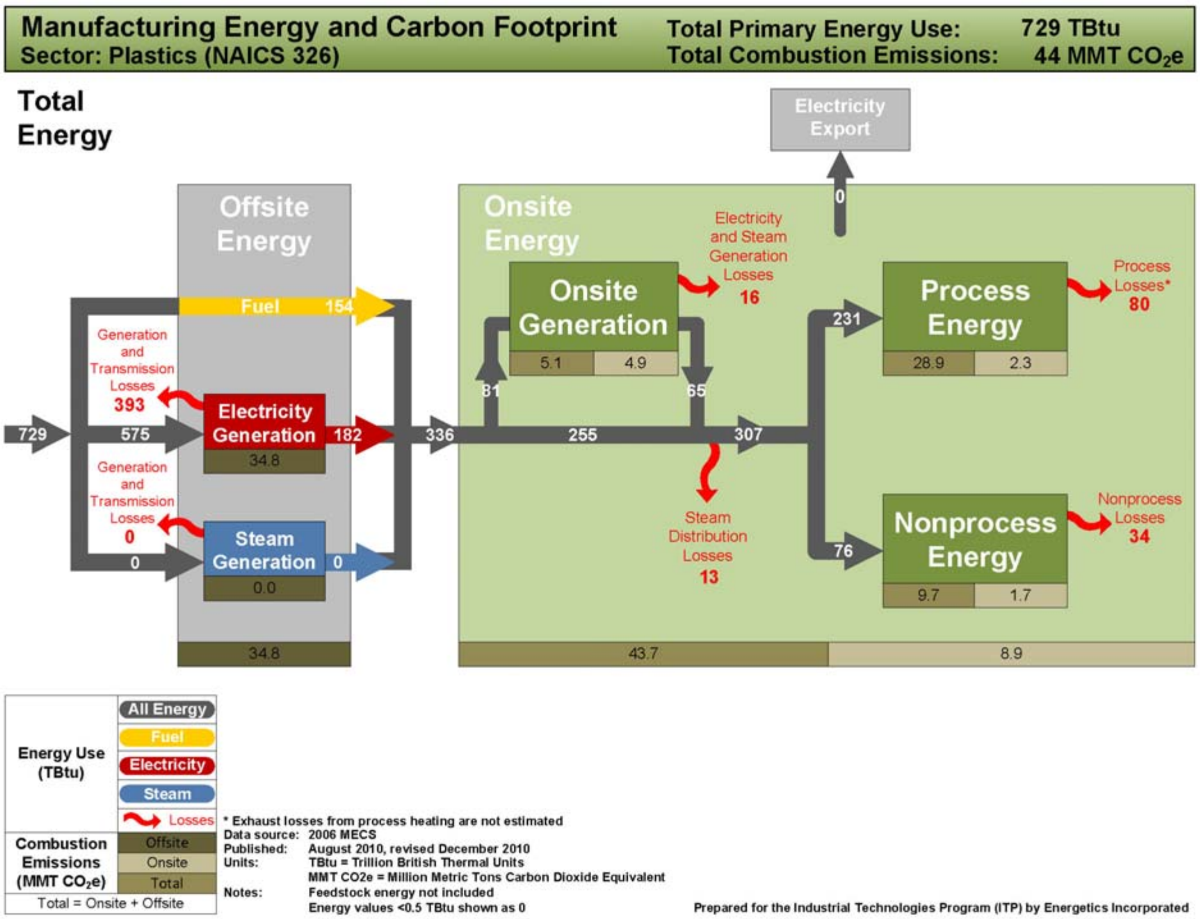
[47] Manufacturing Energy Consumption Survey, 2006

pre-driers, and mixers; and forming semi-manufactured products. Most electricity costs are from machinery of all types, including peripheral equipment such as grinders, hopper fillers, dosing systems, and conveyor belts. The remaining energy balance is attributable to space heating, cooling, compressors, and lighting. Energy consumption varies by key factors such as:

- Chemical properties of plastic material (i.e., different melting temperature)
- End product design, complexity, and size
- Technique used to mold resin into finished bags, film, sheets, bottles, and other products. In this case, energy consumption depends on the heating, molding, and cooling method.

According to the DOE's energy footprint for the plastics products industry (see Figure 16), over 80 percent of energy use goes to production processes and nearly 20 percent is lost in conversion of natural gas, oil, and electricity into useful energy. In 2006, the latest data available, the MECS reported that plastics and rubber product (not including resin) manufacturers used 729 trillion Btu.

Figure 16: Energy Use and Loss Footprint for the Plastics and Rubber Products Industry, 730 Trillion Btu (NAICS 326), 2002



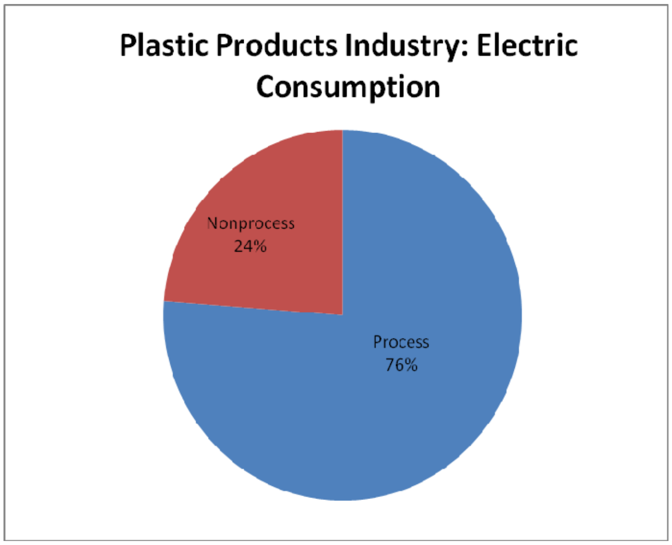
Source: U.S. Department of Energy[48]

[48] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Advanced Manufacturing Office. 2010. *Manufacturing Energy and Carbon Footprint, Plastics*. August 2010. http://www1.eere.energy.gov/industry/pdfs/plastics_footprint.PDF

4.2 Plastics Industry: Energy Consumption by End Use and Energy Efficiency Potential

Figure 17 and Figure 18 display electricity consumption in the plastics industry (NAICS 326) and are based on national industry data from the 2006 Manufacturing Energy Consumption Survey's (MECS) data.

Figure 17: Plastic Products Industry: Energy Consumption by End Use and Energy Efficiency Potential

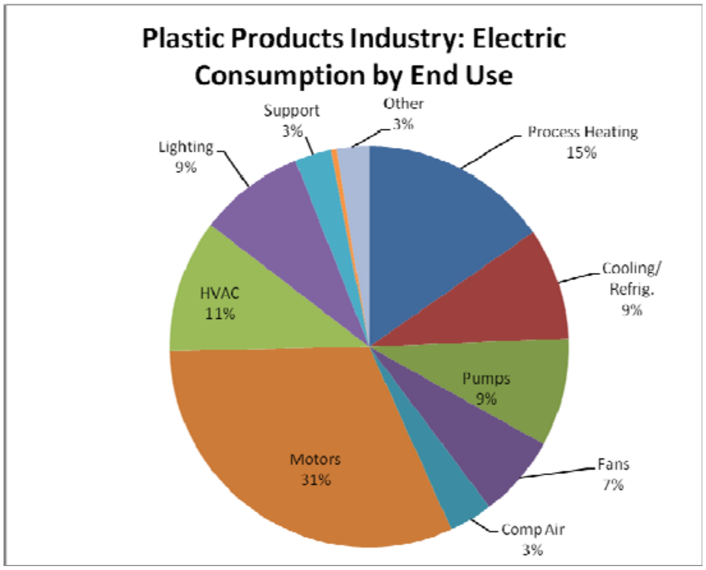


Source: 2006 Manufacturing Energy Consumption Survey[49]

Figure 17 highlights the fact that the overwhelming majority of electric consumption (76 percent) by the plastic products industry is directly related to the plastic product process. Non-process energy use, like facility lighting and HVAC, accounts for a smaller fraction (24 percent) of the industry's electric consumption.

