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Prevalence of Components Necessary For Electrical Demand Side Management Savings Persistence in the Albertan Industrial Market Sector

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Prevalence of Components Necessary For Electrical Demand Side Management Savings Persistence in the Albertan Industrial Market Sector submitted by Cameron A. Sterling in partial fulfillment of the requirements for the degree of Master of Science.

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Abstract

Demand side management (DSM) has been touted by the electric utility industry in North America as a means to reduce electricity use, and defer the need for new generation facilities. However, industry critics doubt whether DSM related savings are long lasting, that is persistent, and as a result have concerns that DSM programs are not prudent investments.

To help address those concerns, this study was designed to determine the prevalence of components necessary for electrical DSM savings persistence to occur in the Albertan industrial sector. Savings persistence components related to the high efficiency motor program (HEMP), a large scale DSM program that was implemented in Alberta, were researched.

It was determined that replacements with high efficiency motors, and government imposed standards, are the predominant savings persistence components that will affect the endurance of HEMP savings the most. Other savings persistence components were also determined from literature and empirical studies.

Respondents tended to indicate that the price of electricity is related to how efficiently it is used. It appears that if the price of electricity was higher, the efficient use of electricity would be a higher priority. In general, it appears that electricity price structures do not promote efficiency.

It appears that the DSM programs with the least risk in Alberta will be those that will eventually be backed up with government standards. However, detailed, temporal

records of the operation, maintenance, and efficiency of the equipment targeted by DSM programs will help ensure that the related savings will endure far into the future.

The data required to identify some important components of savings persistence is generally not recorded by industry at the present time. Until the prevalence of all savings persistence components are identified, and their impact is known, benefits claimed by administrators of DSM programs should be greeted with skepticism.

Acknowledgments

By God, it's finished!

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1. Introduction to the Study

1.1 Background

Engineers have always had an interest in efficiency, that is, reducing the amount of energy required to do work. This was evident in the energy crisis of the seventies (Kemper) that saw oil prices quadruple in 1973-74 and double from 1978 levels in 1979-1980 (Anderson). During that period, the United States electric power industry saw increases in industrial power rates of 11% - 12% (Andreas).

Electric utilities began to apply demand side management (DSM) concepts such as strategic conservation, load management, fuel substitution, and load building, with the intent of increasing the efficiency of electricity use. With the encouragement of the United States government (Arthur D. Little Inc.), most utilities in the United States became involved with DSM in the early eighties after legislation of the Residential Conservation Service program (Gilbert).

DSM in the North American electric power industry increased and evolved to include several variations since the early seventies, despite the stabilization of energy costs and availability of electricity supply in some locales. However, the technique's main premise remains the same: that the managed reduction or alteration of consumer demand can result in lower electricity costs for the utility and consumer (Nadel and Jordan).

In recent years, DSM programs have been very popular with U.S. electric utilities. In 1991 alone, total DSM expenditures were nearly $2 billion dollars in the United States, and are expected to increase significantly (Nadel and Jordan). However, on average, DSM techniques in the power industry are relatively expensive (Eenergy Informer) when compared with supply side options, and DSM programs have met with very modest success (Puga) with respect to potential savings. In response, some government bodies and public interest groups outside Alberta are now questioning the value of power industry DSM investments, and are proposing legislation (Baker and Battle) in their jurisdictions to help ensure the benefits associated with electricity savings.

Generally, although the amount and costs of electricity savings is questioned by the literature, the idea that long term savings associated with DSM programs will in fact occur, appears to be generally accepted. It would seem that reduced consumption of electricity will lead to less electrical demand.

There is, however, evidence contrary to popular wisdom, which indicates that electrical DSM will perhaps trigger increased electrical consumption (Inhaber and Saunders)! Throughout history, conservation measures, that is, attempts to reduce the demand for a commodity, indeed have often led to increased efficiency. But, even though efficiency increased, the use of the commodity also increased, and new sources of the commodity were discovered and made available. Efficiency has increased economic activity (Zwicky).

For example, Thomas Savery's invention of the first steam engine in 1698, precipitated conservationist concerns about the availability of coal. Those concerns led to efficiency improvements embodied in James Watt's steam engine. However, although the Watt engine was a vast improvement in terms of efficiency, its greater efficiency was, in large part, responsible for its popularity and applicability. It has been suggested that, as a result, coal consumption in Scotland alone increased ten times between 1830 and 1863 (Inhaber and Saunders).

Another example can be drawn from the history of steel production. In 1856, Henry Bessemer told the British Association for the Advancement for Science, that fuel was almost unnecessary for the production of steel. Up until that time, steel production required a relatively large quantity of fuel, and as a result was relatively inefficient. The improved efficiency associated with the Bessemer steel production process caused a reduced requirement for fuel. It has been suggested that, as a result, there was a rapid increase in the demand for steel, and a large total increase in the amount of fuel used for steel production (Inhaber and Saunders).

If increased efficiency is a good thing in as much as it promotes greater economic activity, then electrical DSM is a good thing. But electrical DSM may be a case of doing the right thing for the wrong reason. It has not been inarguably established that DSM both increases efficiency and decreases demand at the same time. Electrical utilities are very capable of determining how much money is spent on DSM programs, but effective measurements of savings are elusive. Inhaber and Saunders believe that the problem exists with the concept of conservation, not with measurement techniques available. According to them, effective conservation programs result in greater economic welfare, and often in an increased use of the commodity being conserved (Inhaber and Saunders, 1994).

To help quantify the expected savings associated with any given DSM program, four standard economic tests have been published by the California Public Utilities Commission and the California Energy Commission to screen DSM programs. The tests are widely accepted in both Canada and the United States (Baker and Battle). All of these tests are supposed to be conducted prior to when a DSM program commences to help decide if a DSM program in question should be implemented or not, and the validity of the test results depend strongly upon forecasts and estimations of DSM related savings. They include the Participant's Test, the Total Resource Cost Test, the Utility Cost Test, and the Rate Payer's Impact Measure Test. Benefits and costs associated with each test are defined differently (State of California). Occasionally utilities use a modified total resource cost test called the limited societal test that includes the costs of externalities such as SO_2 emissions (Alberta Power Limited, 1993).

The tests compare the present values of the forecast benefits and costs associated with each DSM program, and express the comparisons as either a ratio between benefits and costs, or as a net present value. Ratio results that are greater or equal to one, and positive net present values are considered favourable for participants, utilities, or society in general, and indicate that the DSM program in question is more cost effective than the avoided costs associated with operating the electrical system. (State of California).

As a good "first cut" to determine the attractiveness of a DSM program, the Participant's Test is used to compare the quantifiable benefits and costs of the utility customer. Benefits that are considered by this test include reductions to customers' bills, incentives paid by the utility, and any tax credits that may be received as a result of the DSM program. Costs that are considered by this test include the customers' expenses which include equipment or materials and sales tax, removal costs, and the customers' time. However, this test does not capture the complexities associated with customer decision making processes, and therefore if this test is not used in conjunction with the other accepted economic tests, experienced interpretations of these test results are required before any conclusions can be drawn from them (State of California).

The Total Resource Cost Test compares all the costs of the participants and utility. Benefits included in the comparison used in this test are the supply costs associated with transmission, distribution, and generation of electricity that were avoided as a result of the DSM program, as well as avoided capacity costs evaluated at marginal cost. Costs included in this test are all utility and participant costs. To use this test effectively, the savings that would occur in the absence of the DSM program should be known, prior to program commencement (State of California).

The Utility Cost Test compares the benefits and costs of a DSM program, as seen by the electric utility. Benefits associated with this test are similar to those of the Total Resource Cost Test, and include the avoided supply costs associated with the transmission, distribution, and generation of electricity that were avoided as a result of the DSM program, as well as avoided capacity costs evaluated at marginal cost. Costs associated with this test include program costs, incentives paid to customers, and increased supply costs if there are load increases. Unlike the Rate Impact Measures Test, revenue lost as a result of the DSM is not included as a cost. As with the Total Resource Cost Test, the savings that would occur in the absence of the DSM program should be known, prior to program commencement (State of California).

