RESULTS FROM CALIFORNIA'S INDUSTRIAL PURCHASES AND PRACTICES SURVEY

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Abstract

The California Energy Commission (CEC) funded the *Nonresidential Market Share Tracking Study* to:

(1) Document baseline conditions for energy efficient products and practices in California;

(2) Identify energy efficient promotion opportunities; and

(3) Help program evaluators document market change for energy efficient products and practices.

The project scope included collecting original data through several different surveys as well as making use of pre-existing data on selected commercial and industrial technologies. This paper presents selected results from the Industrial Purchases and Practices Survey of 2000-2003. The survey addressed most major energy-using technologies that are not industry-specific as well as maintenance practices. Data were collected through in-person interviews and by recording new motor nameplate specifications at 560 sites.

Market share data was collected on 12 different topics including motors, boilers, compressed air systems, maintenance, and industrial refrigeration. The results suggest that there are many opportunities to promote efficiency to the industrial sector. Technologies and market channels that appear to be good targets for such efforts include:

- Developing programs aimed at end-user purchasing personnel and supplier advertising personnel. Specifically, drive demand for premium motors by training private and public procurement personnel to seek packaged equipment that features premium efficiency motors or to specify premium efficiency upgrades as a routine matter. Simultaneously, work with packaged equipment manufacturers to feature NEMA premium-efficiency motors in the packaged equipment offered in the market.
- Working with trade allies to establishing quality standards and standardized diagnostics in motor rewinding.
- Compressed-air system optimization
- Gas boiler heat recovery

A substantial portion of the industrial on-site survey market share and related results as well as selected results from secondary sources and new analysis of the Nonresidential New Construction survey data are available for public use at no charge in the form of an Access database. The database and user interface can be downloaded from the California Measurement Advisory Council Web site at www.calmac.org/NewPubs.asp.[a] The database includes estimates, sample sizes, and standard error for each parameter developed by Aspen.

[a] As of October 14, 2004 the database had not been posted at the site, but it is expected to be there by the time of this paper's publication. Contact one of the paper authors above for assistance in acquiring the database if necessary. MS Access 97 is required to use the database. Users without MS Access 97 or later versions may contact Aspen Systems for a compiled standalone version on CD that does not require Access.

Introduction

The California Energy Commission (CEC) initiated the Nonresidential Market Share Tracking Study[b] in order to document baseline conditions for energy efficient products and practices in California, identify energy efficient technology promotion opportunities, and help program evaluators document market change for energy efficient products and practices. The work completed in 2000-2003 was intended to be the first survey in long-term tracking effort.

The project scope included collecting original data through surveys as well as making use of pre-existing databases on selected commercial and industrial technologies. This paper presents selected results from the Industrial Purchases and Practices Survey 2000-2003 (IPPS).[c] The survey addressed most major energy-using technologies that are not industry-specific as well as maintenance practices. The technologies are:

- Blowers
- Compressed air
- Electric motors
- Electronic process control
- Process fluid pumping
- Gas process heating
- Lighting
- Maintenance practices
- Power generation
- Refrigeration
- Variable speed drives
- Water recovery & reuse

Approach

Aspen collected data through in-person interviews and by recording new motor nameplate specifications at 560 sites. Data were collected in two phases. SICs 20 (Food and kindred products), 35 (Industrial machinery and equipment), and 36 (Electrical and electronic equipment) were surveyed in 2001 and 2002. These industries ranked among the highest in the state in energy use and new capital spending. Facilities in the other industrial SIC Groups were surveyed in 2002 and 2003.

Sample Design. PG&E, SCE, and SDG&E provided billing files for sampling frame development. In Phase 1, we excluded ineligible accounts, aggregated accounts to a single address, and then stratified sites on the basis of SIC, annual electrical usage, and utility service territory. In Phase 2, we also stratified the sample based on proportion of electrical consumption coming from relatively new accounts, since new electrical accounts would, other things equal, likely have more equipment purchases than older sites. We used the Dalenius-Hodges procedure to stratify based on electrical consumption. Sample points were allocated approximately proportional to population between utilities, and approximately uniformly within industries and size classes within a stated utility. This approach resulted in over-sampling of large electrical users and reduced variance in our estimates.

