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ENERGY-EFFICIENT ELECTRIC MOTORS STUDY

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261-192
NTIS-22

March 23, 1981

Work Performed Under Contract No. AC01-79CS40265

Market Facts, Inc.
Washington, DC

U. S. DEPARTMENT OF ENERGY

Division of Industrial Energy Conservation

NOZAKUHI

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Price: Printed Copy A07
Microfiche A01

ENERGY-EFFICIENT ELECTRIC MOTORS STUDY

Submitted to:

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Washington, D.C.

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March 23, 1981

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SECTION I

EXECUTIVE SUMMARY

A. Introduction

The executive summary provides an overview of the background, findings, and recommendations of the energy-efficient motors study. This first section, the introduction, briefly describes the background and purpose of the study. The final sections present major conclusions and recommendations based on findings of the study.

1. Background

To reduce energy usage, the Department of Energy (DOE) has selected a number of technologies with high conservation potential for commercialization. One such technology is the energy-efficient electric motor (EEM).

The one to 125 horsepower electric motor uses 28 percent of all electric power generated in the United States. These integral polyphase motors are used principally by the process industries to drive general purpose machinery such as pumps, compressors and fans. U.S. Census data indicate that in 1979 over two million one to 125 polyphase induction motors were shipped from domestic establishments.

Over the past 20 years motor efficiencies have dropped significantly. Manufacturers' objectives were to produce the most reliable motor for the lowest price. As cheaper materials were substituted, motors became less efficient.

Improved efficiency is achievable, and energy-efficient motors have been available to the marketplace for several years. Users continue to be first-cost oriented despite the fact that life-cycle costing shows rapid payback and extended savings.

DOE commercialization of EEMs is intended to accelerate the motors' acceptance in appropriate applications, particularly where private sector market mechanisms do not or cannot bring about the desired impact. To increase the motors' use, DOE is providing technical and market data to electric motor purchase decision-makers.

2. Purpose

The purpose of the study of motor users was to identify the decision-makers or the individuals most knowledgeable about the purchase and use of electric motors in industry. The study determined the information these decision-makers need, the most effective way to reach them, and the motivating forces behind the purchase of EEMs.

This report includes the findings from a survey of 301 respondents in manufacturing companies which purchased integral horsepower polyphase motors in 1979. The survey measured current knowledge and awareness of EEMs, decision-making criteria, information sources, and other purchase factors.

To supplement the survey of motor users, Market Facts conducted telephone interviews with individuals who specify motors for industrial clients' plant and equipment. If new plants are equipped with EEMs, replacement motors are likely to be EEMs.

The primary data-gathering was followed by a market penetration, distribution channel, and constraint analysis. All of the activities were conducted by Market Facts, Inc., a full service marketing research and consulting company. Market Facts developed and administered the questionnaire used in the survey of motor users.

B. Conclusions and Recommendations

Conclusions, developed from major findings, relate to characteristics of the EEM user and non-user groups, perceptions of EEMs, purchase influencers, and initial cost as a barrier. The recommendations which follow cover target audiences, messages, and media. The motor user is the key to EEM adoption, and most of the conclusions and recommendations focus on the end-user.

1. Conclusions

Following are selected study conclusions:

- There was a high degree of EEM awareness, and purchase activity was very recent. Two-thirds of the respondents were familiar with EEMs; about one-half of those respondents had actually purchased the motors. Of those who purchased, almost two-thirds first did so in 1979, more than twice the number purchasing EEMs for the first time in 1978.
- Firms surveyed in the chemical industry were most likely to have purchased EEMs. About one-half of the chemical firms surveyed did so. Although EEMs are thought to be especially efficient for continuous manufacturing processes, the chemical firms surveyed were equally likely to use a batch or continuous process for manufacture. Firm revenues, number of employees at the respondent's location, and type of production process did not appear to affect the likelihood of EEM purchase.
- No single industry had a distinctly high percentage of non-users of EEMs although respondents in the food and paper industries were less likely to be aware of the motors. Firms not familiar with EEMs were also more likely to have fewer employees at the respondent's site. (The plant management of these firms was more likely to influence the allocation of money for motor purchases.)
- EEM applications corresponded to uses of standard motors. EEM users were more likely to feel that the motors are widely applicable. EEM non-purchasers, however, were more likely to feel that EEMs are applicable only for specialized purposes.

- Reliability, one of the more significant factors in the selection of an electric motor, was the EEM characteristic about which respondents knew the least. Forty percent did not know how EEM reliability compared with standard motors.
- EEMs were perceived by two-thirds of the respondents to be less available than standard motors. Many problems with availability were related to EEMs' newness as a product.
- EEMs were perceived as somewhat more costly to buy and somewhat less costly to run. The principal motivating factors for their use appeared to be economic in nature. Calculation of payback period was the most common method for evaluating investments. Since this method ignores the energy savings to be realized after the payback period, prospective EEM purchasers may not be aware of the motors' full economic benefit to their operations.
- Motor purchases were primarily a plant-level activity. Engineers played the leading role in influencing purchase decisions. Plant managers and purchasing managers were also likely to allocate funds or select a supplier.
- The largest portion of the market surveyed was represented by users of one to 20 horsepower motors. For the most part, firms purchased 10 or fewer motors in 1979. The one to five horsepower range was the only category in which purchasers were more likely to buy more than 10 motors in 1979.
- The rate at which electricity costs have risen and are expected to continue to increase exceeds the rate of increase in electric motor prices. EEMs will become more attractive as an investment.
- The current rate of market penetration by EEMs exceeds the rates projected in earlier commercialization plans. Government informational programs need only accelerate the rate at which EEMs are adopted since the rising cost of electricity is the pivotal factor in EEM adoption.

2. Recommendations

Following is a synopsis of the recommendations for target audiences, messages, and media.

a. Target audiences. The principal target audience is the prospective EEM user. Communications to suppliers are also desirable.

- Communications should be directed primarily to plant engineers. The engineering department's primary areas of influence are choice of model and technical capabilities. Plant managers and purchasing managers also have decision-making roles in the allocation of funds and the choice of supplier. These individuals form a secondary audience.
- Markets should be delineated by principal application and size of motor purchased. Communications should also relate to motors of one to 20 horsepower. Purchasers of these motors comprise a major market segment.
- Suppliers should be apprised of DOE communications plans. Although DOE's chief objective is to promote EEMs by stimulating end-user demand, manufacturers and distributors must have a basis for pursuing the EEM market. Electric motors have been a stable, low-growth mature product, and EEMs may provide manufacturers with an opportunity to increase their market share.
- As electric motor users continue to provide motor specifications when purchasing capital equipment, original equipment manufacturers (OEMs) should be made aware of DOE's efforts to promote EEMs. A prior electric motor study by Arthur D. Little, Inc., (ADL) reported that the end-user will not question motor characteristics of purchased equipment. This recent survey revealed that three out of five respondents provide motor specifications when purchasing capital equipment. Almost one-third of these respondents always specify efficiency of the motor.
- Engineering firms, although not a priority audience, should be made aware of the ability of motor manufacturers to assist in EEM calculations.
- Project engineering groups of firms building new industrial plants should be informed of EEM costing methods.

b. Messages. Messages should provide prospective users with a sound reason for buying the EEM.

- End-users must know whether there are energy-efficient alternatives for a particular application, whether an EEM is equally reliable and available when needed, and how much in electricity costs will be saved as a result of purchasing the motor.
- Communications should emphasize EEMs' cost-effectiveness via the motors' protracted energy savings. Economic benefit is the principal incentive for using EEMs.
- Any EEM reliability advantages should be publicized. Operating data and actual examples of EEM applications and cost savings should be provided to prospective users. If EEMs are more reliable than standard motors, reliability will be a powerful selling point. DOE should explore the reliability issue further with the manufacturers.
- Replacement purchasers should have access to reference tables which identify energy-efficient equivalents of standard motor makes and models.
- Service and delivery time should be communicated by manufacturers. Lack of availability and poor delivery time appear to be impediments to the use of EEMs. Manufacturers and distributors should be informed of DOE's commercialization program and users' current perceptions of availability.

c. Media. The most effective way to reach the primary target audience, plant engineers, is through print media.

- Plant Engineering and Power and Electric Construction and Maintenance are excellent ways to reach plant engineers. These publications were most frequently mentioned by respondents as sources of information about electric motors.
- Industry publications can be used to reach selected audiences; for example, firms in the food industry. A number of respondents said they refer to such publications for electric motor information.
- Pamphlets, brochures, and fact sheets can continue to provide information on the opportunity to obtain additional details from DOE. These items can be mailed, made available through journals, or distributed at industry seminars.

- A profile or checklist of situational factors that would indicate high potential savings for a particular application would allow prospective EEM users to determine if they should further investigate the EEM.

As EEM communications are executed, DOE should allow a minimum of six months before measuring the impact of communications on purchase behavior. This period is related to the time required to study EEMs before their purchase is recommended.

Increased demand for EEMs as a result of DOE's commercialization activities exacerbate any availability or delivery problems that exist. Ongoing contact with suppliers is important in avoiding additional market resistance to EEMs as a result of delivery problems.

C. Summary of Major Findings

This section contains highlights of several topic areas. The first three topics cover electric motor purchase characteristics, respondent awareness of EEMs and EEM purchase characteristics, and are based on the survey of motor users. The final topic areas are based on the analyses of engineering firms, market penetration, distribution channels, and marketing constraints.

1. Electric Motor Purchase Characteristics

The following findings relate to electric motors in general, not specifically energy-efficient motors.

- Engineers within a company were by far the most important source of information for electric motor purchase decisions. (Engineers were the primary respondents to the survey and may be biased toward the role of the engineer. Nevertheless, these respondents were most knowledgeable about motor purchase.)
- Distributors were a key supplier of electric motors. They were used by 83 percent of all respondents. About one-half as many respondents purchased motors directly from manufacturers or as part of original equipment. The most important service these suppliers can render is prompt delivery.
- Rising energy bills were the most important factor in influencing energy conservation activities. The two most important electric motor purchase criteria were reliability and price.
- About one-third of the respondents had standard specifications for motors. More than half included efficiency in standard specifications. For companies which make specifications on a purchase-by-purchase basis, efficiency was less likely to be specified than other factors. Nevertheless, efficiency was somewhat more likely to be specified than was initial cost or manufacturer.
- About 40 percent of the respondents said their replacement purchase procedures differ from new applications. Almost one-half of these respondents placed more importance on the same make, model or size of the motor in replacement.

- Motor purchase decisions were most likely to be made at the plant level. Although several departments are involved, engineers appeared to have the greatest influence in the purchase decision.
- The most common method of evaluating an investment decision was through calculation of payback period. Payback was used by one-third of the respondents. Only one-half as many respondents used life-cycle costing, the method which would fully measure the return on EEMs. Although the average maximum payback period acceptable to all respondents for the purchase of any motor was 3.3 years, the average acceptable payback period required by non-EEM purchasers for the motors was just under two years.
- Respondents were most likely to have purchased integral polyphase motors of 20 horsepower or less. Except for motors of five horsepower or less, companies were more likely to have purchased 10 or fewer motors in a year.
- The most common EEM application was pumps. Applications for EEMs were similar to those for standard motors.

2. Respondent Awareness of EEMs

A surprisingly large portion (almost two-thirds) of the respondents were familiar with EEMs. Most respondents first learned of EEMs through a trade journal or other publication. About one-half of these respondents actually purchased the motors.

A substantial majority, about three-quarters, of the respondents who were familiar with EEMs had considered buying the motors. Of those who considered, two-thirds actually purchased or made plans to purchase EEMs. Almost all of the EEM purchases first occurred in 1978 and 1979.

Although many reasons for not considering or not purchasing EEMs were named, initial cost was mentioned by about 20 percent. A number of reasons for not purchasing were associated with

problems related to the newness of EEMs as a product. EEMs had just come to the attention of some respondents; others wanted to wait and see if the motors are reliable.

3. Energy-Efficient Motor Purchase Characteristics

The following paragraphs discuss energy-efficient electric motors. These findings are based on the responses of the 98 respondents who were familiar with EEMs.

a. Perceptions of Energy-Efficient Motors. Respondents compared EEMs with standard motors.

- About 40 percent of the respondents did not know how the reliability of EEMs compared with that of standard motors. A similar number felt that reliability of standard motors and EEMs was the same.
- Almost two-thirds felt that EEMs were less available than standard motors. Non-purchasers were more likely to feel this way than were those who purchased EEMs.
- About two-thirds of the respondents felt that EEMs were widely applicable. EEM users were more likely to view EEMs as widely applicable than were non-users.
- Most respondents felt that operating costs of EEMs are somewhat lower and that initial price is somewhat higher than that of standard motors.

b. Impact of Initial Cost. Three-quarters of the respondents perceived the initial cost of EEMs to be higher than that of standard motors. Non-purchasers were more likely to perceive the cost of EEMs to be "much" higher while those who purchased EEMs perceived the cost to be "somewhat" higher.

c. Other EEM Purchase Information. Following are some other EEM purchase characteristics:

- Forty percent of EEM purchasers bought EEMs in the one to five horsepower category.
- The average number of motors (new and replacement combined) purchased per company within each horsepower category was eight.
- Approximately 35 percent of the EEMs were purchased for replacement purposes.
- Respondents who did not consider buying EEMs said that it would take an average of about four months to study the motors before recommending their purchase. Other respondents, who had considered purchasing EEMs but did not do so, said they would require just under three months to study EEMs before recommending the motors' purchase.

4. Engineering Firms

Respondents in engineering firms (who specify motors for clients) felt that as electricity costs have increased, EEMs have been coming into wider use. The responsibility for EEM use in new plant and equipment appears to lie with the end-user. For the most part, engineers specify EEMs only upon client request. Otherwise, there is little incentive for engineers to undertake calculations for which they may not be paid.

When ordering motors for a new plant, engineers generally felt that clients are more concerned with the efficiency of motors over 200 horsepower. These motors represent a large portion of the total horsepower provided and dollars invested.

5. Market Penetration

The 1979 market penetration for all EEMs was 9 percent. In the replacement market, EEM penetration was 7 percent.

If 30 percent of all motors purchased receive too little use to be economically advantageous for EEM use, the effective market penetration of EEMs is about 13 percent. This rate far exceeds earlier projections contained in EEM commercialization plans.

For both new and replacement applications, EEMs had a higher penetration among motors of 26 horsepower or more than among motors of 25 horsepower or less. For motors over 25 horsepower, EEM market penetration was 13 percent.

6. Distribution Channels for EEMs

Original equipment manufacturers (OEMs) account for the vast majority of manufacturers' sales of electric motors of 50 horsepower or less. The larger the motor's portion of the equipment cost, the more important is price, particularly where a manufacturer's product is subject to foreign competition. Unless requested by the end-user, the OEM has little incentive to upgrade the efficiency of the product. OEMs are primarily concerned with reliability and low cost.

Distributors account for about 23 percent of the one to 20 horsepower motor units and 35 percent of the 21 to 50 horsepower motors sold by manufacturers. Distributors were the primary source of motors for the users surveyed. The main concern of distributors is inventory turn, and EEMs are more likely to be stocked when the motors are in great demand.

7. Constraints

The principal constraints, identified by the market element to which they relate, to the use of energy-efficient motors are:

a. End-user

- May not be aware of efficiencies that can be achieved.
- May lack information on EEM reliability and availability.
- May not know how to calculate life-cycle costs.
- May have a first-cost orientation.
- Response to electricity cost increases may lag actual event.

b. Manufacturer

- Energy-efficient motors may not be a high priority product.
- May perceive users as not being concerned with efficiency.
- May wish to keep motors competitively priced.
- Does not pay the electricity bill of the end-user.

c. OEM

- Efficiency is a combination of the motor and the driven equipment.
- The greater the motor portion of the product's cost, the less flexibility an OEM has to compensate elsewhere for the incremental cost of an EEM.
- May not perceive end-users to be concerned with the energy-efficiency of the motor.
- Desires to keep equipment competitively priced, particularly when there is foreign competition.
- Does not pay the utility bill of the end-user.

d. Engineering Firm

- Likely to evaluate EEMs only upon client request.
- May be risk-averse; over-sizing or over-designing is common; will design for the maximum possible load.
- Perceives that the client's project engineering group is primarily interested in lowest first cost -- operating costs may not be an important factor in evaluation of bids.
- Some engineers feel that the efficiency of motors larger than 200 horsepower is of greater concern to clients than is the efficiency of smaller motors. Motors over 200 horsepower may represent a far greater dollar investment and provide a substantial portion of the total horsepower needed in a plant.

e. Distributor

- Primarily concerned with stock that will turn over quickly.
- EEMs tend to be premium-priced (and the cost of borrowed funds is high).
- May require a large number of customer requests before stocking; but if the motor is not available when needed, the end-user may buy whatever motor is in stock that will do the job.

SECTION II

INTRODUCTION

A. Background

To reduce industrial energy usage the U.S. Department of Energy (DOE) has identified a number of high conservation potential technologies with accelerated commercialization opportunities. One such technology is the energy-efficient motor (EEM). Wider adoption of the EEM represents a major opportunity for industrial energy conservation.

Energy usage by electric motor drive (exclusive of HVAC and transportation equipment) amounts to approximately 60 percent of all electric power generated in the U.S. The following paragraphs provide background data on the status of electric motor efficiencies.

"Motor efficiencies in the 1-15 hp range have dropped significantly over the past 20 years. This drop coordinates well with the drop in the cost of electricity over the same period; thus efficiency simply became less important. In years succeeding the onset of the energy crises, motor manufacturers have sought to re-establish these product lines of high efficiency motors, but consumers, most of whom are first-cost-oriented, are not attracted by the premium-priced motors even though life-cycle costing shows rapid payback and protracted savings. In addition, 50 percent of all motors are purchased by end-users through original equipment manufacturers (OEM). The OEM purchaser is only interested in first cost, thus the ultimate user does not partake in the decision to procure the efficient motors.

