The United States Industrial Electric Motor Systems Market Opportunities Assessment: Key Results

Mitchell Rosenberg, XENERGY Inc.
Mitchell Olszewski, Lockheed Martin Energy Systems
Paul Scheihing, U. S. Department of Energy

ABSTRACT

This paper summarizes the findings of the *U. S. Industrial Electric Motor Systems Market Opportunities Assessment.* The *Market Assessment* was sponsored by the U. S. Department of Energy. The project's principal objectives were to create a detailed portrait of the inventory of motor systems currently in use in US industrial facilities, estimate motor system energy use and potential for energy savings. The research and analysis to support these objectives consisted primarily of on-site motor system inventories of a probability sample of 254 manufacturing facilities nationwide. In addition to characterizing the motor systems in use, the research effort also gathered detailed information on motor system management and purchasing practices. This paper presents key findings from the Market Assessment in regard to patterns of motor energy use, saturation of energy efficiency measures such as efficient motors and adjustable speed drives, and motor system purchase and maintenance practices.

Introduction

In 1995 The U.S. Department of Energy (DOE) Office of Industrial Technologies commissioned a study to develop a detailed profile of industrial motor-driven systems. The resulting Market Assessment was carried out by XENERGY Inc. under a subcontract with Oak Ridge National Laboratory (Lockheed Martin Energy Systems). The *United States Industrial Electric Motor System Market Opportunities Assessment* was done as one component of DOE's Motor Challenge Program. Motor Challenge is an industry/government partnership designed to help industry capture significant energy and cost savings by increasing the efficiency of motor systems.

The project's principal objectives were to create a detailed portrait of the inventory of motor systems currently in use in US industrial facilities, estimate motor system energy use and potential for energy savings. The research and analysis to support these objectives consisted primarily of on-site motor system inventories of a probability sample of 254 manufacturing facilities nationwide, as well as 11 other non-manufacturing facilities in selected sectors. In addition to characterizing the motor systems in use, the research effort also gathered detailed information on motor system management and purchasing practices. This paper presents key findings from the Market Assessment in regard to patterns of motor energy use, saturation of energy efficiency measures such as efficient motors and adjustable speed drives, and motor system purchase and maintenance practices.

Methods

The survey of industrial facilities or *Market Assessment Inventory* (MAI) consisted of two parts: the motor systems inventory and the practice inventory.

The Motor Systems Inventory. For the Motor Systems Inventory, trained field engineers, accompanied by a representative of the plant, collected detailed information about every motor-driven system they could observe which was used in a production process. In very large plants, motor systems were sampled to contain the amount of time spent on-site with the respondents' personnel. At each plant, the field engineer also worked with plant personnel to take instantaneous load measurements on a sample of motors. These measurements were used to estimate average part loads – a key element in estimates of energy use and potential savings. Through this process, we compiled detailed information on 29,295 motor systems – both the motor itself and the piece of equipment it drove. In addition, we compiled instantaneous load measurements on nearly 2,000 motor systems.

The Practice Inventory. Achievement of significant increases in motor system efficiency depend to a large extent on the adoption of good design, purchase, and management practices. Equipment on the typical factory floor is constantly updated, reconfigured, and readjusted. Under normal patterns of use, motors wear out and need to be rebuilt or replaced every seven to ten years. Motor systems require continual monitoring and maintenance to run at their design efficiency. The Practice Inventory gathered information on the prevalence of actions identified by industry experts as "good practice" in the sample facilities.

The analysis summarized below drew on a wide array of primary and secondary sources. In particular we relied on the judgments of a large panel of industry experts to estimate typical levels of energy savings associated with various categories of efficiency measures.

Key Findings: Motor System Inventory and Energy Use

The following paragraphs provide an overview of the manufacturing motor system inventory. Estimates of aggregate motor system energy use and costs and their distribution among industry groups (SICs) are derived from the *Manufacturing Energy Consumption Survey: 1994* (MECS) and various surveys conducted by the Bureau of the Census. Information on the breakdown of that energy by application and motor size, as well as information on the saturation of efficiency measures come from the MAI.