The Rate Impact Measures Test compares the benefits and costs of a DSM program, as seen by a non - participating customer. Benefits associated with this test are the same as both the Total Resource Cost Test and the Utility Cost Test. Costs associated with this test are the same as those of the Utility Cost Test, but in addition, include costs associated with revenue lost by the utility. Costs and benefits that would occur in the absence of the DSM program should be known, prior to program commencement (State of California).

In addition to the relatively ordinary uncertainties associated with economic forecasts for electricity use such as market prices for oil , natural gas, forest products, chemicals, cement, and coal (Stout and Nault), a couple of other problems associated with the economic tests used for DSM program screening have been identified. First, all accepted economic tests, except the Participant's Test, require knowledge of what savings or revenue would have occurred in the absence of a DSM program. In other words, the net savings or revenue associated with DSM programs must be known before the programs are implemented, if accepted economic tests are to be correctly applied. However, despite the wide spread use of these accepted economic tests, net savings or revenue obtained from DSM programs can only be estimated and not measured (Baker and Battle), and as a result, economic tests used at the outset of DSM programs do not give good indications of what the value of the program will be. Secondly, the persistence of savings needs to be considered. Estimations of savings provided at the outset of DSM programs are 30% - 100% greater than actual savings, in part because of factors which negatively affect electricity savings persistence (Baker and Battle). Inaccurate savings estimates cause false economic analyses of DSM programs, which may lead to instances of inappropriate DSM program implementation.

In Alberta, where there is currently a surplus of generation capacity (Alberta Department of Energy), an electric utility representative emphasized at a meeting of the Association of Energy Engineers in 1994, that any future DSM programs will be termed 'efficiency programs', and will either be profitable or revenue neutral. In light of the above discussion regarding the use of coal in the nineteenth century, his statement was not surprising. However, because of documented difficulties associated with determining net savings and revenue obtained from DSM programs, in addition to unidentified factors related to savings persistence, profitable or revenue neutral DSM programs are extremely difficult to identify.

Research and awareness related to savings persistence will increase the accuracy of savings estimates. The identification of savings persistence components provides a framework which can be used to analyze long lasting DSM savings (Vine). Components necessary for electrical DSM savings persistence to occur must be considered by society, consumers, and industry, before the true value of DSM techniques and factors affecting savings persistence components can be effectively determined.

1.2 Definitions

1.2.1 Demand Side Management (DSM)

DSM, as it exists today, applies to the use of electricity (Baker and Battle). However, the term is starting to be used in the context of other commodities such as water and natural gas (Nadel and Jordan). Demand side management in the broadest sense refers to techniques used to alter the demand of a commodity.

Several variations of electrical DSM exist: strategic conservation, load management, fuel substitution, and load building (State of California).

Conservation program benefits must be weighed against economic development issues. The World Conservation Strategy's definition of conservation addresses this point: conservation is "the management of human use of the biosphere to yield the greatest sustainable benefits to present generations while maintaining the potential to meet the needs and aspirations of future generations" (Gov. of New Zealand). Strategic conservation techniques reduce electricity use throughout the entire year (State of California), normally pay for themselves in one to three years, and use less energy to produce the same goods and services (Nadel and Joran; Puga; Baker and Battle; Zwicky).

Load management techniques alter electricity load curves and can be subdivided further into peak clipping, load shifting, valley filling, and variable pricing techniques (Yau and Rabl; Caskey and Swanson). Fuel substitution and load building techniques increase the use of electricity (State of California). Since this study focuses on the persistence of DSM savings, fuel substitution and load building techniques are not considered further.

To date, some industrial DSM programs consisting of educational services have been started in Alberta, but there has been only one industrial DSM program publicly endorsed by the majority of Alberta's electric utilities: the High Efficiency Motor Program (HEMP) whic[illegible] in Alberta from 1990 through to the end of 1994 (Demand Side Energy Consultants Inc.). HEMP was primarily a conservation program; its intent was to reduce electricity use in Alberta's industrial sector by encouraging the use of high efficiency electric motors (Public Utilities Board).

Aspects of all the above definitions of DSM were contained within a definition that was included in an Alberta Power Limited application to the Alberta's Public Utilities Board for review: "DSM is a broadly used term which includes all initiatives undertaken by a utility and its customers to reduce or manage electrical capacity and energy requirements" (Alberta Power Limited, 1993). However, this definition is too narrow for the purposes of this study, because it does not include government activities, which play an important role in the persistence of demand side management measures (Furness; Baker and Battle). Therefore, the following definition, which includes government, is the definition of DSM used in the context of this study, as it applies to the HEMP, a strategic conservation program: DSM is a broadly used term which includes all initiatives undertaken by an electric utility, its customers, or government, to reduce or manage electrical capacity, and energy requirements.

1.2.2 Industrial Markets

Industrial markets are defined as those Albertan companies that are relatively large consumers of electricity in the primary manufacturing industry subsectors. Factors and components of electricity savings persistence are most relevant to large electricity consumers since they use most of Alberta's generated electricity.

Albertan companies in these categories are primarily in the oil and gas, forest products, chemicals, cement, and coal mining industrial market subsectors (EUPC). Companies in electricity generation subsectors also qualified for inclusion.

It is commonly argued that electricity should be considered a raw material and not a manufactured good (Battle), however this study focuses on electricity use and not on the economic growth of one commodity versus another. In addition, it should be noted that the generation of electricity itself, through the use of pumps, fans, compressors, and other types of machinery, uses as much as 15% of the power that is generated (Babcock and Wilcox). Electric utility companies are significant power users. Therefore, large electricity generating companies were included as primary manufacturers and a subsector of the Albertan industrial market for the purpose of this study.

1.2.3 Persistence of Savings

After DSM programs are implemented, electrical savings can decay after program completion (Keating, 1991). 'Persistence of savings' refers to the constancy, or endurance, of these electricity savings over time.

There are two types of savings associated with DSM: total savings and net savings. Total savings are equivalent to the savings achieved from the use of DSM related efficiency installations or technology, plus the savings that would have been achieved in the absence of the DSM program. Net savings are electricity savings that only occur as a direct result from the implementation of electric utility sponsored DSM programs. If net savings are subtracted from total savings, the difference represents savings that would have been achieved had there been no DSM program (EPRI).

Persistence has two dimensions: measure and program persistence (Keating; Vine). Measure persistence considers the lifetime and operation of an energy efficient installation. It is a subset of program persistence. Program persistence includes the consideration of the total and net savings which result from DSM initiatives.

This study considers components associated with measure and program persistence of total savings, as opposed to just net savings, for three reasons. Accurate estimations of the magnitude of net savings is extremely difficult, if not impossible to obtain, due to contamination of the control group (EPRI). In addition, DSM program design, particular market characteristics, and various methodologies of measurement, contribute to wide ranges of net savings estimates (Saxonis). Also, due to this study's definition of DSM, there is no need to distinguish between utility sponsored DSM program participants and ordinary DSM participants, other than to ensure that the population sample represents the Albertan population of industrial electricity consumers.

Therefore, for the purposes of this thesis, 'persistence of savings' is defined as follows: the long - term temporal endurance of electricity savings that result from DSM related installations or technology.

1.2.4 Components and Factors

Components are defined to be elements, which when combined form an observable result. Although the literature refers to savings persistence components as factors related to the persistence of electricity savings (Vine), this thesis uses a stricter definition of factors.

Factors are defined to be underlying source variables (Kim and Mueller) that are combined to explain components which are observed or measured. When interval or ratio measurement is not possible because of the nature of the data, factors are defined to be considerations that contribute to components.

