California Industry and Energy Efficiency: Opportunities and Past Programs

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ABSTRACT

The study is an energy-efficiency market characterization of California's industrial sector. Using secondary source data from utility, government, academic, and non-governmental organization sources, the research identifies the primary energy efficiency opportunities among industrial customers, both in terms of key industries (based on SIC code) and key technologies / end uses.

Utility program tracking data are analyzed to identify key program measures that have been promoted in prior years and to identify key industries and customer groups that have utilized the utility programs. Program evaluation data are reviewed to identify significant barriers to the implementation of energy efficiency measures. Current energy efficiency programs efforts are compared to the findings of the market characterization.

Research also identifies particular market segments for future research, either among small, medium, and large industrial customers, or for particular end-uses where significant energy efficiency opportunities have been overlooked. Efforts focused on identifying industrial sector energy-efficiency opportunities amenable to both, resource acquisition and to market transformation strategies.

Introduction

The industrial sector is difficult to characterize and study because the facilities and the industries differ widely from one another. This also makes it harder to design properly targeted programs for the industrial sector. Further complicating the design of industrial programs is the fact that studies of the nonresidential market and programs also include commercial and agricultural customers, making it often difficult to identify trends specifically germane to the industrial sector and/or whether the programs are meeting the special needs of industrial customers.

The purpose of this study was to cull out information relevant to the industrial sector customers from the wealth of nonresidential information currently available, to serve as input in the design of future industrial sector energy efficiency efforts.

Methodology

Figure 1 presents an overview of the study methodology, showing project data sources, the data elements garnered from each source, and the flow of analysis.

Major sources of energy usage data are shown on the left-hand side of the figure. These sources (mostly in electronic format) were analyzed to provide an energy usage profile for the industrial sector.

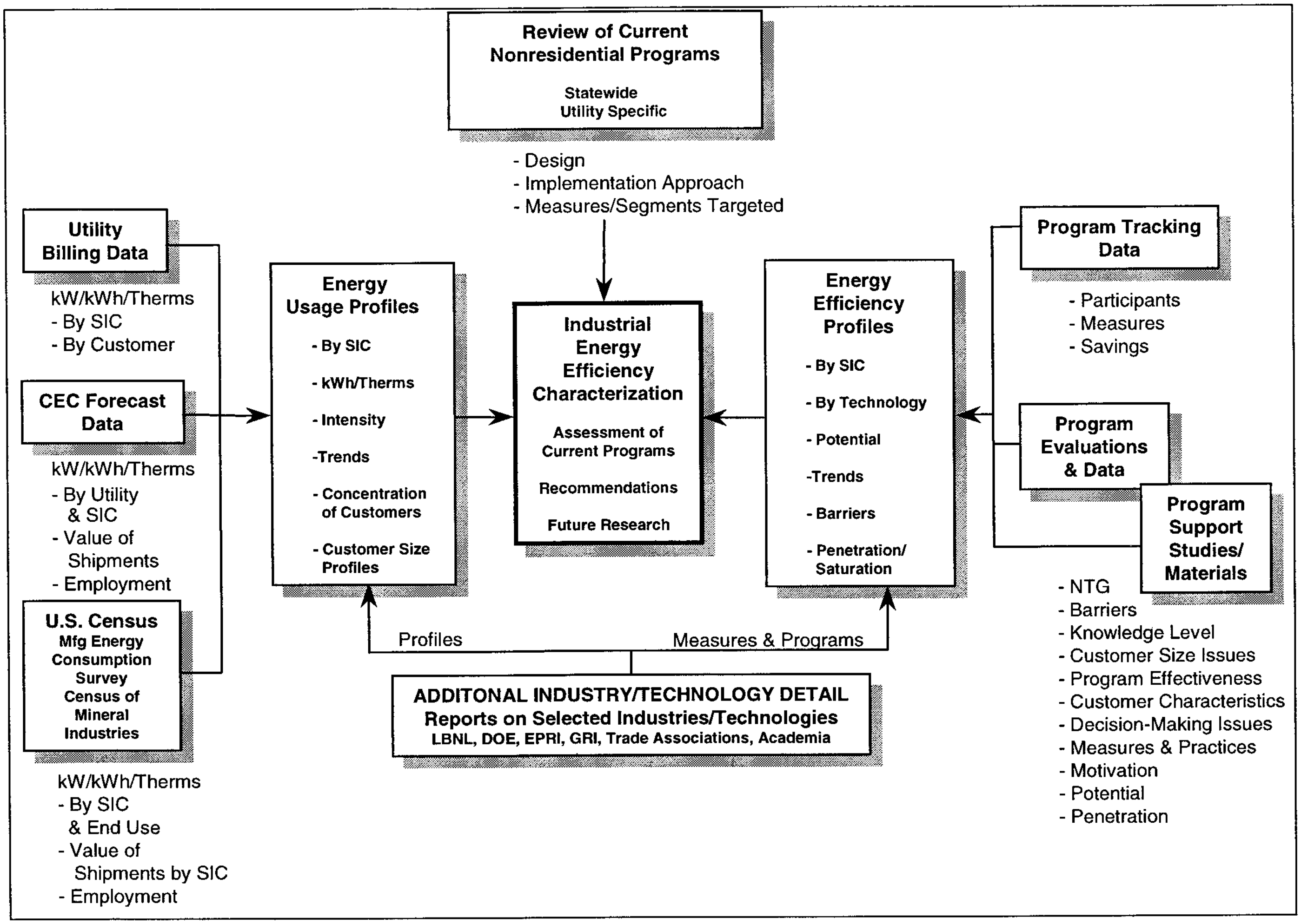


Figure 1: Methodology Overview

On the right-hand side of the figure, key sources of energy-efficiency program information are shown. These data/information sources were utilized to provide an understanding of program effects on the implementation of energy-efficiency measures and practices in the industrial sector. Factors influencing customer decision-making and motivation to install energy-efficiency measures were gleaned from these data.

On the bottom of the figure, the supplemental sources of data are listed. These sources provide additional detail on industrial energy usage characteristics and on available energy-efficiency technologies. Some sources focus on particular industries (such as the pulp and paper industry) and some sources focus on particular end uses or technologies (such as motors or compressed air systems). While many of these studies/sources are more national in focus, the information contained still provides significant, first-level insights into California's industrial market.