"A government study performed by Arthur D. Little, Inc. (ADL) in 1975/76 indicated that much could be easily and economically done to improve motor efficiency significantly and to achieve critical savings in consumption with minimal government involvement. Scenarios of government involvement range from voluntary labeling actions to establishment of efficiency standards. Simultaneous with the development of this ADL report the National Electrical Manufacturers Association (NEMA) undertook a program

to define for its members (representing approximately 85 percent of sales in the industry) guidelines for including efficiency data on the motor nameplate. NEMA chose to pursue its own course and to date has prescribed a format for including efficiency data on the nameplate in the form of a code or numerical rating."¹

Integral horsepower polyphase motors are used principally by the process industries to drive general purpose machinery such as pumps, compressors, and fans. The one to 125 horsepower electric motors use 28 percent of all the electric power generated in the United States--the heaviest energy usage in industry.

More efficiently designed integral horsepower polyphase motors have been available to the marketplace for several years. Improved efficiency and power factor correction is achievable with existing motors as well.

The commercialization program for energy-efficient motors is designed to accelerate their acceptance in appropriate applications, particularly in situations where the private sector market mechanisms do not or cannot bring about the desired impact. To increase use of the motors, DOE is providing technical and other data to industrial decision-makers.

¹Source: Concept Statement for High-Efficiency Motors,
Department of Energy 8/31/78

B. Objectives

The Department of Energy sponsored this study as part of the commercialization activities for energy-efficient motors. The study was designed to identify the industrial decision-makers, the information they need to know, how they can best be reached, and the motivating factors for EEM purchase. A key element of the study was a survey of purchasers of integral horsepower polyphase motors. The survey measured current knowledge and awareness of energy-efficient motors, decision-making criteria, information sources, purchase and usage patterns, and related factors. Survey data provided a basis for the EEM market penetration analysis.

To supplement this knowledge of the user, Market Facts conducted telephone interviews with individuals who specify motors for industrial clients' plant and equipment. Although a relatively small percentage of all electric motors reach the end-user via architectural and engineering or engineering and construction firms, opportunities for using EEMs in new industrial plants are on the rise. U.S. oil companies in 1980 alone launched \$20 billion in refinery work to be completed by 1985.² If new plants are equipped with energy-efficient motors, there is a greater likelihood that replacement motors will also be EEMs.

Other segments of the study, which are based on secondary as well as primary research, provide analyses of distribution channels, commercialization constraints, and the impacts of government programs and rising energy prices.

The results of the study are intended for use by DOE in designing information and education activities that incorporate appropriate objectives, target groups, media, and messages. The desired result is increased use of energy-efficient electric motors.

²"The Construction Boom," Business Week, September 29, 1980.

C. Report Organization

The remainder of this report contains a description of study findings, conclusions and recommendations. Sample questionnaires and copies of letters to respondents are contained in Appendices A through C. Appendices D and E contain descriptions of the methods used in the study.

SECTION III

FINDINGS

Sections A, B, and C of the findings are based on the survey of motor users. Section D is based on the analysis of engineering firms, and Sections E, F, and G are based on the market penetration, distribution channel, and constraint analyses for energy-efficient electric motors.

A. Electric Motor Purchase Characteristics

All respondents provided information regarding the integral polyphase electric motors their company purchased in 1979. The information in this section relates to integral polyphase electric motors in general, not necessarily energy-efficient motors (EEMs).

1. Information Sources for Electric Motor Purchase

So that future DOE communications can be directed to decision-makers, respondents were asked to identify the relative importance of various information sources for purchase decisions. As Exhibit 1 shows, engineers within a company were the most important source of information for electric motor purchase decisions. (Engineers were the principal respondents for this study.) Almost two-fifths of the respondents felt that outside consulting engineers and professional meetings or conferences were not at all important as a source of information.

The publication found most useful was Plant Engineering and Power. Almost one-third of the respondents referred to this source for information about electric motors.

About one-third of the respondents said they would consult a motor manufacturer. A similar number mentioned a local supplier as a source of information for the purchase decision.

2. Sources/Suppliers of Electric Motors

Respondents were asked about their use of electric motor sources. This information revealed the predominant distribution channels in use.

Exhibit 1

Importance of Information Sources
for Purchase of Electric Motors

<u>Source</u>	<u>Average Importance*</u>
Engineers within company	3.30
Distributor's representative	2.67
Manufacturer's representative	2.52
Trade and professional publications	2.16
Outside consulting engineers	1.97
Professional meetings or conferences	1.94
Base	(301)

Source: Question 19

*Scale:

- 4.00 = Very important
- 3.00 = Important
- 2.00 = Somewhat important
- 1.00 = Not at all important

The electric motor distributor was a key source of electric motors for 83 percent of all respondents. More than three-quarters of the companies dealing with distributors purchased more than half of their 1979 requirements from distributors.

Manufacturers, however, directly supplied electric motors to 42 percent of the companies responding. Only one-fourth of those firms purchased more than half of their requirements directly from a manufacturer.

Two-fifths of the respondents purchased motors as part of original equipment. In all cases, these motors constituted less than one-half of each firm's annual requirements.

Respondents were also asked what services they expect from their motor supplier. About three-quarters of the respondents said they expect their motor supplier to provide prompt delivery. About one-fourth expected repair/rewind/installation services and up-to-date technical information. Slightly less than 20 percent mentioned competitive prices and a wide range of stock products.

3. Factors Which Influence Energy Conservation Activities

Respondents rated the importance of various factors such as government guidelines and tax incentives, to their energy conservation activities. These ratings contributed to an understanding of what motivates companies to undertake energy-conserving measures.

Four-fifths of the respondents said that rising energy bills are "very important" in influencing energy conservation activities; thus energy costs are by far the most important factor. Each factor is ranked in Exhibit 2. Industry or trade associations were not very important in influencing energy conservation activities.

Exhibit 2

Importance of Factors which
Influence Energy Conservation Activities

<u>Rank</u>	<u>Factor</u>	<u>Average Importance Rating*</u>	<u>Percentage of Companies for Which Factor is "Very Important" %</u>
1	Rising energy bills	3.73	80
2	Payback	3.31	50
3	Capital costs associated with modifications to existing facility	3.24	45
4	High initial cost of equipment	3.15	41
5	Tax incentives	2.97	32
6	Government guidelines on conservation	2.86	30
7	Availability of high-efficiency equipment	2.72	21
8	Industry/trade association pressures	1.95	6
	Base	(301)	(301)

Source: Question 67a

*Scale: 4.00 = Very important
 3.00 = Important
 2.00 = Somewhat important
 1.00 = Not at all important

4. Electric Motor Purchase Decision Factors

An understanding of electric motor purchase criteria will provide direction for future communications efforts. Such criteria or factors include reliability, price, delivery, manufacturer, and distributor relationships. Respondents were read this list of factors. As each factor was named, respondents ranked the factor on a ten-point scale. A rating of 1 meant that the factor "has no effect on the decision" and a 10 rating meant that it was a "very important factor in the decision." Values from 1 to 10 were assigned to the factors. Averages or means were computed and used to compare the importance of one factor with another. Exhibit 3 shows the factors in order of their importance.

The most important factor was reliability, followed closely by price and prompt delivery. Although they were of some importance to almost all respondents, the motor manufacturer and previous relationship with distributor were less important than were other factors. (Prompt delivery was by far the most important vendor service expected by purchasers.)

Energy efficiency, although not on the list, was mentioned by 44 respondents. These respondents ranked it relatively high in importance.

5. Factors Specified for Electric Motors

In addition to identifying electric motor purchase criteria, the study measured what factors are specified and how frequently they are specified. To do this, respondents provided information about motor specification factors such as initial cost, size, type, etc. These factors are ranked in Exhibit 4 for three respondent groups which are not mutually exclusive; that is, a respondent may be in more than one group.

Exhibit 3
Electric Motor Purchase Decision Factors

<u>Factor</u>	<u>Average*</u>
Reliability of motor	8.87
Price	8.62
Prompt delivery	8.40
Manufacturer of motor	6.76
Previous relationship with distributor	6.74
Base	(301)
Not on list but mentioned by 44 respondents:	
Energy-efficiency	8.18

Source: Question 3a

*Averages are based on ratings from 1 to 10:

1 = "Has no effect on decision"

10 = "Very important factor in decision"

Exhibit 4

Importance of Motor Factors in Purchase

Overall Rank	Factor	ELECTRIC MOTORS		MOTORS IN CAPITAL EQUIPMENT
		STANDARD SPECIFICATIONS	NO STANDARD SPECIFICATIONS	
		% of Companies Including Factor in Standard Specifications	How Frequently Factor Is Specified	How Frequently Factor Is Specified
		%	Average*	Average*
1	Voltage	96	3.84	3.91
2	Type (AC, DC, or enclosure)	95	3.67	3.84
3	RPM	91	3.76	3.57
4	Size (HP)	85	3.66	3.47
5	Torque	60	2.46	2.63
6	Efficiency	56	2.22	2.50
7	Power factor	53	2.25	2.48
8	Initial cost	29	2.22	2.37
9	Manufacturer	29	2.08	2.09
	Base	(100)	(201)	(185)

Source: Questions 6, 8a, and 9b

*Scale:

- 4.00 = Always
- 3.00 = Usually
- 2.00 = Sometimes
- 1.00 = Never

- Respondents whose companies had standard specifications for all motors purchased indicated which factors are included in those specifications. This group represents one-third of all respondents.
- Respondents whose companies did not have standard specifications indicated how frequently (always, usually, sometimes, or never) a factor is specified. These respondents represent one-third of all respondents.
- Respondents whose companies provided specifications for motors when purchasing capital equipment which incorporate motors also indicated how frequently each factor is specified. Two-thirds of all respondents were in this category.

As shown in Exhibit 4, technical factors such as voltage, type, RPM, and size apparently play the most important role in motor purchase. Efficiency plays a somewhat lesser role; almost three-fifths of companies with standard specifications included this factor. Initial cost and manufacturer are least likely to be specified.

6. Purchase Criteria: New vs. Replacement Applications

Electric motor purchases can be for new or replacement applications. Any differences in purchase procedures between these applications should be assessed and, if appropriate, reflected in communications with the market.

About two-fifths of the respondents reported that replacement purchase procedures are different from procedures for new applications. Almost one-half of those respondents said that the same make, model or size is more important in replacement. One-fifth said that prompt delivery is more important.

7. Level of Authority for Capital Expenditure Decisions

Communications plans can be enhanced by an understanding of the roles and responsibilities of procurement decision-makers. Respondents were asked to identify corporate levels at which decisions are made and how those levels might vary.

More than one-half of the companies responding said that capital expenditure decisions are made at the plant level (see Exhibit 5). Almost three-quarters of these companies said that this decision level is the same for all motor purchases and/or capital expenditures in general.

When the decision level varies, it is likely to be based on the value or nature of the purchase (replacement or new application). More than one-half of respondents with different procedures said that motor purchases over a certain amount of money must be approved above the plant level. However, higher approval is more likely to be required for other types of equipment. Where non-motor capital equipment is concerned, over three-quarters said that this requirement for higher approval exists.

Engineering plays the most important departmental role in electric motor purchase. Exhibit 6 shows that engineering has a greater influence on the model purchased, funds allocated, and supplier used than does any other department. (Engineers were the principal respondents for this study and findings represent their perceptions.)

8. Method for Evaluating an Investment

The attractiveness of an investment can be influenced by the method of evaluation used. For example, energy-efficient motors compare favorably to standard motors when life-cycle costing is applied. To provide direction for communications efforts, the study assessed methods of evaluating capital investments and the maximum payback periods acceptable.

Exhibit 5

Level of Authority
for Final Capital
Expenditure Decision

	<u>%</u>
Plant	52
Division	10
Corporate	18
Parent	2
Depends on dollar value	18

Base (301)

Source: Question 13a

Exhibit 6

Departmental Influence
on Various Aspects of
Purchase Decision

Departments Which Influence Decision	Decisions:		
	Model and Technical Capabilities	Allocation of Money	Choice of Supplier
	% of Companies	% of Companies	% of Companies
Engineering	91	50	64
Energy management	9	3	2
Plant management	13	42	13
Finance	3	15	4
Purchasing	6	15	48
Maintenance	3	4	5
Base	(301)	(301)	(301)

Source: Questions 11a, 11b, and 11c

Almost one-third of the respondents said they calculate payback period as a way of evaluating an investment. Only half as many use life-cycle costing, the method which would highlight the return on energy-efficient motor investments. Almost one-fifth calculate the average rate of return; 12 percent compute the internal rate of return, and 9 percent calculate the net present value of the investment. Almost one-fourth of the respondents did not know what method of evaluation their company uses.

The average maximum payback period acceptable for the purchase of any motor was 3.3 years. Exhibit 7 shows the overall spread of acceptable payback periods which ranged from less than 6 months to 5 or more years. For most respondents (62 percent), the payback period for motors is shorter than that required for other purchases.

9. Size, Quantity and Use of Motors Purchased

Purchase information regarding the size, quantity and use of motors purchased can be used to target industries and categories of firms. Exhibits 8 and 9 show that in 1979 companies were most likely to have purchased integral polyphase motors of 20 horsepower or less. Less than half of the respondents reported purchases in each of the horsepower categories above 20 horsepower. These categories are: 21 to 25, 26 to 50, 51 to 125, and 126 and over.

As motor size increases, the total number of units purchased decreases. For all motor categories larger than 5 horsepower, companies were far more likely to have purchased 10 or fewer motors during the year.

The most common use for such motors was in pumps. An average of 41 percent of the motors purchased last year were used in pumps. Exhibit 10 shows the average percentage of motors purchased last year for various applications. (The applications for energy-efficient motors are discussed in Section C.)

Exhibit 7

Maximum Payback Period for Motors

<u>Maximum Payback Period Acceptable</u>	<u>Companies %</u>
< 6 months	1
< 1 year	1
< 18 months	9
< 2 years	3
< 3 years	26
< 5 years	28
5 or more years	32
Base	(301)

Source: Question 16

Exhibit 8

Horsepower Categories of Motors Purchased

<u>Integral Horsepower Category</u>	TOTAL MOTORS	REPLACE- MENT MOTORS
	—	—
	% of Companies Purchasing	% of Companies Purchasing
	%	%
1 - 5	86	74
6 - 20	68	53
21 - 25	37	25
26 - 50	45	27
51 - 125	39	22
125 and over	30	16
Base	(301)	(301)

Source: Question 1a and 1b.

Exhibit 9

Number of Motors Purchased

<u>Integral Horsepower Category</u>	<u>Total Units</u>		<u>Number of Companies</u>	<u>Replacement Motors</u>			<u>Number of Companies</u>
	<u>1-10 %</u>	<u>10+ %</u>		<u>1-5 %</u>	<u>6-25 %</u>	<u>26+ %</u>	
1 - 5	47	53	(260)	40	47	13	(222)
6 - 20	74	25	(204)	69	25	6	(159)
21 - 25	81	19	(111)	77	22	1	(74)
26 - 50	82	18	(134)	83	16	1	(81)
51 - 125	91	9	(117)	91	6	3	(66)
126 and over	88	12	(91)	92	8	-	(47)

Source: Questions 1a and 1b

Exhibit 10

Electric Motor Applications

<u>Category</u>	<u>Average Percentage of Motors Purchased Last Year</u>
	<u>%</u>
Pumps	41
Conveyors	29
Machine tools	26
Fans	20
Blowers	18
Compressors	13
Elevators	9
Base	(301)

Total number exceeds 100% because not all companies purchased motors in every category.

Source: Question 2

Companies which purchased 11 or more integral polyphase electric motors last year differ from companies which purchased 10 or fewer motors in a number of ways. Characteristics of large volume purchasers are described below:

- They were more likely to be familiar with and to have purchased energy-efficient motors (EEMs). This finding was especially true for those firms which purchased motors in the higher horsepower categories.
- These purchasers were more likely to have learned of EEMs from manufacturers' literature.
- As motor size increased, there was a decreasing likelihood of purchasing motors from a distributor.
- More than half of 51-125 horsepower motors were purchased directly from a manufacturer (the only horsepower category for which this finding was true).
- They were more likely to view EEM reliability as similar to that of standard motors.
- They were more likely to view EEMs as less available due the product's newness.
- They were more likely to buy motors in higher horsepower ranges.
- They were more likely to have standard specifications, particularly companies purchasing motors in the higher horsepower ranges.
- Price was more important to these firms.
- Payback was more likely to increase in importance as motor size increases.
- The finance department was more likely to influence the choice of a supplier as motor size increases.
- They were more likely to require shorter payback periods, i.e., less than 18 months.
- They were more likely to calculate operating costs based on watts per hour in the higher horsepower ranges.

Characteristics of companies which purchased 10 or fewer integral polyphase electric motors last year, as compared with companies purchasing larger numbers of motors, include the following:

- Previous relationship with distributor and prompt delivery were somewhat more important as purchase decision factors.
- They were more likely to include energy efficiency in standard specifications if they have them.
- Outside sources, manufacturers' representatives, distributors' representatives, and outside consulting engineers were more important in the purchase decision.

B. User Awareness and Purchase Characteristics

1. Market Awareness and Market Penetration of Energy-Efficient Motors (EEMs)

Exhibit 11 depicts overall awareness and market penetration of energy-efficient motors (EEMs). Almost two-thirds (65 percent) of those interviewed said they were familiar with high efficiency or energy-efficient motors. Most respondents read about EEMs in a trade journal or other publication, and almost one-half had received literature from a motor manufacturer or distributor. Only 16 percent of those familiar with EEMs said that they were called on by a motor salesperson; even fewer learned about the motors at a conference or seminar. Exhibit 12 provides details.

Of those who were familiar with the energy-efficient motors, more than three-quarters (77 percent) had considered buying them. Many different reasons for not considering the purchase of energy-efficient motors were given. The principal reason, named by one-fifth, was that the motors cost too much. (Initial cost is discussed in greater depth in Section C.)

Virtually all respondents who purchased EEMs did so within the last few years. Ninety-three percent first purchased EEMs subsequent to 1977. Six percent purchased EEMs in 1977 and one percent first purchased EEMs in 1971. (See Exhibit 12.)

Slightly more than one-third of those who considered purchasing an EEM did not purchase or made no plans to do so. Again, many reasons were named. The one reason named by the greatest number (18 percent) of respondents was that the initial cost was too much higher.

Fifteen percent decided not to purchase any motors. About one-tenth said that the EEM was not appropriate for their application. Exhibit 13 shows the percentages of respondents specifying reasons for not considering or not purchasing EEMs.