1.3 The High Efficiency Motor Program

The High Efficiency Motor Program (HEMP) was a DSM program targeted primarily at the Albertan industrial sector. It was originally started in 1990 by TransAlta Utilities, and from 1991 to 1994, Alberta Power Limited, Edmonton Power, and the City of Calgary Electrical System also implemented it (Demand Side Energy Consultants Inc.). Despite the current surplus of electricity supply in Alberta, and the fact that the program costs were required to be expensed and could not be added to the rate base, the above utilities agreed to implement the HEMP (Government of Alberta; Public Utilities Board). The HEMP concluded at the end of 1994.

The HEMP provided motor purchasers with rebates that subsidized the costs of purchasing high efficiency motors. The intent of the program was to create awareness of energy efficiency by promoting the sales of high efficiency motors, permanently changing customer buying patterns, and establishing high efficiency motors as the predominant choice of motor purchasers and suppliers (Demand Side Energy Consultants Inc.).

A summary of the program, completed by a consultant company that was hired by the above utilities, provides some interesting figures that indicate the size of the HEMP. A total of 11,302 high efficiency motors were purchased with HEMP rebates, and a total 311,567 electric motor horsepower was affected by the program. Rebates to motor purchasers totaled $2,306,304. In addition, the summary states that 46.4 GW.h of electrical energy is saved each year, and 8.4 MW of electrical demand is conserved as a result of the program (Demand Side Energy Consultants Inc.). Government sponsored efficiency standards are mentioned, but savings persistence is not otherwise noted.

The HEMP was an incentive program. A rebate incentive of 0.5 cents / kW.h of conserved energy was justified by the utilities and approved by the Public Utilities Board on the basis that this incentive was equal to or less than the difference between forecast long run marginal costs of electricity and the forecast incremental consumption costs of a representative industrial customer (Public Utilities Board). Utility representatives indicate that the reasoning behind this approach was chosen because ideally, in an economic sense, the price of electricity seen by customers should be equal to the marginal cost of electricity (Stout and Nault).

In a related hearing, it was indicated that the accepted economic tests and in particular the Rate Payer Impact Measures Test, when applied to the HEMP, were satisfied if the rebate incentive of 0.5 cents / kW.h was used (Public Utilities Board; Stout and Nault). In addition, the rebate level permitted purchasers to obtain a simple payback on the premium they paid for a high efficiency motor, in two years or less. Furthermore, it was noted that similar rebate levels had recently been approved for the portion of the HEMP administered previously by an electric utility (Public Utilities Board).

A graph, which depicts the forecast load without HEMP, and a load curve with HEMP factored in, was never produced prior to the implementation of the HEMP or subsequent to it for several reasons. The Public Utilities Board did not request such a graph. Secondly, such a graph was not required to persuade the Public Utilities Board to approve the HEMP. It was sufficient for the HEMP to pass the Ratepayer Impact Measures Test, which it did. Thirdly, economic justification was not the only reason for HEMP approval, and benefits that are difficult to assign a price to were also considered. The utilities and customers were represented by a collaborative group that emphasized the societal benefits associated with the HEMP at least as much as the economics of the program (Stout).

Using a twenty year service life, a discount rate of 6%, and an 80% load factor, the 0.5 cents / kWh incentive approved by the Public Utilities Board translates to $400 / kW of demand reduction (Public Utilities Board). Rebates were calculated using the following formula:

Rebate = horsepower($400/kW)*(0.746 kW/hp) **
((100/Base Efficiency) - (100/High Efficiency))

In the above formula, 'horsepower' refers to the size of the particular motor under consideration in terms of horsepower. 'Base Efficiency' refers to the average efficiency of standard motors available in the market place for a particular motor size and speed. 'High Efficiency' refers to the efficiency of the particular high efficiency motor in question. As the marketplace changed, the base efficiency levels were changed to reflect increases in the average efficiencies of standard motors. Qualifying 'High Efficiency' levels were also set and changed periodically to reflect changes in the marketplace. Rebates at the above prescribed levels permitted motor purchasers to obtain a simple payback on the premium they paid for high efficiency motors in two years or less (Alberta Power Limited, 1991).

The Public Utilities Board approved the HEMP with few strings attached. They did not require any utility to conduct measurements that would indicate what benefits resulted from HEMP. The Public Utilities Board stipulated that costs associated with the HEMP could not be added to the rate base, but could be expensed.

Value associated with the experience obtained from implementing the HEMP was noted by the Public Utilities Board. It considered "that the experience gained through the pilot program (HEMP) can be used to modify and increase the effectiveness of future, more comprehensive, energy efficiency programs" (Public Utilities Board). It was certainly the intent of some Albertan electric utilities to pursue other energy conservation programs in the future, and the Public Utilities Board inferred that rebate levels may be set at levels that would match the entire cost of deferred generation if future programs are less experimental and more broadly targeted (Public Utilities Board).

The HEMP was important for several reasons. It was the first large scale DSM program undertaken in Alberta. Albertan utilities that generate over 83% of Alberta's electricity capacity participated in the program.

Secondly, its impact was significant. In Alberta, it is likely that the HEMP was primarily responsible for the change in the percentage of new motor sales in terms of horsepower, from 1% to 57%, that occurred between 1989 and 1994 (Demand Side Energy Consultants Inc.). Motors account for approximately 80% of industrial energy use in Alberta (Demand Side Energy Consultants Inc.), and industry uses approximately

49% of all supplied electrical energy (EUPC). High efficiency motors save between 3% and 8% of input power (Demand Side Energy Consultants Inc.) Therefore, even a 3% efficiency gain in all electric motors ope[illegible]d in the Alberta industrial market sector, would likely reduce overall provincial energy use by approximately 1%, or about 4300 GW.h. per year, if persistence of the savings is assumed. The HEMP program apparently saves about 1% of that, or 46 GW.h of energy each year in Alberta (Demand Side Energy Consultants Inc.). A similar amount of energy savings could be observed if about 1% of all the electric motors in the Albertan industrial market sector had an efficiency gain of about 3%.

Thirdly, the HEMP will serve as a model from which to structure other programs. Albertan utilities have expressed interest in implementing other larger, and more comprehensive conservation programs (Public Utilities Board). The HEMP provides valuable lessons that should be noted before investments in DSM programs ar[illegible] increased.

1.4 Electricity Supply and Demand in Alberta

The generation capacity available in Alberta is linked on an interconnected electric grid that provides the province with electricity. As of 1993, Alberta had 8991 MW of installed capacity. The vast majority of this power, 7678 MW or more than 85% of the installed capacity, is generated by utilities with transmission, distribution, and generation capability: Alberta Power Limited, Edmonton Power, TransAlta Utilities, and The City of Medicine Hat. Medicine Hat is capable of providing 182 MW, or about 2% of all installed capacity. Approximately 6%, or 525 MW of the installed capacity is available outside of the province, from either British Columbia or Saskatchewan. Slightly less than 9%, or 788 MW of installed capacity, is generated in Alberta by companies other than electric utilities (Government of Alberta).

The province enjoys a surplus of electrical capacity. Load forecasts conducted in 1993 indicated that the capacity of existing generation will meet the 1.8% average annual growth in electricity demand, until approximately 1999, when some existing generation units begin to retire from service (Government of Alberta).

Alberta industry enjoys the most inexpensively priced electricity in Canada, and Canadian electricity prices in Canada are amongst the lowest in the world (Government of Alberta). This situation is expected to continue for some time. The price of existing generation is estimated to remain approximately stable despite the anticipated decline of capacity due to scheduled retirements. As of 1994, future generation costs are expected to increase at about the inflation rate, subject to variations in the price of natural gas (Government of Alberta). In a 1991 application to the Public Utilities Board, Alberta Power Limited anticipated that the marginal cost of generation was about 3.14 to 3.46 cents / kW.h, and industrial customers would pay approximately 0.5 cents per kW.h less than that for incremental consumption (Alberta Power Limited, 1991). During the time period in which the HEMP was implemented, the Public Utilities Board was the regulatory body responsible for the rates charged by the investor owned utilities (Government of Alberta).