These three information groups provide a good, initial characterization of the industrial sector in terms of energy use and energy efficiency. Significant areas of energy-efficiency opportunities (technologies and market segments) are highlighted using these data.

The fourth information area outlined in Figure 1 relates to a review of current California energy-efficiency programs that target the industrial sector. This review provides an understanding of program design, implementation approaches, market barriers the programs address, and targeted sectors and technologies.

Finally, the information developed in the program analysis is reviewed in light of the industrial market attributes developed in the characterization analysis. The fit between current programs and current opportunities and barriers is assessed. Recommendations are made regarding future programs and areas (sectors and technologies) that should be targeted for additional studies.

Results – Energy Usage

Energy Usage by Industrial Group

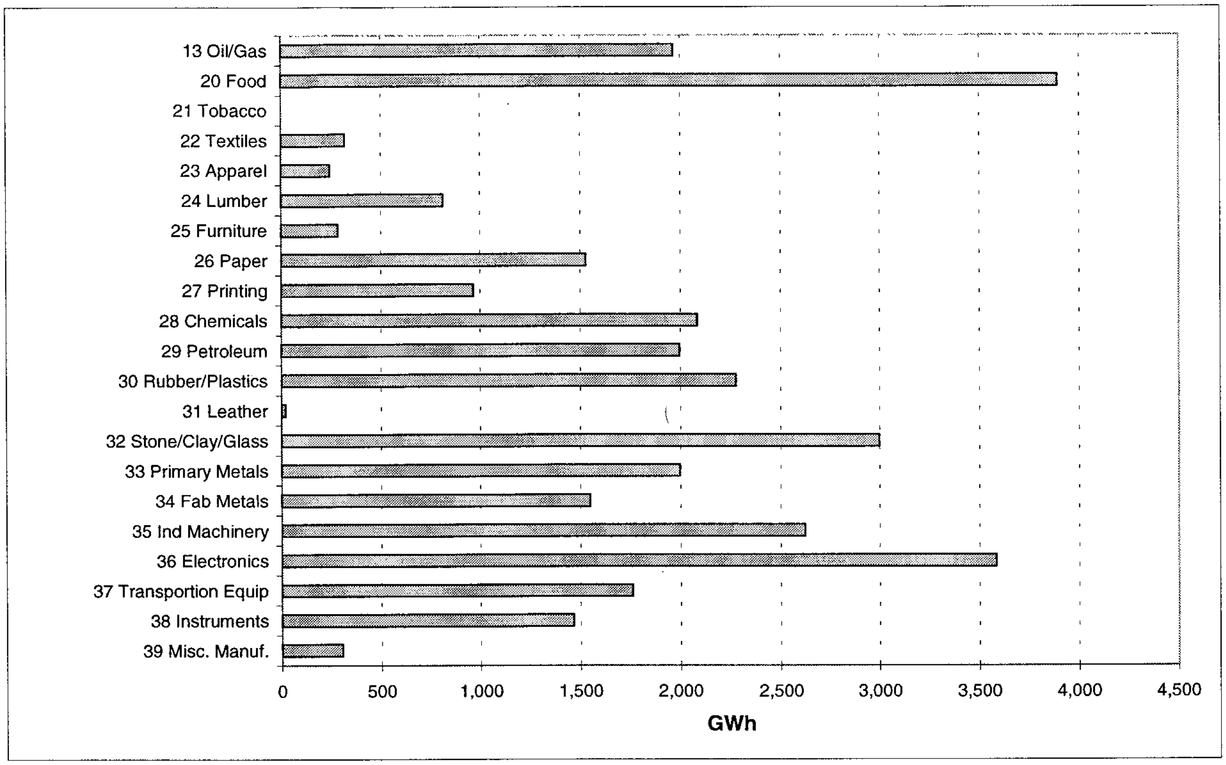
Electric energy consumption for the major California utilities is shown for key industrial SIC (Standard Industrial Classification) groups in Figure 2. The largest four industries (20 Food, 36 Electronics, 32 Stone, Clay and Glass, and 35 Industrial Machinery) consumed over 2,500 GWh each. Together, these industries account for about 40% of industrial electric usage. The next five largest SICs (30 Rubber and Plastics, 28 Chemicals, 33 Primary Metals, 29 Petroleum Refining, and 13 Oil and Gas Extraction) all consume about 2,000 GWh per year, accounting for another 30% of industrial consumption.

Natural gas consumption figures are shown in Figure 3. Petroleum refining (SIC 29) is by far the largest consumer of natural gas. The next five largest consuming industries (20 Food, 13 Oil and Gas, 26 Paper, 32 Stone, Clay, and Glass, and 28 Chemicals) all use over 200 million therms per year each. These six industries account for over 80% of industrial gas consumption.

Using CEC forecast data, *projected* growth rates were calculated for the 2000 to 2005 period. The industries (of larger size) with the fastest growing electric usage include Lumber (SIC 24), Chemicals (SIC 28), Rubber/Plastics (SIC 30), Electronics (SIC 36), Transportation Equipment (SIC 37), and Instruments (SIC 38). These industries show annual electric growth rates ranging from 2.5% to 4.5%. The industries with the fastest growing gas usage tend to be smaller gas-consuming industries (24 Lumber, 27 Printing/Publishing, 30 Rubber/Plastics, 36 Electronics, 37 Transportation Equipment, and 38 Instruments). The largest natural gas consuming industries (13 Oil/Gas, 20 Food, 29 Petroleum, and 32 Stone/Clay/Glass) show annual gas growth rates in the 2% to 3.5% range.