[49] U.S. Energy Information Administration. 2009. *2006 Energy Consumption by Manufacturers*. June 2009. http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html

Figure 18: Electric Consumption by End Use



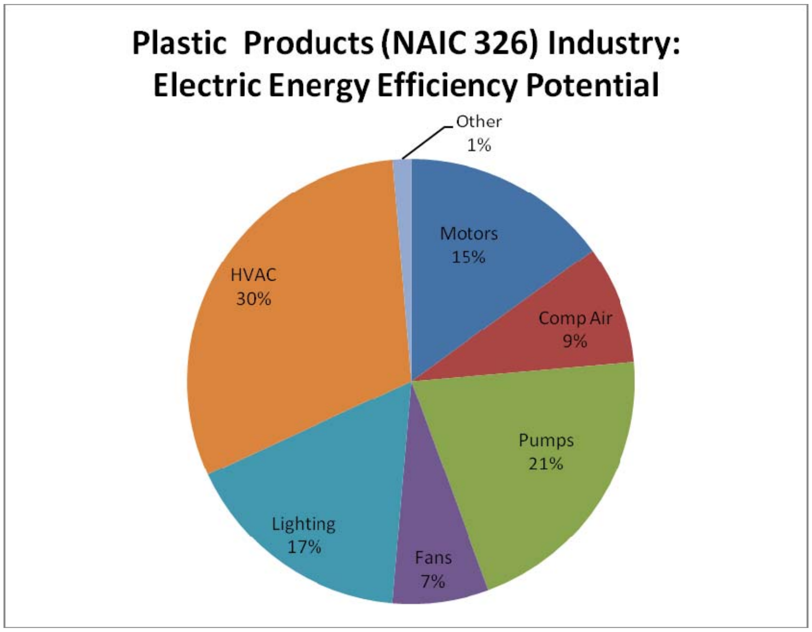
Source: 2006 Manufacturing Energy Consumption Survey

Figure 18 expands on the high-level consumption information presented in Figure 17 and shows electric consumption by end use for the plastic products industry. Half of the total electric consumption in the plastic industry can be attributed to machine drives as defined by the the Manufacturing Energy Consumption Survey (MECS). Using information from prior studies,we were able to break down machine drive consumption into motors (31 percent), pumps (9 percent), fans (7 percent), and compressed air (3 percent).[50,51] Facility lighting (9 percent) and HVAC (11 percent) constitute the majority of non-process electric consumption in the plastic industry.

[50] KEMA and Lawrence Berkeley National Laboratory, 2005. *California Statewide Industrial Sector Energy Efficiency Potential Study.* Prepared for Pacific Gas and Electric Company.

[51] XENERGY. 1998. *United States Industrial Electric Motor Systems Market Opportunities Assessment*. Prepared for Oak Ridge National Laboratory and DOE's Office of Industrial Technologies. December 1998.

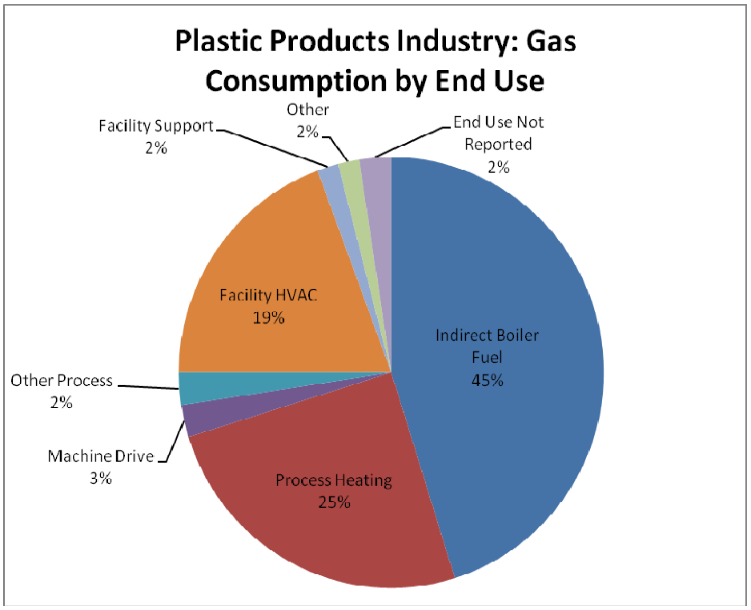
Figure 19: Plastics Energy Efficiency Potential



Source: 2006 Manufacturing Energy Consumption Survey

Figure 19 presents the electric energy efficiency potential by end use for the plastic products industry (NAICS 326). The largest potential for electric energy savings lies in HVAC improvements, accounting for 30 percent of the total energy savings potential in the plastic industry. There are also significant energy savings opportunities related to pumps (21 percent), lighting (17 percent), and motor (15 percent) measures.

Figure 20: Plastics Gas Consumption by End Use



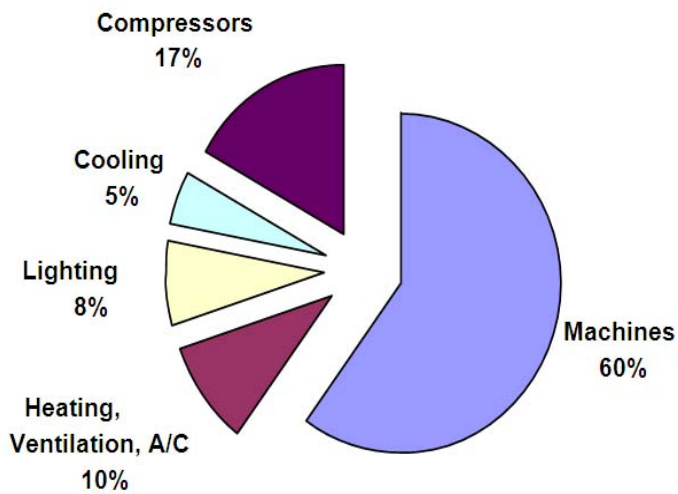
Source: 2006 Manufacturing Energy Consumption Survey

Figure 20 breaks down the end use consumption of natural gas for the plastic industry. The majority of natural gas usage within the plastic industry is dedicated to boiler fuel (45 percent) and process heating (25 percent). Energy consumption associated with facility HVAC is the third-largest natural gas end use within the plastic products industry.

An international source provides another view of the overall energy by end use in the plastic industry.[52] Key processes driving energy consumption are the melting of raw materials; cooling; drives for peripheral equipment such as compressors, grinders, mixers.

[52] Leonardo Energy. 2009. *Power Quality and Utilization Guide, Plastics Industry*. January 2009. http://www.leonardo-energy.org/webfm_send/8

Figure 21: Energy Balance of a Plastics Processing Plant



Source: Leonardo Energy[53]

4.3 Production Processes

To produce plastic, the basic processes require inputs of natural gas and crude oil, which are refined, heated, mixed, blended, melted, cooled, and shaped into finished products using a variety of processing methods. Production processes steps vary by type of plastic: resin or plastics products.