Industrial customers consume most of the electricity in Alberta (EUPC), and large industrial consumers have a good idea of how much electrical power they will require in the near future (Stout and Nault). Utility representatives indicate that in the short term, electrical load forecasts are primarily based on interactions with major electricity consumers that exchange information about anticipated load requirements. The High Efficiency Motor Program (HEMP) altered the load forecast primarily because the independent forecasts produced by industrial customers reflected what industrial customers thought their use of high efficiency motors would be. Customer forecasts are accumulated, and the consolidated information is used to form the basis of a near term electric utility load forecast (Nault).

Long term forecasts are more complicated and involved. A primary consideration of long term forecasts are the price fluctuations of major industrial electricity consumers' products. Price fluctuations of those products have substantially more impact on a forecast than the use of a few new purchases of high efficiency electric motors. Long term savings associated with high efficient motors are assumed to remain constant over a twenty year period of time, and are treated as constants in long term forecasts (Stout and Nault).

Utility representatives indicate that demand elasticity of high efficiency motors was not considered when constructing the load forecast prior to the implementation of the HEMP, or determining the HEMP rebate incentive, for several reasons. It would be extremely difficult, if not impossible, given the vast number of variables, factors, variations in types of industry, different uses of electric motors, different internal economics associated with each industrial subsector, etc. to obtain useful data. Secondly, there is a lack of confidence that the Public Utilities Board would accept such information as reliable evidence, given the lack of reliable data. The Public Utilities Board has never validated data related to demand elasticity of electricity or electrical machinery. Thirdly, the absence of demand elasticity analysis has not negatively affected the accuracy of load forecasts in the past (Stout and Nault).

1.5 Importance of the Research

1.5.1 Assistance to Industry and Government

Two areas associated with DSM require research (Baker and Battle):

a) risk and uncertainty associated with DSM programs, and

b) implementation guidelines for DSM programs.

This study partially addresses DSM risks and uncertainties by identifying components associated with electricity savings persistence. The identification of these components provides a framework to assist analyses of electricity savings persistence (Vine). The industrial market sector, government, and society benefits in several ways by potentially reducing the risk and uncertainty associated with DSM programs through the identification of savings persistence components.

1.5.1.1 Benefits to Industry

In general, the first priorities of industry do not include energy efficiency. Viability (Elliot and Geller, 1993), making a profit (Elliot and Geller, 1993), productivity, safety, and environmental issues (Smith) are more important to industry than energy efficiency. Economical operation is the highest priority for industry, and according to some literature, energy efficiency is simply a relatively unimportant contributor to the bottom line (MacLeod; Steinmeyer). When considering the overall manufacturing sector, capital and labor costs are approximately twenty times greater than energy costs (Steinmeyer).

However, efficient use of energy is a contributor to industry's bottom line. In Alberta, an energy intense economy, energy costs have a significant impact on the viability of Albertan industry (Percy and Ogus). Benefits to industry, associated with this research, are listed below.

1.5.1.1.1 Increased Productivity

Total processing costs generally drop by about 20% for each doubling of cumulative production in manufacturing processes; energy costs are not scale related and may not drop by the same amount (Steinmeyer). However, energy efficiency is still directly related to industrial productivity (Puga), so if energy efficient savings decay, productivity will suffer. Recognition of components associated with electricity savings persistence is therefore of importance to industry.

1.5.1.1.2 Increased Competitiveness

Energy efficiency is directly related to competitiveness (Meadows and Usibelli) because it "lowers (electrical) intensity per unit of output, enhancing productivity and" makes "business more competitive in the regional, national, and international markets" (Wooley). Japan is a prime example of this phenomena in that it reduced its electricity intensity in the manufacturing sector between 1973 and 1986 by at least 20% more than US manufacturers during the same period (Wooley). New technology and energy sources have led to increased competition (Environment Council of Alberta; Baldwin), profitability, and market share (Green).

With the changes to electric utility regulation in Alberta, suppliers of new generation will have to compete with each other to attract customers, and utility companies' generation costs in Alberta will no longer be pooled and averaged for the consumer by the Electric Energy Marketing Act (Government of Alberta). Established electric utilities will want to generate electricity for as little cost as possible (Frey). Independent power producers (IPPs) are a threat to established electric utilities if IPPs can provide electricity at cheaper prices. Those industries that utilize energy efficient technologies and ensure the persistence of the related savings, will be more competitive than those that do not.

1.5.1.1.3 Better Electricity Savings Estimates

The identification of electricity savings persistence components will facilitate better estimations of true electricity savings prior to capital investment, and therefore will assist in prudent capital investment.

1.5.1.2 Benefits to Electric Utilities

1.5.1.2.1 Better Customer Service

One of the concerns of electric utilities in general is customer service, retention of customers (Elliot and Geller, 1993), and price of service (Marsh). In increasingly competitive markets such as Alberta, where there is an expected surplus of electricity capacity until approximately the year 2000 (Government of Alberta), customer service (Garton) and cost of service (Elliot and Geller, 1993) is of paramount importance when considering the role of DSM.

Although Alberta enjoys relatively low costs of electricity when compared to national or international prices, electricity prices have increased in the past few years due to government policy changes (Jernberg; Sandmoen) such as the removal in 1990 of the Alberta Government's portion of an income tax rebate paid to Alberta's electric utilities from 1969 to 1990, and the introduction of the GST in 1991. In addition, the recent withdrawal of the federal portion of an income tax rebate (Ovenden; Taylor) threatens to increase Alberta's electricity prices by an additional 7%.

Information that helps improve the impact that energy efficiency ideas have on customers is of interest to electric utilities. Knowledge of savings persistence components provides a framework from which energy efficiency can be analyzed.

1.5.1.2.2 Environmental Protection

Another concern of electric utilities is environmental protection (Smith). In principle, strategic conservation programs reduce electricity demand and energy use in an economically sound manner. However, positive impacts attributable to less generation over the longer term can be accurately claimed only if savings persistence components are considered in DSM evaluations.

1.5.1.2.3 Identification of Regulatory Considerations

Although a collaborative of stakeholders submitted a DSM strategic framework application (Alberta Power Limited, 1993) to the Public Utilities Board (PUB), no response from the PUB has yet been given. The identification of savings persistence factors will help identify risks associated with DSM options, and thus should help to outline any dialogue that utilities and regulatory bodies will have in the future with respect to DSM. Awareness of persistence related issues has grown significantly in the last few years; no references to electricity savings persistence were included in the strategic framework application.

1.5.1.2.4 Responsible Resource Allocation

Load forecasts are the first step in utility planning (Baker and Battle) and are required to determine utility operational requirements (Marsh). Load forecast accuracy plays a large role in determining the effectiveness and productivity of capital investment schedules (Gellings). Utilities are interested in the load impact of DSM programs (MacLeod) since implemented efficient technologies can defer the need for generation, transmission, and distribution equipment (Vogt and Conner). Inclusion of savings persistence factors in the forecasting process will lead to more prudent capital investments since the effects of DSM programs affect load growth (Gellings).

As DSM becomes more widespread, integrated resource planning (IRP) is becoming more widely accepted in the USA and Canada (Baker and Battle). IRP is an economic comparison that considers various supply and demand side options on an equal basis, and indicates the least expensive option. To permit effective IRP, evaluations of demand side options must consider savings persistence components. Otherwise, the true value of demand side options will not be accurately estimated.

Once the installation of energy efficient measures is complete, requirements for accurate measurement of DSM related electricity savings are becoming increasingly stringent. Awareness of persistence factors will assist in obtaining accurate and cost effective impact evaluations. Knowledge of persistence factors will assist these evaluation processes. Traditionally, utility managers made decisions about investing in power plants and transmission facilities based on high reliability and low electricity costs (Baker and Battle). The identification of savings persistence components will assist IRP in the future.