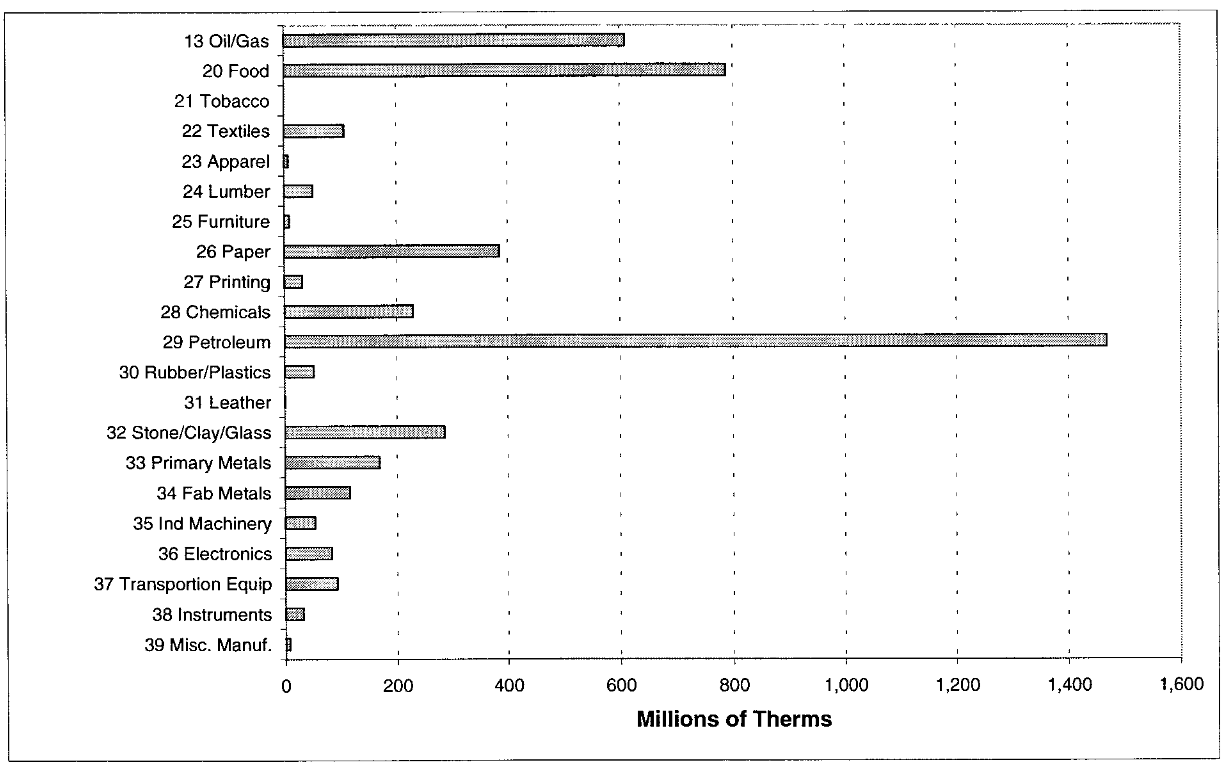
Energy Usage by Customer Size

Energy use in the industrial sector is dominated by large customers. Table 1 shows the breakdown of small and large sites in the California industrial sector. For electricity, large sites with electric demand of 500 kW or more account for about 4% of the sites, 74% of the kWh consumption, and 73% of the kW demand. The largest 1,000 electric sites account for about two-thirds of total industrial electric consumption. The very small industrial customers, with demand less than 50 kW, comprise over 70% of all industrial sites but account for less than 10% of industrial electricity consumption. For natural gas, the largest 4% of sites, categorized as large non-core customers, account for about 94% of the natural gas use. The top 100 gas sites account for about two-thirds of total industrial natural gas consumption.



Source: Utility Billing Data

Figure 2: Electric Consumption by 2-Digit SIC Grouping



Source: Utility Billing Data

Figure 3: Natural Gas Consumption by 2-Digit SIC Grouping

Table 1: Small-Large Site Breakdown

	Electric			Natural Gas	
	Sites	GWh	MW	Sites	Millions of Therms
Small	71,502	8,974.7	2,059.6	38,526	292.4
Large	2,766	24,920.6	5,561.3	1,339	4,301.3
% Large	4%	74%	73%	3%	94%

Large electric customers are defined as using more than 500 kW.
Large natural gas customers defined as using more than 250,000 therms per year.
Source: Utility Billing Data

End Use Energy Consumption

For the manufacturing industries (SICs 20-39), end use energy consumption estimates are available from the Manufacturing Energy Consumption Survey (MECS). MECS is the Energy Information Administration's (EIA's) survey of energy use and related activities by U.S. manufacturers. MECS provides end use split estimates for all 2-digit manufacturing SICs and for selected 3-digit and 4-digit SICs. The most recent MECS data, reflecting consumption in 1998 are now being provided using NAICS, the North American Industrial Classification System. These data were available too late to be included in this study. Instead data from the 1994 MECS are utilized.

To develop California-specific end use estimates, the MECS end-use splits were applied to California billing data consumption, first at the 4-digit level where MECS 4-digit splits were available, then at the 3-digit level and then the 2-digit level for consumption in remaining 3-digit and 4-digit SICs not directly covered in the MECS. For example in SIC 29 – Petroleum and Coal Products, the MECS data contain end use energy estimates for all of SIC 29 and for SIC 2911 (Petroleum Refining). The MECS end use splits for SIC 2911 were first applied to the California billing data for SIC 2911. Then the MECS end use splits for SIC 29 minus SIC 2911 were applied to the remainder of the SIC 29 billing data.

Figure 4 shows the breakdown of electric usage by key end use. The process machine drive component comprises just about half of the electricity consumption in manufacturing and about 70% of process electricity use. The other largest process end uses are process heating (11% of consumption) and process cooling (7% of consumption). Facility lighting and HVAC usage account for just over 20% of manufacturing electricity use, about evenly split between the two.

A more disaggregate motor breakdown is obtained by combining data on the estimated end use splits with a motor application breakdown from the DOE Industrial Motor Systems Assessment Study (XENERGY 1998). Figure 5 shows the results. Pumping and material process applications are the largest electric using applications, accounting for about half of the motor load. Pumps are used to move a variety of materials, including water, fuels, chemical solutions, and oils. Materials process applications include cutting, grinding, shredding, mixing, and materials joining and separation. Other noted applications are split fairly evenly at between 10% and 15% each. Materials handling includes transportation of materials on conveyor belts and positioning of materials in various stages of processing. Fans (excluding HVAC fans) are used mainly in process heating and cooling applications and for the removal of exhaust gasses. Compressed air is commonly used to operate equipment, position pneumatic and hydraulic devices, pressurize and atomize, and agitate liquids.