Recruitment. From our frames, we drew stratified random samples for recruiting. Before calling, we sent targeted sites letters from the CEC Chairman explaining the purpose and importance of the study and indicating endorsement by the California Chamber of Commerce and the California Manufacturers and Technology Association.

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[b] Aspen Systems Corporation was the prime contractor for the Study. Williams-Wallace Management Consultants and Robert Thomas Brown Company were contributing subcontractors.

[c] The commercial side of the project addressed chillers, lighting, and windows. Primary data collection included telephone interviews with 104 upstream market actors (chiller manufacturers, lighting manufacturers, and window and lighting distributors, dealers, installers, and designers) and use of secondary data from existing databases and reports.

To protect against non-response bias, we called the sites chosen in waves, attempting multiple calls at various times of the day across a period of weeks to each site before opening up another wave of sites to calling. We used computer aided telephone interviewing to easily record data, schedule callbacks, and help us monitor our progress relative to our recruiting goals in each stratum. During the recruiting calls, we collected data on the number of motors the site had bought in the last three years and whether or not the site had technologies that we expected to be relatively rare. Thus, we were able to target such sites if we felt we needed larger samples for a given technology of interest.

Questionnaire Design. The onsite questionnaire was 58 pages long in Phase 1 and 70 pages long in Phase 2. Before finalizing the survey questions, we conducted an informal survey of 28 experts and suppliers of refrigeration, motors, motor rewinding, automatic lubrication, etc. We used these interviews to refine questions and help develop pre-survey estimates of market share. We also pre-tested the questionnaires on 20 sites prior to each Phase.

Survey Administration. The site visits generally took 1.5 to 2 hours, during which the surveyor asked questions on technologies and practices including compressed air systems, blowers, automatic lubrication, variable speed drives, motors, electronic process control, refrigeration, water recovery and re-use, power generation, and maintenance. We also collected nameplate data from a stratified random sample of motors onsite. In Phase 2, we added sections on gas process heating and fluid process pumping, and two questions on lighting.

Data Quality Assurance. Database programmers created user-friendly data-entry interfaces for capturing the data from the questionnaires. There were over 300 automated and manual QC checks for completeness, range checks, skip patterns, cross-checks, and ratio checks. The data entry program warned staff when they entered suspicious data. If they continued entry of the suspicious data, a record was output to a database table containing the warnings and reasons for the warnings. A senior engineer reviewed reports from this database and determined whether the suspicious data should be investigated further and in certain cases made follow-up calls to surveyors and end-users to verify data elements.

Results

The Nonresidential Market Share Tracking Database contains nearly a quarter of a million records on summary statistics for the raw data collected through the surveys.

A major focus of the study was electric motors. Figure 1 shows that in the food, machinery/computers, and electronics industries (Phase 1), new motors mostly enter manufacturing plant as a component of purchased equipment, instead of being purchased separately. In the case of the other industrial groups, separate motor purchases predominate. We also learned that, of all motors purchased during the three previous years, about 19 percent were premium-efficiency in the case of facilities in the Phase-1 industry groups. This can be contrasted with the finding that only about 12 percent of the motors were premium-efficiency, on average, for the other industry groups (Phase 2). Table 1 shows the distribution of the percentage of premium-efficiency motors purchased by SIC.

Respondents reported that they consider cost effectiveness for individual motor purchases -- only 2.3 percent did so in Phase 2 -- yet less than six percent of those same respondents specify "energy efficient" or "premium efficiency" motors as a matter of routine policy.