1.5.1.2.5 Increased Competitiveness

Electricity savings persistence could help create new markets for Albertan utilities. Electric utilities in the pacific northwest have shortages of supply and high marginal costs (Meadows and Usibelli). If electricity efficiency in Alberta increases and persists, Alberta's excess supply and low marginal costs provide for the potential of electricity exports. The identification of electricity savings persistence components will help ensure electricity efficiency persistence, and excess supply.

IPPs will soon not be the only competitive threat to established utilities. John Rowe, President and CEO of The New England Electric System and other electric utility industry leaders, stated that research is now required to ensure the economic advantages of central-station generation. Customers in the future will eventually have the option of having fuel cells in their homes with capacities of up to 1 MW (Rowe, 1995).

Identification of electricity savings persistence factors helps to ensure the economic advantage of central station generation by deferring the need for new generation sources.

1.5.1.3 Benefits to Society and Government

Primary interests of Government include the economic health of society, and environmental protection (Elliot and Geller). These topics often draw immediate and opposite viewpoints from environmentalists and industry representatives. However, common ground between these two groups must be found since the incorporation of environmental considerations into business practices will improve long term competitiveness, and not limit it (Government of Canada; Crowley and Donoghue). The welfare of the environment cannot be considered in isolation of the economy, if the health of both is to be ensured (Environment Council of Alberta (ECA); Kelly, 1987). Indeed, "sustainable development ensures that the use of our resources and environment does not damage prospects for their use by future generations" (Alberta's Round Table on Environment and Economy). Components of economic and environmental health that are associated with savings persistence, are listed below.

1.5.1.3.1 Economic Health and Prosperity

Economic stability and diversification can be assisted by energy efficiency (Newman). Despite the fact that many industry representatives feel they are operating at peak energy efficiency and not much more energy can be saved (Nelson, K.), estimates of potential industrial energy efficiency improvements vary from 13-40% (Nadel and

Jordan; Baker and Battle). Demand reductions that can result from energy efficiency measures could help ensure that industry is less susceptible to the effects of any change in energy supply or price (Zwicky). In addition, some economic models have indicated that persistent energy efficiency leads to more jobs, higher personal income, and marginally higher GDP. However, despite the forecast net job growth, employment in some sectors, most notably electric utilities, oil and gas industries, and coal mining industries would suffer net job losses (Geller, 1992). Excess capacity, realized from sustained energy efficiency, cc[illegible]oten[illegible]ally be exported to markets outside of provincial boundaries. Energy [illegible] reduces energy intensity and energy costs (Newman), which in turn can lea[illegible]d competitiveness (Meadows and Usibelli). This study assists in estimating long lasting electrical efficiency by identifying savings persistence components.

Another aspect of economic stability is related to the stability of electricity supply. Accurate forecasts of electricity demand and supply, that include considerations of efficiency improvements, are required to ensure that supply is available when needed (Gellings). The identification of electricity savings persistence components will help determine and ensure any required future supply.

1.5.1.3.2 Environmental Protection

There is a growing consensus that environmental problems must be addressed globally to achieve any real solutions (Baker and Battle). Pressure is mounting on industrialized nations to implement energy efficiency policies because, in part, forecast coal use in developing countries such as China and India threatens to compound the documented problems (ECA; Climate Change Task Group) associated with global warming. In addition, although coal does not burn cleanly when compared to natural gas, coal is the only energy source that is forecast to be used in the long term (Vogt and Conner). Nearly 90% of Alberta's electrical utility generated electricity produces CO_2 as a byproduct, and 75% of that electricity is produced from coal (Alberta Department of Energy). From 1973-1985, the energy intensity of IEA countries as a whole decreased by 20% (IEA), but Canada continues to be one of the most energy intensive industrialized nations and uses twice as much energy per unit of GDP as Japan does. Pressure on Alberta to reduce gaseous emissions, by means of electricity savings, is significant (Climate Change Task Group).

Alberta produces 26.7% of Canada's $C0_2$ emissions, or approximately 0.25% of the world's emissions, and coal based electric generation is the main source of the emissions (Climate Change Task Group).

1.5.2 Why Alberta?

Alberta was selected for this study because:

a) Alberta's energy reliant economy, its surplus of available electricity, and the impending deregulation of electricity generation in Alberta provided for an interesting perspective on DSM issues.

b) The author had a prior affiliation with an electric utility company in Alberta. This association led to an interest in the topic, and facilitated the collection of data within fiscal and time constraints. However, no remuneration was received and the study was conducted independently.

1.5.3 Contribution to the Literature

There is little reported research related to the persistence of electricity savings. Several reasons account for this. Prior to the late 1980's, persistence was assumed to be relatively constant by DSM program operators (EPRI); and until recently, persistence was not considered an important issue (Vine). In addition, there have been few programs of sufficient duration that would facilitate persistence studies (EPRI; Vine), and research associated with DSM impact evaluations has only recently begun (Vine). Despite the numerous papers on the successes of electrical DSM, and some concerns about over-measurement, there is momentum for more accurate DSM impact measurements and persistence studies. However, the literature did not contain a baseline that indicated the prevalence of components required for electrical DSM savings persistence in industrial sectors.

The few studies that comment on industrial DSM savings persistence are not comprehensive, and usually only consider the technical lifetime of a DSM installation (Nelson and Ternes). In addition, the estimated lifetime of DSM measures is based on the expectations of participants (BC Hydro), the life expectancy of the measure as given by manufacturers, engineering estimates (Vine), or by laboratory tests that do not reflect actual operation or maintenance environments. However, factors contributing to these operation or maintenance practices, and even the prevalence of these inappropriate practices amongst industrial market subsectors, are not included in published reports.

The fact that utility planners and regulators need accurate forecasts to reflect the effects of DSM programs in the future (Gellings), necessitates studies associated with the risk and uncertainty of DSM programs in terms of the persistence of their effects. As recently as 1992, there was not even a consensus as to how to measure the risk associated with DSM programs when comparing demand and supply side options (Baker and Battle).

Before any meaningful discussion of how to measure risk associated with DSM persistence savings can begin, components of DSM persistence must be identified. This study differs from others in that it explores the prevalence of electricity savings persistence components in the Albertan industrial sector associated with the installation of high efficiency motors, and whether these components enhance or detract from electricity savings persistence.

The questions that this research was directed at were:

What electricity savings persistence components associated with high efficiency motor installations are prevalent in Alberta's industrial market sector?

What factors are related to the identified savings persistence components?

1.6 Research Methodology and Scope of Work

1.6.1 Scope

The prevalence of savings persistence components associated with DSM savings in the industrial sector, as they pertained to HEMP, were determined by archival and empirical studies. The archival portion of the research consisted of an exhaustive literature review which identified components of electrical DSM savings persistence and how they enhance or detract from savings persistence. The empirical study involved questionnaires that asked questions about the prevalence of savings persistence components in the Albertan industrial market sector, related to the use of electric motors. The study's commencement coincided with the end of the HEMP.

Savings persistence components associated with the use of electric motors were analyzed for at least two reasons. Approximately 78% of energy used in the industrial sector is consumed by electric motors (Nadel, Shepard, et al). Secondly, the only large scale industrial demand side management program in Alberta during the early 1990's was the High Efficiency Motor Program. The use of electrical motors is therefore integral to a study of electrical DSM savings in the Albertan industrial market sector.

1.6.2 Structure

The study is presented in three parts. Part A summarizes the literature survey , and the components identified by it. Part B summarizes the raw data collected by the empirical portion of the study. Part C analyzes the results of the empirical study, summarizes the factors and components it identified, and makes conclusions.