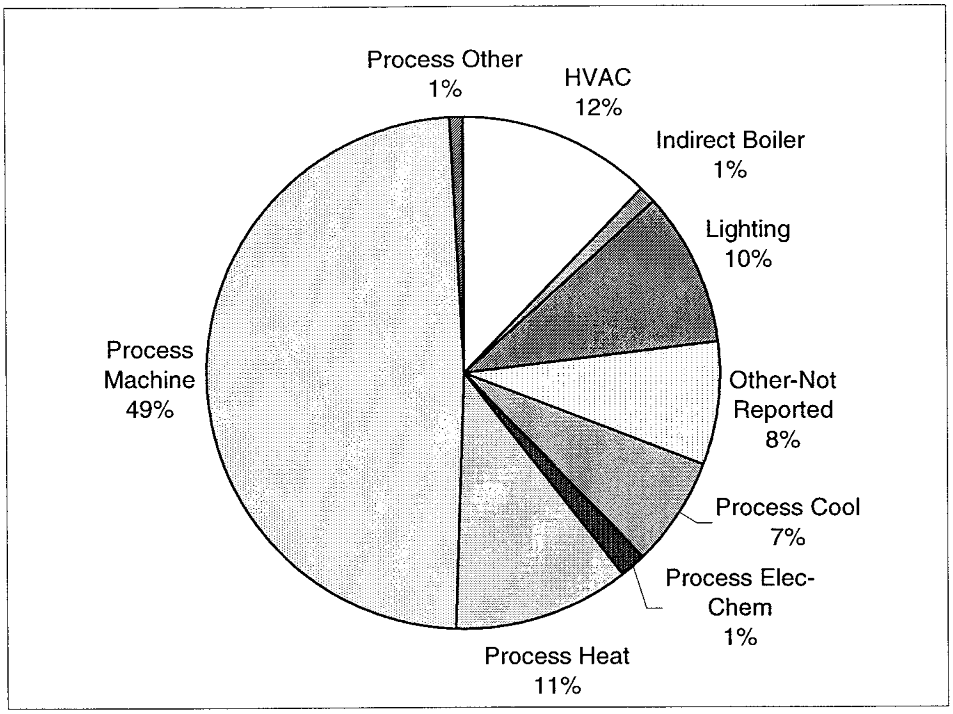


Figure 4: Manufacturing End Use Breakdown of Electric Consumption

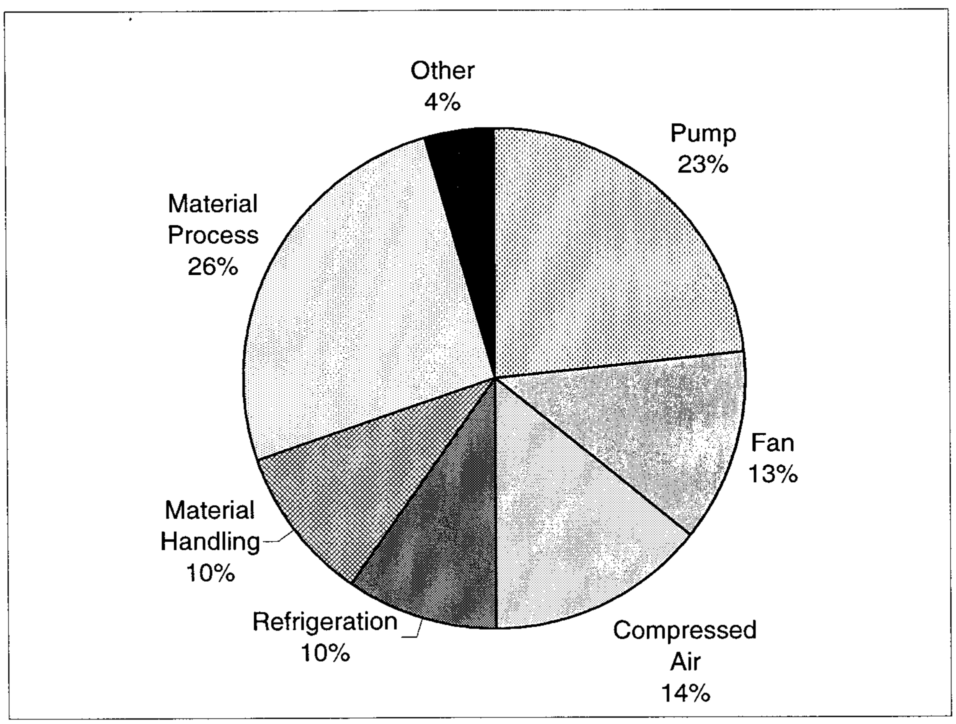


Figure 5: Breakout of Motor Consumption by Application

Electric process heating provides some advantages over fossil-fuel based heating, including improved temperature control, cleaner operations, and reduced maintenance. Techniques include induction, resistance, microwave, and infrared heating. Applications include cooking, melting (metals, glass, plastics), drying and curing (food, lumber, paper, textiles, chemicals, plastics, metals), and direct product heating (metals, chemicals, petroleum, electronics). Process cooling includes refrigeration (food processing) and cooling of materials (chemicals, petroleum products, metals, electronic components) in various stages of the production process.

Figure 6 shows the breakdown of natural gas usage by key end use. As shown, most of the gas use in manufacturing goes to process heating and indirect boiler fuel (for the production of steam and hot water). As noted above for electricity, key process heating applications include cooking, melting, drying, curing, and materials heating. Boilers are used to produce steam and hot water that are used in a variety of applications, including cooking, cleaning and sanitation, process heating, concentration and distillation of liquids, and to drive mechanical equipment.