Figure 1: Sources of Motors Bought in the Last Three Years

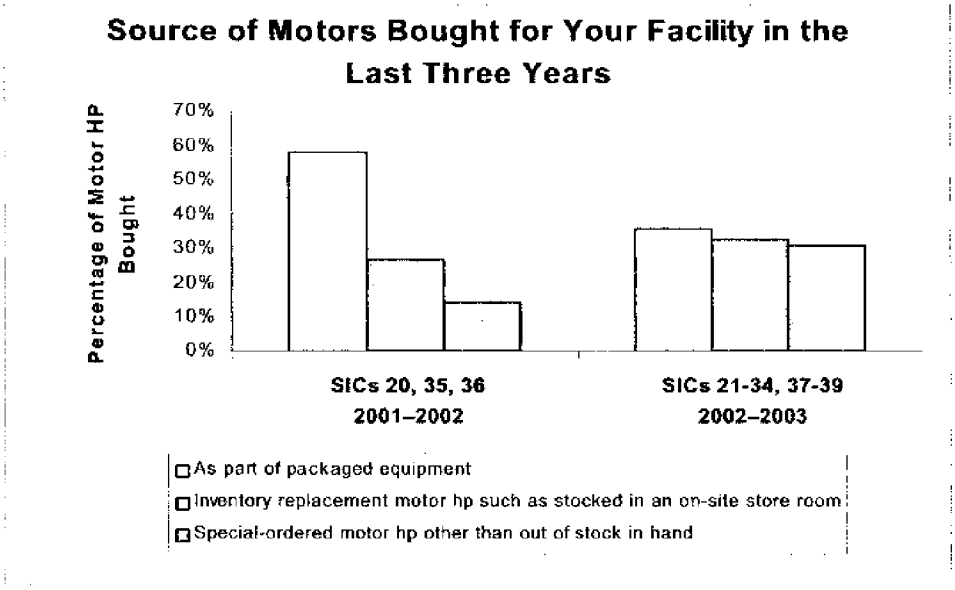


Table 1: Premium Efficiency Motor Market Share, Combined Phases 1 and 2

SIC	SIC Description	Percentage of Motor HP Purchased in The Last Three Years That Meet or Exceed NEMA "Premium Efficiency" Standards (1-200 HP Motors only)
20	Food and kindred products	21.3%
26	Paper and allied products	43.9%
28	Chemical and allied products	4.6%
30	Rubber and misc. plastic products	18.4%
32	Stone, clay, glass, and concrete	13.4%
34	Fabricated metal products	7.4%
35	Industrial machinery and equipment	23.4%
36	Electrical and electronic equipment	10.4%
37	Transportation equipment	16.3%
38	Instruments and related	8.9%
20-39	TOTAL	15.0%

End-users in other industries were also surveyed, but the number of responses was insufficient to report results by individual SIC for this parameter. They are included in the total.

Motor efficiency has gradually increased over the last twenty years but has still not reached its potential. According to a smaller national study the saturation of premium efficiency motors in the industrial market in 1997 was 9.1%.[d] Based on this study of recent purchases, the market share will eventually

[d] Survey of 265 facilities. "United States Industrial Electric Motor Systems Market Opportunities Assessment," for Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, by Xenergy, Burlington, MA, December 1998, p. 48.

plateau at about 15 percent market share without further intervention. This exceeds the 1997 national average but leaves substantial unrealized savings.

When having motors rewound, less than 15 percent of customers require winding resistance or core test results or delivery of oven chart records on burnout temperature. Only about one in four customers require that the motor rewinder provide a repair report at all.

Gas Process Heating

In Phase 2, questions about gas process heating were asked if the facility used at least 10,000 therms/year or spent $5,000/year in gas bills. Table 2 shows the principal results. They reveal a significant sensitivity to gas-cost management. Over 20% of facilities had stack heat recovery and condensate heat recovery on their boilers. Presence of electronic ignition is even higher, at 31%, suggesting a market which does not need intervention, as this feature is not applicable to all boilers. Oxygen control (O_2 trim) is used at about 14% of sites. Survey participants also had an opportunity to report on retrofit-type changes made to the boilers. The most common were reducing the steam pressure and increasing boiler piping and jacket insulation.