2. Part A - Components and Factors of Savings Persistence Identified in the Literature

2.1 Methodology

Components of electricity savings persistence on a micro level were identified with a literature search. Subsequently, factors that contribute to the identified components were recognized based on case studies, observations and conclusions of researchers, and other theoretical studies. Factors identified in this manner were consolidated and listed.

Approximately four hundred papers related to DSM, authored by electric utility companies, energy consultants, government representatives, or academics, including numerous policy papers and legislation related to DSM, published by provincial, federal, and international bodies, were read. In addition, newspaper articles, world wide web postings related to energy efficiency, and presentations given by industry representatives were included.

All these sources tended to concentrate on a few topical areas: testimonials or lessons learned by electric utility companies, electricity savings measurement techniques, economic analysis, environmental issues, and DSM implementation techniques. There is little research that specifically discussed electricity savings persistence or components related to it.

2.2 Results

2.2.1 End User Components

Vine lis d several components related to the persistence of energy savings associated with implementing an energy efficient measure (Vine). These components are applicable to any energy efficient measure, including high efficiency electric motors. They relate most directly to the end user. The components he included, applicable to high efficiency motors, were:

- installation aspects;
- lifetime;
- possible motor failure;
- possible replacement of motors;
- removal of motors;
- alterations to the motors;
- rebound;
- surge;
- changes to the operation schedule;
- whether or not its efficiency decays;
- maintenance and repair activities.

Unlike Vine's paper, other literature does not deal with the entire concept of savings persistence at once. Rather, some of it discusses aspects of savings persistence that can be grouped into one of Vine's categories. The categories listed above can be described in the context of this study, as they apply to the use of electric motors. The savings persistence components, together with related factors identified by the literature review, are summarized in Table 1.

2.2.1.1 Aspects of Installation

The establishment of a baseline efficiency during commissioning provides a point of reference for maintenance checks in the future. Without it, there is no way of knowing if the efficiency of the motor has increased or decreased since installation. In addition, savings cannot commence until the motor is installed and operating. A baseline efficiency is a component necessary for the determination of savings persistence.

Motors with different brand names have different efficiencies (Nadel, Shepard et al). Knowledge of the brand name helps to determine the baseline efficiency of the motor.

In some cases, motors and equipment are received from the original equipment manufacturer (OEM) together in one package. In such cases, the brand name of the motor is more difficult to specify. Approximately 80% of all motors 20 hp or less, and 15% of all motors 124 hp or more, are supplied by OEMs with equipment. Virtually all motors used in the residential sector, most motors used in commercial buildings, and a sizable portion of the motors used in industry are provided by OEMs (Nadel, Shepard, et al). OEMs can supply various motors with varying efficiencies, especially if the efficiency of the motors are not specified by the purchaser..

2.2.1.2 Lifetime

The lifetime of an electric motor determines the time period in which capital expenditures are not required for motor replacement. A long lifetime enhances savings persistence, subject to the effects of other savings persistence components.

Lifetime can vary depending on how it is calculated. A BC Hydro study indicated that electric motor lifetime ranges from 6.5 to 40 years, depending on which industrial sector is considered, whether rewinds are included, and whether you talk to a vendor or user (BC Hydro).

High efficiency motors are generally expected to last longer than standard efficiency motors. This is partly because their bearings and windings are not subjected to as much heat as standard efficiency motors (Nadel, Shepard, et al).

2.2.1.3 Failure

If a high efficiency electric motor fails, then a capital expenditure is required to replace it in order to resume operations. Any energy savings achieved by the motor are offset by the capital cost of the replacement motor. A low rate of failure contributes to savings persistence, subject to the effects of other savings persistence components (Vine).

Most electric motor failures are the result of bearing or winding failure. However, high efficiency electric motors fail less often from bearing or insulation problems as a result of lower operating temperatures (Nadel, Shepard, et al).

2.2.1.4 Replacement

If a motor needs to be replaced due to failure or some other reason, the efficiency of the replacement will affect savings persistence. For savings persistence to continue, the efficiency of the replacement motor must be equal or better to the efficiency of the motor it is replacing, subject to other savings persistence components.

During the period when this study occurred, purchasing a high efficiency motor for replacement purposes was affected by a number of things. Limited access to capital encouraged purchasers to obtain relatively inexpensive standard efficiency motors. High efficiency motors generally cost an extra 10-40 % (Nadel, Shepard, et al). The availability of high efficiency motors was not as great as standard efficiency motors, and the price of the high efficiency motors is affected by this (Hirshleifer). Insufficient supply of energy-efficient technology exists because retooling for new technologies is expensive and the inflated demand induced by DSM programs has likely been unexpected (Baker and Battle). Price and delivery time are the most prominent purchase decision criteria. Industries need a payback on their investment in one to three years (Nadel, Shepard et al).

2.2.1.5 Removal

The removal of an electric motor from service without replacement will indeed reduce electricity use. However, if the removed motor is replaced with a less efficient motor, in addition to incurring capital costs associated with the replacement motor purchase, savings persistence associated with the first installation is lost.

2.2.1.6 Alterations

Changes to electric motors affect their efficiency. For example, rewinding an electric motor can increase the core loss of a motor by 40%, with the effect of reducing its overall efficiency by 1% (Nadel , Shepard, et al.). Alterations which increase efficiency enhance savings persistence, subject to other savings persistence components.

The efficiency of electric motors is also governed by the load at which they operate at. The peak efficiency of most electric motors is approximately 75% of full load. Changes to driven machinery can affect the load on the motor, and therefore the motor efficiency. High efficiency motors maintain their efficiency at a wider range of loads than standard efficiency motors (Nadel, Shepard, et al). However, decreasing the load of an electric induction motor below 75% of full load, will decrease it efficiency. Operation at low efficiency causes the use of more electricity than would otherwise be required.

2.2.1.7 Rebound

Conservation can lead to greater economic activity, and more use of a conserved commodity (Zwicky). Rebound occurs when electrical savings create greater economic activity and a greater demand for electricity. For example, if a company installs a number of high efficiency electric motors thereby saving enough money to increase the number of operating hours or number of machines operating, and does so, rebound will have occurred. Rebound contributes to the loss of savings persistence, subject to other savings persistence components. It increases the use of electricity.

2.2.1.8 Surge

Enthusiasm for energy efficiency can lead to the installation of additional energy efficiency measures, that is, surge. If the installation of high efficiency electric motors creates enough enthusiasm for efficiency, so that further equipment modifications are made to increase efficiency even more, surge will have occurred. Surge contributes to the enhancement of savings persistence, subject to other savings persistence components.

Surge is not common in industry, since improvements in facilities and processes are not necessarily considered productive. Industry has a much larger rate of return requirement than society (Johnston). The time period in which an energy efficient investment creates a net saving is an impediment to further investment (Nadel, Shepard, et al). Small returns on efficiency improvements do not encourage surge.

New technology itself can cause greater conservation and is required for productivity and overall growth of efficiency. The method in which new technologies are introduced into the market determines whether they will cause more conservation activities (Boyd). However, technological change does not depend on energy prices (Steinmeyer). Technologically available options may simply not be economically feasible (Baker and Battle). Surge will occur if efficiency improvements make economic sense to industry.

Efficiency improvements in the US slowed since 1985 due to the plunge in oil prices, and an economic recession that cut investments (Geller). If profits are good, companies will invest in improvements, including energy efficiency (Elliot and Geller).

Fuel prices, profits, and the economy affect surge activities. However, windows of opportunity may only be brief, since improvements can often only be done when capital is replaced (Meyer).

Sometimes, small firms are unaware of the technology which is available, and as a result, further improvements in efficiency are not made (Nadel and Jordan). Utilities or other companies with amp[illegible]pertise in this area may be of some assistance under the right circumstances. Awareness of available technology enhances surge.