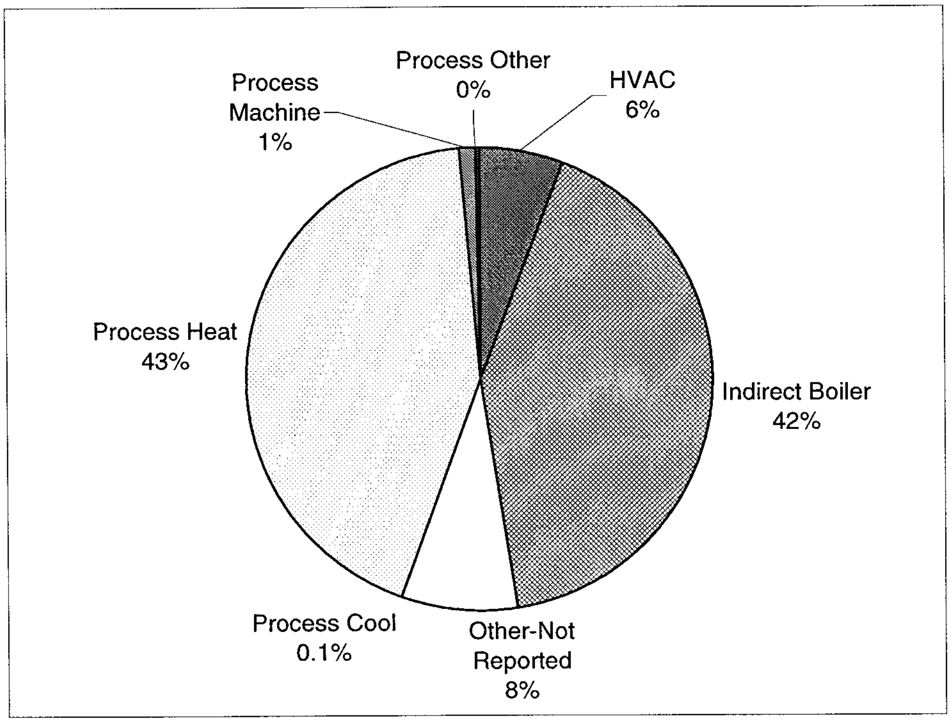


Figure 6: Manufacturing End Use Breakdown of Natural Gas Consumption

Results – Energy Efficiency Potential

The potential for energy efficiency savings in the California industrial sector was estimated by first developing savings fractions for key end uses or applications based on a review of available studies. The savings fractions were then applied to the end use consumptions estimates developed above. The objective of the analysis was to identify energy savings estimates that were realistically and cost-effectively achievable using currently available technologies. While not always explicitly noted in each reviewed study, a payback period of three years or less appeared to be a standard cutoff in determining cost effectiveness of the various measures. Energy efficiency potential is discussed next, by key end use.

Motor Systems

Motor system efficiency potential is summarized in Table 2. Savings fraction estimates were developed from the DOE Industrial Motor Systems Assessment Study (XENERGY 1998). System-specific measures savings potential is shown at the top of the table, and general motor efficiency measures that apply to all systems are shown at the bottom of the table. System efficiency measures can save up to 9% of motor energy use, with the potential for pump system savings and compressed air system savings of 15% or more of each systems energy use. Applicable motor efficiency measures can save another 5% of total motor energy usage.

Key fan system measures include: improved inlet and outlet design, reduction if fan oversizing, install ASDs, replace standard V-belts with cogged V-belts, install more efficient fan models, and improve O&M practices (such as tightening belts and cleaning fans).

Pump system measures include: utilizing holding tanks to equalize flow over the production cycle, eliminate bypass loops, increase piping diameter, reduce system capacity safety margins, matching pump size to loads, installing parallel systems for variable loads, reduce pump speeds for fixed loads, install ASDs for variable loads, install more efficient pumps, replace belt drives with direct couplings, and improve O&M practices (such as replacing worn impellers and maintaining bearings and seals).

Compressed air system measures include: reducing system pressure through better design, eliminating poor applications for compressed air (such as blowing, cooling, and cleaning), segmenting systems with remote applications and special requirements (such as higher pressure), sizing compressors correctly, installing standard part-load controls, using parallel compressors and controls to reduce part loading, installing ASDs, replacing older compressors with more efficient models, and instituting an ongoing maintenance plan to identify and reduce leaks, change filters, and service compressor components.

Table 2: Industrial Motor Savings Potential in California

Application / Measure	Energy Use (GWh)	Savings Potential (GWh)	Savings %
Motor System Measures			
Fan System	2,338	118	5%
Pump System	4,237	803	19%
Compressed Air Systems	2,703	461	17%
Other Process Systems	7,808	154	2%
All Systems	17,086	1,535	9%
Motor Efficiency Measures (Apply to All Systems)			
Efficiency Upgrades	17,086	581	3%
Motor Downsizing	17,086	205	1%
Replace vs. Rewind	17,086	142	1%
All Motor Efficiency Measures	17,086	928	5%
Motor Systems Totals	**17,086**	**2,463**	**14%**

Lighting

Electric savings potential for the lighting end use is outlined in Table 3. The lighting energy breakdown by fixture type is developed from an industry survey conducted for one of the California utilities in 1997 (Aspen 1998) with judgmental assumptions made to adjust the data to current-period shares. Savings percentages were developed assuming: (1) incandescent lighting is converted to compact fluorescent, (2) standard fluorescent lighting is converted to T8s with electronic ballast, and (3) mercury vapor lighting is converted to high pressure sodium. Available data did not support the assessment of lighting control measures or day lighting.

Table 3: Lighting Energy Savings Potential

Fixture Type	% Lighting Energy	Savings %	GWh Savings
Incandescent	5	72	99
Std Fluorescent / Std Ballast	58	24	421
Std Fluorescent / EE Magnetic Ballast	13	14	53
T8 / Electronic Ballast	14	-	-
Mercury Vapor	2	35	21
Metal Halide	4	-	-
High Pressure Sodium	2	-	-
Low Pressure Sodium	negligible	-	-
Skylights	2	-	-
Other	negligible	-	-
Total Lighting Savings Potential		**20**	**594**

Total Lighting Energy = 2,997 GWh

Space Cooling

Cooling energy savings potential estimates are summarized in Table 4 . Total HVAC energy use, developed using MECS data and utility billing data were converted to cooling energy use using additional industrial survey data from 1997 (Aspen 1998). The cooling savings percent is based on overall estimates developed from commercial energy efficiency potential studies. There was not sufficient data available to provide additional detail on industrial cooling savings. The commercial cooling studies addressed measures such as high efficiency DX systems, high efficiency chillers, economizers, evaporative pre-coolers, energy management systems, and cooling system maintenance.

Table 4: Cooling Energy Savings Potential

HVAC electric use	3,754 GWh
Cooling fraction	58%
Cooling electric use	2,161 GWh
Cooling savings percent	24%
Total Cooling Savings Potential	**519 GWh**

Indirect Boiler Use

For California, natural gas use in indirect boilers is estimated to be about 1,649 million therms a year (based on analysis of MECS and utility billing data). The U.S. DOE – Alliance to Save Energy Steam Challenge Steam Challenge program estimates that optimization of industrial steam systems can save 30-40% of steam system energy use through the introduction of their BestPractice approach (U.S. DOE OIT) which focuses on system improvements and controls. Their target is for 20% efficiency improvements by 2010. A similar estimate of economically-achievable savings in the 18-20% was developed by Lawrence Berkeley National Laboratory (LBNL 2001). At 20%, potential energy savings for the boiler end use are about 330 million therms per year. Table 5 highlights some key steam system efficiency measures.