Market Awareness and
Market Penetration of
Energy Efficient Motors

Total Respondents: (301)

Source: Questions 23, 25, and 37

Exhibit 12

How Respondents First Learned
About Energy-Efficient Motors

	<u>%</u>
Trade journal or other publication	63
Literature from manufacturer/distributor	47
Motor salesperson called	16
Conference/seminar	12
Newspaper	2
Someone in the company	2
Other	10

Base (197)

Source: Question 24

Year EEM Was First Purchased:

	<u>%</u>
1979	64
1978	26
1977	7
1971	2
Base	(53)

Source: Question 50

Exhibit 13

Reasons for Not Considering
the Purchase of EEMs

	<u>%</u>
Cost too much	20
Don't need any	18
Not available in size or type needed	13
Don't have proper application	9
Other*	49
Base	(45)

Reasons for Not Purchasing
EEMs (after Consideration)

	<u>%</u>
Initial cost is too much higher	18
Decided not to purchase any motors	15
Not appropriate for application	11
No need yet	11
Not available in size or type needed	9
Could not get delivery	4
Other	26
Base	(54)

*"Other" reasons were varied. Although several reasons were related to the product's newness and lack of information, the reasons were not sufficiently similar to form another category.

Source: Questions 26a, and 38a

2. Characteristics of Those Not Familiar with Energy-Efficient Motors

Respondents who said they were not familiar with EEMs differed from the companies which were familiar (and may or may not have purchased them). Some ways in which they differed are:

- Industry pressures and government energy conservation guidelines were much more important.
- These respondents were somewhat more likely to be in the food or paper industries.
- These companies tended to have fewer employees (30 percent had fewer than 100 employees) at the respondent's location.
- Professional meetings and conferences were slightly more important as an information source.
- They were somewhat less likely to purchase directly from a manufacturer.
- These respondents attributed more final purchase decision responsibility to plant management than to engineering. Plant management was also somewhat more likely to influence the choice of model and technical capabilities in companies not familiar than in companies which were familiar with EEMs.
- Most motor purchase decisions were more likely to be made at the same level. The same purchase criteria were more likely to be applied to both new and replacement purchases.

3. Characteristics of Those Which Purchased Energy-Efficient Motors

Following are some observations comparing respondents who purchased EEMs with those who were familiar but did not report EEM purchases:

- Purchasers placed somewhat more importance on rising energy bills, availability of high efficiency equipment, and industry pressures.
- They placed slightly less importance on the initial high cost of equipment.

- These respondents were somewhat more likely to be in the chemical industry. (One-half of chemical firms represented in the study purchased EEMs. Firms in this industry were more likely to be aware of EEMs and more likely to have considered purchasing EEMs.) Between 24 and 31 percent of the respondents in the food, paper, petroleum, and metals industries purchased EEMs.
- They were more likely to consider energy efficiency when making purchase decisions.
- These firms were more likely to have learned of EEMs from manufacturers' literature although the principal source of information for all groups was trade journals and other publications. These publications were also relatively more important in the purchase decision, as were company engineers. In particular, Plant Engineering and Power was much more likely to be relied upon. The motor salesperson was not an important influence.
- The purchasing department of these firms was more likely to influence the decision to buy and choice of supplier than the purchasing department of non-purchasers of EEMs.

1. Perceptions of Energy-Efficient Motors

Following are perceptions of firms which were familiar with energy-efficient motors regarding various aspects of the motors:

a. Reliability. Although reliability was the most important purchase decision factor, approximately 40 percent of the respondents did not know how the reliability of EEMs compared with that of standard motors. A similar number felt that the reliability of standard motors and EEMs was the same. No respondents who purchased EEMs felt that the motors were less reliable than standard motors.

b. Availability. Almost two-thirds of the respondents perceived EEMs as less available than standard motors. Non-EEM purchasers were more likely to feel this way than were those who purchased the motors. Reasons attributed related to the newness of the product and the fact that manufacturers are not geared up for production yet.

c. Applicability. About two-thirds of the respondents felt that EEMs were widely applicable. Respondents who purchased EEMs were more likely to report their wide applicability than were those who did not.

d. Operating Costs. Very few respondents felt that the operating costs of EEMs were somewhat higher than those of standard motors; 4 percent felt they were the same, and 74 percent said the costs were somewhat lower. Almost one-fifth of the respondents did not know how operating costs compared.

Although perceptions of operating costs did not differ dramatically among the groups of purchasers and non-purchasers, those who purchased were more likely not to know how the operating costs compared. Forty-four percent of EEM purchasers said they did not collect information on the costs and savings associated with EEMs. Most of those who did know noted lower energy requirements as the reason for lower operating costs.

2. Reasons for Not Purchasing Energy-Efficient Motors; the Impact of Initial Cost

Of the respondents familiar with EEMs, about 75 percent perceived the initial cost to be higher than that of standard motors. One-half provided a variety of reasons for not purchasing or not considering energy-efficient motors. No more than 20 percent of these firms named the same reason. Initial cost, cited by one out of five, was the main reason for not considering or not purchasing energy-efficient motors. Exhibit 13 displays the various reasons that were mentioned by firms which did not consider EEMs and firms which considered but did not purchase the motors.

The companies which actually purchased EEMs, however, were more likely to view the cost as "somewhat higher." Many non-purchasers perceived the cost of EEMs to be "much higher" than standard motors but, as a group, were also less likely to know what the cost differences are. Exhibit 14 shows a comparison of perceptions based on purchase behavior.

Following are some observations of respondent firms' characteristics and behavior with respect to initial cost:

- Overall, most (69 percent) of the companies which have standard specifications did not include initial cost in those specifications.
- Firms with revenues of \$50 million or more were more than twice as likely to specify initial cost than were firms with less than \$50 million in revenues.
- More than 90 percent of the firms with a batch process did not specify initial cost.
- The larger the company, the more likely the initial cost of EEMs was perceived as "much higher" than standard motors.
- Of EEM purchasers, those in the petroleum industry were most likely to view initial cost as "much higher" than that of standard motors. (The petroleum firms were less likely to include initial cost in standard specifications.)

Exhibit 14

Perceptions of
Initial Cost of Energy-Efficient Motor
as Compared with Standard Motors

<u>Initial Cost of EEM as Compared with Standard Motors</u>	<u>Considered</u>		<u>Did Not Consider</u>
	<u>Pur- chased</u>	<u>Did Not Purchase</u>	
	<u>%</u>	<u>%</u>	<u>%</u>
Much higher than	8	13	22
Somewhat higher than	66	65	56
The same as	3	6	-
Somewhat lower than	1	-	-
Much lower than	-	-	-
Don't know	-	17	10
Base	(98)	(54)	(45)

Source: Questions 27, 39, and 52

- The average acceptable EEM payback period which would be required by non-purchasers was just under two years.
- The importance of price as a purchase factor tended to increase with motor horsepower but not necessarily with the quantity of motors purchased. (Price appeared to be somewhat more important to firms in the primary metals industry.)

- Price was more important to companies which
- include initial cost in their specifications. These firms are also more likely to specify price for motors in original equipment and more likely to be purchasers of ten or fewer motors in a year.

- The fewer employees firms had, the more
- frequently they tend to specify initial cost.

3. Applications for Energy-Efficient Motors

As Exhibit 15 shows, energy-efficient motors purchased in 1979 were most likely to be used in pumps or fans and were least likely to have been used in elevators. Almost 70 percent of those with EEMs said they are widely applicable in their company. Only 15 percent said they are applicable only to specialized equipment, usually large horsepower pumps, blowers and fans.

Although EEM applications, for the most part, parallel applications for all motors (standard and EEM), some differences were noted. The percentage of firms purchasing EEMs was compared with the percentage of firms purchasing any electric motors (standard and EEM). This comparison revealed that EEMs were slightly more likely to be purchased for use in fans and less likely to be purchased for use in machine tools and conveyors than were standard motors purchased in 1979.

Respondents from companies which did not buy EEMs were slightly less likely to feel that EEMs are widely applicable. Instead they were more likely to envision specialized applications within their company.

Exhibit 15

Applications for Energy
Efficient Motors

<u>Application</u>	<u>% of Companies</u>
Pumps	42
Fans	32
Blowers	24
Conveyors	19
Compressors	13
Machine tools	10
Elevators	4
Other	11
Base	(98)

Source: Question 51

4. Number and Size of Energy-Efficient Motors Purchased

Respondents who purchased EEMs indicated the number of EEMs (total and replacement) they had purchased in 1979 in each of the following horsepower categories: 1 to 5, 6 to 20, 21 to 25, 26 to 50, 51 to 125, and 126 and over.

Two-fifths or 40 percent of EEM purchasers bought EEMs in the 1 to 5 horsepower category. Slightly more than one-fourth bought EEMs in the 6 to 20 horsepower category. Between 12 and 19 percent of EEM purchasers bought EEMs in each of the four higher horsepower categories. The average number of motors purchased per company within each category was eight.

Overall, the percent of total respondents purchasing energy-efficient motors in each horsepower category ranged from 10 to 17 percent. EEMs were less likely to be purchased in more than one motor size category than were standard motors. EEMs were also less likely than were standard motors to be purchased for replacement purposes. Approximately 35 percent of the energy-efficient motors were purchased for replacement purposes.

5. Time Required to Study EEMs before Recommending

Finally, the average time for studying EEMs before a recommendation would be made was 4 months for those who did not consider buying any EEMs. About two-fifths of these respondents said study would take one month, and almost 30 percent indicated that study of EEMs would take 6 more months.

Respondents who did consider purchasing EEMs but decided not to said that it would take an average of 2.8 months to study EEMs before recommending them. About three-fifths said it would take one month, and 15 percent said study would take 6 or more months.

D. Influence of Engineering Firms

The engineers who were interviewed for this part of the study were involved in the design or construction of large industrial plants. All were involved in the specification of electric motors, and all felt that EEMs are coming into wider use. This trend is expected to continue and accelerate. The overriding reason for increased use of EEMs is rising energy costs.

At present, attitudes toward EEMs range from extremely favorable to fairly negative. For the most part, engineers specify EEMs only upon client request. The biggest obstacle appears to be the client. Many EEM users are first-cost oriented, do not request EEMs, or do not calculate life-cycle costs, according to respondents.

Another major barrier may rest with the motor manufacturer. Respondents believe that guaranteed efficiencies are not available. The motor users simply do not know what they are buying for the extra cost. (Guaranteed efficiencies may be difficult to provide since motor efficiency may vary with application and ambient conditions.)

These barriers and others are further described in the sections which follow. The findings from the interviews with engineers who specify motors are broken out by category, depending on whether the findings relate primarily to the engineering firm which specifies the motor, the motor manufacturer, or the motor user.

1. Engineering Firms

For the most part, EEMs are evaluated only upon client request. Many respondents first investigated EEMs at the request of a client. For some engineering firms, however, alternative evaluations of both standard and energy-efficient motors are

becoming standard practice. One respondent said his firm prepares calculations for standard motors, and EEM evaluation involves little extra cost. When recommended, EEMs are usually accepted by the client. This respondent is employed by a very large engineering and construction firm in the primary metals industry.

Motor manufacturers' programs for calculating and comparing costs are available, and some firms say that all the parameters and formulae for evaluation are well known. However, the calculations can be complex. Once operating parameters are included, the engineering firm's client must apply the appropriate cost of capital and tax rate to complete the analysis. Unless the client requests, there is little incentive for most engineering firms to perform these evaluations.

Some engineers feel that the cost of their time for performing the evaluations may outweigh any energy savings to the client. If calculations are not included in the contract, the time spent researching, comparing costs, and justifying EEMs will dilute the contractor's profits. Under a fixed price contract, such calculations would never be considered for motors smaller than 200 horsepower.

Some respondents specify EEMs according to operating hours -- for example, if motors are operated 1,000 hours or more per year. One respondent, with one of the largest engineering and construction firms in the petrochemicals industry, said that payback in this case occurs within three or four months. When subcontracting to motor suppliers, one engineering firm evaluates kilowatt losses at a fixed dollar rate.

A respondent, who represents a medium sized engineering and construction firm in the petrochemicals industry, felt that EEMs are not worthwhile since every motor under 100 horsepower is approximately sized as follows:

<u>Horsepower Required</u>	<u>Extra Horsepower Specified</u>
Under 10	25%
10 to 30	20%
31 to 50	15%
51 to 100	10%

Another individual, a consulting engineer who heads a small technical analysis firm, felt that there is more to be gained by specifying a correctly sized motor than by specifying an energy-efficient but oversized motor. Overall, a main concern is that the motor work, and a guiding principle is "not to be sued." If HVAC systems can be designed to carry the expected load 97.5 percent of the time (rather than 99 percent of the time) at lower first cost and lower operating costs, engineers are more likely to design for 99 percent, despite the higher costs. "When through, the equipment will have been designed for all but the most far-fetched contingency," said this respondent.

2. Motor Manufacturers

EEMs may be difficult to evaluate because of the lack of efficiency guarantees that could be provided by manufacturers. Engineering firms often do not know how much efficiency they are buying for their client. As mentioned earlier, guaranteed efficiencies may not be possible if efficiency varies with application and operating conditions. Nevertheless, manufacturers maybe able to determine the most prevalent uses and conditions, and provide efficiency guarantees within ranges that are based on identified parameters.

Although this study addresses the one to 125 horsepower motor, most respondents pointed out that manufacturers should improve the efficiencies of motors in excess of 200 horsepower. The following example was provided by a department head in a consulting engineering and design firm in the paper, pulp and tobacco industries.

<u>Size (Horsepower)</u>	<u>Number of Motors</u>	<u>Total Horsepower</u>	<u>Cost</u>
1 to 15	3,000	30,000	\$1,000,000
200 to 10,000	450	135,000	\$5,000,000

The larger motors, although fewer in number, account for a vastly greater portion of the total horsepower and cost. Thus, their efficiency is more important to the user.

3. Motor Users

The motor user who pays the operating costs is ultimately responsible for accelerating the use of EEMs. Engineering firms do not specify EEMs, because they are not requested to do so by the client. There is little incentive for engineers to undertake analyses for which they may not be paid.

The engineering firm usually deals with the client's project engineering group. Many firms felt that their clients' project groups are primarily interested in lowest first cost. Respondents felt that their clients are also interested in payback periods and many have to be sold on the concept of life-cycle costing. For clients, the relevant life may not be that of the motor but that of the plant (for chemical plants about 7 to 12 years). One respondent said that exposed aluminum surfaces precluded the use of EEMs in certain chemical applications.

Required payback periods varied from less than two or three years for a paper client to four years for a petrochemical firm. Respondents said their clients are primarily concerned with motors larger than 200 horsepower. The example in the previous section illustrates why.

One respondent said that most domestic clients have not been including efficiency standards in contracts. However, this firm's international clients require efficiency data for plant operations and tie operating efficiency to additional contractor profits.

This firm is a very large design, engineering and construction firm in the petroleum refining and petrochemicals industry.

This respondent also said that utilities require contractors to guarantee energy consumption in their bids. If measured efficiency in operation is not better than or equal to that stated in the bid, the supplier is penalized. For other types of plants, the focus is not economy of operation but rather performance of equipment and how well the product meets specifications.

E. Market Penetration

This section provides an estimate of the market penetration of energy-efficient electric motors (EEMs) in the one to 125 horsepower range. Market characteristics of a subset of motors in the one to 25 horsepower range will be discussed as well. General trends toward the adoption of EEMs, the influence of recent electricity cost increases and the effects government policy will also be discussed briefly.

Data from the motor users' survey and analysis of engineering firms will provide a basis for the market penetration analysis. Secondary sources such as the U.S. Department of Commerce, Bureau of the Census and the National Electric Manufacturers' Association (NEMA) could not be used since information on EEMs is not isolated from data on standard motors. The 1976 study of EEMs by Arthur D. Little, Inc., (ADL) and several working memoranda to Argonne National Laboratory (1979) were used to supplement primary data.

The motor users surveyed were firms in the five most energy-consuming industries. The market penetration of EEMs within this market may be greater than for industry in general. In conformance with OMB Supporting Statement for CS-499S/M, the data generated by the motor users' survey will not be used to make national projections of EEM sales and motor purchase and usage rates. National projections of industrial energy conservation resulting from the purchase and use of EEMs will also not be made.

1. EEM Awareness and Purchase Rates

There appears to be a relatively high level of awareness of EEMs. The survey of motor users revealed that:

- About two-thirds of users surveyed were familiar with EEMs.
- About one-half had considered buying EEMs.
- One-third actually purchased EEMs.

a. EEM Purchases Analyzed by Numbers of Firms

Exhibit 16 shows the number of firms which purchased EEMs in each size category. For each category, about 13 percent of the firms surveyed purchased at least one EEM. For replacement motor categories, 11 percent of the firms surveyed purchased at least one EEM.

As Exhibits 17 and 18 show, the awareness and purchase rates of EEMs are highest for firms in the chemical industry and for plants with 500 or more employees. Manufacturing process type does not make a significant difference with respect to awareness of EEMs.

b. EEM Purchases Analyzed by Motor Units

As Exhibit 19 shows, EEM market penetration for all 1979 motor units purchased by survey respondents was less than 10 percent. Not known, however, is which portion of the remaining 90 percent or so represents cases in which EEMs are not economically feasible. A previous ADL study estimated that about 30 percent of all motors receive too little use to be potential EEM applications. As electricity costs rise, however, the motor usage breakeven point will drop.

In terms of total units, EEMs are somewhat less likely to be purchased for replacement purchases than are standard motors. However, as also shown in Exhibit 19, replacement motors larger than 25 horsepower are more likely to be EEMs. Motors of 25 horsepower or less will be discussed in a later section.