Table 2: Gas Boiler Energy Efficiency Options Reported for the Phase 2 Industry Groups [c]

Questions and Responses	SICs 21-34, 37-39	
	Estimate	Std. Error
Gas process heating energy-efficiency options present on boilers		
Stack heat recovery	22.2%	5.5%
Condensate heat recovery	20.9%	5.5%
Other heat recovery	7.5%	4.5%
Automated tuning (O_2 trim control)	13.8%	4.9%
Electronic ignition	31.1%	4.9%
Turbulators for firetube boilers	9.9%	4.8%
Gas process heating energy-efficiency options installed on boilers in the last three years		
Stack heat recovery	10.7%	4.8%
Condensate heat recovery	3.0%	1.7%
Other heat recovery	0.0%	0.0%
Automated tuning (O_2 trim control)	1.9%	1.0%
Electronic ignition	11.8%	4.9%
Turbulators for firetube boilers	0.7%	0.7%
Increased pipe and boiler jacket insulation	22.1%	1.3%
Reduced boiler blow-down cycle	3.6%	1.6%
Reduced steam pressure	37.6%	0.7%
Variable speed drives on larger forced-draft and induced-draft fans	2.4%	1.5%
Automatic flue damper	4.3%	2.1%
Smaller boiler for low-load conditions	0.7%	0.7%
Other	0.2%	0.2%

[c] Table 2 includes standard error information. In the database this is reported for all results for which such a statistic could be calculated.

Process Fluid Pumping

We collected data on process fluid pumping systems at facilities with pumps totaling at least 50 hp. Table 3 presents the incidence of firms having taken specific measures in the past three years. The most common was replacing worn impellers or bearings. While this does save energy, it is primarily a maintenance issue and is likely performed mainly as these components wear; in fact, the attendant energy benefits may even be unrecognized. Activities that directly save energy, trimming impellers, replacing with higher efficiency pumps, and increasing pipe diameters, have lower but still substantial activity levels. Many of these types of upgrades improve system performance as well as save energy. This segment of the industrial market may be most responsive to programs and messages that stress the non-energy benefits of efficiency measures.

Table 3: Pump Efficiency Upgrades Reported in the Phase 2 Industry Groups

Questions and Responses	SICs 21-34, 37-39	
	Upgrade ever performed	Upgraded in last 3 years
Trimmed pump impellers	11.8%	5.2%
Installed or modified pump control system	23.7%	18.3%
Redesigned pipe layout to reduce friction losses	49.0%	42.9%
Replaced with higher efficiency pumps	41.8%	34.4%
Increased piping diameter	47.1%	38.6%
Replaced worn impellers or bearings	88.4%	77.0%

Refrigeration

Refrigeration questions were asked at sites with at least 20 hp of mechanical cooling for other than human comfort. In Phase 1, the questions were only asked of firms in SIC 20 (food and kindred products). Because many of the products of this industry group are perishable, it is not surprising that it exhibits a relatively high saturation of efficiency measures. Table 4 provides comparative market-share data.

Table 4: Market Saturation Ratios for Selected Refrigeration Efficiency Options

Questions and Answers	2001–2002	2002–2003
	SIC 20	SICs 21-34, 37-39
Percentage of refrigeration hp with heat recovery	8.8%	1.5%
Percentage of refrigeration hp with floating head	25.7%	4.3%
Percentage of refrigeration hp that is ammonia-based	79.6%	4.3%

Compressed Air

Nineteen percent (Phase 2) to 36 percent (Phase 1) of compressor horsepower was governed by automatic controls to optimally sequence multiple-compressor operation.

Our estimates indicate that more than three times as many facilities have converted electric equipment to pneumatic compared to the reverse. Using compressed air for motive power can use 10 times as much energy as an electric motor so this decision likely represents one that increases energy use. About 62 percent of sites search for compressed air leaks regularly more than once per year but only 22% to 42% reported having a comprehensive compressed-air audit performed. About four percent have been able to

save energy by reducing system pressure in the last two years. These results are indicative of attention to managing compressed air system energy costs, although perhaps not systematically. Experts agree that compressed-air efficiency requires a systems approach. Full savings potential from leak repair may not be realized if there are other inefficient part load controls, for example. Program opportunity may exist in emphasizing the systems approach, offering compressed-air audits, promoting the Compressed Air Challenge, etc.