Aggregate motor system energy use: Industrial motor systems represent the largest single electrical end use in the American economy. In 1994, industrial electric motor systems used in production consumed over 679 billion kWh, or roughly 23 percent of all electricity sold in the United States. Motors used in industrial space heating, cooling, and ventilation systems used an additional 68 billion kWh, bringing total industrial motor system energy consumption to 747 billion kWh or 25 percent of all electricity sales. This is roughly equal to *total electric sales to the commercial sector in 1994 (795 billion kWh).* Process motor systems energy accounts for 63 percent of all electricity used in industry.

Table 1 shows the distribution of motor systems energy use by major industry groups.

Table 1
Motor Drive Consumption in Manufacturing and Selected Non-Manufacturing Industries (in Gigawatt Hours per Year)

Industry Categories	Net Electric Demand* (million kWh)	Motor System Energy (million kWh)	Motor System Energy as % of Total kWh
Manufacturing	**917,834**	**541,203**	**59%**
Process Industries (SICs 20,21,22,24,26,27,28,29,30,31,32)	590,956	419,587	71%
Metal Production (SIC 33)	152,740	46,093	30%
Non-metals Fabrication (SICs 23,25,36,38,39)	106,107	50,031	47%
Metals Fabrication (SICs 34,35,37)	68,031	25,492	37%
Non-Manufacturing	**167,563**	**137,902**	**82%**
Agricultural Production (SICs 01, 02)	32,970	13,452	41%
Mining (SICs 10, 12,14)	44,027	39,932	90%
Oil and Gas Extraction (SIC 13)	33,038	29,866	90%
Water Supply, Sewage, Irrigation (SICs 494, 4952,4971)	57,528	54,652	95%
Total All Industrial	***1,085,397***	***679,105***	***62.6%***

* 'Net Demand for Electricity' is the sum of purchases, transfers in, and total onsite electricity generation, minus sales and transfers off site. See MECS 1994. Other sources: Department of Agriculture, 1992, Census of Mineral Industries, 1992, ADL 1980, EPRI 1988, EPRI 1992.

Concentration of motor system energy use by industry. Table 2 demonstrates that motor drive energy is highly concentrated within a small number of industry groups, especially in the manufacturing sector. The ten 4-digit SIC groups listed in Table 2 account for over 50 percent of drive energy in manufacturing. Yet these groups contain fewer than 3,000 or 2.5 percent of all manufacturing establishments with 20 or more employees. The finding of high concentration of drive energy use suggests program strategies tailored to the applications and decision purchase decision making practices common in the listed industry groups.

Distribution of motor energy by application. There are significant variations in the distribution of motor system energy by application among different industries. As shown in Table 3 fluid applications (pumps, fans, compressors) account for 61 percent of motor system energy in manufacturing. Pumps account for 59 percent of total motor systems energy in the petroleum industry, versus 25 percent for all manufacturing. Compressed air systems account for 28 percent of motor systems energy in Chemicals, versus 16 percent in all manufacturing facilities.

The heavy concentration of motor system energy in fluid systems is an important finding because methods to improve the efficiency of such systems are fairly well understood *and* because virtually every industry uses these systems. They are particularly heavily concentrated in the process industries.

Table 2
Distribution of Motor System Energy: Top 10 4-Digit SIC Groups

Industry Description	% of Total Manu. Motor Energy	Establish-ments (20+ employees)
Paper Mills	10.3%	310
Petroleum Refining	7.5%	247
Industrial Inorganic Chem	6.9%	568
Paperboard Mills	5.0%	219
Blast Furnace & Steel Mills	4.7%	284
Industrial Organic Chem	5.3%	631
Industrial Gases	4.0%	623
Plastics Materials & Resins	2.5%	456
Cement, Hydraulic	1.7%	190
Pulp Mills	1.2%	55
Total of Top 10	*49.1%*	*3,583*