Exhibit 16

Market Penetration of EEMs
Based on Number of Firms

Horsepower Category	<u>All Motors</u>		<u>Replacement Motors</u>	
	Number of Respondents Purchasing Motors in This Category	% of Firms Purchasing EEMs in This Category	Number of Respondents Purchasing Replacement Motors	% of Firms Purchasing Replacement EEMs in Category
1 - 5	(260)	15%	(222)	10%
6 - 20	(204)	12	(159)	10
21 - 25	(111)	17	(74)	15
26 - 50	(134)	12	(81)	9
51 - 125	(117)	10	(66)	11
126+	(91)	13	(47)	11

Weighted Average: 13%

11%

Source: Questions 1a, 1b, 49a, 49b

Exhibit 17

Awareness and Purchase of EEMs by Industry
 (Based on Number of Firms)

<u>Industry</u>	<u>Number of Firms</u>	<u>Purchased EEMs</u>	<u>Familiar but Did Not Purchase</u>	<u>Not Familiar</u>
Chemicals	(69)	51%	23%	26%
Petroleum	(46)	24%	37%	39%
Paper Products	(65)	31%	29%	40%
Food	(60)	28%	32%	40%
Primary Metals	(61)	25%	46%	30%
Base	(301)	(98)	(99)	(104)

Source: Questions 23, 25, 37 and 72

Exhibit 18

Awareness and Purchase of EEMs by Company Size
(Based on Number of Firms)

	<u>Number of Firms</u>	<u>Purchased EEMs</u>	<u>Familiar but Did Not Purchase</u>	<u>Not Familiar</u>
<u>Number of Employees</u>				
Less than 100	(62)	21%	15%	50%
100 to 249	(71)	35%	27%	38%
250 to 499	(64)	33%	30%	38%
500 to 999	(53)	38%	38%	25%
1,000 or more	(51)	37%	45%	18%
Base	(301)	(98)	(99)	(104)

Source: Questions 23, 25, 37 and 71

Exhibit 19

Market Penetration of Energy-Efficient Motors
(Based on 1979 Motor Units Purchased By Survey Respondents)

Replacement Motors

<u>Motor Size</u> <u>(Horsepower)</u>	<u>Total</u> <u>Units</u>	<u>EEMs as</u> <u>a % of</u> <u>Total Units</u>	<u>Total</u> <u>Replacement</u> <u>Units</u>	<u>Total</u> <u>Replacement</u> <u>Units as a</u> <u>% of</u> <u>Total Units</u>	<u>% of</u> <u>EEM Units</u> <u>Used for</u> <u>Replacement</u>	<u>Replacement</u> <u>EEMs as a</u> <u>% of All</u> <u>Replacement</u> <u>Motors</u>
		<u>%</u>		<u>%</u>	<u>%</u>	<u>%</u>
1 - 5	(6,623)	6	(3,709)	56	40	4
6 - 20	(2,407)	11	(1,145)	48	34	8
21 - 25	(1,004)	16	(381)	38	31	13
26 - 50	(995)	14	(314)	32	34	15
51 - 125	(752)	13	(226)	30	43	19
126+	(688)	11	(133)	19	33	18
TOTAL	(12,469)		(5,908)			
Aggregate %:		9		47	36	7
Base for aggregate %:	(1,093)			(5,908)	(397)	(5,908)

Source: Questions 1a, 1b, 49a, 49b

Rapid penetration of EEMs in the electric motor market has been a recent occurrence. Virtually all users surveyed first purchased EEMs within the last few years:

Year EEM was first purchased:

	<u>%</u>
1979	64
1978	26
1977	7
1971	2

Base (53)

Source: Question 50

Recent increases in electricity costs may account for the figures shown above. During the analysis of engineering firms, in-depth discussions with engineers, who were usually department heads and construction firms, revealed that the rising cost of energy will be the pivotal factor in their clients' decisions to use EEMs.

2. Analysis of EEMs in the One to 25 Horsepower Range

Electric motors of 25 horsepower or less represent a major segment of the motors in the one to 125 integral horsepower range. The survey of electric motor users revealed that 80 percent of all integral horsepower motors purchased by respondents in 1979 were motors of 25 horsepower or less. (See Exhibit 20.) The U.S. Department of Commerce reports similar figures although the motor categories are not directly comparable (one to 5 horsepower, 5.1 to 20 horsepower and so forth). Nevertheless,

Exhibit 20

--One to 25 Horsepower Motor Units--
Comparison with Motors Over 25 Horsepower

Percentage of Total Units Purchased in 1979, by size:

<u>Horsepower</u>	<u>Standard Motors</u>			<u>EEMs</u>			<u>All Motors</u>			
	<u>New</u>	<u>Replacement</u>	<u>Total</u>	<u>New</u>	<u>Replacement</u>	<u>Total</u>	<u>New</u>	<u>Replacement</u>	<u>Total</u>	<u>Base</u>
1 - 25	73%	90%	81%	72%	71%	72%	73%	89%	80%	(10,034)
Over 25	27%	10%	19%	28%	29%	28%	27%	11%	20%	(2,435)
(Base)	(5,865)	(5,511)	(11,376)	(696)	(397)	(1,093)	(6,561)	(5,908)	(12,469)	(12,469)

Percentage of Units Purchased for Replacement, by size:

	<u>Standard Motors</u>	<u>EEMS</u>	<u>All Motors</u>
1 - 25	54%*	36%	52%
(Base)	(9,250)	(784)	(10,034)
Over 25	26%	37%	28%
(Base)	(2,126)	(309)	(2,435)

*Read: 54% of the standard motors in the 1 - 25 range were used for replacement.

Source: Questions 1a, 1b, 49a, 49b

shipments of one to 20 horsepower motors accounted for 90 percent of the units and 59 percent of the dollar value of electric motors from one to 125 horsepower shipped in 1979.³ Exhibit 20 also shows that energy-efficient motors of 25 horsepower or less were not as likely to be purchased for replacement purposes as were standard motors. (More than one-half of the one to 25 horsepower standard motors were for replacement while only slightly more than one-third of the EEMs in that range were for replacement.) On the other hand, EEMs of 26 horsepower or more were more likely to have been purchased for replacement purposes than were standard motors.

As Exhibit 21 shows, the penetration of EEMs in motor sizes of 25 horsepower or less is about 8 percent for all motors (10 percent for the new applications and only 5 percent for replacement motors). EEMs have a larger share in motor sizes above 25 horsepower. The data do not reveal how many of the motors represent actual potential EEM opportunities; as mentioned earlier, about 30 percent of all motors may receive too little use to be justified for EEM replacement. Some of the engineers interviewed for the analysis of engineering firms felt that users are more concerned with the efficiencies of motors larger than 200 horsepower. There may be 6 to 7 times more motor units of less than 15 horsepower, but these units represent only about one-fifth of the total horsepower used and dollars spent.

³"Motors and Generators," Current Industrial Reports, Census Bureau, U.S. Department of Commerce, 1979.

Exhibit 21

One to 25 Horsepower Motor Units
Comparison with Motors Over 25 Horsepower

EEM Market Penetration:

<u>Horsepower:</u>	New Application	Replacement	All Motors
1-25 (Base)	10% (4,799)	5% (5,235)	8% (10,034)
Over 25 (Base)	11% (1,762)	17% (673)	13% (2,435)
All Motors (Base)	11% (6,561)	7% (5,908)	9% (12,469)

SOURCE: Questions 1a, 1b, 49a, 49b

F. Distribution Channels

In 1979, Arthur D. Little, Inc., (ADL) prepared several working memoranda for Argonne National Laboratory on distribution channels for electric motors. Because these data are recent, no attempt will be made to duplicate the in-depth interviews that were conducted with original equipment manufacturers (OEMs) and with motor manufacturers. These findings will be synthesized with primary research -- the results of the electric motors users' survey and the analysis of engineering firms -- and with recent trends such as rises in energy costs.

Exhibit 22 shows the number of manufacturers, number of units and value of total shipments of integral horsepower polyphase induction motors in each horsepower category. Not known is exactly how many distributors and OEMs sell one to 25 horsepower motors or products which incorporate those motors. Department of Commerce publications on materials consumed do not provide this information.

Thomas Register (1979) lists approximately 350 electric motor manufacturers and distributors. Not all of the firms listed sell the type of motor being studied, and OEMs are not included. (Trade associations were not willing to provide information on their members.) Exhibit 23 shows the distribution channels (based on numbers of motor units sold to end-users) for electric motors, and Exhibit 24 shows the sources of electric motors as reported by survey respondents. Although the motor users surveyed reported that distributors are a principal source of electric motors, the ADL estimates show that only 18 percent of electric motors are sold by the distributor to the end user. Since distribution channels are not likely to shift significantly in a year or so and survey respondents represented five industries, the ADL estimates are probably more representative of the actual situation.

Exhibit 22

Manufacturers of Integral Horsepower
Polyphase Induction Motors 1979 *

<u>Horsepower</u>	<u>Number of Manufacturers</u>	<u>Number of Units</u>	<u>Value of Total Shipments (\$1,000)</u>
1-5	35	1,417,349	\$178,668
5.1-20	32	473,204	138,544
21-50	25	155,556	117,348
51-125	19	59,069	104,359
126-200	18	19,461	79,548
201-500	15	8,171	82,827
Over 500	12	<u>3,858</u>	<u>162,764</u>
	Total	2,136,668	\$864,058

Total firms manufacturing integral horsepower motors and generators
other than for land transportation equipment: 63 firms

*Does not include motors classified by case diameter, 1 hp and over.
(Approximately 2 million shipped in 1978.)

Source: "Motors and Generators," Current Industrial Reports, 1978,
U.S. Department of Commerce, Bureau of the Census.

Exhibit 23

Distribution Channels for Electric
Motors (Average Sales in Units per Year)

<u>Motor Size</u> <u>(Horsepower)</u>	<u>Number of</u> <u>Motors</u> <u>(000s)</u>	<u>Mfr.</u> <u>(%)</u>	<u>Sources of Motors</u> <u>Sold Directly to</u> <u>End-User</u>		
			<u>Distributor</u> <u>(%)</u>	<u>OEM</u> <u>(%)</u>	<u>A/E</u> <u>(%)</u>
1-20	(3,724.2)	2	17	79	2
21-50	(152.0)	4	28	65	3
51-125	(59.7)	15	33	45	7
All Motors (1-125):		2	18	78	2

Total Motor Units: 3,935,900

Source: Working memorandum No. 71 to Argonne National Laboratory, dated 8/14/79, Arthur D. Little, Inc., estimates.

Exhibit 24

Survey of Motor Users:
Sources of Electric Motors

<u>Source</u>	<u>Base</u>	<u>Percentage of Motors Purchased from Source</u>		<u>Percentage of Respondents Purchasing Through Source</u>
		<u>1% to 50%</u>	<u>51% to 100%</u>	
Manufacturer	(125)	74%	26%	42%
Distributor	(249)	22%	78%	83%
As part of original equipment	(122)	100%	--	41%

Source: Question 12

1. OEMs

Original equipment manufacturers (OEMs) account for the vast majority of motor manufacturers' sales of electric motors of 50 horsepower or less. Estimates by Arthur D. Little, Inc., (ADL) based on 1977 data attributed 74 percent of the 3.7 million one to 20 horsepower motor sales and 60 percent of the 152,000 21 to 50 horsepower motor sales to OEMs.

The three most important motor purchase criteria (performance, reliability and delivery) can usually be met by several manufacturers. As a result, price often becomes the major decision factor, particularly when a manufacturer's product is subject to foreign competition. For the most part, OEMs feel that the end-users have not been concerned with energy-efficiency, and, hence, there is little incentive for the OEM to initiate use of energy-efficient motors in equipment. (The OEM also wants to be sure that the equipment will not fail during the warranty period.)

Following is a list of equipment categories with a brief description of some of the major issues for manufacturers of each type of equipment:

a. Pumps

- They are the most common application for electric motors; centrifugal pumps receive the widest use. A major impediment to more efficient but more expensive pumps is the "first cost syndrome," but incentive for purchasing efficient equipment will strengthen as energy costs rise.⁶

⁶ Settles, Gary S., et al., "Energy-Efficient Pump Utilization," Journal of Energy, January, 1977, pp. 65-72.

- The motor users surveyed reported that more than one-third of the motors purchased in 1979 were used in pumps.
- The paper and pulp industry is becoming more efficiency conscious.
- Customer pressure has prompted action to upgrade pump efficiencies in certain categories.
- There is a tendency to oversize the pumps.
- Most pumps are rebuilt twice during their life.

b. Fans and Blowers

- The survey of electric motor users revealed that, on the average, respondents used about 38 percent of the electric motors purchased in 1979 for fans and blowers.
- OEMs feel that end-users are not fully aware of EEM availability, quality or advantages.
- Fans and blowers are part of the HVAC system and are purchased from a manufacturer's representative.
- Energy-efficiency concerns of the user are not communicated directly with the manufacturer. (Manufacturers offer to substitute other motors for their standard motor.)
- Motors compete (for use in fans) on the basis of performance, quality, noise level, energy-efficiency, and price. In general, motors are ordered on the basis of serviceability, life expectancy, delivery, and price.
- A motor may be replaced 3 or 4 times during the life of a fan or blower.
- A motor can account from 10 to 50 percent of the product's cost, depending on the materials used in manufacturing the product.

c. Compressors

- An average of 13 percent of the motors purchased by users surveyed were for use in compressors.
- All motors under 15 horsepower (representing one-third of the dollar volume) are used intermittently; motors from 15 to 50 horsepower are used by both continuous users and intermittent users, while all compressors over 50 horsepower are almost always used continuously.
- Although end-users were said to be concerned with efficiency, reliability and serviceability are more important. Not surprisingly, continuous users are more concerned about efficiency than are intermittent users.
- Because they are more likely to be used intermittently, EEM motors of 25 horsepower or less may not provide an economic advantage when used in compressors.
- A motor will probably be replaced at least once during the life of a compressor.
- The compressor industry is "starting to examine" EEMs. (Efficient reciprocating compressors increased in market share as a result of the 1973 oil embargo.)
- The cost of motors accounts for about 10 to 20 percent of the cost of a compressor.

d. Machine Tools

- Motor users surveyed used about one-fourth of the motors purchased in 1979 in machine tools.
- The machine tool industry is cyclical in nature and sensitive to the treatment of corporate consumption allowances.
- Foreign competition has recently made significant inroads to the U.S. market.
- Firms in this industry do not perceive many end-users to be energy-conscious (except those large firms with energy policies).

- Motors account for 4 to 5 percent of the cost of the final product; they are replaced twice during the product's lifetime.

e. Air Conditioning

- A very small percentage of the motor users surveyed purchased motors for use in HVAC equipment in 1979.
- This industry has been closely examined for efficiency and the effects of government regulation.
- The energy-conscious segment of this industry's market was reported to be between 5 and 25 percent. The large industrial user is more concerned with efficiency than is the speculative builder. In many cases, by the time the end-user is involved, air conditioning is a minor factor in the building project.
- As was evident in the analysis of engineering firms, many HVAC systems are over-designed. The design of multi-stage central build-up systems is a growing trend that is economical in large buildings and will eliminate the tendency to over-design HVAC systems.
- The principal HVAC motor purchase factors are reliability, delivery, and price.

In summary, most OEMs perceive the energy-conscious segment of their market to be small. OEMs are primarily concerned with reliability and low cost.

The economics of energy-efficient equipment for the user are influenced by the cost of energy and the use of the equipment. Although rewinding may decrease the size of the replacement market, most types of equipment outlast motors. Thus, there may be significant EEM potential in the replacement market.

OEMs have shown, however, that they will respond to market demand. Efficient reciprocating compressors increased in market share as a result of the 1973 oil embargo, and the compressor industry is starting to examine efficiency. In the pump industry, customer pressure has prompted action to upgrade efficiencies in certain categories of pumps.

Responsibility for change rests with the user, and, as noted earlier, as electricity costs climb, users will begin to look for more efficient equipment. Recognizing this, many motor manufacturers have directed their campaigns to the end-user rather than to OEMs or distributors.

2. Distributors

Distributors account for about 23 percent of the 3.7 million one to 20 horsepower motor units and 35 percent of the 152,000 21 to 50 horsepower motors sold by manufacturers. As motor size increases, the distributor's share of electric motor sales also increases. Of the motor users surveyed, more than four-fifths had purchased electric motors from a distributor in 1979.

As representatives of electric motor manufacturers, distributors stock motors that are sold to small OEMs and end-users. The distributors' primary concern is with inventory turn. With the high cost of funds, distributors will not stock items that will not sell readily. They will more likely wait until the item is requested in high volume by customers. The distributors will stock EEMs only as the result of market demand. But until distributors stock EEMs, many motor users, to avoid downtime losses, will buy whatever motor is available that can do the job.

Although some manufacturers approach moderate-sized businesses through their distributorships, manufacturers' experience has indicated that the market pull or end-user oriented approach is the most effective. Most manufacturers are pursuing a market pull strategy.

G. Marketing Constraints

The principal market constraints to the use of energy-efficient motors are:

1. End-user

- May not be aware of efficiencies that can be achieved.
- May lack information on EEM reliability and availability.
- May not know how to calculate life-cycle costs.
- May have a first-cost orientation.
- Response to electricity cost increases may lag actual event.

2. Manufacturer

- Energy-efficient motors may not be a high priority product.
- May perceive users as not being concerned with efficiency.
- May wish to keep motors competitively priced.
- Does not pay the electricity bill of the end-user.

3. OEM

- Efficiency is a combination of the motor and the driven equipment.
- The greater the motor portion of the product's cost, the less flexibility an OEM has to compensate elsewhere for the incremental cost of an EEM.

- May not perceive end-users to be concerned with the energy-efficiency of the motor.
- Desires to keep equipment competitively priced, particularly when there is foreign competition.
- Does not pay the utility bill of the end-user.

4. Engineering Firm

- Likely to evaluate EEMs only upon client request.
- May be risk-averse; over-sizing or over-designing is common; will design for the maximum possible load.
- Perceives that the client's project engineering group is primarily interested in lowest first cost -- operating costs may not be an important factor in evaluation of bids.
- Some engineers feel that the efficiency of motors larger than 200 horsepower is of greater concern to clients than is the efficiency of smaller motors. Motors over 200 horsepower may represent a far greater dollar investment and provide a substantial portion of the total horsepower needed in a plant.

5. Distributor

- Primarily concerned with stock that will turn over quickly.
- EEMs tend to be premium-priced (and the cost of borrowed funds is high).
- May require a large number of customer requests before stocking; but if the motor is not available when needed, the end-user may buy whatever motor is in stock that will do the job.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Most of the constraints to EEM purchase ultimately reflect the awareness, knowledge, and needs of the motor end-user. The first set of conclusions relates to characteristics of the EEM user and non-user groups, perceptions of EEMs, purchase influencers, and initial cost as a barrier. The remaining conclusions address the impact of government programs, rising energy prices, and the current rate of market penetration of EEMs.