Resin manufacturers use raw inputs of oil or natural gas, which is compounded and mixed with chemicals into many different types of resins. The end result is raw plastic in the shape of pellets, flakes, fluids, or powders. This process encompasses the following steps:

1. Refining of crude oil and natural gas
2. *Cracking*[54] of petrochemical products in high-temperature furnaces;
3. Combining monomer materials like ethylene or propylene with a catalyst to form flake material of polymer
4. Blending of flake-like materials with chemicals and additives

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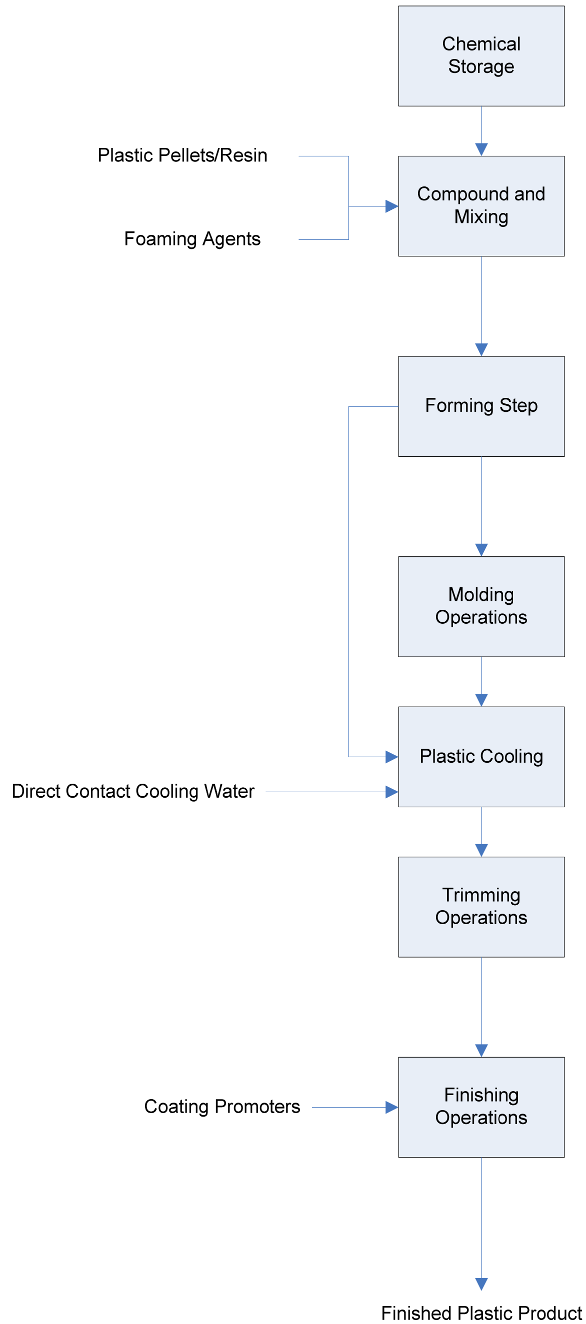
[53] Ibid.

[54] Cracking refers to a series of chemical processes to convert complex chemicals to simpler compounds

5. Melting polymer and then extruding it in a stream, which is cooled and cut into small pellets in the pelletizer
6. Resin pellets are shipped to customers
7. Customers manufacture plastic products by using processes such as extrusion, injection molding, blow molding, and others, depending on the final shape required.

Plastics products manufacturers use resin as raw input, and blend with additives to alter and improve the basic mechanical, physical, or chemical properties. Plastic material is formed and molded using a variety of processes, the most common being injection molding, extrusion, and blow molding. Slightly different processes are used to make foamed plastics products. Plastics products are then cooled, cut or trimmed and finished. These are then transported by rail, container cargo ship, or truck. Figure 22 shows the simplified plastics product making process, using raw inputs of resin in the shape of pellets. Actual production processes will vary depending on type of plastic end product desired.

Figure 22: Plastics Products Manufacturing Process



Source: U.S. Environmental Protection Agency[55]

[55] U.S. Environmental Protection Agency. 2005. *Profile of the Rubber and Plastics Industry, 2nd Edition*. EPA Office of Compliance Sector Notebook Project. Report number EPA/310-R-05-003. February 2005.

Each plastic processing method is adapted for specific applications; the most common are detailed below.

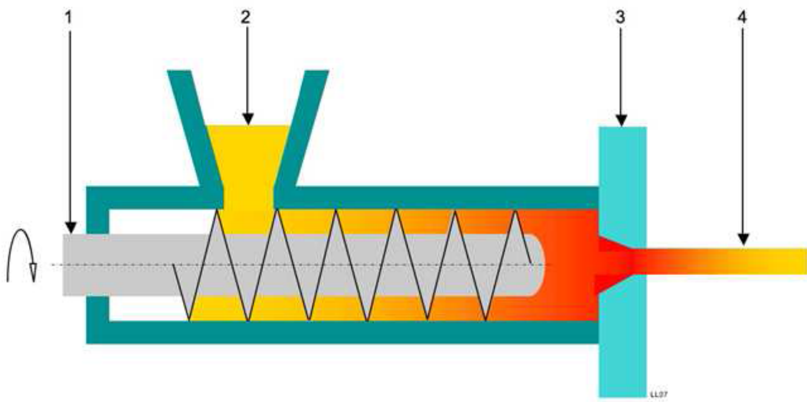
Compounding/Mixing: molten plastic formulations are mixed or compounded with additives to achieve a homogenous blend. Equipment to compound or mix the formulation will vary by type of end-use product required, but the most common include dispersive and distributive mixing, heat, co-kneaders, twin screws, and internal mixers.

Forming: molten plastic is moved from the mixer and undergoes an intermediate step to prepare for the molding process, which varies by plastic shape desired. The plastic may be stretched, pulled, lifted into shape, similar to clay modeling, and is sent directly to cooling, skipping the molding step.

Molding: molten plastic material is injected into or forced through a mold (also called a die), depending on the process type. Injection molding produces plastic parts such as bottle caps, containers, pocket combs, and automotive parts or any product for which a mold can be made and large quantities are needed. Plastic material forced through a mold or die produces long, continuous streams that are cut into long, narrow shapes such as rods or plastic fibers. The most common molding and forming processes are described below; each is adapted for specific applications and end-use products.

> **Extrusion Molding:** This process produces a continuous stream of plastic of a defined shape, such as lengths of plastic pipe, tubes, and thin film (see Figure 23). Plastic pellets are gravity fed into the hopper, where a screw pushes the resin grains through a heated barrel; then the resin grains are pressed together and melted. The mold at the end of the screw presses the plastic into the correct shape, and the resulting product is cooled in a water bath or by air on a conveyer belt. When the product has reached the desired length, it is cut to size. This is the most common molding process.

Figure 23: Extrusion Molding Process



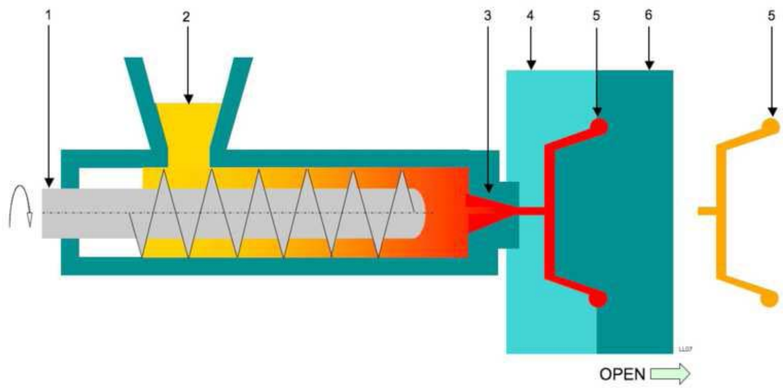
Extruder unit (1), Extruder (2), Granulate (3), Extrusion mold (4), Extrusion profile

Source: Leonardo Energy[56]

Injection molding is a cyclical process, mainly used for making plastic parts such as children's toys (see Figure 24). Fluid plastic is forced into a mold using an injection technique. The production cycle for producing these identical parts is typically less than a minute between parts. The plastic is added, heated, and forced through a nozzle into a mold. The difference between injection molding and extrusion lies in the mold. With extrusion, the mold is an opening where the plastic continuously flows out in a certain shape. With injection molding, the mold is a template into which the plastic is forced. The mold consists of two parts that are pressed against each other using hydraulics or powered by electricity. After the product has cooled and hardened, the mold opens and the product is finished.