Generally the level of compressed air maintenance activity that would affect energy use is comparable or slightly better than that found in a 1998 New England study and the previously noted DOE study.[f]

Wastewater Recovery and Re-Use

Table 5 provides the estimated market shares for water-recovery systems, as well as the proportion of systems that also feature heat recovery. Between 12% and 14% of plants had water recovery systems installed. Between 3 and 11 percent of those featured heat recovery.

Table 5: Proportion of Plants with Water Recovery, with and without Heat Recovery

Questions and Answers	2001–2002 SICs 20, 35, 36	2002–2003 SICs 21-34, 37-39
Proportion of facilities with a water recovery and reuse system	13.5%	11.5%
Proportion of wastewater recovery systems that include heat recovery	2.5%	10.9%

Non-Emergency Onsite Generation

As the study was conducted both during and immediately following the California power crisis of 2000 and 2001, stakeholders were interested in customers' use of and plans for self-generation. Table 6 addresses this question.

Table 6: Non-Emergency Onsite Generation

Questions and Answers	2001–2002 SICs 20, 35, 36	2002–2003 SICs 21-34, 37-39
Proportion with a power supply used regularly to generate electricity	1.1%	2.2%
Of those with on-site generation, proportion Currently planning on installing additional generation capacity	W	1.8%

W = Withheld, less than 10 respondents

Maintenance Practices

Table 7 provides the key data pertaining to energy-related maintenance practices.

Table 7: Energy-Related Maintenance Activities

[f] A group of New England utility companies commissioned a regional study on the state of industrial compressed air efficiency in 1999. The study included a survey of 30 end users. *Compressed Air Systems Market Assessment and Baseline Study for New England*, Aspen Systems, 1999. Also see *Benchmarking Current System-Wide Compressed Air Market Efficiency Practices in the Northeast United States and Programmatic Strategies to Improve Them*, Maxwell et al., 2001.

Question and Responses	2001–2002				2002–2003
	SIC 20	SIC 35	SIC 36	SICs 20, 35, 36	SICs 21-34, 37-39
Over the last two years, has maintenance effort on energy-related issues such as compressed air, blowers, and lubrication, increased, decreased or stayed the same?					
Increased substantially	1.7%	0.8%	0.4%	**0.9%**	**2.8%**
Increased somewhat	21.6%	18.4%	16.0%	**18.6%**	**8.6%**
Stayed the same	70.6%	76.5%	72.2%	**74.2%**	**87.8%**
Decreased somewhat	0.0%	0.1%	7.8%	**1.8%**	**0.5%**
Decreased substantially	0.0%	4.0%	0.3%	**2.3%**	**0.1%**
Don't Know	6.1%	0.3%	3.2%	**2.3%**	**0.1%**

In the two years preceding the survey, about ten percent of sites reported having had staff attend training that included energy management as a topic.

Overall, the results of study reveal substantial variations in energy efficiency purchasing patterns and operating practices between SICs. There appears to be a moderate level of energy efficiency activity in California.

Accessing the Public Database

The public version of the Nonresidential Market Share Tracking Study Database contains selected results from:

- The Industrial Purchases and Practices Survey;
- The Upstream Market Actor Survey (lighting, windows, and chillers);
- Secondary sources (lighting, windows, and chillers, VSD's, electronic process controls, energy management systems, maintenance, packaged air conditioning, and specialized food processing technologies); and
- New analysis of the Nonresidential New Construction Survey.

The database is available for public use at no charge.[8] The database and user interface can be downloaded from the California Measurement Advisory Council Web site at www.calmac.org/NewPubs.asp. Or, go to the www.calmac.org Web site, click on "Searchable Database," and then "Perform Simple Search" for "Nonresidential Market Share Tracking Study." The complete final report is available from the same host site. Chapter 5 of the Final Report provides details on usage if instructions are needed.

The database is 4 MB zipped and 33 MB unzipped. It is organized by technology. After the user selects a technology of interest on the second database screen, the IPPS ("Industrial") data-selection screen will always appear as the first data source option if IPPS data for that technology are available. See Figure 2.

[8] Aspen Systems and the CEC retain the complete non-public database with all raw responses and compiled results. If readers review the on-site questionnaire (found in Appendices A and B of the project final report) and do not find responses of interest in the public database or wish to inquire about alternate analyses of the raw data, please contact the authors for possible assistance.