1. EEM User and Non-User Characteristics

A surprisingly large portion (two-thirds) of the user respondents were familiar with EEMs; one-half of the aware respondents actually purchased the motors. Survey data provided some insight into the nature of the firms that were most likely to have purchased or to have made plans to purchase EEMs. These data revealed differences among the firms which were already familiar with EEMs. (Some of these firms may have considered and subsequently purchased the motors; others may not have considered or decided not to purchase EEMs.) The section on EEM non-user groups discusses the characteristics of firms which were not familiar with EEMs, or were familiar and did not purchase the motors.

a. EEM Users. Respondent firms in the chemical industry were more likely to be aware of and to have purchased EEMs. (The chemical firms surveyed were equally likely to use a batch or continuous process for manufacturing.) Firm revenues, number of employees at the respondent's location, and type of production process did not appear to affect the likelihood of EEM purchase.

Not surprisingly, the firms which were familiar with EEMs were more likely than firms not familiar with EEMs to place importance on rising energy costs and energy-efficiency in making purchase decisions. Almost two-fifths of EEM purchasers said

that EEMs were high on the capital expenditure priority list in their companies. These firms were also more likely to have learned of EEMs from manufacturers' literature. They were not necessarily more likely to have purchased greater numbers of motors in 1979.

Although EEM uses paralleled applications for standard motors, EEM purchasers were less likely to buy EEMs in more than one motor size category in 1979. EEMs were also less likely to be purchased for replacement purposes than were standard motors. These data suggest that EEMs may not be as available for replacement applications or, more likely, may not be considered for purchase by individuals who are responsible for ordering replacement motors.

EEM purchase appears to be on the rise. First-time purchases, among those interviewed, increased rapidly between 1977 and 1979. Almost two-thirds of the respondents who purchased EEMs first did so in 1979, more than twice the number of respondents who first purchased EEMs in 1978.

b. Non-user Groups. No single industry had a distinctly high percentage of non-users of EEMs. Between 24 and 31 percent of the respondents in the food, paper, petroleum, and metals industries purchased EEMs. However, specific groups of non-users were identified to some extent.

Of those firms which were familiar with EEMs, firms in the food industry were least likely to have considered EEMs. Of the firms which considered EEMs, companies in the primary metals industry were least likely to have purchased the motors.

Respondents in the food and paper industries were less likely to be familiar with EEMs than were respondents in other industries. Firms not familiar with EEMs were also likely to have fewer employees at the respondent's site. The type of manufacturing process and company size did not appear to have any influence on EEM awareness and purchase.

Respondents indicated departments or areas of responsibility which influence purchase decisions such as model and technical capabilities, allocation of money or actual expenditure, and choice of supplier. Although engineering departments had the greatest overall influence, the plant management of firms not familiar with EEMs was somewhat more likely to influence model and technical capability and supplier than was the plant management of firms which were familiar with EEMs. Firms not familiar with EEMs comprised the only group in which plant management was more likely than engineering to influence allocation of money. Plant managers are a secondary communications audience.

Not surprisingly, energy-efficient motors were not high on the capital expenditure priority list of firms which did not consider or purchase the motors. Almost two-thirds of the firms which did not consider purchasing EEMs said that energy-efficient motors are near the bottom of the list with respect to capital expenditures in their company. Low EEM priorities may reflect a need for information about the motors' cost-effectiveness.

2. Perceptions of EEMs

The survey results identified several areas where additional or more accurate information may be required. These areas include reliability, applicability, availability, and economy of EEMs.

a. Reliability. Reliability was the most important factor in the selection of a particular motor. Yet, a significant portion (two-fifths) of respondents familiar with EEMs did not know how the reliability of EEMs compared with that of standard motors. Of respondents who did know, most perceived the reliability of EEMs and standard motors to be equivalent. No EEM purchasers felt that the motors were less reliable than standard motors. If EEMs are actually more reliable than standard motors, reliability, converted to economic benefit, may be a strong incentive for prospective purchasers.

b. Applicability. Uses for EEMs appeared to be another area of uncertainty. Respondents who did not purchase EEMs were less likely to feel that the motors are widely applicable than were EEM purchasers. Almost 70 percent of firms which purchased EEMs said the motors are widely applicable in their company. Only 15 percent of the EEM users felt that EEMs are applicable to specialized equipment (usually large horsepower pumps, blowers, and fans). Information regarding EEM applications may motivate non-users to consider EEMs for uses previously thought infeasible.

c. Availability. Most two-thirds of the respondents felt that EEMs were less available than standard motors. This finding may mean that when prompt delivery is important, respondents may be less likely to consider EEMs.

Prompt delivery was only somewhat important as a purchase factor. One-fifth of the respondents with different replacement purchase procedures said that prompt delivery is more important in replacement. However, unless assured of adequate demand, distributors may be reluctant to stock EEMs and prompt delivery will remain a problem.

One-quarter of those respondents attributed the lack of availability to the fact that manufacturers are not geared up yet. Many reasons for not purchasing EEMs were associated with the product's newness, and some respondents appeared to have a "wait and see" attitude. Communications should keep the market informed of changes in availability, service levels and delivery time.

d. Economy. As will be discussed in Section 4 of the conclusions, respondents perceived the initial cost of EEMs to be somewhat higher and operating costs to be somewhat lower than costs of standard motors. The overall principal motivation for using EEMs appeared to be based on EEM economics or financial value. Payback, the most commonly used evaluation method, obscures the true life-cycle value of EEMs.

About three-quarters of the respondents identified the evaluation method used for capital investments. Two-fifths of these respondents mentioned payback while half as many said they use life-cycle costing methods. Although payback is simple to calculate, the method ignores energy savings beyond the payback period. Since relatively few respondents mentioned using life-cycle costing methods, the economic benefits associated with EEMs may not be readily apparent to prospective purchasers. If adequately described in manufacturer, distributor, and DOE publications, life-cycle costing methods may be a way to overcome objections to initial cost.

Motor price is an important purchase decision factor, and rising energy costs are by far the most important factor in influencing energy conservation activities. As energy costs rise the incremental cost of EEMs will be offset by the motors' efficiency, and the market may increasingly switch to energy-efficient motors. As mentioned earlier, if EEMs are proven to be more reliable than standard motors, reliability, when converted to dollar savings, can also be a powerful motivating factor.

3. Purchase Influencers

Within a firm there appeared to be three separate influencers: engineers, plant managers and purchasing managers. Communications should reflect the roles of these decision-makers.

Although engineers had by far the most influence on the choice of model and technical capabilities, plant management had almost as much influence on the actual decision to allocate the money. The purchasing department played an important role in influencing the choice of supplier.

Communications should be directed to these decision-makers at the plant level. This targeting is particularly important when attempting to reach firms not currently familiar with EEMs. Although headquarters and financial executives are more likely to approve larger or more expensive capital investment decisions--for example, where high horsepower motors are concerned, study findings support the hypothesis that motor purchases are plant-level activities.

Communications audiences can be delineated in other ways such as by application. Communications are more effective if tailored to the requirements or concerns of the targeted audience, such as users of pumps. (More than one-third of the motors are used in pumps.) There may be specific features of EEMs that pertain to a motor's eventual application. Communications can also provide information regarding EEM applications that appear to have been overlooked by the market.

Another example might be users of one to 20 horsepower motors. The greatest motor efficiencies are achieved in this range, and these users comprise a large portion (about 90 percent) of the total market surveyed. Users of one to 20 horsepower motors can be isolated for the sake of tailoring communications to their requirements.

Electric motor manufacturers comprise another communications target audience. Although some manufacturers have developed informational and promotional materials, other manufacturers may not have taken a role in educating the market about EEMs. Polyphase integral horsepower motors have, in the past, been a stable low-growth product for a mature market. EEMs, however, may represent an opportunity for manufacturers to increase their overall market share.

Respondents also indicated how they first learned of EEMs. Manufacturers' representatives were ranked third in importance (out of six sources) as information sources for the purchase of all electric motors. Yet, few respondents first learned of EEMs from manufacturers. Less than one-half of the respondents received manufacturers' or distributors' literature.

Respondents indicated the total number of motors they purchased in 1979. Respondents who purchased 10 or fewer motors that year were less likely to have learned of EEMs from manufacturers' literature than respondents who purchased more than 10 motors in 1979. In all motor horsepower categories, respondents who purchased 10 or fewer motors represented one-half to 90 percent of the market surveyed, an important segment for motor manufacturers.

Purchasers of 10 or fewer motors were more likely to have less than 500 employees at the respondent's site. The more employees and firm revenues reported, the more likely a company was to buy motors in higher horsepower ranges as well as in greater numbers (11 or more) of motors in a year. Firms in the food industry were more likely to purchase 10 or fewer motors in the one to 20 horsepower range. Petroleum and paper firms were more likely to purchase 10 or fewer motors in the one to 5 horsepower range.

The ADL study cited earlier pointed out that manufacturers know how to build EEMs and would do so, provided sufficient demand existed for the motors. DOE can stimulate end-user demand by publicizing data regarding reliability, applicability, and costing methods to the appropriate audiences.

Professional organizations may be a source of information regarding new technologies or new applications. Industry and trade associations, although not a significant source of information in purchase decisions, can potentially assume a more active part in disseminating information about EEMs. The survey revealed that those respondents who were not aware of EEMs tended to place more importance on professional meetings and conferences as a source of information about electric motors.

4. Initial Cost as a Barrier

Virtually all respondents perceived the initial cost of EEMs to be higher than the cost of standard motors. The cost, however, was more likely to be viewed as "somewhat" higher rather than "much" higher. Price was second in importance only to reliability as a purchase decision factor. Nevertheless, no more than one-fifth of those respondents who decided not to purchase EEMs said that initial cost was the reason for not doing so. In addition, most firms did not include initial cost in specifications. These findings seemed to imply that payback or life-cycle costing may overcome problems posed by high first cost.

Although payback requirements may vary by industry and economic conditions, the average acceptable payback period required by non-purchasers for EEMs was just under two years. This period was shorter than that required by all respondents for motors in general.

Payback was the most common method used for evaluating an investment. The method was mentioned by about one-third of the respondents. Most respondents said the payback period required for motors is equivalent to the payback required for other capital investments. Although payback is simple to calculate, the method ignores energy savings beyond the payback period.

Life-cycle costing should be introduced to prospective purchasers. This method, by taking into account energy savings over the life of the motor, will minimize the negative effects of higher initial cost and enhance the attractiveness of EEMs as an investment. (Most respondents were already aware that operating costs of EEMs are somewhat lower.) In addition, since initial cost and manufacturer are least likely to be specified, most companies will be able to purchase EEMs without revising specifications.

5. Impact of Government Programs and Rising Energy Prices

The Arthur D. Little (ADL) 1976 study of energy-efficient electric motors estimated the total potential for energy savings (1977 through 1990) from the use of more efficient electric motors in the industrial and commercial sectors. ADL estimated that without government communications programs, energy consumption savings would reach 34 percent of annual potential in 1990. With effective government programs this potential would approximate 70 percent in 1990.

ADL projections are based in part on a constant 7 percent annual increase in electricity costs (assuming a 5 percent rate of inflation). As shown below, the greater rate of increase in estimated energy consumption savings would occur in the earlier years of the program:

Average Annual Increase in Energy Consumption Savings

	<u>No Government Programs</u>	<u>Effective Government Programs</u>
1980 - 1985	30%	43%
1986 - 1990	19%	18%

Recent increases in the cost of energy are very likely to accelerate the rate at which EEMs are adopted over the next few years, without much effort on the part of the government. Exhibit 25 shows how recent electricity prices have risen far beyond those projected in 1976. Indeed, actual 1980 industrial electricity costs per kilowatt hour have exceeded the costs projected for 1985. Part C of Exhibit 25 shows that an 8 percent inflation rate applied to the EIA projections (Part B, Exhibit 25) results in an average annual increase in electricity costs of about 11-12 percent through 1985, dropping to 8 percent through 1990.

Exhibit 25

Electricity Costs
(Cents per Kilowatt Hour)

A. Arthur D. Little, Inc., 1976 projections:

	<u>1980</u>	<u>1985</u>	<u>1990</u>
Commercial	4.4	6.1	8.6
Industrial	2.3	3.2	4.4

SOURCE: Statistical Year Book of the Electric Utilities Industry, Edison Electric Institute for 1974 base year electrical power costs to which a 5 percent inflation rate was applied.

B. Energy Information Administration 1985 and 1990 projections:

Cents per Kilowatt hour
(Converted from mills/kWhr)

	Actual <u>1980</u>	<u>1985</u>	<u>1990</u>
Commercial	5.7	5.9	5.9
Industrial	3.9	4.3	4.3
World Oil Price/Bbl:	\$23.00	\$37.00	\$41.00

SOURCE: 1980 Annual Report to Congress, E.I.A. 1985 and 1990 costs are stated in 1979 dollars.

C. EIA projections, adjusted for 8% annual inflation:

	Actual <u>1980</u>	<u>1985</u>	<u>1990</u>
Commercial	5.7	9.4	13.7
Industrial	3.9	6.8	10.0

The Arthur D. Little, Inc., (ADL) study of electric motors reported that motor efficiencies in units under 15 horsepower dropped between 1956 and 1976, reflecting declining electricity costs. Although EEMs are available, widespread use of these motors may not be achievable. For example, virtually all air compressor motors under 15 horsepower are used intermittently. These motors represent about one-third of the dollar volume of all compressor motors.⁴ If the ratio of dollars to units for compressors is similar to that of all motors (based on Department of Commerce figures for one to 125 horsepower electric motors), these motors of less than 15 horsepower would represent more than one-half of all compressor motor units. Although compressors account for about 18 percent of industrial electricity consumption⁵ and appear to be a good opportunity for EEM use, when a motor is used intermittently, the economics of EEMs are more difficult to justify.

⁴ADL Working Memorandum No. 76 to Argonne National Laboratory, dated 8/23/79.

⁵ADL study of energy-efficient electric motors, 1976.

6. EEM Market Penetration

As mentioned earlier, the survey of motor users revealed that awareness of EEMs is fairly high (two-thirds of the respondents were familiar with EEMs), that market penetration is about 10 percent, and that this penetration occurred within the last few years. If 30 percent of all motors purchased receive too little use to be economically advantageous EEM applications, the effective penetration rate increases to about 13 percent. This penetration rate far exceeds the 1982 and 1985 projections that were made in the 1978 Commercialization Plan for High Efficiency Electric Motors. Exhibit 26 shows the previous penetration estimates which, when made, were described as conservative for two reasons: Funding for the program was not scheduled to begin until FY 1980, and research to determine the current level of penetration had not been conducted at that time.

Regulations and incentives for the use of EEMs are probably unnecessary. Oil decontrol, electricity cost increases, and general business investment incentives will induce industrial motor users to look for efficient ways to produce goods.

Exhibit 26

Market Overview of High-Efficiency Electric Motors*

<u>Expected Market And Penetration</u>	<u>1982</u>	<u>1985</u>	<u>1990</u>	<u>2000</u>
● Total Market (Quad)	2.6	2.7	3.0	3.6
● Penetration (Quad)	.06	.1	.4	N/A
● Percent of Market Penetrated	2.3%	3.7%	13.3%	N/A

Source: Phase IV Commercialization Plan for High-Efficiency Electric Motors, 9/25/78.

In its role as a catalyst -- providing information which stimulates demand -- DOE appears to have generated some interest in EEMS. A number of the engineering firms interviewed reported having seen the DOE Fact Sheet on energy-efficient electric motors.

Even though the use of EEMS has spurted in recent years, the survey of motor users found that information is needed on life-cycle costing, EEM availability and reliability, and energy-efficient replacement equivalents of standard motors. This information should be communicated to plant engineers who make motor purchase decisions. Outreach tools can include pamphlets or fact sheets, messages in trade journals, and presentations at association meetings. The survey of users found that Plant Engineering and Power is an important source of information for decision-makers. Meetings, however, have not traditionally been a source of information for motor purchase decisions and this approach should be tested. The recommendations outlined in the Survey of Motor Users and the Analysis of Engineering Firms are supported by subsequent findings.

The information described above, coupled with rising energy costs as a pivotal factor, will provide motor manufacturers with receptive markets for their individual promotional campaigns. The recommendations presented here will only accelerate a process that has already been set in motion by soaring energy prices.

Electricity sales in general are expected to experience an average annual increase of 3.4 percent through 1985 and 2.9 percent through 1990. Because of higher prices and efficiency improvements, demand for electricity is expected to increase at less than half the rate of the '60s and early '70s. Commercial growth in electricity sales will be moderate while industrial use of electricity will grow more rapidly than that of other sectors of the economy. This growth will be due to the substitution of electricity for fossil fuels.⁷

Nevertheless, the projected rate of increase in the cost of electricity exceeds the rate at which electric motor prices have risen between 1977 and 1979. (1979 is the most recent year for which Department of Commerce data are available.) If motor price increases continue to average about 7 percent per year while electricity costs climb at 12 percent through 1985, the EEM will be ever more attractive as an investment.

⁷"National Energy Outlook 1980-1990," Shell Oil Company, August, 1980, p.18.

B. Recommendations

The following recommendations cover target audiences, messages, and media. These recommendations are based on the analysis of survey data and also take into account several previous EEM study findings.

1. Target Audiences

Communications should be directed to plant engineers, plant managers, and purchasing managers. Plant engineers are the principle target audience. However, plant managers are also likely to influence the final decision to allocate the money, and purchasing managers are likely to influence the choice of supplier. New construction project engineering groups also influence new plant and equipment expenditures.

End-user audiences can be further refined to include users of specific applications; for example, firms with primarily pump applications. Communications can also be tailored to address any special requirements related to motor size, particularly motors of 20 horsepower or less.

Findings revealed that 1979 purchasers of 10 or fewer motors in the one to 20 horsepower range were a large market segment. These firms were somewhat more likely to be in the food, petroleum, and paper industries.

The ADL study on energy-efficient electric motors reported that about 50 percent of the motor unit volume is purchased through distributors. Although the data do not translate directly to the number of units purchased, this recent survey revealed that in 1979 more than twice the percentage of respondents (83 percent) purchased motors from a distributor as from a manufacturer or OEM (about 40 percent each). Due to their importance, distributors should be informed of DOE activities to

accelerate the use of EEMs by stimulating demand. Since distributors are concerned with inventory turn, many distributors will probably wait until EEMs are in high demand before stocking the motors.