Sources: 1994 Manufacturing Energy Consumption Survey, Census of Manufacturers

Table 3
Distribution of Motor Drive Energy by Application, Manufacturing

Application	SIC 28 - Chem	SIC 26 - Paper	SIC 33 - Metals	SIC 20 - Food	Other Industries	All SICs Percent
Pump	26.0%	31.4%	8.7%	16.4%	19.0%	**24.8%**
Fan	11.9%	19.8%	15.3%	7.5%	13.5%	**13.7%**
Comp. Air	27.7%	4.6%	14.3%	7.7%	15.0%	**15.8%**
Refrigeration	7.7%	5.0%	0.1%	29.4%	7.1%	**6.7%**
Subtotal: Fluid Systems	*73.3%*	*60.7%*	*38.4%*	*61.1%*	*54.6%*	***61.0%***
Mat'l Handling	1.4%	7.4%	47.1%	6.1%	10.3%	**12.2%**
Mat'l Process	23.6%	21.3%	12.6%	26.1%	31.0%	**22.5%**
Other	1.8%	10.6%	1.9%	6.7%	4.1%	**4.3%**
Subtotal: Other Systems	*26.7%*	*39.3%*	*61.6%*	*38.9%*	*45.4%*	***39.0%***
All Applications	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*	***100.0%***

Source: Market Assessment Inventory

Saturation of energy efficiency measures. Saturation of the most common motor system efficiency technologies -- energy-efficient motors and adjustable speed drives -- is relatively low. The inventory found that motors meeting EPAct standards accounted for 9.1 percent of all motors currently in use, with the highest concentration (25.5 percent) in the 101 - 200 horsepower range. EPAct compliant motors use 18.7 percent of total motor systems energy in manufacturing.

The inventory found that 9 percent of all observed motor systems, accounting for 4 percent of all motor system energy were equipped with adjustable speed drives. Over 90 percent of the ASD-equipped motor systems were of 20 horsepower or less. In this size range, it is more likely that the ASD was installed primarily to increase control over the production process rather than to save energy. Based on the application of engineering screening criteria for the application of ASDs, we estimate that motors representing 18 to 25 percent of total manufacturing motor systems energy could be cost-effectively equipped with ASDs.

Distribution of motors by part load. At part loads of 50 percent or below, motor operating efficiency drops off precipitously. The problem can be addressed by replacing the motor with one sized more appropriately to the load. Based on instantaneous load measurements of nearly 2,000 motors operating under reportedly normal conditions, we found that 44 percent were operating at part loads below their efficient operating range. For pump, fan, and other fluid systems, low part loads may indicate that the entire system is operating at far below its optimal efficiency.

Key Findings: Potential Energy Savings in Motor Systems

Savings Estimation Methods

Estimates of energy savings associated with upgrading motor efficiency were developed directly from on-site observations, using calculation methods embedded in the MotorMaster+ software. We estimated potential energy savings for motor efficiency upgrades and correction of motor oversizing by applying standard engineering formulae to estimates of energy usage of the motor systems to which the measures would most likely apply.

To estimate "system level savings" we developed and implemented the following three-step process.

- ***Estimate total energy usage by major application.*** We used the results of the inventory to estimate energy use by major application category: pumps, fans, air compressors, and other process systems.
- ***Compile expert opinion and case studies on measure applicability and savings fractions.*** XENERGY solicited the opinions of industry experts – primarily consulting engineers, manufacturers' technical staff, and industry association representatives – regarding the percentage of systems to which various measures in the major application categories could be cost-effectively applied. We also solicited their opinion on the average savings these measures could achieve, in terms of

percentage of initial system energy use. We gathered similar information from case studies and other documents. Using this information, we formulated high, low and midrange estimates of potential savings for each principal measure type within the major motor system application categories.

- ***Calculate high, low, and midrange savings estimates.*** The savings estimates were calculated by applying the following formula:

$$Applicability_{(High,Midrange,Low)} \times Average\ Savings\ Fraction \times System\ Energy$$

Because the motor systems grouped under "Other Process Systems" are so diverse, we did not feel it would be appropriate to apply to them the savings estimation process described above. Rather, we applied the method for speed control measures alone. Thus, the potential savings for this category is likely to be somewhat underestimated. Throughout this analysis, we used a three year simple payback as the economic threshold for estimating applicability factors. These savings estimates can be understood as the economic potential for motor system efficiency improvements in existing industrial facilities.