Corporate structure also plays a role in determining whether efficiency improvements are made. If the person making decisions that affect equipment efficiency has no incentive to increase efficiency, improvements are less likely to occur (Nadel, Shepard, et al).

Improvements to energy efficiency are often the byproducts of changes made to improve quality or safety, to increase productivity, or to reduce emissions (Steinmeyer). They are not often made for the sake of improving efficiency. In industry, a positive rate of return is usually required between one to three years (Nadel and Jordan, Puga; Baker and Battle).

2.2.1.9 Operational Changes

The length of time that equipment operates at a particular load determines how much power the equipment consumes. Changes to the operation schedule or equipment loading will affect power consumption, and thus savings persistence. In addition, the quality of the power supply, in terms of voltage unbalance, under or over voltage, and harmonics, affect electric motor efficiency (Nadel, Shepard, et al). Longer operating hours, increased loads, and poor power quality tends to contribute to losses in savings persistence since more power will be used under these circumstances.

2.2.1.10 Efficiency Changes

Changes to the efficiency of equipment will alter power consumption. Increases in efficiency tend to decrease the amount of power used and enhance savings persistence, subject to rebound effects. High efficiency motors use less power than standard efficiency motors because they have a higher power factor, have 20-40% fewer losses, and run cooler as a result (Nadel, Shepard, et al). Losses to motor efficiency occur as a result of electrical losses, magnetic or core losses, windage and friction losses, and stray losses. Minimization of these losses results in greater efficiency, and an enhancement of savings persistence, subject to other savings persistence components (Nadel, Shepard, et al).

2.2.1.11 Maintenance and Repairs

Maintenance is an effective method of reducing costs. Not much capital is required to implement it (Zwicky). Similarly, it follows that proper maintenance and repair procedures help to maintain motor efficiency and extend motor lifetime (Nadel, Shepard, et al).

Disregard for maintenance, and poor repairs contribute to a loss in savings persistence, subject to other savings persistence components. For example, poor lubrication often results in electric motor failure. Also, poor rewinding procedures damage electric motors and change their magnetic properties, thereby reducing their efficiency. Many repair shops do not follow published rewind procedures that are designed to minimize efficiency losses, but instead compete on speed and price (Nadel, Shepard, et al). Despite the fact that rewinding an electric motor reduces its efficiency, consumers will often choose that option over replacement for motors over 40hp in size due to the reduced downtime and lower capital cost. Down time is averted whenever possible (Nadel and Jordan; Baker and Battle).

Small to medium sized firms do not have the time or expertise to address efficiency related issues (Nadel and Jordan). Large and small companies have different needs. Larger companies can analyze their opportunities and implement them on their own. However, there are still opportunities for giving them support.

2.2.2 Government Policy Components

Government should become involved "whenever policy goals are not being met; when it can enhance existing environmental, economic, development, or regulatory activities by including energy components; to bring industry, utilities, academia, and others together to share information, develop policies, and collaborate on projects; to gain 'real world experience' to form well grounded policies" (Meadows). Government is responsible for providing guidelines of integrated resource planning to ensure a balance between supply and demand side resources, and more broadly between energy resources (Baker and Battle).

The roles of the provincial and federal governments, as they relate to energy efficiency, are very complex. Both have jurisdiction over energy efficiency (Baker and Battle). The Alberta Government has the ability to set energy efficiency standards on equipment , and it can set building codes which municipalities can follow if they choose (Baker and Battle). The Federal Government has the power to prescribe energy efficient standards on equipment and building codes for buildings, and regulate them with respect to provincial trade and imports (Baker and Battle). The definition of government roles is [illegible] difficult with the Canadian constitutional crisis as provincial [illegible] struggle for and begin to achieve more financial and political independence [illegible] government (Baker and Battle). Without consistent government policy at both the federal and provincial levels, policies will be fragmented, and government involvement will not be as effective (Baker and Battle).

Regardless of what government policies may exist in a given locale, claims of government contributions to energy achievements are not validated by industry, perhaps in part because results are very difficult to identify (Steinmeyer). Industry and government do not always get along. The focus government puts on energy efficiency seems forced and does not correspond to industrial priorities (Steinmeyer). There is antipathy towards any government interference, since many government activities do not appear to make sense to engineers at the working level (Steinmeyer). If the push for energy conservation on the part of regulators raises costs too high, industries may relocate or obtain other sources of power.

Government involvement in DSM can be broken down into three categories: information, specific incentives, and standards (IEA). Information and incentive programs permit voluntary industry action; standards tend to require involuntary behavior. Voluntary programs have the advantage of enabling industries to choose energy efficiency approaches which are most effective (Steinmeyer).

2.2.2.1 Information

Information programs usually consist of publicity campaigns, energy audits, labels and guides, technical handbooks, advisory services, training and education (IEA). They keep the idea of energy efficiency in the mind of industry, but serve primarily as a prompt for making free choices that lead to energy efficiency. However, prompts without appropriate consequenc[illegible] not always precipitate desired behaviors (Daniels). Information programs, if administered without any other type of involvement, will likely not enhance savings persistence.

2.2.2.2 Incentives

Specific incentives provide the positive or negative consequences that pure information programs are lacking. Financial penalties for not using efficient equipment is one example of an incentive (Nadel and Jordan). In Europe, the European Community has proposed an energy / CO_2 tax which has been approved in concept by the European environment ministers, and is now in the process of extensive evaluation (Baker and

Battle). If a tax rate is to make a difference, it must be large enough to impose a burden (Baker and Battle).

Tax incentives clearly show manufacturers and builders that the government is committed in the long term to energy efficiency. Incentives, such as taxes, will be entrenched into the government's system. Furthermore, standards promote voluntary behavior that causes the installation of energy-efficient equipment. Also, tax incentives do not require a preset level, whereas standards do (Baker and Battle).

Market based incentives are innovative ways to obtain energy efficiency. For example, tradable emission rights, higher waste disposal fees, and green taxes can be used to reduce pollution and encourage fuel efficiency (Government of Canada).

The price of electricity can also act as an incentive for savings persistence. Electricity prices in Canada are lower than most industrialized nations (Government of Alberta). Utility mandates have been to provide electricity at the least possible price (Baker and Battle). However, low electricity rates directly contradict the goals of DSM since the price of energy remains low relative to cost of investment required to increase efficiency (Baker and Battle; Puga; Zwicky).

Rates in Alberta are declining rates; the more electricity you use, the less it costs. In addition, often a contract is agreed to where a minimum cost for energy or power demand is assessed regardless of whether the energy or power is used. What is needed to promote savings persistence, is inclining or steady rate structures (PARC Symposium, 1991). The rate of price change is very important; larger rates of change cause industry to take more notice, and raise their sensitivity to energy costs as a production cost.

Energy intensity falls when energy prices rise faster than the price of capital and capital equipment (Steinmeier). Higher prices are effective in reducing inefficiencies if there is not a lack of knowledge or experience with respect to energy efficiency (Boyd). Electric power rates which reflect underlying market fundamentals as opposed to political and developmental objectives, need to be developed if savings persistence is to be enhanced (Baker and Battle). However, higher electricity prices have an adverse affect on productivity in electricity using sectors (Boyd).

2.2.2.3 Standards

Standards are often set according to political criteria (Baker and Battle). Examples of energy efficiency standards typically relate to building codes, appliance efficiency standards, automobile fuel efficiency standards, and recently to electric motors (IEA; Government of Canada).

Standards are not effective at ensuring savings persistence. One reason is that "the huge variety of technologies and organizations in factories, workshops, etc., makes it difficult to design regulations which will not require costly measures of verification"(IEA). Difficulties with fines include the inability of government to set accurate standards (Baker and Battle), and the inability to set fines commensurate with the offense (Baker and Battle). Another problem with standards is that they can easily be dismissed as interest wanes (Baker and Battle)

Standards help ensure that minimum efficiency levels are met, but discourage producers from exceeding minimum levels and thus achieving full economic potential.