Motor manufacturers comprise another audience. If manufacturers are aware of DOE's commercialization activities, they may be more likely to expand EEM marketing efforts. One particular effort is assistance with EEM cost evaluation. As such opportunities are recognized, the manufacturers' own marketing efforts can displace DOE involvement.

The OEMs, although not a high priority audience, should also receive DOE communications regarding EEMs. The ADL study reported that efficiency is not a concern to OEMs and that the end-user will not question motor characteristics of purchased equipment. This situation appears to be changing. This most recent survey found that more than 60 percent of the respondents provide motor specifications when purchasing capital equipment. Almost one-third of those respondents always specify efficiency, and only one-fourth never specify efficiency. If this trend is growing, OEMs should be informed, since OEMs have shown that they will respond to market demand.

At present, industry and trade associations appear to play a minor role in influencing energy conservation activities. Although these organizations are not currently an important source of information for electric motor purchase they may be a source for information on new technologies or applications. The survey, however, did not address ways to reach these audiences.

2. Messages

Communications to end-users should emphasize respondents' prime motivator with respect to energy conservation activities -- rising energy bills -- and the role of EEMs in reducing energy consumption. Information such as that contained in the "Energy

Efficient Electric Motors" Fact Sheet (DOE/CS-0163) should continue to be disseminated to prospective EEM users. Since few respondents used life-cycle costing methods, sample calculations and instructions for applying the calculation to varying circumstances are important. The key factor in the decision to buy is economic in nature. EEMs must be shown to be cost-effective and available to users. The manufacturer can play a key role in assisting in cost analysis by both end-users and engineering firms.

Because of their primary importance in the purchase decision, any reliability advantages of EEMs should be emphasized. In addition, examples of different industry applications for motors can show users how EEMs may fit their application. Manufacturer-guaranteed efficiency ranges, based on different sets of operating parameters, would allow motor purchasers to have a more accurate picture of how much efficiency is being purchased.

DOE communications should urge motor users to include EEM manufacturers on users' approved vendor lists. Personnel who order motors should be encouraged to consider energy efficiency. Operating data, gathered from EEM users, would be useful for publishing a set of case studies. The case studies can cover a variety of industrial applications and serve as examples of the economic feasibility of EEMs. (Plant Engineering and Power, an important source of motor information, would be a particularly good medium for presenting case study results.) Firms building new plants should be urged to require estimates of operating efficiencies in contractor bids, and costs associated with oversizing motors should be illustrated.

Replacement buyers should have access to reference tables which identify the energy-efficient equivalent of their standard motor. Thirty-six percent of the EEM units purchased by respondents in 1979 were used for replacement purposes. (When replacement purchase procedures differ from motor purchases for

new applications, many respondents reported that purchase of the same make, model or size is more important.) Prompt delivery was also more important for one-fifth of these respondents. Communications regarding availability and delivery are also necessary.

Virtually all EEMs were purchased by respondents within the past few years. Motor users may not be aware that EEMs are a well-known, low-risk technology. As EEM production and distribution are stepped up, communications which dispel beliefs about lack of availability or poor delivery time will overcome negative perceptions. To fill this information need, DOE would have to work closely with manufacturers, dealers, and purchasers.

DOE should provide suppliers with information about commercialization activities and supply the supporting market data. With more data on sales opportunities, suppliers may take a more aggressive stance in promoting EEMs' cost-effectiveness. Unless EEM profit margins justify this approach, suppliers are not likely to go after the market on their own.

3. Media

The most effective way to reach users, particularly engineers, is through print media. DOE's communications to plant engineers should be primarily through Plant Engineering and Power and Electric Construction and Maintenance. These two publications were found most useful for information about electric motors by 32 percent and 16 percent of the respondents, respectively. No other publication was named by more than six percent. Electric Construction and Maintenance would probably be a way to reach individuals responsible for ordering replacement motors.

Almost one-half of the respondents indicated that their purchasing department influences the choice of a supplier. Almost as many said plant management influences the decision to allocate money. As a secondary communications strategy, DOE should investigate ways to reach purchasing and plant management decision-makers.

As discussed earlier, purchasers of 10 or fewer motors in the one to 20 horsepower category were likely to be in the food, paper, or petroleum industries. Since purchasers of 10 or fewer motors in 1979 were somewhat more likely to rely on outside sources of information, manufacturers should make a special effort to reach individual industries. These industries can be targeted through industry publications. Although not mentioned as frequently as Plant Engineering and Power, individual industry publications were cited by some respondents as a source of information in the motor purchase decision. Some examples include Food Processing and Food Engineering.

Users of specific motor applications, such as pumps, may also be reached through trade publications. Communications should highlight the EEM for a particular use. In addition, trade association mailing lists can be used for direct mailings.

APPENDIX A

LETTERS TO RESPONDENTS

Department of Energy
Washington, D.C. 20585

September, 1980

Dear Respondent:

The U.S. Department of Energy appreciates your willingness to participate in this voluntary study of electric motors. The study is being conducted under the Energy Policy and Conservation Act (Public Law 94-163) and the Federal Energy Administration Act of 1974 (Public Law 93-275) as part of our efforts to promote increased energy efficiency.

As you may know, about 60 percent of all the electric power generated in this country is used to power motor-driven equipment. Through the study being conducted by Market Facts, we want to learn more about how motors are purchased and used. This information can be helpful in our efforts to improve energy efficiency. The information you provide will remain anonymous.

Therefore, I want to thank you in advance for your help. If you have any questions on this study or our related electric motor programs, please write or call me at (202) 252-9207.

.V7

Very sincerely yours,

Albert Hayes
Resource Manager
Office of Commercialization
Conservation and Solar Energy
U.S. Department of Energy
Forrestal Building
Washington, D. C. 20585

AH:cel

MARKET FACTS INC. 100 SOUTH WACKER DRIVE CHICAGO, IL 60606 (312) 641-5200

Chicago
New York
Ft. Lauderdale
Washington, D.C.
Los Angeles
Toronto
Montreal
Vancouver

Dear Respondent:

Thank you for agreeing to participate in our study of electric motors for the U.S. Department of Energy. Our interviewer will be calling you at the following appointed day and time:

Day	Date	Time	AM/PM
-----	------	------	-------

During the interview you will be asked about the electric motors your company purchased last year in the 1-125 horsepower range. Some of the questions will concern the sources from which you purchase electric motors, the information used in making a purchase decision, and the departments within your company involved in these decisions. We expect that you will be able to answer these questions by drawing on your experiences with the purchasing of electric motors. You may not know the answers to other questions such as the proportions of motors purchased last year for different applications. On the back of this letter we have listed the information we need which may not be at your disposal immediately. We would appreciate your obtaining the information in advance of the interview so that the actual interviewing can be conducted as efficiently as possible.

This study is being conducted under the authority of the Federal Energy Administration Act of 1974 (Public Law 93-275) and Part D of the Energy Policy and Conservation Act (Public Law 94-163) (42 U.S.C. 6341 et seq). Your participation is entirely voluntary, and the information you provide will remain anonymous.

Enclosed is a copy of a letter from the U.S. Department of Energy explaining the purpose of the study. Your assistance is necessary in carrying out an important energy conservation program.

Our interviewer will be calling you at the appointed time. In the meantime, thank you for your cooperation.

Sincerely,

Nancy Klein
Study Director

NK/dr

Enclosure

INFORMATION NEEDED FOR THE INTERVIEW

1. Numbers of electric motors purchased last year:

<u>Integral Horsepower Category</u>	<u>Total Units Purchased</u>	<u>Replacement Units Purchased</u>
1-5 horsepower		
6-20 horsepower		
21-25 horsepower		
26-50 horsepower		
51-125 horsepower		
126 horsepower and over		

2. Percentage of motors purchased last year to be used in

Fans
 Blowers
 Pumps
 Elevators
 Compressors
 Conveyors
 Machine tools
 Other applications

Total should equal 100%

3. Company specifications for purchases of electric motors - either stand alone or as component parts of other capital equipment such as fans (i.e., cost, size, type, manufacturer, voltage, RPM, torque, power factor, efficiency, other company specifications).
4. Company policy or guidelines for purchasing motors and other equipment.
5. Methods of evaluation used for capital investment calculations (i.e., average rate of return, payback, internal rate of return, net present value, life cycle costing, or other methods).

APPENDIX B

SCREENER QUESTIONNAIRE

MARKET FACTS, INC., 100 SOUTH WACKER DRIVE, CHICAGO, ILLINOIS 60606

B-2

JOB NO. 6327
OMB No. 038-S80004
Exp. 12/31/80

ENERGY EFFICIENT ELECTRIC MOTORS STUDY
- SCREENER -

I.D. No. _____

MARKET FACTS' REP.: _____

FIELD SERVICE ORGANIZATION: _____ NTC _____

DATE: _____ TIME BEGAN: _____ AM/PM TIME ENDED: _____ AM/PM

(ASK TO SPEAK TO THE CHIEF ENGINEER)

Hello, I'm _____ of Market Facts, an independent marketing research firm in Chicago. We are conducting a study of electric motors for the U.S. Department of Energy.

- 1a. Are you the individual who is most knowledgeable about the purchase and use of electric motors.

Yes. 1 → (SKIP TO QU. 2)

No 2

- 1b. I am looking for the individual in your company who is most knowledgeable about integral polyphase electric motors, that is, integral threephase A.C. motors. Can you tell me his or her name please?

Name: _____

Telephone No: _____

(ASK TO SPEAK WITH THAT PERSON. IF HE/SHE IS AVAILABLE, REINTRODUCE YOURSELF AND CONTINUE WITH QU. 1A. IF HE/SHE IS NOT AVAILABLE, SET UP CALLBACK ON SAMPLE CARD.)

(RECORD NEW NAME AND TELEPHONE NUMBER ON SAMPLE CARD.)

2. Market Facts is conducting this study under the authority of the Federal Energy Administration Act of 1974 (Public Law 93-275) and Title III, Part E of the Energy Policy and Conservation Act (Public Law 94-163). Your participation in the survey is entirely voluntary and your responses will remain anonymous.

3. Did your company purchase any integral polyphase electric motors between one and 125-horsepower in 1979?

Yes. 1

No 2 → (THANK AND TERMINATE)

4. Market Facts would like to interview you about your company's purchase and use of electric motors. I would like to mail you a description about the motor information we will be asking you about, then ask you a few questions on the telephone. May I please make an appointment to call you about seven days from now?

Yes. 1 → Date: _____

No 2 → Time: _____ (SKIP TO QU. 6)

5. Is there another person in your company who would be knowledgeable about electric motors?

Yes. 1 →

(ASK FOR THAT PERSON'S NAME AND PHONE NUMBER) →

Name: _____ (Write In:)

Phone: _____ (Write In:)

No 2 → (THANK RESPONDENT AND TERMINATE)

RECORD ID # _____

6. I would like to verify your mailing address and phone number.

Respondent's Name: _____

Title: _____

Company Name: _____

Address: _____

City, State, ZIP: _____

Telephone Number: _____ Ext.: _____

Thank you very much. Your letter will be sent in today's mail. I'm looking forward to talking with you soon.

APPENDIX C

DECISION-MAKER QUESTIONNAIRE

MARKET FACTS, INC., 100 SOUTH WACKER DRIVE, CHICAGO, ILLINOIS

C-2

JOB NO. 6327
OMB No. 038-80004
Expires 12-31-80
Card #1
ID. No. _____

(1-3)
(4-7)

DECISION - MAKER QUESTIONNAIRE

ENERGY EFFICIENT ELECTRIC MOTORS

Market Facts' Rep: _____ 8

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 11
Qualify: Time Began: _____ AM/PM Time Ended: _____ AM/PM
Interview: Time Began: _____ AM/PM Time Ended: _____ AM/PM
DATE: _____

(ASK TO SPEAK WITH QUALIFIED RESPONDENT FROM SCREENER)

Hello, my name is _____ from Market Facts Incorporated, an independent marketing research firm in Chicago. You were called a few days ago regarding a study of electric motors we are conducting for the U.S. Department of Energy. This study is being conducted under the authority of the Federal Energy Administration Act of 1974 (Public Law 93-275) and Title III Part E of the Energy Policy and Conservation Act (Public Law 94-162). Your participation in the survey is entirely voluntary and your responses will remain anonymous. Have you received and read the materials we sent you last week?

Yes 1 → (SKIP TO QU. 1) No 2

(IF RESPONDENT HAS NOT RECEIVED/READ LETTER, SCHEDULE ANOTHER APPOINTMENT IN TWO DAYS.)

Date: _____ Time: _____ AM/PM

(IF RESPONDENT REFUSES, ASK IF THERE IS ANOTHER PERSON IN THE COMPANY WHO CAN ANSWER QUESTIONS ABOUT ELECTRIC MOTORS.)

- A. Are you responsible for the use and ordering of electric motors for any other facility than the one at _____? (READ THE ADDRESS OFF THE BACK OF THE SCREENER)

Yes 1 No 2 → (SKIP TO QU. 1a) (12)

- B. Exactly how many separate facilities are you responsible for the use and ordering electric motors for? (RECORD ANSWER IN BOXES.)

13

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 15

- C. Are you able to give us data for the facility at _____ separately? (READ THE ADDRESS OFF THE BACK OF THE SCREENER)

Yes 1 No 2 (16)

- 1a. I would like some information about the integral polyphase motors your company purchased last year. For each horsepower range that I'm going to read, I'd like for you to tell me the total number of units that your company purchased. (READ EACH CATEGORY AND RECORD TOTAL NUMBER BELOW UNDER QU. 1a.)

- 1b. (FOR EACH CATEGORY IN WHICH THE RESPONDENT REPORTED A PURCHASE IN QU. 1a ASK QU. 1b.) How many of these motors were for replacement purposes? (RECORD ACTUAL NUMBER BELOW UNDER QU. 1b)

INTEGRAL HORSEPOWER CATEGORY	QU. 1a	QU. 1b
	TOTAL UNITS	REPLACEMENTS UNITS
1 - 5 Horsepower	_____ (17-20)	_____ (41-44)
6 - 20 Horsepower	_____ (21-24)	_____ (45-48)
21 - 25 Horsepower	_____ (25-28)	_____ (49-52)
26 - 50 Horsepower	_____ (29-32)	_____ (53-56)
51 - 125 Horsepower	_____ (33-36)	_____ (57-60)
126 Horsepower and over	_____ (37-40)	_____ (61-64)

(65-79 open)

--

 80
Card 2
Dup. 1-3

2. I'd like to remind you that now, and throughout the interview, I am referring to integral polyphase motors. Can you tell me about what percentage of the motors your company purchased last year fall into the following categories of applications.

APPLICATION	%
Fans	(4-6)
Blowers	(7-9)
Pumps	(10-12)
Elevators	(13-15)
Compressors	(16-18)
Conveyors	(19-21)
Machine tools	(22-24)
Other applications (SPECIFY)	(25-27)
	(28-30)

31
32

(TOTAL MUST EQUAL 100%)

- 3a. I am going to read a list of factors that might play a role in decisions to buy electric motors. I'd like you to tell me how important you feel each factor is in selecting a particular motor. We will use a ten-point scale with "1" being "has no effect on decision" and "10" being "very important factor in decision". How would you rate "reliability of motor"? (RECORD BELOW.) And how would you rate "previous relationship with distributor"? (RECORD BELOW.) (CONTINUE RATING ALL OF THE REMAINING FACTORS.)

FACTORS	HAS NO EFFECT										VERY IMPORTANT FACTOR
Reliability of motor	1	2	3	4	5	6	7	8	9	10	(33)
Previous relationship with distributor	1	2	3	4	5	6	7	8	9	10	(34)
Manufacturer of motor	1	2	3	4	5	6	7	8	9	10	(35)
Price	1	2	3	4	5	6	7	8	9	10	(36)
Prompt delivery	1	2	3	4	5	6	7	8	9	10	(37)
Other (SPECIFY)	1	2	3	4	5	6	7	8	9	10	(38)
	1	2	3	4	5	6	7	8	9	10	(39)

40 ☐ 4

- 3b. Can you think of any other factors that might play a role in decisions to buy electric motors?

Yes 1 No 2 → (SKIP TO QU. 4) (42)

(RECORD RESPONSE UNDER "OTHER" QU. 3a.)

- 3c. How would you rate this factor on its importance to your buying decisions still using the 1 through 10 scale. (CIRCLE RATING UNDER QU. 3a.)

- 4a. Does your company have a policy which provides purchasing guidelines based on things such as motor application or dollar size of purchase?

Yes 1 No 2 → (SKIP TO QU. 5) (43)

- 4b. Please briefly describe the key elements of this policy:

44
46

5. Does your company have a set of standard specifications for all motors purchased?

Yes 1 No 2 → (SKIP TO QU. 7) (47)

6. I am going to read a list of specifications. Please tell me which are included in your company's standard specifications (READ LIST. CIRCLE YES OR NO.)

<u>Specifications</u>	<u>Yes</u>	<u>No</u>
Initial cost	1	2 (48)
Size of motor in terms of horsepower	1	2 (49)
Type of motor, in terms of AC, DC or enclosure ..	1	2 (50)
Name of manufacturer	1	2 (51)
Voltage	1	2 (52)
RPM	1	2 (53)
Torque	1	2 (54)
Power factor	1	2 (55)
Efficiency	1	2 (56)
Other (SPECIFY)	1	2 (57)
.....	1	2 (58)
		59 ☐ 60

----- SKIP TO QU. 9a -----

7. Are specifications drawn up each time a motor is purchased?

Yes 1 No 2 (61)

- 8a. I am going to read a list of possible specifications for electric motors. I would like for you to tell me if your company always, usually, sometimes, or never specifies each one. (READ EACH SPECIFICATION AND RECORD RESPONSE.)