Table 5: Steam System Efficiency Measures

Measures	Savings Potential
Boilers	**2-5%**
Boiler tune-ups	1-2%
Heat recovery equipment	2-4%
Emissions monitoring and control	1-2%
System Operation and Maintenance	**10-15%**
Water control	10-12%
Load control	3-5%
Distribution System	**15-20%**
Steam leaks and traps	3-5%
Condensate return	10-15%
Insulation	5-10%
Total	**30-40%**

Source: DOE-Alliance, 2000

Process Heat

The U.S. Industrial Combustion Vision, facilitated by the U.S. DOE, targets energy efficiency improvements of 20-50% by the year 2020. However, the vision acknowledges that large efficiency improvements will require technology improvements in furnace design, sensors and controls, and heat recovery processes that are beyond current efficiency capabilities. Savings that are economically attainable with current technologies are much lower. Table 6 lists key process heating measures and estimates of their potential savings using current technologies. Increased insulation, utilizing newer, better-insulating materials may provide that largest impacts. Improved combustion using more advanced control strategies provides the next largest area for savings. The savings potential for waste heat recovery is less than is cited for boilers since direct-fired heating units mainly use air preheaters as their only form of waste heat recovery. By applying a conservative 8% savings potential estimate to the California process heat gas use estimate of 1,700 million therms per year (developed by combining MECS and utility billing data), an estimate of potential energy savings of 136 million therms per year is obtained. Note, a number of energy saving measures, such as elimination of heat transfer equipment in drying and the use of electro-technologies, are applicable to process heating systems. However, energy savings estimates could not be developed from the available information.

Table 6: Process Heating Efficiency Measures

Measures	Savings Potential
Improved Refractory (Insulation)	5-10%
Combustion Controls/Sensors	3-5%
Reduction of Excess O_2	2-3%
Waste Heat Recovery	1-3%
Total	**10-15%**

Industry Specific Measures

There are a large number of industry-specific energy efficiency measures that can be applied to particular industrial processes. However, due to the high variability and limited applicability of these measures, it was not possible to quantify potential impacts on California industrial energy use. Examples of such measures include: electron beam sterilization in the food industry, application of liquid membrane technologies in the chemicals industry, black liquor gasification in the pulp and paper industry, ultrasonic drying in the textiles industry, biodesulfuriztion in the petroleum refining industry, and strip casting in the metals industry. In addition, introduction of computerized controls and sensors can be used to reduce waste in many different production processes. Additional information on the applicability and cost-effectiveness of many industry-specific measures is available from sources such as the Lawrence Berkeley National Laboratories (www.lbl.gov) and the Office of Industrial Technologies (U.S. DOE, www.oit.doe.gov).

Energy Efficiency Potential Summary

Table 7 summarizes industrial energy efficiency potential by measure and industry. For electric savings potential, measure targeting motor systems account for about two-thirds of the overall savings potential, with lighting and space cooling measures splitting the remaining potential about evenly. Key industries, with about 300 GWh or more of savings potential each, include food (SIC 20), petroleum refining (SIC 29), stone, clay and glass (SIC 32), industrial machinery (SIC 35), and electronics (SIC 36). Key industries with large natural gas savings potential include food (SIC 20), paper (SIC 26), and petroleum refining (SIC 29).

Table 7: Summary of Energy Efficiency Savings Potential

	Electric Potential - GWh					Gas Potential - Millions of Therms			
Industry Category	Motors	Lighting	Space Cooling	Total Electric	% of Industry Total	Boilers	Process Heat	Total Gas	% of Industry Total
20 Food	320	54	44	374	12%	101	13	114	25%
21 Tobacco			-	0	0%	0	0	0	0%
22 Textiles	28	6	5	34	1%	13	2	16	3%
23 Apparel	14	8	14	22	1%	0	0	1	0%
24 Lumber	84	12	9	96	3%	4	2	6	1%
25 Furniture	21	9	9	30	1%	0	0	1	0%
26 Paper	148	21	24	169	6%	54	5	59	13%
27 Printing	74	23	42	97	3%	1	1	2	0%
28 Chemicals	222	24	9	245	8%	24	5	30	6%
29 Petroleum	338	11	9	349	11%	95	66	161	34%
30 Rubber/Plastics	175	29	18	204	7%	4	1	5	1%
31 Leather	1		-	1	0%	0	0	0	0%
32 Stone/Clay/Glass	312	38	21	350	11%	3	19	22	5%
33 Primary Metals	112	21	13	133	4%	4	10	14	3%
34 Fab Metals	122	35	35	156	5%	4	5	9	2%
35 Ind Machinery	154	85	57	239	8%	4	1	5	1%
36 Electronics	160	88	91	248	8%	6	3	8	2%
37 Transportion Equip	88	67	85	155	5%	7	2	9	2%
38 Instruments	75	54	24	129	4%	3	0	4	1%
39 Misc. Manuf.	15	9	12	25	1%	0	0	1	0%
Total All Industry Groups	2,463	594	519	3,057	100%	330	136	466	100%

Results – Review of Utility Program Information

Utility program information reviewed during this study included program tracking data and program evaluation data and reports.

Program Tracking Data

Utility energy efficiency program tracking data was reviewed for the years 1995 through 1999. The review focused mainly on rebate programs (utility rebate programs, third-party rebate programs, and standard performance contracting programs). Table 8 summarizes program activity by industrial group and key end use (data resolution did not permit a good disaggregation of program impacts by measure). Process measures accounted for the largest amount of impacts (61% of electric impacts and 97% of natural gas impacts), followed by lighting and HVAC.