After selection of the technology and IPPS as the data source, the user can specify data segmentation (SIC and utility service territory) and questionnaire items of interest (arranged by questionnaire question number). An example of the estimates selection screen appears in Figure 3. An example summary statistics results screen follows in Figure 4.

Figure 2: Database Selection Screens

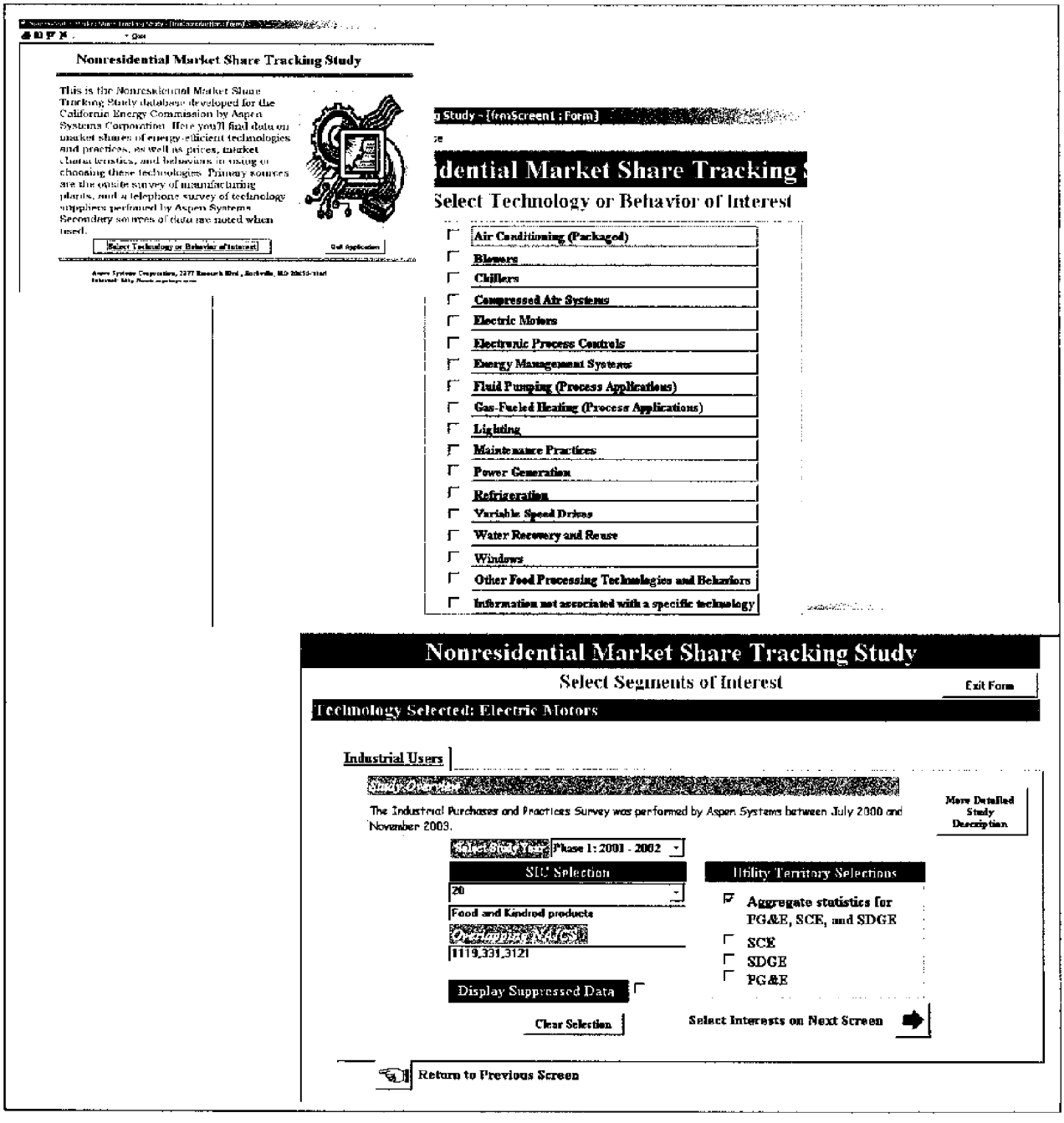


Figure 3: Example of the Estimates Selection Screen

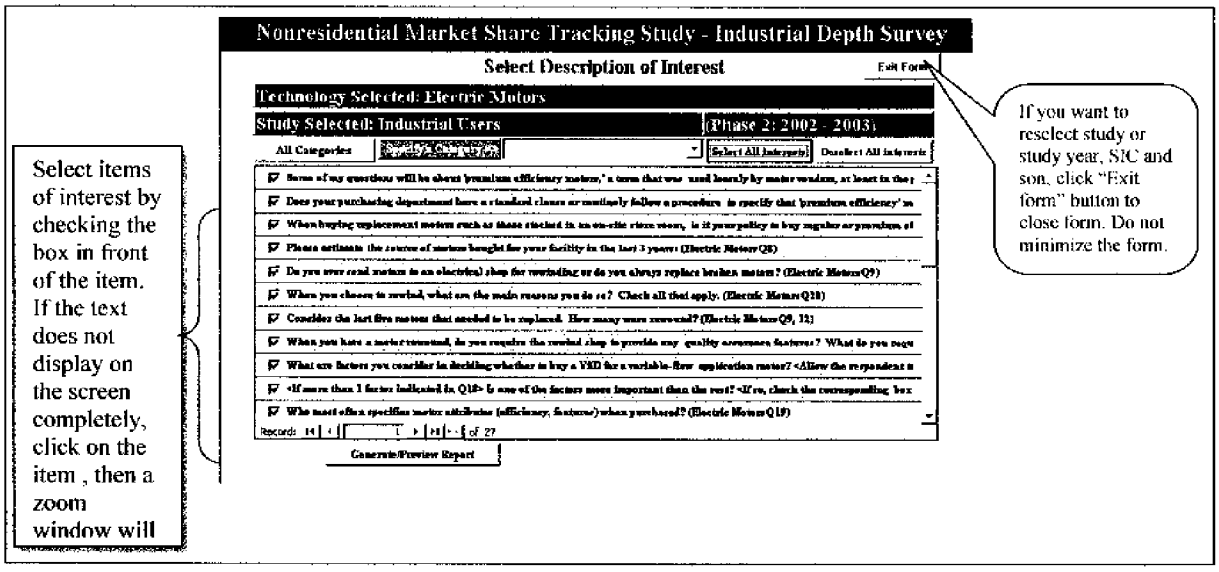
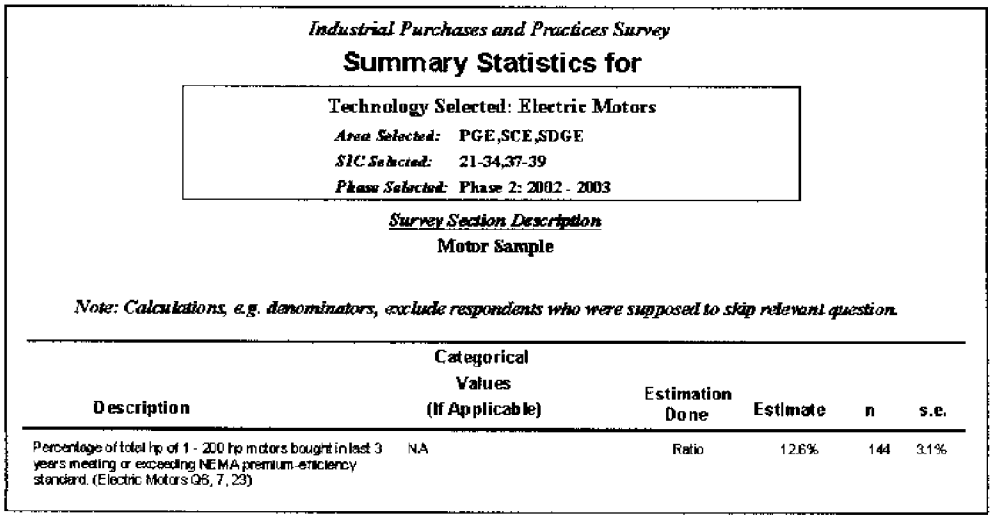