<u>Specifications</u>	<u>Always</u>	<u>Usually</u>	<u>Some- times</u>	<u>Never</u>
Initial cost.....	1	2	3	4(62)
Size of motor	1	2	3	4(63)
Type of motor, in terms of AC, DC or enclosure	1	2	3	4(64)
Name of manufacturer	1	2	3	4(65)
Voltage	1	2	3	4(66)
RPM	1	2	3	4(67)
Torque	1	2	3	4(68)
Power factor	1	2	3	4(69)
Efficiency	1	2	3	4(70)
Other specification (SPECIFY)	1	2	3	4(71)
.....	1	2	3	4(72)
				73 ☐ 74

- 8b. Can you think of any other possible specifications for electric motors that your company might specify?

Yes 1 No 2 → (SKIP TO QU. 9a) (75)

(RECORD RESPONSES UNDER "OTHER" ON QU. 8a.)

- 8c. Would your company always, usually, sometimes, or never specify this other specification for electric motors? (CIRCLE RESPONSE UNDER QU. 8a.)

9a. Does your company provide specifications for motors when purchasing capital equipment which incorporate electric motors, such as fans?

Yes 1 No 2 → (SKIP TO QU. 10a) (76)

(77-79 open)

9b. I am going to reread the list of possible specifications for motors. I would like for you to tell me if your company always, usually, sometimes, or never specifies each one when buying capital equipment which incorporates motors, such as fans. ☒ 80
(AFTER READING LIST, RECORD RESPONSE BELOW.)

Card 3
Dup. 1-3

Specification	Always	Usually	Sometimes	Never
Initial cost	1	2	3	4(4)
Size of motor, in terms of horsepower ..	1	2	3	4(5)
Type of motor, in terms of AC, DC or enclosure	1	2	3	4(6)
Name of manufacturer	1	2	3	4(7)
Voltage	1	2	3	4(8)
RPM	1	2	3	4(9)
Torque	1	2	3	4(10)
Power factor	1	2	3	4(11)
Efficiency	1	2	3	4(12)
Other (SPECIFY)	1	2	3	4(13)
	1	2	3	4(14)

15 ☐ ☐ 16

9c. Are there any specifications which I have not read?

Yes 1 No 2 → (SKIP TO QU. 10a) (17)

(RECORD RESPONSE UNDER "OTHER" ON QU. 9b.)

9d. How often does your company specify this? (CIRCLE RESPONSE ON QU. 9b.)

10a. When you are handling the purchase of motors for new applications, are your procedures different than when replacement motors are involved?

Yes 1 No 2 → (SKIP TO QU. 11) (18)

10b. Can you tell me how your procedures differ between new applications and replacement motors? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- Prompt delivery is more important in replacement 1
- Use of same vendor is more important in replacement 2
- Purchase of same make/model/size is more important in replacement 3
- Open stock is more important in replacement 4
- Efficiency and power factor can be considered in new purchases 5 (19)
- Bidders list is used for new applications 6
- Cost benefit analysis is performed for new application 7 (20 Open)
- Other (SPECIFY) _____

The next three questions are about the decision-making process for capital expenditures like motors. Many departments or areas of responsibility can influence the purchase decision in terms of the actual motor and the supplier. Some of these departments or areas of responsibility are ... (READ LIST OF DEPARTMENTS BELOW.)

11a. First, which of these departments would influence the choice of model and technical capabilities needed in your operation? (CHECK ALL AREAS MENTIONED UNDER QU. 11a BELOW.) Are there any other departments not listed which influence the decision? (WRITE IN ON LINES.)

11b. Which departments would influence the actual final decision to allocate the money or make the expenditure on a motor? (CHECK ALL AREAS MENTIONED UNDER QU. 11b BELOW) Are there any other departments not listed which influence the decision? (WRITE IN ON LINES)

11c. Finally, which departments would influence the choice of the supplier that would provide the motor? (CHECK UNDER QU. 11c BELOW) Do any other departments influence the choice of supplier? (WRITE IN ON LINES.)

Department	(21-22) QU. 11a	(23-24) QU. 11b	(25-26) QU. 11c
Engineering	1	1	1
Energy management	2	2	2
Plant management	3	3	3
Finance	4	4	4
Purchasing	5	5	5
Other departments (SPECIFY) _____	6	6	6
	7	7	7

12. I am going to read a list of sources of electric motors, please tell me the percentage of last year's purchases each source accounts for. What percentage of last year's purchases of electric motors were bought ...

	%
Directly from manufacturer.....	(27-29)
From distributor	(WRITE IN) (30-32)
As part of original equipment such as a fan	(33-35)
Other (SPECIFY) _____	(36-38)
	(39-41) 42
(TOTAL MUST EQUAL 100%)	

13a. At which of the following levels of authority would the final decision be made about a capital expenditure such as a motor? Is it at the ...

Plant level	1
Division level	2
Corporate level or	3 (44)
The parent company	4

13b. Is this level the same for almost all motor purchases?

Yes 1 (SKIP TO Q1. 14) No 2 (45)

13c. How does this level differ? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY)

- Larger motors must be approved above plant level 1
- Larger quantities of motors must be approved above plant level 2
- Purchases over a certain amount of money must be approved above plant level 3
- New applications must be approved above plant level 4 (46)
- Replacement motors can be purchased at plant level 5
- Purchases under a certain amount can be made at plant level 6
- Other (SPECIFY) _____

14a. Is the level you mentioned for electric motors the same for almost all capital expenditures?

Yes 1 → (SKIP TO QU. 15) No 2 (48)

14b. In what way is the level different? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY)

- Replacement equipment can be purchased at plant level 1
 New equipment must be approved above plant level 2
 Purchases over a certain amount of money must be approved
 above plant level 3
 Specified items can be purchased at plant level 4 (49)
 Expenditures involving tax credit must be approved
 above plant level 5
 Other (SPECIFY) _____ (50 open)

15. In making the capital investment calculation, which, if any, of the following methods of evaluation do you use? Do you use ...

- Average rate of return 1
 Payback 2
 Internal rate of return 3
 Net present value 4 (51)
 Life cycle costing 5
 Other methods (SPECIFY) _____ (52 open)

16. Thinking in terms of payback period, exactly what would you consider the maximum period acceptable for the purchase of any motor?

(WRITE IN:) MONTHS (53-55)

17. In your opinion, is the period different than for most other purchases?

Yes 1 No 2 → (SKIP TO QU. 19) (56)

18. In what way is this payback period different? Would you say the period is ...

- Longer than the payback period for other purchases or 1 (57)
 Shorter than the payback period for other purchases 2

19. I am going to read a list of possible information sources that might be consulted when deciding to purchase electric motors. Would you please rate the importance of each source of information to your decision as very important, important, somewhat important or not at all important. Would you say the ... (READ INFORMATION SOURCES) is very important, important, somewhat important or not at all important?

	VERY IMPORTANT	IMPORTANT	SOMEWHAT IMPORTANT	NOT AT ALL IMPORTANT
Manufacturer's representative.....	1	2	3	4 (58)
Distributor's representative	1	2	3	4 (59)
Engineers within your company	1	2	3	4 (60)
Outside consulting engineers	1	2	3	4 (61)
Professional meetings or conferences .	1	2	3	4 (62)
Trade and professional publications ..	1	2	3	4 (63)

20. Which publications do you find most useful regarding information about electric motors? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

New Equipment Digest 1
Industrial Maintenance and Plant Operation 2
Engineers Digest 3
Chemical Engineering 4
Materials Management 5 (64)
Plant Engineering and Power 6
Electric Construction and Maintenance 7
Purchasing World 8
Other (SPECIFY) _____

(65 open)

21. What other sources of information, if any, would you consult in making your decision to purchase electric motors? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Motor manufacturer 1
Local supplier 2
Consulting engineer 3 (66)
Another company engineer 4
Other (SPECIFY) _____

(67 open)

22. What kinds of services do you expect from your motor supplier? (DO NOT READ LIST) (PROBE:) What other kinds of support do you expect your supplier to provide? (CIRCLE ALL THAT APPLY.)

General consulting services 1
Analytical services 2
Competitive prices 3
Periodic service calls 4
Reduced costs 5 (68)
Up-to-date technical information 6
Wide range of stock products 7
Prompt delivery 8
Repair/rewind/installation services 9
Other (SPECIFY) _____

(69 open)

23. A number of manufacturers are now marketing electric motors that have high efficiency or energy efficient ratings. For example a standard 10-horsepower motor would have an average efficiency rating of 85; a high efficiency motor's rating would be above 90. Are you familiar with high efficiency or energy efficient motors?

Yes 1

No 2 — (SKIP TO Q. 67a, PAGE 17) (70)

24. How did you learn about these high efficiency motors? (DO NOT READ RESPONSES) (PROBE:) Did you learn about these motors in any other way?

Motors salesperson called on me 1
Received literature from motor manufacturer/distributor .. 2
Read about it in trade journal or other publication 3
Someone in the company told me 4 (71)
Read about it in the newspaper 5
Learned about them at conference/seminar 6
Other (SPECIFY) _____

(72 open)

25. Has your company considered buying any of these motors?

Yes 1 → (SKIP TO QU. 37, PAGE 10) No..... 2 (73)

26a. Why hasn't your company considered buying these motors? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY)

Don't need any 1
Cost too much 2
Don't have the proper application 3 (74)
Not available in size or type needed 4
Other (SPECIFY) _____

(75 open)

26b. If your company were to decide to purchase high efficiency electric motors, about how long would it take from the time you began studying the motors before a recommendation would be made?

(WRITE IN:)

--	--	--

MONTHS (76-78 open)

(79 open)

26c. If you were recommending the purchase of a high efficiency motor, what would be the longest payback period you would consider acceptable? Would it be ...

3

 80 Card 4 Dup. 1-3

Less than six months 1
Less than one year 2
Less than 18 months or 3 (4)
Less than two years 4
Other (SPECIFY) _____

27. Although you may have answered this question somewhat, I'd like to ask you to compare high efficiency motors to standard motors. Do you think the initial cost of high efficiency motors is ...

Much higher than 1
Somewhat higher than 2
The same as 3 (5)
Somewhat lower than or 4
Much lower than standard motors ... 5

(DON'T READ) → Don't know 6

28. Compared to standard motors, do you think the operating costs of high efficiency motors are ...

Much higher than 1 → (SKIP TO QU. 30)
Somewhat higher than 2
The same as 3 → (SKIP TO QU. 31) (6)
Somewhat lower than or 4
Much lower than standard motors ... 5

(DON'T READ) → Don't know 6 → (SKIP TO QU. 31)

29. What factors contribute to these lower costs? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Less energy required 1
Motor lasts longer/has longer life... 2 (7)
Less maintenance required 3
Other (SPECIFY) _____

SKIP TO QU. 31

30. What factors contribute to these higher costs? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Motor has shorter life 1
 More frequent maintenance required 2
 Bearings wear out faster 3 (8)
 Initial cost is higher 4
 Other (SPECIFY) _____

(9 open)

31. In terms of reliability, would you say that high efficiency motors are ...

Much more reliable 1 → (SKIP TO QU. 33)
 Somewhat more reliable 2
 The same as 3 → (SKIP TO QU. 34) (10)
 Somewhat less reliable or 4
 Much less reliable than standard motors 5

(DON'T READ) → Don't know 6 → (SKIP TO QU. 34)

32. Why do you think high efficiency motors are less reliable? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Not as widely used or proven 1
 Less is known about their application ... 2 (11)
 Newer product, so less proven 3
 Other (SPECIFY) _____

----- SKIP TO QU. 34 -----

33. Why do you think high efficiency motors are more reliable? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Higher quality, so last longer 1
 Motors run cooler, so last longer 2 (12)
 Less maintenance required 3
 Other (SPECIFY) _____

34. In terms of availability, would you say that high efficiency motors are ...

Much more available 1 → (SKIP TO QU. 35b)
 Somewhat more available 2
 The same as 3 → (SKIP TO QU. 36a) (13)
 Somewhat less available, or 4
 Much less available than standard
 motors 5

(DON'T READ) → Don't know 6 → (SKIP TO QU. 36a)

35a. Why do you think high efficiency motors are less available? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- High efficiency motors not manufactured in all sizes 1
- High prices make distributors less willing to carry 2
- Not made by all manufacturers 3
- Manufacturers not geared up yet 4 (14)
- Something new just coming out 5
- Not as much in demand 6
- Cost more 7
- Have fewer uses/applications 8

Other (SPECIFY) _____

(15 open)

----- SKIP TO QU. 36a -----

35b. Why do you think high efficiency motors are more available? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- Manufacturers/distributors enjoy bigger profit margins 1
- Greater interest now in energy efficiency 2 (16)
- Greater emphasis on new product marketing 3
- Other (SPECIFY) _____

36a. Overall, how would you rate the applicability of the high efficiency motor in your company? Is the motor ...

- Applicable only to specialized equipment 1 (17)
- Widely applicable 2
- Applicable only to HVAC equipment 3 } (SKIP TO QU. 36c)
- Not applicable at all 4

36b. What types of specialized equipment? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- Large horsepower pumps 1
- Large compressors 2
- Blowers and fans 3 (18)
- Other (SPECIFY) _____

36c. Thinking about the priorities for capital expenditures in your company, would you say that high efficiency motors are ...

- High on the priority list 1
- In the middle of the list 2 (19)
- Or near the bottom of the list 3

----- SKIP TO QU. 67a, PAGE 17 -----

37. After considering these motors, have you purchased any or made plans to do so?

Yes 1 (SKIP TO QU. 49a, PAGE 14) No 2 (20)

- 38a. Why did you decide not to purchase a high efficiency motor? (DO NOT READ RESPONSES.)
(PROBE:) Any other reason? (RECORD UNDER OTHER.)

Not appropriate for application 1
 Initial cost was too much higher 2
 Didn't have size /type needed 3 (21)
 Could not get delivery 4
 Decided not to purchase any motors 5
 Other (SPECIFY) _____

(22 open)

- 38b. If your company were to decide to purchase high efficiency electric motors, about how long would it take from the time you began studying the motors before a recommendation could be made?

(WRITE IN:)

--	--	--

MONTHS

(23-25)

- 38c. If you were recommending the purchase of a high efficiency motor, what would be the longest payback period you would consider acceptable? Would you consider ...

Less than six months 1
 Less than one year 2
 Less than 18 months or 3 (26)
 Less than two years 4
 Other (SPECIFY) _____

39. Although you may have answered this question somewhat, I'd like to ask you to compare high efficiency motors to standard motors. Do you think the initial cost of high efficiency motors is ...

Much higher than 1
 Somewhat higher than 2
 The same as 3 (27)
 Somewhat lower than or 4
 Much lower than standard motors ... 5

40. Compared to standard motors, do you think the operating costs of high efficiency motors are ...

Much higher than 1 } → (SKIP TO QU. 42)
 Somewhat higher than 2 }
 The same as 3 } → (SKIP TO QU. 43) (28)
 Somewhat lower than or 4
 Much lower than standard motors 5

- (DON'T READ) → Don't know 6 → (SKIP TO QU. 43)

41. What factors contribute to these lower costs? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Less energy required 1
 Motor lasts longer/has longer life ... 2 (29)
 Less maintenance required 3
 Other (SPECIFY) _____

----- SKIP TO QU. 43 -----

42. What factors contribute to these higher costs? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Motor has shorter life 1
 More frequent maintenance required 2
 Bearings wear out faster 3 (30)
 Initial cost is higher 4
 Other (SPECIFY) _____

(31 open)

43. In terms of reliability, would you say that high efficiency motors are ...

Much more reliable 1 → (SKIP TO QU. 45)
 Somewhat more reliable 2
 The same as 3 → (SKIP TO QU. 46) (32)
 Somewhat less reliable or 4
 Much less reliable than standard motors .. 5

(DON'T READ) → Don't know 6 → (SKIP TO QU. 46)

44. Why do you think high efficiency motors are less reliable? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY)

Not as widely used or proven 1
 Less is known about their application.. 2
 Newer product, so less proven 3 (33)
 Other (SPECIFY) _____

----- SKIP TO QU. 46 -----

45. Why do you think high efficiency motors are more reliable? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Higher quality, so last longer 1
 Motors run cooler, so last longer 2 (34)
 Less maintenance required 3
 Other (SPECIFY) _____

46. In terms of availability, would you say that high efficiency motors are ...

Much more available 1 → (SKIP TO QU. 47b)
 Somewhat more available 2
 The same as 3 → (SKIP TO QU. 48a) (35)
 Somewhat less available or 4
 Much less available than standard motors .. 5

(DON'T READ) → Don't know 6 → (SKIP TO QU. 48a)

47a. Why do you think high efficiency motors are less available? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- High efficiency motors not manufactured in all sizes 1
- High prices make distributors less willing to carry 2
- Not made by all manufacturers 3
- Manufacturers not geared up yet 4
- Something new just coming out 5 (36)
- Not as much in demand 6
- Cost more 7
- Have fewer uses/applications 8
- Other (SPECIFY) _____ (37 open)

----- SKIP TO QU. 48a -----

47b. Why do you think high efficiency motors are more available? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- Manufacturers/distributors enjoy bigger profit margins 1
- Greater interest now in energy efficiency 2 (38)
- Greater emphasis on new product marketing 3
- Other (SPECIFY) _____

48a. Overall, how would you rate the applicability of the high efficiency motor in your company? Is the motor ...

- Applicable only to specialized equipment 1
- Widely applicable 2
- Applicable only to HVAC equipment 3 } (SKIP TO QU. 48c)
- Not applicable at all 4

48b. What types of specialized equipment? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

- Large horsepower pumps 1
- Large compressors 2
- Blowers and fans 3 (40)
- Other (SPECIFY) _____

48c. Thinking about the priorities for capital expenditures in your company, would you say that high efficiency motors are ...

- High on the priority list 1
- In the middle of the list 2 (41)
- Or near the bottom of the list 3

----- SKIP TO QU. 67a, PAGE 17 -----

49a. I would like some information about the high efficiency motors your company purchased last year. For each horsepower range that I'm going to read, I'd like for you to tell me the total number of units that your company purchased. (READ CATEGORY AND RECORD TOTAL NUMBER BELOW UNDER 49a.)

49b. (FOR EACH CATEGORY IN WHICH THE RESPONDENT REPORTED A PURCHASE IN 49a ASK 49b.) Of these, how many units were bought for replacement purposes? (RECORD NUMBER BELOW UNDER 49b.)