[56] Leonardo Energy. 2009. *Power Quality and Utilization Guide, Plastics Industry*. January 2009. http://www.leonardo-energy.org/webfm_send/8

Figure 24: Injection Molding Machine



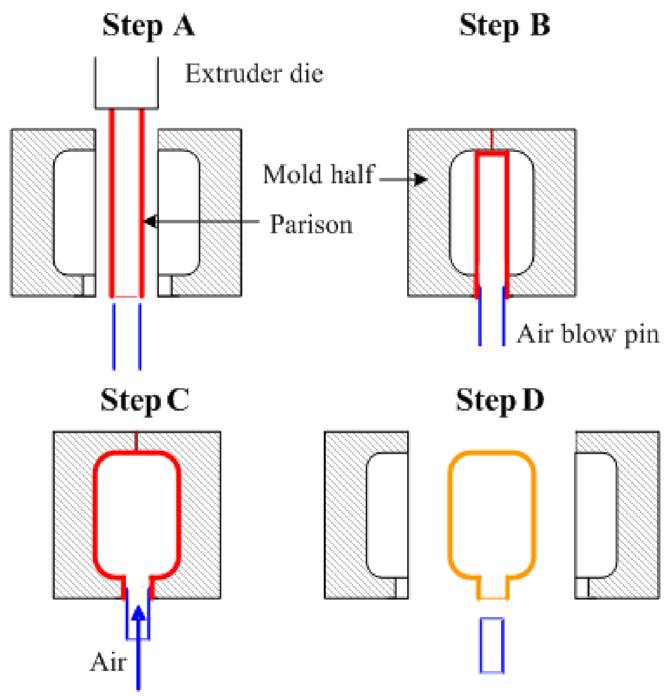
Injection unit: 1 Extruder, 2 Granulate feeder, 3 Injection opening (nozzle), 4 Lower part of mold, 5 Product, 6 Upper part of mold.

Source: Leonardo Energy[57]

Blow molding is used to produce hollow plastic shapes such as plastic bottles and cans. This process is similar to injection and extrusion molding until the material is carried into the hopper (see Figure 25). For extrusion blow molding, the melted plastic material is extruded in the form of a tube. Next, the mold closes around the tube. Compressed air blows the plastic and pushes it against the cold wall. Under pressure, the plastic object is cooled. Injection blow molding utilizes a pre-form mold. Plastic material is transferred to the pre-form, which is then placed in a blow mold. The plastic is heated and then compressed air is used to blow the pre-form plastic to the desired shape.

[57] Ibid.

Figure 25: Extrusion Blow Molding Machine



Source: Leonardo Energy[58]

> **Reaction injection molding** is a newer injection process that injects chemically reactive liquids to turn into plastic inside the mold. Because this method requires little heating, it uses considerably less energy.

Cooling: Various methods exist to cool the plastic products: under blown air or in a water bath, then hardened on a moving belt, as in extrusion molding; or held within a mold until has cooled and hardened, as in injection molding. Because blow molding has similar processes to either injection or extrusion, the cooling processes are similar as well.

Finishing: The plastic parts may be machined, trimmed, milled, printed or etched, punched, assembled, welded, drilled, and polished using chemical vapors or flame, among other practices to achieve the final product.

[58] Ibid.

The bulk of the energy consumed is during the molding of the plastic. Heaters and motors consume the majority of the energy.[59]

4.4 Current Practices

Rising and volatile energy prices are a major concern for plastics producers, particularly for small to medium sized firms that have slim margins and little room to balance operating expenses against profitability. Consequently, many plastics manufacturing companies are turning to energy reduction to stay competitive in regional and global markets.

While a great deal of emphasis in the plastics industry on energy efficient heating and processing of the plastic, there has been much less emphasis on energy efficient cooling—a process that uses as much, if not more, energy and a process with huge opportunities for energy efficiency improvements. Plastics processing uses large amounts of energy to heat raw materials and to mix, shape and cut into finished products. In every case, there is also a need to remove this heat from the process to solidify the plastic and complete the process, typically with cooling water. This means that the provision of a reliable and consistent source of cooling water is essential for fast and repeatable process times in all sectors of the plastics processing industry.

Sustainability and environmentalism are major industry concerns for an industry facing public perception issues around single use, non-degradable products (e.g., bags, packaging, etc.) and chemical additives posing health risks (e.g., bisphenol-A in plastic bottles). The plastics industry has responded by changing product formulation and incorporating organic materials (called bioplastics) and recycled plastics.

4.4.1 Efficiency Improvements

Standard industrial efficiency measures for motors and drives, molding equipment, lighting, and other basic processes are primary options to reduce industry energy consumption. Options such as high-efficiency motors and variable-speed drives have excellent payback for both new and replacement purchases.[60] To illustrate, the U.S. DOE analyzed efficiency improvements for 11

[59] Ibid.

[60] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Industrial Technologies Program and The Society of the Plastics Industry, Inc. 2005. *Improving Energy Efficiency at U.S. Plastics Manufacturing Plants, Summary Report and Case Studies.* Report Number DOE/GO-102005-2111. September 2005. http://www1.eere.energy.gov/industry/bestpractices/pdfs/plastics_report.PDF

plastics manufacturing facilities in 2003, under a partnership with industry trade group SPI to save energy, reduce waste or increase productivity. Although none are located in SCE's territory, the recommendations are indicative of opportunities for all manufacturers of resin and plastics products. The top recommendations, and the corresponding total estimated annual savings in parenthesis, are: installation of large storage tanks ($573,000) and improvements to water cooling systems ($132,000). Several recommendations involved relatively major expenditures, but would have major impacts on the company's annual operating costs as well.

In addition, the DOE categorized recommendations by plant-related processes, such as compressed air systems, lighting, and heating and cooling, by the average recommended savings per assessment (see Table 7). Compressed air had the highest number of efficiency recommendations, followed by lighting, HVAC and motors. While many recommendations relate to basic mechanical systems such as HVAC and compressed air, these are a relatively small portion of overall manufacturing energy use. However, productivity improvements have the highest payback, by many orders of magnitude. This may include reviewing manufacturing equipment and systems are correctly matched for the required processes, and staff training to ensure efficient equipment operation and maintenance.

Table 7: No. of Recommendations and Potential Average Cost Savings, by Major Improvements Categories

Improvement Category	Number of Recommendations	Average Annual Cost Savings per Category (estimated)
Compressed Air	29	$27,143
Lights	16	$17,012
HVAC	15	$14,695
Motors	8	$13,460
Heat recovery	7	$16,845
Insulation	6	$19,480
Waste reduction	6	$7,640
Load shedding/power factor	6	$12,690
Productivity	4	$240,217
Controls	3	$15,570

Source: U.S. Department of Energy and The Society of the Plastics Industry[61]

Descriptions of key plastic industry energy efficiency processes follows.