Findings

Aggregate potential savings. Potential industrial motor system energy savings using mature, proven, cost-effective technologies range from 11 percent to 18 percent of current annual usage or 62 to 104 billion kWh per year, in the manufacturing sector alone. Potential savings in the non-manufacturing industries are estimated at an additional 14 billion kWh. The potential motor system energy savings for all industries translate into reductions in energy costs up to $5.8 billion. Realization of these savings would reduce carbon equivalent emissions by up to 29.5 million metric tons per year.

Concentration of savings in fluid system improvements. Improvements to the major fluid systems – pumps, fans, and air compressors – represent up to 62 percent of potential savings. This estimate does not include savings associated with improving the efficiency of the motors driving these systems. The technical aspects of optimizing pump, fan, and air compressor systems are well understood (if not widely implemented).

For specific facilities and systems, potential savings far exceed the industry average. Motor Challenge has documented major cost-effective projects which have reduced energy consumption at the motor system level by an average of 33 percent, and by as much as 59 percent.

Table 4
Estimated Potential Motor System Energy Savings by Type of System and Measure

	Potential Energy Savings (GWH/Yr)			As % of
Measure	**Low**	**Midrange**	**High**	**Total Motor GWH/Year**
Motor Efficiency Upgrades				
Upgrade all integral AC motors to EPAct Levels		13,043		2.3%
Upgrade all integral AC motors to CEE Levels		6,756		1.2%
Improve Rewind Practices		4,778		0.8%
Total Motor Efficiency Upgrades		24,577		4.3%
Systems Level Efficiency Measures				
Correct motor oversizing	6,786	6,786	6,786	1.2%
Pump Systems: System Efficiency Improvements	8,975	13,698	19,106	2.4%
Pump Systems: Speed Controls	6,421	14,982	19,263	2.6%
Pump Systems: Total	15,396	28,681	38,369	5.0%
Fan Systems: System Efficiency Improvements	1,378	2,755	3,897	0.5%
Fan Systems: Speed Controls	787	1,575	2,362	0.3%
Fan Systems: Total	2,165	4,330	6,259	0.8%
Compressed air systems: System Eff. Improvements	8,559	13,248	16,343	2.3%
Compressed air systems: Speed Controls	1,366	2,276	3,642	0.4%
Compressed air systems: Total	9,924	15,524	19,985	2.7%
Specialized systems: Total	2,630	5,259	7,889	0.9%
Total System Improvements	36,901	60,579	79,288	10.5%
Total Potential Savings	*61,478*	*85,157*	*103,865*	*14.8%*

Distribution of potential savings by type of measure. Table 4 shows how potential savings are distributed among different kinds of measures and end uses in manufacturing only. Potential efficiency improvements in non-manufacturing facilities add another 14 billion kWh in annual savings. The savings in the major groups of measures are additive. The term "CEE Efficiency Levels" refers to a set of motor efficiency standards proposed by the Consortium for Energy Efficiency which are somewhat higher than the standards recently promulgated by the Federal government. Nearly two-thirds of all potential savings derive from system improvements, such as the substitution of adjustable speed drives for throttling valves or by-pass loops in pumping systems or fixing leaks in compressed air systems. Improvements to the major industrial fluid systems – pumps, fans, and air compressors – present between 45 and 62 percent of the total savings opportunities, taking into account low and high estimates.

Patterns of potential savings across industries. Table 5 shows potential motor systems energy savings by application for each two-digit SIC group. The bolded cells indicate measure groups with particularly high concentrations of potential savings. These 23 SIC/measure groups (out of 126) account for 70 percent of all potential savings. These findings suggest the need to concentrate efforts to assist end-users in saving energy on those industries and end-uses with the highest potential.

Potential savings by application and motor size. The MAI found that each industry has a characteristic map of motor system energy savings potential that mirrors closely the map of motor system energy consumption Figure shows that potential savings opportunities cluster in the application/horsepower groups with the greatest amounts of energy in the Paper and Allied Products industry. Most of the savings in the paper industry are concentrated in improvements to pump systems. The concentration of many of the savings opportunities in systems driven by large motors suggests that their implementation will require considerable planning and capital outlay.