Table 8: Industrial Rebate Program Accomplishments 1995-1999 (Tracking System Gross Savings)

	# Part-	Electricity Impacts (GWh)				Gas Impacts (Mil of Therms)		
Industry Category	icipants	Process	Lighting	HVAC	Total	HVAC	Process	Total
13 Oil/Gas	66	78.51	0.06	0.14	78.71	-	9.92	9.92
20 Food	424	55.66	9.05	10.38	75.09	-	5.01	5.01
21 Tobacco	-	-	-	-	-	-	-	-
22 Textiles	37	1.37	3.36	0.05	4.78	-	0.65	0.65
23 Apparel	17	0.01	0.76	0.05	0.81	-	0.09	0.09
24 Lumber	127	26.39	6.52	0.03	32.94	-	0.46	0.46
25 Furniture	38	0.25	3.17	-	3.43	-	0.14	0.14
26 Paper	89	32.74	6.36	0.75	39.85	-	0.38	0.38
27 Printing	208	10.37	9.39	9.12	28.88	0.06	0.02	0.08
28 Chemicals	135	21.20	2.16	3.38	26.74	0.09	3.34	3.43
29 Petroleum	37	9.99	2.19	6.34	18.52	0.44	6.63	7.07
30 Rubber/Plactics	172	29.05	5.96	3.29	38.29	-	0.12	0.12
31 Leather	10	0.93	0.17	-	1.11	-	0.18	0.18
32 Stone/Clay/Glass	91	46.19	7.08	0.02	53.29	-	2.34	2.34
33 Primary Metals	94	16.59	5.85	1.28	23.72	-	0.77	0.77
34 Fab Metals	237	10.13	6.92	0.33	17.39	-	2.44	2.44
35 Ind Machinery	357	18.14	22.77	14.33	55.24	0.01	0.07	0.08
36 Electronics	326	17.13	20.51	28.26	65.90	0.11	0.34	0.45
37 Transportion Equip	154	50.14	39.83	12.86	102.83	0.29	0.67	0.96
38 Instruments	183	6.96	18.43	12.09	37.48	-	-	-
39 Misc. Manuf.	66	5.98	0.93	0.47	7.38	-	-0.04	-0.04
Total All Industry Groups	**2,868**	**437.74**	**171.48**	**103.16**	**712.37**	**1.01**	**33.53**	**34.54**

Key industries contributing to electric impacts included Transportation Equipment (SIC 37), Food (SIC 20), Oil/Gas Extraction (SIC 13), Electronics (SIC 36), Industrial Machinery (SIC 35), and Stone, Clay, and Glass (SIC 32). Each industry accounted for over 50 GWh of impacts. For natural gas, key industrial include Oil/Gas Extraction (SIC 13), Petroleum Refining (SIC 29), Food (SIC 20), and Chemicals (SIC 28), each accounting for over 3 million therms of savings.

Although measure-specific detail was hard to assess due to differences in classifications between utilities and limited resolution, some information on specific measure types could be addressed. Key

HVAC measures included chillers, adjustable speed drives, and energy management systems. These accounted for about two-thirds of electric HVAC impacts. For lighting, T8's accounted for 60% of program impacts and high-intensity discharge (HID) lighting accounted for 15% of impacts. Remaining lighting measures were predominantly controls. Key electric process measures included compressed air system improvements, adjustable speed drives, pumps, motors, and process heating. Key natural gas process measures included boilers, process heating improvements, and measures involving gas-driven oil pumping systems.

A comparison of the program accomplishments in Table 8 with identified energy efficiency potential in Table 7 is provided in Table 9. Results show that past rebate programs have been more effective at targeting electricity-saving measures than gas-saving measures. Clearly, electricity savings have been a focus of the rebate programs in California. The ratio of electric tracking savings to identified potential is about 0.18 whereas the ratio of gas savings to gas potential is only 0.07 (both excluding impact in the oil and gas extraction industry). For electricity, lighting measures have had the biggest penetration; the ratio of impacts t potential if about 0.30. In general, program accomplishments have been relatively well dispersed across the different industrial groups. (Note, the impact-to-potential ratios don't exactly correspond to the fraction of savings potential captured by the rebate programs because of definitional issues – i.e. program impacts are more heavily weighted to equipment-related savings while the potential analysis focuses more on implementation of lower-cost maintenance and control measures. However, the ratios do help provide a good indication of whether program activity has been targeting the key energy consuming end uses.)

Table 9: Comparison of Energy Savings Potential and Program Accomplishments

	Electric - GWh				Gas - Millions of Therms		
	Process	Lighting	Space Cooling	Total Electric	HVAC	Process	Total Gas
Energy Savings Potential (Table 7)	2,463	594	519	3,057	-	466	466
Program Impacts, 95-99 (Table 8)*	359	171	103	634	1	34	35
Ratio: Impacts to Potential	0.15	0.29	0.20	0.21	-	0.07	0.07

* To be comparable to potential estimates, program impacts exclude SIC 13, Oil/Gas extraction.

While the utility programs have done reasonably well in targeting the appropriate end uses for industrial energy efficiency, they have focused mainly on the purchase and installation of new equipment. Review of the literature on energy savings potential reveals that considerable savings can be obtained by making "systems" more efficient, often through the use of improved operation and maintenance practices, improved system design, and the installation of control measures. These types of measures aren't easily promoted through traditional rebate programs. In many cases, industrial customers are not aware of the types of measures that can be instituted to achieve energy savings or the magnitude of savings that can be achieved through the implementation of systems solutions. Programs that seek to inform customers on their energy efficiency potentials, options, and associated benefits/costs and connect them to contractors and financing, providing turn-key projects, are likely to garner significant cost-effective energy savings that are missed by traditional incentive programs.

Program Evaluation Information

Program evaluation information developed since the mid 1990's was reviewed to assess a number of factors such as net-to-gross, barriers to energy efficiency installations, and customer needs and wants. Key results are summarized below.

Net-to-Gross Ratios. Program impact evaluations were reviewed for the 1995 through 1999 period. A key element that was developed from the review was an examination of net-to-gross ratios. Table 9 shows net-to-gross ratios by end use and Table 10 shows net-to-gross ratios by industrial group. Overall, industrial net-to-gross ratios averaged about 0.70. Motor efficiency measures tended to achieve the highest net-to-gross ratios while process and HVAC measures were associated with the lowest ratios. The food, lumber, printing, rubber and plastics, and stone, clay, and glass industries were associated with the lowest net-to-gross rations of 0.63 or lower. The paper, petroleum, instruments, and electronics industries averaged net-to-gross ratios above 0.75.