Motors: Penetration of energy efficient motors is sizable among industrial manufacturing due to government and utility programs. Motors are most efficient when their load equals the rated capacity, but actual operational conditions require the loads to vary. Within the plastics industry, the use of variable frequency drives has led to significant improvement in energy use. Vendors and engineering service providers have developed specific expertise to assist the industry. Additionally, some manufacturers have developed and implemented a motor management policy to optimize purchase and operation of energy efficiency motors.

Injection Molding: Electricity usage accounts for more than 90 percent of the energy costs in injection molding, but only 5–10 percent of the energy consumed is actually input to the plastic polymer. The remaining 90–95 percent is used to operate the machine. Thus, large savings can be realized without affecting the product in any way. Improvements in managing the heating and cooling steps reduce the energy required.

Molding Machines: Newer generation machines often have improved energy efficiency that can reduce product costs by over 3 percent. Correct sizing is also key to optimizing efficiency.

[61] Ibid.

All-electric Molding: Newer all-electric machines can reduce energy use by between 30 percent and 60 percent, depending on the molding and the machine. In some cases, shorter cycle times are also possible to further reduce energy consumption and increase productivity. All-electric machines also eliminate the need for cooling the hydraulic system, along with the associated energy use.

Extrusion: Extrusion is both a final forming process for products, as well as an intermediate process for other processes such as injection molding and blowmolding. The energy used in the extrusion process is directly related to operation of a screw embedded within the extruder. The cost-effective operation of extrusion screws is therefore essential to many plastics processing companies. Driving the screw is an electric-driven process: When the resin is fed into an extruder, melted and forced through a die, approximately 50 percent of the total energy is used to drive the screw that forces plastic through the extruder barrel. The remaining 50 percent is used for heating, ancillaries, and utilities. Much of the energy required to plasticize and heat the polymer comes from the heating the polymer as it is moved by the extruder screw along the barrel. In some cases, no additional heating is required and barrel cooling is necessary.

Whatever the age of the machine, it is essential to get the right extruder for the job and the screw diameter and design must be specific for the polymer and product. Extruders run most efficiently (not only in energy terms) when operating at the design conditions for the motor and screw. Ideally, the extruder should be set to run at the maximum design speed, as this is usually the most efficient setting. The screw speed should only be reduced from the maximum if there is difficulty producing good product.

> **Extrusion Blowmolding:** The major energy use is the extruder area of the blowmolding machine and this typically uses 40 percent of the total machine energy. Whatever type of basic machine is used, good process control will give more efficient operation and reduce operational costs, not simply in terms of energy efficiency.

Hydraulic Drives: The hydraulic drive is the oldest concept in terms of technical development. In recent decades, multiple energy-saving pumps have been used in the hydraulic systems in combination with pressure regulating valves. With no load, the system is provided with pressure by the smallest pump. Because multiple pumps are used, energy savings can be achieved of up to approximately 30 percent compared to the older system with its single pump. These new, more economical hydraulic systems are generally used in most modern machines. The conversion of an older existing machine may be a worthwhile consideration.

Electrical Drives: Fully electrically driven injection molding machines have been on the market for some time now. Servo motors are used to open and close the mold. Greater energy efficiency is achieved by eliminating the no-load losses. These losses are absent because continuous pressure does not have to be maintained anywhere within the system. Direct transmission is used for fully electrical machines. The initial cost of an electrically driven machine is generally higher than a hydraulically driven machine. However, the energy savings can make an electrically driven machine financially attractive in the long term.

Three-Dimensional Printing (Additive Manufacturing): Computer blueprint files of 3-D objects can be developed, and the object can be produced from plastics or resins on a 3D printer or fabricator. The printer builds the object by progressively adding layers of plastic or resin until the full object is manufactured.[62] Originally designed to make prototypes, the technology is increasingly competitive with small runs of injection molded items.

4.4.2 Capital Expenditures for Energy Efficiency

While the current recession has negatively impacted funding for voluntary projects, savings opportunities are still considered. These typically will have short payback (2 years or less), and energy savings that impact the bottom line and allow manufacturers producers to lower their product prices.

Improved energy-efficient technology now makes it possible to re-equip a factory for permanently lower operating costs. Areas for investment include:

- Energy-efficient motor selection
- All-electric injection molding machines
- Inverter controls for hydraulic-injection molding machines
- Variable-frequency drives
- Lighting schemes and controls
- Compressors and controls.

[62] The Economist 2011. Technology: Print me a Stradivarius, How a new manufacturing technology will change the world. February 10. http://www.economist.com/node/18114327

Additionally, many energy efficiency measures do not require capital expenditures but rather require an effective implementation and monitoring program implemented by trained employees. In the best-case scenario, energy efficiency becomes part of the corporate culture.

5. Market Intervention

This section presents the results from primary research conducted in two phases: an industry leader meeting via webinar and one-on-one interviews conducted with industry stakeholders. Industry leader meeting attendees included vice presidents and other executives, trade association directors, energy managers from various manufacturers, and representatives from KEMA, ACEEE, and SCE. KEMA also conducted five one-on-one interviews with major energy users in California and the SCE service territory to solicit input from those unable to attend the industry leader meeting and confirm feedback from the meeting. Interviewees included corporate energy managers and plant operations staff. KEMA focused on mid-sized manufacturers of specialty and commodity plastics products to solicit a broad array of opinions in the largest energy consuming sectors (e.g., plastic bottles, bags, and specialty products). Our insights and conclusions are presented below.

5.1 Effective Utility Programming

Customers interviewed in the plastics sector support utility programming, and most participated in both demand response and energy efficiency incentive programs. Despite this broad participation, it was clear that gaps existed in their program knowledge. During the interview process, we found that customers did not fully understand the programs or seek rebates when completing retrofit or replacement projects. For example, one customer regularly conducted retrofit and upgrade projects, but had not investigated utility rebates for at least two years. Another customer participated in a demand response program, referred to as a *blackout* program, but was unsure how it worked other than receiving a monthly utility bill credit. These experiences point to additional education and communication that would be well received to help orient customers within the utility customer programs and to solicit increased program participation. The following provides more details on these findings.

- *Communications/Education*: Evidence of program knowledge gaps appears to hinder broader program participation. This is not surprising since utility programming is more challenging in industries such as plastics with low-market-concentration levels, where utility representatives cannot effectively reach the large, diffuse customer base. Customers interviewed praised their utility reps, and spoke with them on average every other month. More concerted communication may be required across the broad customer base to fully realize energy efficiency potential in this sector.
- *Third-party Consultants:* Two respondents reported positive experiences with third-party consultants, which provided several benefits to the customers: another source of utility

program information, in addition to their representative; and an outside entity to handle rebate paperwork. The respondent who declined to seek rebates for an existing project may find engaging a third party would remove barriers to utility program participation.

- *Existing Utility Programs:* Similar to other industries, many of the respondents participated in incentive programs as well as demand response and enthusiastically supported the utility's efforts to assist in energy efficiency. However, these respondents reported less enthusiasm for energy efficiency projects in the past few years because the industry revenues have declined. Similar to other industries, while utility programs will not *make or break* the decision for large capital projects, continuing to offer rebate programs will help overcome barriers to small to medium sized projects.

5.2 Drivers of Energy Decision-Making

The following sections describe plastics manufacturers' approach to energy efficiency projects, including planning, financing and decision-making criteria.