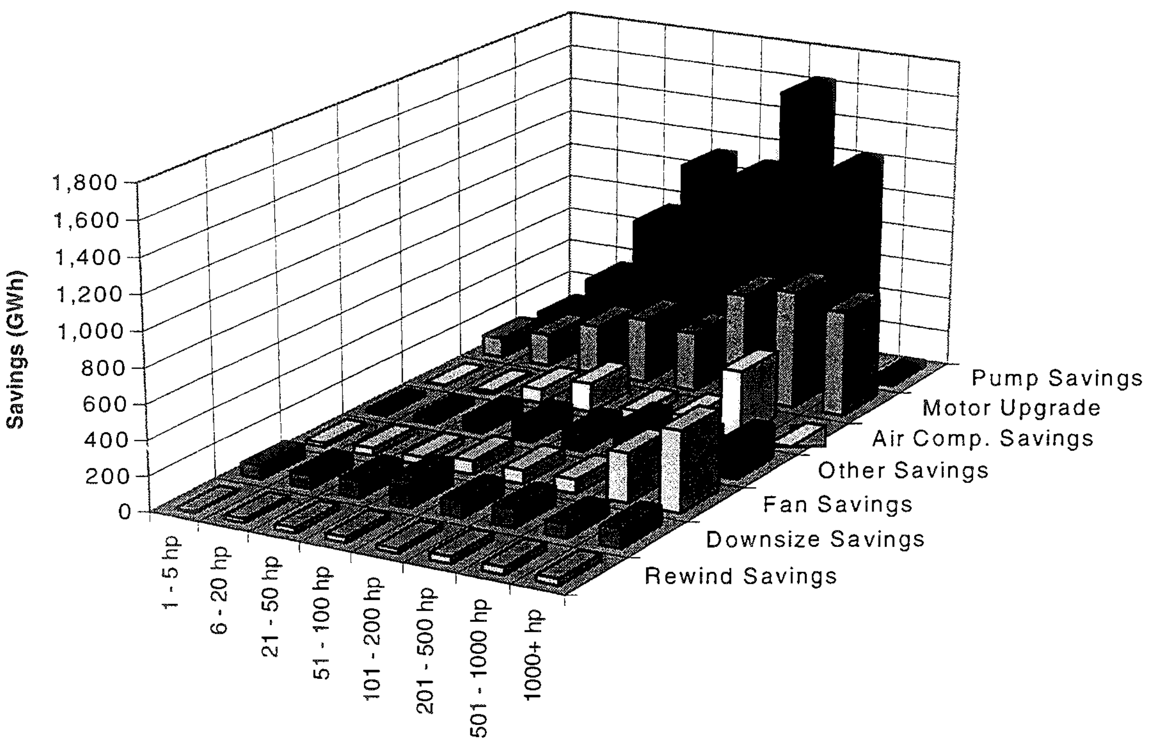

Figure 1
Energy Savings Opportunities in the Paper Industry

Key Findings: Motor System Purchase and Maintenance Practices

In addition to the motor inventory, facilities were surveyed on their motor system purchase and maintenance practices. The following paragraphs summarize key findings on customers' awareness and implementation of the elements of best practice. Percentages reflect weighting of Practice Inventory results to the population.

Most motor purchase decisions are made at the plant level. Even among multi-site organizations, 91 percent reported that all motor purchase decisions were made at the plant level.