HIGH EFFICIENCY MOTORS	Qu. 49a	Qu. 49b	(66-79 open)
	TOTAL UNITS	UNITS BOUGHT FOR REPLACEMENT	4 80 Card 5 Dup. 1-3
1 - 5 horsepower	_____ (42-45)	_____ (4-7)	
6 - 20 horsepower	_____ (46-49)	_____ (8-11)	
21 - 25 horsepower	_____ (50-53)	_____ (12-15)	
26 - 50 horsepower	_____ (54-57)	_____ (16-19)	
51 - 125 horsepower	_____ (58-61)	_____ (20-23)	
126 horsepower and over	_____ (62-65)	_____ (24-27)	

50. When did you buy the first high efficiency motor?

(WRITE IN:) 19 (28-29)

51. In which of the following applications are these motors being used? Are you using high efficiency motors in ...

Fans 1
Blowers 2
Pumps 3 (30)
Elevators 4
Compressors 5
Conveyors 6
Machine tools 7
Other applications (SPECIFY) _____

(31 open)

52. Now, I'd like to ask you to compare your company's experience with high efficiency motors to standard motors. Was the initial cost of high efficiency motors ...

Much higher than 1
Somewhat higher than 2
The same as 3 (32)
Somewhat lower than or 4
Much lower than standard motors ... 5

53. Compared to standard motors, are the operating costs of high efficiency motors ...

Much higher than 1 → (SKIP TO QU. 55)
Somewhat higher than 2
The same as 3 → (SKIP TO QU. 56) (33)
Somewhat lower than or 4
Much lower than standard motors ... 5

(DON'T READ) → Don't know 6 → (SKIP TO QU. 56)

54. What factors contribute to these lower operating costs? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Less energy required 1
Motor lasts longer/has longer life 2
Less maintenance required 3 (34)
Other (SPECIFY) _____

55. What factors contribute to these higher operating costs? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Motor has shorter life 1
 More frequent maintenance required 2
 Bearings wear out faster 3 (35)
 Initial cost is higher 4
 Other (SPECIFY) _____
 _____ (36 open)

56. How are the operating costs calculated? (DO NOT READ RESPONSES CIRCLE ALL THAT APPLY.)

Watts per hour 1
 Company formula/rule of thumb 2 (37)
 Comparison of electricity costs, hours
 of usage and efficiency ratings 3
 Other (SPECIFY) _____

57. You may have already answered this question somewhat, but I'd like you to tell me exactly what information, if any, your company collects on the costs and savings associated with high efficiency electric motors? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Don't collect any 1
 Hours motors are in use everyday 2
 Electricity rates in plant area 3 (38)
 Total hours motors in use before replacement 4
 Maintenance hours put in 5
 Repair costs incurred 6
 Other (SPECIFY) _____
 _____ (39 open)

58. After the cost and savings information is collected, do any of the following managers in your company receive reports on this information? Does the ...

	<u>Yes</u>	<u>No</u>
Chief engineer	1	2 (40)
Purchasing manager	1	2 (41)
Energy manager	1	2 (42)
Plant manager.....	1	2 (43)
Financial manager	1	2 (44)
Controller	1	2 (45)
Other (SPECIFY) _____	1	2 (46)
_____	1	2 (47)

59. Are these reports distributed to any of the following levels of management in your company? Are they distributed to the ...

	<u>Yes</u>	<u>No</u>
Plant level	1	2 (50)
Division level	1	2 (51)
Corporate level	1	2 (52)
Parent company	1	2 (53)

60. In terms of reliability, would you say that high efficiency motors are ...

Much more reliable 1 → (SKIP TO QU. 62)
 Somewhat more reliable 2
 The same as 3 → (SKIP TO QU. 63) (54)
 Somewhat less reliable or 4
 Much less reliable than standard motors 5
 (DO NOT READ) → Don't know 6 → (SKIP TO QU. 63)

61. Why do you think high efficiency motors are less reliable? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Not as widely used or proven 1
 Less is known about their application 2 (55)
 Newer product, so less proven 3
 Other (SPECIFY) _____

 SKIP TO QU. 63

62. Why do you think high efficiency motors are more reliable? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Higher quality so last longer 1
 Motors run cooler so last longer 2
 Less maintenance required 3 (56)
 Other (SPECIFY) _____

63. In terms of availability, would you say that high efficiency motors are ...

Much more available 1 → (SKIP TO QU. 65)
 Somewhat more available 2
 The same as 3 → (SKIP TO QU. 66a) (57)
 Somewhat less available or 4
 Much less available than standard motors 5
 (DO NOT READ) → Don't know 6 → (SKIP TO QU. 66a)

64. Why do you think high efficiency motors are less available? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

High efficiency motors not manufactured in all sizes 1
 Higher prices make distributors less willing to carry 2
 Not made by all manufacturers 3
 Manufacturers not geared up yet 4 (58)
 Something new just coming out 5
 Not as much in demand 6
 Cost more 7
 Have fewer uses/applications 8
 Other (SPECIFY) _____
 _____ (59 open)

----- SKIP TO QU. 66a -----

65. Why do you think high efficiency motors are more available? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Manufacturers/distributors enjoy
 bigger profit margins..... 1
 Greater interest now in energy
 efficiency 2 (60)
 Greater emphasis on new product
 marketing 3
 Other (SPECIFY) _____

- 66a. Overall, how would you rate the applicability of the high efficiency motor in your company? Is the motor ...

Applicable only to specialized equipment .. 1
 Widely applicable 2
 Applicable only to HVAC equipment 3 } (SKIP TO QU. 66c) (61)
 Not applicable at all 4

- 66b. What types of specialized equipment? (DO NOT READ RESPONSES. CIRCLE ALL THAT APPLY.)

Large horsepower pumps 1
 Large compressors 2
 Blowers and fans 3
 Other (SPECIFY) _____ (62)

- 66c. Thinking about the priorities for capital expenditures in your company, would you say that the purchase of additional high efficiency motors is ...

High on the priority list 1
 In the middle of the list 2 (63)
 Or near the bottom of the list 3

- 67a. Now that I've asked you about high efficiency motors, I'd like you to tell me about your company's energy conservation activities. I'd like you to tell me whether each factor I read is very important, important, somewhat important, or not at all important. (READ EACH FACTOR.)

FACTORS	VERY IMPORTANT	IMPORTANT	SOMEWHAT IMPORTANT	NOT AT ALL IMPORTANT
Government guidelines on conservation	1	2	3	4 (64)
Tax incentives	1	2	3	4 (65)
Industry/trade association pressures	1	2	3	4 (66)
Rising energy bills	1	2	3	4 (67)
High initial cost of equipment	1	2	3	4 (68)
Capital costs associated with modifications to existing facility	1	2	3	4 (69)
Availability of high efficiency equipment	1	2	3	4 (70)
Payback	1	2	3	4 (71)
Other (SPECIFY) _____	1	2	3	4 (72)
_____	1	2	3	4 (73)

- 67b. Are there any other factors that might influence energy conservation?

Yes 1

No 2 → (SKIP TO QU. 68)

74 ☐ ☐ 75

(76)

- 67c. How would you rate this factor? (RECORD RESPONSE UNDER "OTHER" ON QUESTION 67a.)

Now I would like to ask a few questions so that we can classify your company's responses with those of others.

68. Is your company a subsidiary of another company?

Yes 1

No 2 → (SKIP TO QU. 70)

(77)
(78-79 open)
☐ 80
Card 6
Dup. 1-3

69. What is the name of the parent company?

(WRITE IN): _____

70. What were your company's (not parent company's) revenues for the last fiscal year? (READ RESPONSES)

Less than \$10 million 1

\$10 million to \$49 million 2

\$50 million to \$99 million 3

\$100 million or more 4

(4)

(DO NOT READ) → Don't Know 5

Job No. 6327
Page 19

71a. About how many people does your company employ at this location? (READ RESPONSES.)

Less than 100 1
 100 to 249 2
 250 to 499 3 (5)
 500 to 999 4
 1,000 or more 5

(DO NOT READ) — Don't Know 6

71b. (ASK ONLY OF THOSE PEOPLE WHO ANSWERED YES ON QU. A.) How many employees altogether are there in all the facilities that you are responsible for? (RECORD ANSWER IN BOXES)

6 11

72. Which of the following categories best describes your company's product? (READ RESPONSES.) (IF "OTHER", WRITE THE PRODUCT ON THE LINE.)

Chemicals 1
 Petroleum refining 2
 Paper products 3 (12)
 Food 4
 Primary metals 5
 Other (SPECIFY) _____

(13 open)

73. I am going to read a list of categories of production facilities. (READ LIST.) Which category best describes the production facility in your company? (CIRCLE APPROPRIATE CATEGORY. IF "OTHER", WRITE THE CATEGORY ON THE LINE.)

Continuous process 1
 Intermittent or batch process 2
 Job work oriented 3 (14)
 Assembly line 4
 Other (SPECIFY) _____

(15 open)

(16-79 open)

☒ 80

Thank you for your cooperation. The information provided by you and others will be important to planning and research decisions. As we said before, your responses will be kept completely confidential.

Once again, thank you for your help with this study.

(RECORD TIME ENDED ON FIRST PAGE.)

APPENDIX D

METHODOLOGY FOR MOTOR USERS SURVEY

This appendix describes the methodology used for the survey of industrial decision-makers who purchase and use integral polyphase electric motors. The section covers the interviewing method, sampling plan, respondent profile, and general questionnaire topics.

A. Interviewing Method

Structured telephone interviews were conducted with 301 qualified respondents. This data collection method was deemed to be better suited to meeting time, cost and quality constraints than mail surveys or personal interviews.

The qualified respondent was a chief engineer or other individual, such as energy manager or purchasing official. The respondent was considered the person in the company most knowledgeable about the purchase and use of electric motors.

Both the function and technical nature of motors suggest that engineers are key decision-makers. Because of their participation in motor purchase decisions, engineers are also expected to know what information is required for capital expenditures.

B. Description of Sampling Plan

The universe from which respondents were selected consisted of a list of all manufacturing operations with 20 or more employees in five SIC codes as follows:

- SIC 20 Food and Kindred Products
- SIC 26 Paper and Allied Products
- SIC 28 Chemical and Allied Products
- SIC 29 Petroleum and Coal Products
- SIC 33 Primary Metals Industries

These codes were selected because they represent the top five industry groups with the highest energy consumption by electric motors. Companies with fewer than 20 employees were excluded from the universe. These smaller firms would have been difficult, perhaps impossible, to reach. Therefore, to provide maximum useful information with the available resources, the decision was made to concentrate on companies with at least 20 employees. The universe consisted of approximately 25,300 companies.

To ensure adequate coverage of the large users of electric motors in each industry, stratification was viewed as necessary in the design of this sample. Stratification by numbers of electric motors purchased or by energy use would have been desirable if this information were available. Because this information is unavailable, stratification by number of employees served as an approximation.

Sampling with certainty was considered in the design of the sample. However, applying the optimal cutoff point formula indicated that the universe does not contain any firms that are large enough to warrant sampling with certainty. Therefore, a stratification plan based on number of employees was developed.

Examination of the distribution of firms indicated that the following five strata would result in the best coverage of the universe:

- Fewer than 100 employees
- 100 to 249 employees
- 250 to 499 employees
- 500 to 999 employees
- More than 1,000 employees

Stratification by SIC code was also indicated to allow for examination of trends within each industry.

A screener questionnaire was used in contacting potential respondents by telephone. The qualified respondent was defined as a chief engineer, purchasing manager or other individual in any company which purchased at least one integral polyphase electric motor in the horsepower range of one to 125 in 1979. The incidence of such a purchase was expected to be high, approximately 80 percent. The actual incidence rate was 60 percent.

Once the qualified respondent was identified, the interviewer arranged a specific appointment for the actual interview by telephone. The appointment scheduling task was performed for two reasons: 1) to allow for a letter to be sent describing the types of information which would be solicited during the actual interview and 2) to encourage high response and completion rates because the appointment would be made at the respondent's convenience.

An informational package was mailed to each respondent on the same day as the screening call was made. The package included the letter confirming the appointment and outlining the motor information request. Also enclosed was a letter from the Department of Energy expressing the agency's appreciation for the respondent's cooperation. Appendices B, C, and D contain copies of the letters, screener questionnaire and decision-maker questionnaire.

C. Respondent Profile

The sampling plan was designed to provide for equal distribution of respondents in the five targeted industries. However, because of the smaller number of firms in SIC 29, slightly fewer respondents were interviewed in that category. The 301 respondents represented the five industries as follows:

<u>SIC</u>	<u>Industry</u>	<u>% of Sample</u>
20	Food	20%
26	Paper	22
28	Chemical	23
29	Petroleum	15
33	Primary metals	<u>20</u>
		100%

The sample was stratified by number of employees in five categories. The actual breakdown of respondents was as follows:

<u>Employment Category</u>	<u>% of Sample</u>
Less than 100	21%
100 to 249	24
250 to 499	21
500 to 999	18
1,000 or more	<u>17</u>
	100%*

Because continuous process operations are believed to offer the best opportunities for the application of energy-efficient motors, respondents were asked about their production facilities. The respondents fell into the following categories:

<u>Type of Process</u>	<u>% of Sample**</u>
Continuous process	62%
Intermittent or batch process	34
Job work oriented	7
Assembly line	10
Other	2

*Adds to slightly more than 100% because of rounding.

**Adds to more than 100% because of multiple answers.

Respondents were also asked about the annual revenues of their company for the last fiscal year. The following information was provided:

<u>Revenue Category</u>	<u>% of Sample</u>
Less than \$10 million	7%
\$10 million to \$49 million	10
\$50 million to \$99 million	3
\$100 million or more	25
Don't know	<u>54</u>
	100%

The substantial portion of respondents who could not answer the revenue question indicates that engineers may not be well informed or concerned about financial aspects of their companies. Their lack of information is not explicable in terms of this study. However, the lack of information handicaps the data analysis for the study because of the desire to determine if targeting by company revenues would be a worthwhile commercialization strategy.

D. Nature of Data Collected

The survey measured respondents' perceptions of integral horsepower polyphase electric motors in general and energy-efficient motors (EEMs) in particular.

The following topics were covered by questions asked of all 301 respondents. The questions referred to all integral horsepower polyphase electric motors, not just motors defined as energy-efficient.

- Size and quantity of motors purchased in 1979 (total units and replacement units).
- Motor application or use.
- Importance of purchase factors such as reliability and price.
- Purchasing guidelines and specifications.
- Items included in specifications and frequency specified.
- Purchase decision-makers and influencers (departments and level in company).
- Variations in policies if a replacement purchase.
- Investment evaluation methods, payback criteria.
- Motor information sources.
- Supplier services expected.
- Importance of factors which influence energy conservation activities.
- Revenues, employees, industry, production method, and parent/subsidiary status.

Those respondents who were familiar with EEMs were also asked:

- How they learned of EEMs and whether they considered or purchased EEMs.
- Reasons for not considering or not purchasing EEMs (if applicable).
- Time required to study EEMs before recommending (if they did not purchase any).
- Payback period required.
- Perceptions of initial and operating costs, reliability, availability and applicability.
- EEM priorities as a capital expenditure.

The following topics were included in questions that were asked only of respondents who actually purchased or had plans to purchase EEMs:

- Size and quantity of EEMs purchased in 1979 (total units and replacement units).
- Year in which EEMs were first purchased.
- Applications in which their EEMs are used.
- Calculation, collection and dissemination of operating cost data.

All of the data were cross-tabulated by:

- Purchase behavior (considered, purchased or did not consider).
- Industry, revenues, employees and manufacturing process.
- Number and size of motors purchased.
- Type of supplier
- Level of decision-maker in the organization.

- Importance of government conservation guidelines, tax incentives, and industry trade association pressures to energy conservation activities.
- Efficiency and initial cost as specifications.

E. Precision of Data

Survey results or findings which pertain to the entire sample (i.e., all 301 respondents) are more precise than findings which relate to a subgroup such as EEM purchasers or respondents in one industry. Ninety-five percent of the time, or 95 times out of 100, the range of error will not be more than 6 percentage points in either direction when the responses to any one question are split 50-50. (That is, when 50 percent of the respondents answer one way, the actual percentage may range from 44 to 56 percent.) This range of error drops to two percentage points as the responses approach 95-5.

For a subgroup, the precision of findings decreases due to sample size. For a subgroup of approximately 100 respondents, such as EEM purchasers, there is a 95 percent certainty that the percentages noted in the findings will not vary by more than 10 percent. This possible error range drops to 4 percent as the split in results moves from 50-50 to 95-5. For subgroups smaller than 100 respondents, the range of possible error can be even greater.

APPENDIX E

**METHODOLOGY FOR ANALYSIS
OF ENGINEERING FIRMS**

Firms engaged in the engineering and construction of large industrial plants were the primary respondents for this part of the study. Some of the respondent firms provide only architectural and engineering services; others provide all three services or engineering services alone. For simplicity, all respondent firms will be referred to as engineering firms.

The respondent firms' clients represent the following industries: petroleum, petrochemicals, chemicals, paper and pulp, tobacco, primary metals, and others. Most of the individuals who responded are senior electrical engineers or departmental heads.

Respondent firms were selected from several sources, including Dun and Bradstreet's Million Dollar Directory, Moody's Handbook of Common Stocks, and the National Society of Professional Engineers' Practice Directory. Most respondent firms have revenues in excess of \$200 million per year, and almost all have clients in one or more of the five most energy-consuming industries. The respondents were individuals who are knowledgeable about the specification of electric motors in industrial plant and equipment. They also had ordered motors within the last two years.

The interviews were unstructured. The discussions generally covered the following topic areas:

- Perception of EEMs, including first cost/efficiency trade-offs.
- Specification of EEMs; client initiation of evaluation.

- Perceptions of client priorities; client awareness of EEMs; barriers to client request for EEMs.
- Barriers to specification of EEMs by engineers.
- Methods for evaluating EEMs.
- Decision process for EEM purchase: incentives, barriers.
- Information needed by clients and engineering firms.
- Key determinants of EEM future.
- Outlook for EEMs.

The information presented here represents the opinions and experiences of the individual respondents and their firms. The interviews were used to explore issues, to identify perceptions based on experiences of senior engineers in some of the very largest engineering firms, and to ascertain the knowledge and awareness of these firms with regard to energy-efficient motors. The data are qualitative in nature and supplement the information gleaned from the survey of motor users who are the actual decision-makers.