5.2.1 Energy Efficiency Planning

Cost savings is the primary driver of energy efficiency projects among customers interviewed. Other contributing factors include corporate mandates to become *green*, which customers have partially satisfied by decreasing energy usage. Similar to other industries, customers interviewed did not typically undertake projects solely for the cost savings. Respondents reported moderate interest in energy efficiency programming since energy cost, while significant, less critical than raw materials and labor, the top two industry costs. Nonetheless, respondents reported seeking cost savings where possible. This is particularly relevant during the current economic downturn since customer revenues have declined and driving operational efficiency increases the company's bottom line.

Table 8 displays manufacturers' self-reported ability to undertake energy efficiency practices or investments, where a rating of "1" means the company has completed all or nearly all cost-effective measures. Among the five respondents, the average rating is "2.3" out of "5," indicating that these customers have already undertaken investments in energy efficiency projects. Projects completed were primarily standard energy efficiency measures such as VSDs, higher efficiency motors, and upgraded lighting. This overall rating also indicates that additional projects are available since no customer reported a rating of number "1," meaning they believe that all or nearly cost effective measures have been taken. This indicates barriers do exist.

Firms interviewed approached energy efficiency planning and implementation in similar ways. Typically, the engineering or plant management staff collects energy efficiency project ideas from numerous sources such as their utility representative, third-party consultant or vendors or colleagues; evaluates the most promising projects, and then submits a proposal to management for approval. Available project savings are critical at every step of the process, from engaging customer interest to final approval stages. For several smaller customers that indicated they fund energy efficiency measures from bank loans the total project cost could make or break the project, regardless of savings levels. One respondent enthusiastically interest in on-bill financing or other utility sponsored financing methods.

Table 8: Self Reported Manufacturer's Ability to Undertake Energy Efficiency Investments, Using Scale 1–5[63]

Manufacturer Type	Self-Reported Rating: EE Projects Undertaken	Notes
Plastic Bottles	#2	Numerous upgrades (chiller system; air compressors) and lighting retrofit completed in past 3 years.
Plastic Bottles	#2	Estimated 80-90% potential projects are completed; energy efficiency is kept top of mind.
Plastic Bags	#2.5	Energy efficiency is important, but cost & time are drawbacks; lighting retrofit being considered.
Plastic Bottles	#3	Leased space inhibits energy efficiency opportunities; time involved is large drawback.
Polystyrene Foam	N/A	Corporate goal to continually increase energy efficiency.

Source: KEMA, Inc.

5.2.2 Investment Priorities

In the plastics industry, energy typically ranks third, behind the cost of raw materials (# 1) and labor (# 2). Managing energy is deemed important by the respondents, but other business priorities take precedence when they seek to reduce operating expenses. This was emphasized by one respondent who noted that any energy efficiency investments typically rank lower in priority than other, more critical business issues involving raw material sourcing and

[63] Scale: 1 = invests heavily in energy efficiency. 5= energy efficiency is a low priority

labor/personnel. Table 9 displays respondents' ratings of energy as a business priority. These respondents were asked to use a ratings scale comprised of the following: not at all a priority, low priority, medium priority, high priority, very high priority. As indicated, three of four indicated 'high priority,' which confirms that energy costs are important in the industry but not the highest rating.

Table 9: Customer Rating of Energy as Business Priority

Manufacturer Type	Rating - Energy as Business Priority[64]	Notes
Plastic Bottles	High	Contracted with third-party provider to seek energy cost reductions.
Plastic Bottles	High	Energy is 6-7% operational costs and ranks below cost of raw materials (#1) and labor (#2).
Plastic Bags & Film	High	Energy cost is important, but not the highest business priority.
Plastic Bottles	Low	Energy cost reductions sought when other business priority projects completed.
Polystyrene Foam	N/A	Corporate goal to continuously increase energy efficiency.

Source: KEMA, Inc.

Several respondents all mentioned two important investment priority criteria: project payback length and total project cost. Any projects with over two years' payback will face strenuous hurdles, according to interview respondents. This typical payback period has not changed significantly in the past decade, despite the economic downturn, since it is tied to customer contracts. While these respondents represented smaller plastics manufacturers, the finding also applies to other, larger firms due to similar customer contract cycles. Table 10 shows customer-reported payback periods typically required for energy efficiency projects.

Plastics firms typically tend to sign customer sales contracts for from several months to several years, and are reluctant to undertake projects that require longer payback periods than their customer contracts. One company interviewee reported that because the firm looked at energy

[64] Ranking scale: Not at all a priority, low priority, medium priority, high priority, very high priority

savings in a shorter timeframe, the focus is on basic equipment modifications and replacements such as lighting, VSDs, and air compressors.

Table 10: Payback Periods, by Manufacturer Type

Manufacturer Type	Payback
Plastic Bottles	2 years
Plastic Bottles	2 years
Plastic Bags & Film	1 year
Plastic Bottles	1 year
Polystyrene Foam	n/a

Source: KEMA, Inc.

Total project cost is important since many plastics sector firms are smaller, privately held manufacturers that have fewer resources than larger companies. Some reported seeking outside financing, typically bank loans, to undertake larger energy efficiency projects. Depending on the manufacturer's available credit, total project cost could make or break projects, regardless of payback periods. This does not apply to firms that manufacture raw plastics material or have large-scale commodity plastics products operations. These firms can be subsidiaries of multinational corporations and can draw on parent credit resources or use operating budgets to fund smaller projects. None of those interviewed use operating budgets for major energy efficiency projects, typically above $25,000–$50,000.

5.2.3 Project Financing

Energy efficiency projects are primarily funded through capital budgets, according to the interview respondents. These respondents noted significant difficulty securing project financing. Given the diverse array of smaller, niche manufacturers, financing in the plastics sector can be a significant barrier. One respondent enthusiastically suggested utility financing options, such as on-bill financing, or zero percent interest rates, to surmount this hurdle. It is not certain that financing is the major hurdle industry wide, and whether financing options would significantly improve adoption rates of energy efficiency options and technologies.

5.3 Cycles of Innovation

Many plastics products are sold as commodities and lowering overall manufacturing costs is key to competitiveness. Other, typically smaller manufacturers produce specialty products according to customer specifications. Because energy ranks lower than other business costs, manufacturers first seek savings from labor and raw material sourcing, the major industry expenses. Energy efficiency projects undertaken tend to be standard, such as higher efficiency motors, VSDs, and behavioral changes, rather than more innovative solutions. This is due to lack of staff time, project expense, and difficulty securing management approval for more complex projects. One respondent noted that if energy was the largest component of their cost, the firm would be more innovative in identifying and implementing energy efficiency projects. Many of the *low-hanging fruit* projects have been completed, according to the respondents, and any projects undertaken for energy savings alone are uncommon.

Similar to other industries, companies with sustainability or energy efficiency goals are also more likely to participate in government and utility forums that focus in these areas. For example, the EPA has had forums for the plastics industry. In California, the ARB meets with industry groups to achieve compliance with AB 32.

Respondents noted receiving sufficient information about innovative energy efficiency practices, from numerous sources such as equipment vendors, utility representatives, and third-party consultants. In one case, a third-party consultant assumed the customer had a much higher degree of interest in energy efficiency innovation and did not understand the industry cost structure and primary interest in relatively standardized projects at the lowest payback possible. This customer described a flooding effect that inhibited decision making for any energy efficiency project at that time. Understanding and tailoring the message to each customer is important to drive program success rates.

5.4 Customer Assessment

Customers interviewed stated they have all participated in utility programs and would consider any program that meets their needs and internal criteria for payback, as well as saves on energy costs. The following sections describe customers' rating of their utility program awareness, experience, and satisfaction.