Table 5
Potential Savings by SIC and Application

		Estimated Potential Energy Savings: GWH/Yr				
SIC	Industry Category	Fan System	Pump System	Compressed Air Systems	Other Proc. Systems	Motor Upgrade
20	Food and Kindred Prod.	157	1,250	494	517	1,376
21	Tobacco Products					
22	Textile Mill Products	170	593	408	166	743
23	Apparel & Other Textile Prod.	1	0	68	15	47
24	Lumber and Wood Prod.	153	243	324	341	432
25	Furniture and Fixtures	87	5	78	33	173
26	Paper and Allied Prod.	1,082	6,293	773	881	3,197
27	Printing and Publishing	52	17	74	90	305
28	Chemicals and Allied Prods.	942	7,556	6,813	994	4,219
29	Petroleum and Coal Prod.	271	6,159	1,352	169	1,736
30	Rubber and Misc. Plastics Prod.	113	1,851	813	411	1,498
31	Leather and Leather Prod.	27	0	0	0	22
32	Stone, Clay, and Glass Products	31	18	96	20	117
33	Primary Metal Industries	738	1,537	2,150	1,085	3,199
34	Fabricated Metal Prod.	34	181	303	80	298
35	Industrial Machinery and Equip.	28	195	200	94	368
36	Electronic and Other Electric Equip.	18	1,554	513	43	609
37	Transportation Equip.	353	1,109	941	242	1,195
38	Instruments and Related Prod.	71	119	123	78	263
39	Misc. Manufacturing Industries					
	All Industry Groups	*4,330*	*28,681*	*15,524*	*5,259*	*19,799*

Awareness of the availability of energy efficient motors and understanding of their performance advantages is low. Only 19 percent of respondents reported being aware of "premium efficiency" motors, the common marketing designation for motors that met Energy Policy Act standards prior to their promulgation in October 1997.

Only 22 percent of customers surveyed reported that they had purchased any efficient motors in the past year. Among all customers surveyed, the average reported percentage of efficient motors purchased in the past year was 12 percent. According to the Bureau of the Census *Current Industrial Reports,* efficient motors constituted 15 percent of all 1 - 200 horsepower units shipped domestically in 1996. Thus we believe that customer reporting on this topic was fairly accurate.

Industrial customers' decision-making process regarding rewind versus replacement of failed motors is a major leverage point for improving the "fleet efficiency" of the electric motor inventory. MAI respondents were asked to report the percentage of motors they rewind in each horsepower category. The results from these questions are shown in Table 6. Not surprisingly, the percentage of motors rewound upon failure increases with size. This is largely because the difference in cost between purchasing a replacement motor and rewinding the failed unit increases with size.

Table 6
Percentage of Motors Rewound
By Horsepower Category and Company Size

	Company Size					
	Large	Med/Large	Medium	Sm/Med	Small	Total
1 - 5 hp	19%	20%	16%	19%	23%	**20%**
6 - 20 hp	62%	62%	55%	50%	68%	**61%**
21 - 50 hp	84%	80%	83%	79%	79%	**81%**
50 - 100 hp	90%	90%	86%	87%	94%	**90%**
101 - 200 hp	94%	89%	93%	85%	97%	**91%**

Respondents to the Practices Inventory reported that they rewound a given motor three times, on average. Larger motors tend to be rewound more often than smaller ones. Given the increases in motor efficiency since the implementation of EPAct standards in 1997, and the fact that many rewind jobs lead to losses in efficiency, it is clear that programs or policies to promote the decision to replace versus repair failed motors will increase overall motor system efficiency. Unfortunately, only 12 percent of respondents identified operating costs as a consideration in the rewind versus replace decision, compared to 67 percent who mentioned the price difference between replacement and rewinding.

Industrial customers most frequently refer to the size of the failed, existing motor in determining the size of replacement motors. Instantaneous load measurements conducted as part of the Motor Systems Inventory found that over 40 percent of motors in use were operating at less than 40 percent part load. These findings suggested that the practice of oversizing motors was widespread. Customers' responses to criteria used to select the size of replacement motors was consistent with this finding. Inventory respondents reported using the size of the motor being replaced most often as the criterion for selecting the size of new motors. Twenty-nine percent reported using this criterion exclusively. This practice would tend to perpetuate any oversizing in the selection of the original motor.

Except in the largest facilities, the level of knowledge and implementation of systematic approaches to motor systems energy efficiency is low. Although the engineering and industrial management community, with the support of Motor Challenge, has elaborated a set of best practices for motor systems design, purchase, and management, few companies are aware of these practices and fewer still have adopted them. The savings analysis demonstrated that significant energy savings opportunities exist in fluid systems. The practices survey supports this in that 24 percent of the population reported they had not performed any improvements in their fluid systems. The results are most pronounced for compressors, where 52 percent of facilities have not undertaken any improvements. Details of improvements done for each of the fluid systems are shown in Table 7.