Overall, industrial net-to-gross ratios tend to fall below net-to-gross ratios for other customer segments. For the same period of analysis (the second half of the 1990's), commercial sector programs averaged net-to-gross ratios of 0.89 and residential programs had net-to-gross ratios of 0.81. It appears that, compared to other segments, more industrial customers were likely to have implemented energy efficiency measures anyway, without the incentives provided by the California utilities.

Table 9: Net-to-Gross Ratios by End Use

End Use	Net-to-Gross Ratio	Number of Observations
HVAC	0.67	310
Lighting	0.72	1,152
Miscellaneous	0.72	10
Motors	0.84	190
Process	0.70	425

Source: Impact evaluations of California's industrial energy efficiency programs.

Table 10: Net-to-Gross Ratios by Industrial Group

Industry Category	Net-to-Gross Ratio	Number of Observations
13 Oil/Gas	0.68	53
20 Food	0.63	228
21 Tobacco	-	-
22 Textiles	0.54	14
23 Apparel	1.00	8
24 Lumber	0.41	83
25 Furniture	0.66	18
26 Paper	0.90	88
27 Printing	0.54	169
28 Chemicals	0.71	89
29 Petroleum	0.85	52
30 Rubber/Plactics	0.62	120
31 Leather	0.99	6
32 Stone/Clay/Glass	0.63	73
33 Primary Metals	0.65	69
34 Fab Metals	0.70	119
35 Ind Machinery	0.72	263
36 Electronics	0.76	264
37 Transportion Equip	0.69	147
38 Instruments	0.77	125
39 Misc. Manuf.	0.81	31

Source: Impact evaluations of California's industrial energy efficiency programs.

Barriers to Energy Efficiency Implementation: Review of more recent evaluations of the California SPC (Standard Performance Contract) programs (XENERGY 1999 and 2001) provides some insight into key barriers to the installation of energy efficiency measures. Key barriers identified in customer interviews included:

- Costs associated with increasing energy efficiency;
- Uncertainty over projects savings;
- The time it takes to get informed about energy efficiency opportunities and projects;
- Time and cost associated with selecting contractors for projects; and
- Uncertainty about the savings information provided by energy efficiency firms.

The SPC evaluations also revealed a number of factors regarding large utility customers:

- Over 90% had taken recent actions to reduce energy use;
- Over 60% had identified energy efficiency opportunities but had not implemented them, mostly due to cost factors;
- Less than 30% of the customers had separate budgets for energy efficiency projects;
- Most customers had a target payback threshold of 3 years or less for energy efficiency projects; and
- Local utilities received the highest credibility rating for providing energy efficiency related information.

Compressed Air Research: Review of recent research undertaken by the California utilities to better understand the compressed air market (Customer Opinion Research 1999) provides some insight into customer attitudes, opinions, and practices with regard to an industrial "system." It is likely that these findings will also be applicable to other industrial systems such as steam systems and pumping systems. Key findings from the compressed air research include:

- Many customers do not understand key technical aspects of their compressed air system;
- Around two-thirds of the surveyed customers have done nothing to reduce their compressed air system costs – many realize they are missing opportunities but cite lack of time as a key barrier;
- Most customers perform routine maintenance on their compressed air systems, but little performance testing is undertaken; and
- Many customers indicated that they would be interested in a compressed air performance analysis service, but weren't sure how valuable it would be or how much they would be willing to pay.

Large Customer Needs and Wants: A large customer needs and wants study, relying many on focus-group activities involving industry experts, was recently completed for the California utilities (Quantum 2001). Key findings from this study, as they pertain to increasing energy efficiency opportunities, include:

- Industry representatives view utilities as experts on energy-related issues, but indicate that the utilities are perceived as failing to understand industry needs;
- There is a strong desire on the part of industry representatives to enter into mutually beneficial partnerships with their utility suppliers;
- Strategic guidance should be provided in executive-level interactions, facilitated by experienced consultants and industry associations, and supported by solid background research and analysis;

- Tactical guidance on specific energy efficiency opportunities should continue to be provided by account representatives, utilizing certain types of expert consultants as necessary;
- Programs should be industry specific and should be promoted as enhancing productivity first, energy efficiency second.

Conclusions

Some of the more important conclusions developed from the study are presented briefly below.

- Most energy use, and thus savings potential, is concentrated in the largest sites. The largest 4% of electric sites account for over 70% of the electricity use. The largest 3% of natural gas sites account for over 90% of industrial gas use. For programs to achieve large impacts and optimize the use of public funds, they need to target these large sites.
- Key energy areas of industrial efficiency potential include motors, steam, and process heating systems. In many cases, improving a "system" can provide significant cost-effective savings, sometimes in lieu of purchasing expensive new equipment.
- Industrial energy efficiency potential appears to remain large relative to the past five years of program activity. Natural gas savings potential is still relatively untapped.
- Historically, industrial net-to-gross ratios associated with California rebate programs are lower than those for other customer segments (typically 0.67 to 0.84 vs .81 to .89 in residential and commercial sector programs respectively). However, many industrial customers still cite "lack of capital" as a major barrier to implementing energy efficiency projects.
- Many customers appear to be uniformed about the costs and benefits of energy efficiency projects. They often do not have a good understanding of the energy efficiency aspects of key energy using systems (e.g. compressed air, pumping, steam).
- Mostly, energy efficiency programs have been component focused, not system focused, where symbioses between components can lead to much higher savings potentials in industrial facilities. This will require careful modification of current programs to broaden the scope of their efforts.
- Industrial customers look to the utilities to provide credible guidance to help them pursue energy efficiency opportunities.

Implications for Future Program Design:

The current array of utility programs that rely predominantly on customer incentives will continue to achieve significant impacts, especially under the current energy environment. However, these programs that tend to favor equipment change-outs will continue to miss opportunities to improve the energy efficiency of industrial systems. Programs that focus on customer education and programs that provide expert facility analyses will most likely be more effective at targeting "system" energy efficiency. Such programs could

- Target large customers;
- Be run through the current network of utility customer representatives;

- Provide site-specific studies of key energy using systems, conducted by industry experts and at little or no cost to the customer these studies should identify key energy efficiency measures, provide savings estimates, and provide cost effectiveness calculations;
- Provide financial incentives for some of the measures identified in the site study while leaving the customer to pay for the most cost-effective measures; and
- Assist the customer in implementing the project.
- Provide unbiased M&V of results for customer to see savings and institute EE O&M practices that are more likely to lead to continued enhancements to their systems.

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