5.4.1 Utility Program Awareness

Respondents reported awareness levels ranging from fair to good for utility sponsored energy efficiency programs, indicating that additional marketing and education may be effective. On a scale of “1” to “10,” where “1” represents the highest awareness, two of five respondents indicated levels at “5” or “6.” One of these customers indicated that more frequent electronic communications (e.g., newsletter and email updates) would be helpful to better understand utility programming options. Two additional respondents noted sufficient familiarity with utility programming options.

Customers reported learning about utility programs through a wide range of sources, from utility representatives’ contact (in-person, email or telephone), vendors, colleagues, and conferences. This wide range of sources serves to reinforce the utility programming message through repeated contact.

Utility representative contact tended to occur monthly or every few months. All respondents noted this was sufficient because they felt their representative was available and responsive if additional support was required between contact periods.

5.4.2 Customers’ Experience

Customers uniformly praised California utilities’ industrial programs, particularly for the ease of participation. Many plastics sector businesses seek cost savings at the lowest payback possible, using the least internal resources. According to customers interviewed, the utility programs meet expectations in terms of cost and energy savings, and required comparatively little staff effort. According to these basic metrics, SCE’s programs fit industry respondents’ needs, particularly if a third-party consultant is engaged to handle rebate program paperwork. One customer praised the demand response program for the automatic monthly utility bill savings since minimal shutdowns had been required in the past few years. No respondents requested energy experts with sector specific expertise.

Customers interviewed reported high satisfaction and very few negative comments or constructive feedback about the utility programming.

6. Next Steps and Recommendations

This investigation has revealed that plastics customers are willing to consider new approaches, including a comprehensive approach to addressing their energy needs, beyond simply retrofitting equipment. Some suggested elements of that approach are presented below, and additional research focused on the feasibility of each of these recommendations would be prudent. Two key components of a successful effort are the participation of regulatory staff in the development of the options and CPUC recognition of the utilities' role in changes to a customer's policies and procedures regarding energy.

Our research suggests a number of opportunities for both program implementation and program evaluation.

6.1 Program Implementation

1. **Increase Electronic Communications.** Knowledge gaps identified in program understanding appear to inhibit broader participation. This is not surprising since many smaller firms operate in the plastics industry, making it difficult for utility representatives to effectively reach the large, diffuse customer base. More concerted electronic communications such as more frequent email check-ins or newsletters may assist to fully realize energy efficiency potential in this sector.
2. **Time Communications According to Customers' Contract Cycles.** Many plastics firms operate under customer contracts spanning one to two years, which impacts their willingness to undertake projects. Utility representatives can leverage this information by targeting communications suggesting projects to start near the beginning stages of customer contracts. Customers that have recently signed a multiyear sales contract will be more receptive to longer term projects than customers that face uncertain contract renewal or imminent expirations. Due to timing and planning, representatives may want to regularly seek information about customers' contracts. Because firms look for energy savings in a shorter timeframe, the focus is on basic equipment modifications and replacements such as lighting, VSDs, and air compressors. Customers that have one key long-term contract are more likely to undertake more complex, longer payback projects.
3. **Understand Industry Business Priorities**. Energy typically ranks third, behind the cost of raw materials (first) and labor (second) in the plastics industry. While managing energy costs is important, other business priorities take precedence when customers seek to reduce

operating expenses. Firms where energy is a largest component of their cost would be more likely to seek innovative ways to identify and implement energy efficiency projects.

4. **Leverage Customer's Internal Programs.** The most sophisticated customers typically have established strong internal energy efficiency programs. Firms that have accepted corporate sustainability or energy efficiency goals have a vested interest in reducing energy. Utility offerings that further enable the energy-savvy customers to achieve savings have low market barriers. For example, utilities could offer technical and management assistance for companies seeking to achieve ISO 50001 certification.
5. **Increase Promotion of Third-party Providers.** Customers universally praised third-party providers for simplifying the program process, and removing barriers such as lack of staff time and paperwork requirements. Increasing promotion of these entities would likely increase participation among customers who view program participation as too complex or time consuming.
6. **Encourage Low-cost Improvements.** In this economic climate, companies are most receptive to projects with the shortest possible payback. Programs that focus on low- and no-cost items, such as improving reliability through a predictive and preventative maintenance programs, can engage customers with limited financial options

. what research do you think would be worthwhile to pursue given these results?

6.2 Evaluation

1. **Build on Existing Support.** Customers interviewed praised SCE's energy programs and are interested in continuing the conversation. These customers recognized the benefits of energy and cost savings, and access to utility representatives, which is key since many rely on the utility to learn about new programs.
   – **Develop Innovative Pilots to Suit Differing Customer Needs.** Although there are a few large multinational customers that may be energy savvy, few customers are likely to be receptive to highly sophisticated offerings such as the Superior Energy Performance program. However, this industry may be receptive to shorter term programs like the Energy Trust of Oregon's *Kaizen Blitz* pilot program[65] and t Puget

[65] Navigant. 2010. *Kaizen Blitz Pilot, Report One*. Prepared for Energy Trust of Oregon. October 2010 http://www.affiliatedrecon.com/studies/OR/Energy_Trust/General/ETO-Kaizen-Blitz-Pilot.PDF

Sound Energy's Resource Conservation Manager Program.[66] Energy Trust's program offers an initial audit and one year of technical assistance, but requires the participants to set goals and implement fast payback options. The Puget Sound program offers grants for a resource conservation manager and incentives for energy efficiency improvements. This program focuses on and rewards improvements in behavior and utility cost accounting.

2. **Demonstration.** Risk aversion to new technologies is a strong barrier to new equipment adoption in this industry. Conducting demonstration projects (for example fuel cells) or using measurement techniques that can show where savings are possible (compressor leaks), and how energy efficiency can support reliability, quality and environmental concerns have the best potential to encourage adoption.

3. **Engage the Uninterested in Measurement.** One of the biggest challenges in the industrial sector is getting participation. One opportunity for engaging the less interested customers is to focus on the measurement of their electricity, and assist them in breaking down their bill to specific processes or unit operations. Then the company can seek opportunities specific to those operations.

[66] Puget Sound Energy. *2010 Business Energy Management, Resource Conservation Manager Program*. February 2010.
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A. Plastics and Chemicals Industrial Research Forum Question Set and Interview Guide

Research Forum Question Set

Introduction:

- Introduce KEMA
- Go over the project and the objectives
- Go around the room or make introductions via telephone.: Tell us about your job. How do you contribute to the decisions around energy in your organization?

Section 1: What drives decision-making for energy? Who initiates ideas for projects?

How does energy fit in with key priorities in your industry? (**For KEMA forum leader: list priorities identified in each report here and prompt discussion as required. Typically, priorities are safety, quality, meeting regulations, cost, competition.**

1. Where does energy rank in the management and operations of your business? Would your executive management agree with this ranking of importance?
    a. In your knowledge of the industry, is energy efficiency an integral part of strategic planning and risk assessment? Why or why not? If yes, in what ways? If not, what are other factors that are more important?
    b. Generally speaking, what proportion are energy costs relative to your operating costs? Do you see this proportion increasing in the future? By how much?
2. How have energy use patterns changed over the past 10 years? What drives the growth of energy use?
3. What drives investment in energy efficiency in the **plastics** industry in general? In the **resin/commodity products** industry? In the **specialty products (e.g. specialty shaped products)** industry? What are the key differences among them?
4. What drives investment in energy efficiency in the **chemicals** industry? In the **industrial gas** industry? In the niche and specialty (including **pharmaceutical) industry?**
5. What are the main opportunities for your organizations to save energy?

a. Behavioral, operations? (i.e., Management systems, preventative/predictive maintenance, Smart Mfr. – use of sensors, controls, , EMS, process optimization including EE)Retrofits and equipment upgrades
    i. in the **Plastics** industry? (Motors and drives (e.g. extruders, grinders, air compressors); Heaters (on extruder barrels, driers etc.); and Cooling systems and (on extrusion cooling troughs, injection molds, and drives)
    ii. In the **Chemicals** industry (Separations process such as distillation; chemical synthesis; process heating; and electrolysis).
b.
c. Process upgrades? (major changes, such as new motors, major equipment conversion)

6. What are the primary barriers to adoption of these opportunities?

7. Regarding capital and maintenance investments at your organization (i.e. major capital projects of any type, including mid-sized retrofits):

    a. How is energy efficiency financed? Operating budget vs. capital budget.
    b. How difficult is it to acquire capital for investment? Does the industry have alternative or innovative ways of raising capital? (i.e., private partnerships)
    c. How aware are you of IOU programs to help you manage your energy? Their technical support? Their incentives?