Conclusions

The *U. S. Industrial Electric Motor Market Opportunities Assessment* was designed to characterize and quantify electric motor use and opportunities for related energy savings among U. S. Manufacturers. In so doing, it brought into sharp relief the opportunities and challenges that face business and government organizations interested in improving motor system -- as well as overall production – efficiency.

Achieving component-level efficiency. Most motor efficiency upgrades can be achieved fairly easily by selecting the most efficient available motor for the application at hand at the time of new purchase or replacement of failed motors. In particular, the economics of replacing versus rewinding motors can be quite compelling. Widespread adoption of efficient purchase practices appears to face a number of major barriers associated with lack of customer understanding of the costs and potential benefits of such policies. Moreover, motor dealers who also provide rewind services may also be reluctant to "sell against" their rewind services, which provide much higher gross margins per unit than sales of new equipment.

Achieving system-level efficiency. System efficiency measures offer the greatest potential for large and cost-effective energy savings. However, they often require a significant amount of effort on the part of industrial end users and their vendors to identify, design, implement and maintain. Even the largest customers face barriers of limits on the engineering and maintenance staff time needed to measure and analyze system operation in advance of developing system-level improvements. In most industries, energy is a small component of total production costs. Thus it is difficult to obtain management support for dedicating resources to motor system improvement projects. On the supply side of the market, relatively few consultants and vendors perceive significant benefits to incorporating efficiency improvement into standard roster of services.

The sponsors of national and regional motor system efficiency programs are now grappling with how to integrate the findings of the *Motor System Market Assessment* and their own working experience into a new generation of programs. On the demand side, these programs are focusing on methods to help customers quickly and inexpensively identify motor system efficiency opportunities. On the supply side, these efforts concentrate on exploring and developing business models for motor system efficiency services which may ultimately prove profitable, and therefore, self-sustaining.

Table 7
Reported System Measures Undertaken
During the Two Years Prior to the Inventory

	Size Categories[1]					
	Large	Med/Large	Medium	Sm/Med	Small	Total
Fan Systems						
Retrofitted with ASDs	20%	7%	1%	0%	1%	1%
Retrofit with inlet guide vanes	9%	1%	0%	0%	3%	2%
Checked components with large pressure drops	3%	1%	10%	0%	3%	3%
No fan systems in facility	0%	29%	24%	18%	43%	38%
No improvements	67%	49%	45%	80%	33%	40%
Pump Systems						
Substituted speed controls for throttling	22%	8%	11%	1%	0%	1%
Used parallel pumps to respond to variations in load	14%	4%	2%	0%	3%	2%
Reduced pump size to fit load	0%	5%	7%	11%	3%	4%
Increased pipe diameter to reduce friction	5%	6%	6%	11%	1%	3%
No pump systems in facility	13%	28%	24%	17%	40%	35%
No improvements	45%	57%	42%	52%	34%	38%
Compressed Air Systems						
Replace 1-stage rotary screw units with more efficient models	7%	16%	29%	2%	4%	6%
Use parallel compressors to respond to variations in load	23%	12%	10%	13%	7%	8%
Reconfigured piping and filters to reduce pressure drops	14%	24%	5%	13%	1%	5%
Added multi-unit controls to reduce part load consumption	23%	10%	6%	0%	4%	4%
Reduce size of compressors to better match load	10%	6%	1%	2%	1%	1%
Fixed leaks	42%	40%	34%	36%	15%	20%
No compressed air systems in facility	0%	3%	0%	1%	10%	8%
No improvements	39%	44%	37%	62%	52%	52%
No Reported Improvements	30%	27%	14%	45%	21%	24%

[1] The size categories are based on sample stratification cut points. All establishments in each 2-digit SIC group were initially allocated to Large, Medium, and Small size strata, with roughly one-third of all establishments in the SIC group in each size stratum. In some regions, we needed to combine adjacent groups to provide a sufficiently large sample frame. Thus Large and Medium/Large are not mutually exclusive size designations.