Figure 4: Example of Summary Statistics Report



Industrial Purchases and Practices Survey

Summary Statistics for

Technology Selected: Electric Motors

Area Selected: **PGE,SCE,SDGE**

SIC Selected: **21-34,37-39**

Phase Selected: **Phase 2: 2002 - 2003**

Survey Section Description

Motor Sample

Note: Calculations, e.g. denominators, exclude respondents who were supposed to skip relevant question.

Description	Categorical Values (If Applicable)	Estimation Done	Estimate	n	s.e.
Percentage of total hp of 1 - 200 hp motors bought in last 3 years meeting or exceeding NEMA premium-efficiency standard. (Electric Motors Q6, 7, 23)	NA	Ratio	12.6%	144	3.1%

Recommendations

The IPPS was intended to be the first wave of a tracking series. Subsequent data collection would provide time series data that reveals trends far better than this two-phase study can. We recommend repetition of the study. It will be enlightening to learn how the market has changed, how much the California "energy crisis" affected results, and where program designers should concentrate their efforts in the future. The existing snapshot of the industry reveals certain market characteristics that should be considered by current program designers and evaluators:

Selected key recommendations based on the results are presented below. Additional results and recommendations can be found in the project final report.

Motors. The study revealed that less than one third of new motors are bought as standard replacement motors. The majority of motors come into the plant "on skids" as part of packaged equipment or as special orders. These market channels may not have received enough attention in premium efficiency motor programs relative to their importance, and may be a reason that the market share is only about 15 percent in spite of statewide efforts. Based on the results of this study, we advise program administrators to expand or develop programs specifically aimed at end-user purchasing personnel and packaged equipment manufacturers' representatives. Train private and public procurement personnel to seek packaged equipment that features premium efficiency motors. Simultaneously, work with equipment manufacturers to include premium-efficiency motors in the packaged equipment either as part of the base product or a value-added optional upgrade.

Motor rewinding opportunities also exist, including establishing quality standards and standardized diagnostics.

Compressed Air. While managers are reasonably proactive regarding leak repair and system pressure settings, compressed-air system optimization remains an opportunity for energy efficiency, especially system maintenance and controls. 60% to 70% of compressors still use the inefficient (for many applications) throttling mode of part load control. Less than 10% use VSDs.

Gas. Many efficient boiler technologies appear to have been implemented throughout the state. Heat recovery is one that may be underutilized for certain size systems and worthy of promotion.

Training. Energy management training is only reaching about five percent of industrial sites per year. This remains a substantial opportunity for promotion of energy efficient technologies and practices.

Conclusions

Aspen Systems conducted a 560-site survey of industrial facilities in California between 2001 and 2003. The results reveal substantial variation between industries in adopting energy efficient technologies and practices. Overall there appears to be a moderate level of activity to improve energy efficiency in California. The results reveal specific technologies and market channels with potential for additional energy savings purchases and practices.

This paper presents selected results and findings from the study. The public database with more results has been posted at the CALMAC Web site and is available for download so that program designers, evaluators, and other interested parties may examine a substantial portion of the compiled results.

References

1. Aspen Systems Corporation, with Williams-Wallace Management Consultants and Robert Thomas Brown Company, *Nonresidential Market Share Tracking Study, Final Report on Phases 1 and 2*, for the California Energy Commission, Rockville, MD, December 2003.

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3. Maxwell, Jonathan B., R. Clarke, F. Gordon, E. McGlynn, and H. Powell, *Benchmarking Current System-Wide Compressed Air Market Efficiency Practices in the Northeast United States and Programmatic Strategies to Improve Them*, for ACEEE Summer Study on Energy Efficiency in Industry, July 2001.

4. Xenergy, *United States Industrial Electric Motor Systems Market Opportunities Assessment*, for the Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, Burlington, MA, December 1998.