8. Would you say it is typical or not for firms to solicit input from employees at various levels and departments into investment decision making? If not typical, does it happen at all? If so, in what way(s)?

9. For major investment decisions, what is the typical process and timing from idea to start of implementation?

10. How are investment priorities determined?

    a. What are your investment criteria? What is the typical and shortest payback period needed to make an efficiency upgrade that requires capital investment attractive?

    b. How do you determine which project to invest in? How does management determine a project is worthwhile? What are the key deciding criteria to move forward on a project? (e.g. regulatory, safety, cost, increased production capacity, improved quality, new products, etc). How would you rank these criteria in terms of influencing how projects are prioritized?
    c. If the project could include energy efficiency improvements, do you involve your utility?
11. How has the recession/recovery affected your energy use? More, less or about the same? Any shift in types of fuels used?

Section 2: Cycle of innovation. What kinds of changes or innovations would cause you to retool or rebuild? Examples?

(list factors of innovation in plastics)

Production equipment evolves constantly due to new ways of producing specialty plastics as companies seek to find new uses for existing plastic and synthetic rubber materials. Most technical advances come from the suppliers of machinery and raw plastics materials.

12. How mature is the industry infrastructure in regards to age of equipment and systems? Do you foresee a need for substantial upgrades in the future? About how long? Near-term? Long-term?

13. What types of efficiency investments have been popular in the past ten years?

    a. Energy Management Systems and process control optimization

    b. Process and product optimization – feeds, rates, heat input, combustion process, etc

    c. New products or processes

    d. Steam projects- efficient boilers, dryers, leak repairs

    e. Electric loads: VFDs, efficient motors

    f. Heat recovery

    g. Air compressor optimization

14. What do you foresee the trend will be (regarding efficiency investments) in the future?

15. What organizations would you point to as particularly innovative? Why do you see these organizations as innovative, what are they doing that makes them innovative? (i.e. vendors? Utility engineers, consultants?)

16. What internal needs are shaping innovation?
    a. New products, Product improvements,
    b. New processes,
    c. Quality, cost, reliability, safety
17. What external factors drive innovation that effect energy use?
    a. Fuel prices
    b. Carbon trading
    c. Regulations and legal issues

18. (for companies operating in California) Do you foresee the implementation of AB-32 or other upcoming regulations will make a difference in your operations? Do you see that this will change how you manage energy?

19. How do your organizations access the latest information on energy efficiency technology?

20. If not mentioned, probe for comments on the following:

    a. Do you foresee more efforts to increase self-generation to service your own electricity demand?

    b. Validate the trends in innovation in operations such as; storage to facilitate load-shifting; plant optimization; improvements in optimization technology beyond SCADA

Section 3: Experience with Utility Programs and Networks of Expertise

21. What roles do others (e.g. contractors, consultant, etc.) play in moving EE projects forward?

22. Do you partner with the utility? Do you see the utility as a partner? What kind of resources and assistance do you look for from the utility? Is there more they could be doing to help you manage your energy use? What else should they be doing?

23. Have you participated in any energy efficiency or management programs offered by either the Department of Energy or your utility? Why or why not? Did the program address your needs? Would you participate again? Why or why not?

24. What would encourage your company's management to sign up for energy efficiency or demand response programs? Any past examples of either participation or non-participation and why?

Interview Guide

Section 1: Introduction

Hello. My name is [Interviewer Name] calling from KEMA Inc., an energy consulting firm. Your utility [Pacific Gas & Electric or Southern California Edison] has hired KEMA to conduct research to improve their industrial energy efficiency programs in the cement sector. You have been identified as someone knowledgeable at your company about energy efficiency decisions and participation in utility energy efficiency programs. Is this correct? [If no, ask for a colleague referral. If yes, start the interview questions below.]

First, I'd like to ask you about what drives decision-making in energy efficiency first, then ask about your thoughts on your utility's energy efficiency programs. Your responses are confidential. This interview will take approximately 30 minutes.

Section 2: What Drives Energy Efficiency Decision-Making?

1. What does energy efficiency mean at your company?
2. On a scale of one to ten, with 1 being the highest and 5 being the lowest, How would you describe your company's commitment to implementing energy efficiency practices or investments? (where 1 = invests heavily in energy efficiency or your company has taken all or nearly all cost-effective actions to reduce energy costs, 5 = only replace equipment on burnout)
3. Where does energy rank in terms of your business operation decisions?
   (Not a priority * low priority * medium priority * high priority * very high priority)
   a. What factors drive that ranking? i.e., need energy reliability for production/will pay any costs; energy costs in top 10 operating costs/huge impact on variable costs; or both?
4. What are the primary energy efficiency improvements that your company plans to make over the next…
   a. 2-5 years?
   b. 5-10 years?
5. How short of a payback does your company require to invest in energy efficiency measures?
6. How does your company typically pay for energy efficiency investments?
   a. What are the challenges involved with access to capital?

   b. How can the utility help with those barriers?
7. What other barriers are there to investment in energy efficiency in this industry?

Section 3: Utility Programs Communications

1. Please describe the typical process at your organization, from how you hear about energy efficiency programs offered by your utility to the final decision to participate or not.
   a. Who is involved?
   b. Who needs to participate in the decision-making process?
2. Are you familiar with the energy efficiency programs offered by your utility?
   a. How do you hear about utility sponsored programs? e.g. vendors, utility rep, colleagues, other?
3. Do you feel you have enough knowledge about the energy efficiency programs your utility offers? If no,
   a. Why not?
   b. How do you gather information to make an informed decision?
4. How often do you speak or meet with your utility representative?
   a. Would you prefer to meet: *more/less or the same?*
   b. How would you prefer to meet? *1-on-1, group, seminar?*

Section 4: Utility Programs Experience

1. What are the major factors your company considers when deciding whether to participate in a utility-sponsored program?
2. 2. What type of utility sponsored program(s) are you most likely to participate? Least likely? Has this shifted over time? If so, why?
3. Does your utility offer energy efficiency and/or energy management programs that address your important energy concerns?
   a. If not, what is missing?
4. Has your company participated in any utility sponsored energy efficiency program recently (e.g. past 2-3 years)?

If NO,

a. What factors have contributed the most to your decision not to participate in an energy efficiency program?
b. What would encourage you to participate? i.e. different type of program offerings; better/more communication about program opportunities; business need; other?

If YES,

a. What is the most effective and beneficial energy efficiency program you have participated in? Please explain what you found beneficial.
b. What led to your company's decision to participate i.e., how did you learn about the program, who at your company spearheaded the decision to participate?
c. Did participating meet your expectations?
    i. If yes, how?
    ii. If not, why not?
d. Would you participate in this program again? Why or why not?

Would you mind if I contacted you again as needed?

Thank you for your participation.