Standards must be enforced (IEA). Given that these levels are set according to existing technologies, standards are likely to provide baselines and not targets (Baker and Battle).

In addition, standards referred to by Bill C-41 only restrict the import or trading between provinces of equipment that does not meet specified efficiency criteria (Government of Canada). Existing standards affect only installation, and replacement savings persistence components. Standards which encompass all components related to savings persistence, so not exist at this time. An Alberta Government energy efficiency standard does not currently exist. In lieu of Percy's and Ogus' modeled carbon tax effects, very unpopular memories of the National Energy Program, environmental buffers, and the Albertan Government's reluctance to impose efficiency regulations, only voluntary efficiency programs such as the Voluntary Gaseous Emission reduction Plan are likely to be instituted in Alberta at present. The Alberta Government does support voluntary industrial energy efficiency.

However, if utilities are deregulated, governments will have no option but to impose standards and taxes with pollution credits if they want to reduce CO_2 emissions and encourage conservation (Furness). Increased taxes affect the ratio of energy cost to capital cost, and thus maximize the use of existing technology (Steinmeyer).

Standards are expected to generate large savings (between 34-44 billion dollars in energy use), subject to other savings persistence components. They will incur minimal costs to manufacturers and builders. Utilities are expected to lose some revenue however, but air pollutants in 2015 are expected to be reduced by 1.5 to 2.0% (Baker and Battle).

2.2.3 Utility Components

Many small to medium sized companies do not have the expertise to take full advantage of the available energy efficient technology. If there is a lack of after installation support, and if operators are improperly trained, they will return to the old operating system (Biemer and Rose). Savings persistence would thus be lost.

The use of all available technology will help ensure that savings persistence is enhanced. Companies which have the required expertise, such as electric utilities, would enhance savings persistence if they could assist companies with a shortage of expertise. Benefits of partnerships to industrial customers include greater energy efficiency, productivity, improved quality, reduced environmental impacts, and improved worker health and safety (Puga). If electric utilities provide the assistance, their benefits include demand and energy efficiency, load retention, load growth, and a higher rate of return (Puga). Benefits to the community would include revitalized economic growth, preservation / creation of jobs, improvement of environment, and a higher tax base (Puga).

Rebate programs, such as HEMP, do not constitute a partnership, since they have uncertain long term benefits for utility and customer (Puga).

The environment, electrotechnologies, and electric load are commonalties which bring the electric utilities and industry together (MacLeod). Common interests such as these should be developed and recognized (Elliot and Geller). However, a number of differences, misunderstandings, or barriers between utilities, industries, and energy efficiency exist. To enhance savings persistence, they must be overcome.

2.2.3.1 The Utility Perspective

For example, utilities need to better understand how industry makes financial decisions (Meadows and Usibelli). Some utilities would question if the management time required to meet industrial proposals is justified (Elliot and Geller). Partnerships will likely not take place with transmission and distribution sides of utilities if deregulation takes place (Barkovich; Furness). Shareholders and ratepayers will find it difficult to support and take on risks associated with true partnership (Furness).

Four types of risks associated with promoting energy efficiency exist to utilities: regulatory, market, measurement, and competitive (Baker and Battle). US regulators have said energy efficiency investment expenditures were imprudent in the past and have excluded them from the rate base (Baker and Battle). DSM costs are not fully recoverable since money tied up in efficiency investments is not recoverable until the next rate hearing. There is a potential for the utility to loose revenue. Energy efficiency can lower absolute levels of demand and since electricity rates are held constant between cases, revenues can be permanently lost as a result of efficiency improvements. Ratepayers cannot benefit from revenue improvements via DSM since the rate hearings will likely reduce rates if revenue has increased (Baker and Battle).

If the barriers associated with uncertainty of regulator's actions are removed, it will help alleviate the problem with uncertainty of DSM impacts by providing guidelines for evaluation and integrated resource planning (Baker and Battle). Regulators could facilitate the removal of barriers by providing the information required at rate hearings (Baker and Battle).

The literature does not recommend one solution that should be adopted to help utilities recover costs of energy efficiency programs. However, if costs could be recovered with certainty, the risks to utilities could be alleviated. It follows that electric utilities would be more willing to assist industrial customers with achieving energy efficiency, and savings persistence would be enhanced.

Suggestions for recovering utility costs include a risk premium that will allow for compensation for the uncertainty of energy efficiency impacts, recovery of lost revenues, and / or lost opportunities (Baker and Battle). Another would ensure equalization of demand and supply side resources (Baker and Battle). If the benefits and costs associated wiih DSM occur in the same period, expensing DSM is sufficient, otherwise levelizing costs may be more appropriate to reduce electricity rate variability. The problem here is that since savings persistence is extremely difficult to measure, no one really knows for sure how long costs would have to be levelized. Still another suggestion would consider either an allowance for recovery of lost revenues or provide a bonus for DSM activity (Baker and Battle).

2.2.3.2 The Industry Perspective

Industry needs to better understand utility economics. It needs to see long term utility commitment to energy efficiency and to see it come from the top of the utility organization. Industry is concerned about the impact of conservation investments on rates, and wants to better understand the impact of utility DSM programs on the competitive balance between industries (Meadows and Usibelli). Energy efficiency recommendations must address individual business strategies (Smith). The identification of productivity or environmental problems must be made, and the implementation of energy efficient solutions should be in keeping with industry priorities (Elliot and Geller). Customer perspectives must be understood (Nadel and Jordan). Some industries want financial assistance while others do not want to add to their liabilities (Elliot and Geller). The confidentiality of energy use data must be ensured if industries are to willingly participate (Roop and Kinzey).

Situations where the assistance of electric utilities has shown to increase energy efficiency have occurred when technical assistance and other services are tailored to the customer's needs (Baker and Battle), customer perspectives are understood (Nadel and Jordan), and close regular contact is maintained with the customer throughout installation and into the commissioning and operation phases (Baker and Battle). These conditions will help enhance savings persistence, through the promotion of energy efficiency programs.

Table 1, Summary of Components and Factors Identified by the Literature Review

Component	Enhancing Factors	Detracting Factors
End User Components		
Aspects of Installation	• establishment of a baseline efficiency • knowledge of brand name	• original equipment manufacturers that use standard motors • poor record keeping
Lifetime	• long life time • high efficiency motors	• short life time • standard efficiency motors
Failure	• lack of failure	• failure • cost of replacement
Replacement	• lack of replacement • replacement with a motor which is as efficient or more efficient than the original • unlimited access to capital • equal or lower purchase prices for high efficiency motors • good availability • standards which affect import and trade • good delivery time	• replacement • replacement with a motor that was less efficient than the original • limited access to capital • higher purchase prices of high efficiency motors • poor availability • poor delivery time
Removal	• removal with no replacement	• removal • removal and replacement with a motor that is less efficient

Component	Enhancing Factors	Detracting Factors
Alterations	• changes which increase efficiencies • changes to cause electric motor operation at loads of approximately 75%	• rewinds, especially those that are not done well • changes to cause electric motor operation at loads of less than 50%
Rebound	• lack of rebound	• existence of rebound • conservation • greater economic activity
Surge	• enthusiasm for energy efficiency • new technology • corporate structures which permit empowerment • good profits • need to reduce emissions • need to increase productivity • need to improve quality and safety	• lack of interest in energy efficiency • large required industrial rate of return • time period in which energy efficiency creates a net saving • economically infeasible technology • lack of information • government regulations • poor economic growth • low fuel prices • improvements are timed to match replacement of capital
Operational Changes	• constant load or load reduction • decreases in operating time periods • good power quality	• increasing load • increases in operating time periods • poor power quality

Component	Enhancing Factors	Detracting Factors
Efficiency Changes	• increases to efficiency • high efficiency motors	• decreases to efficiency • standard efficiency motors • electrical losses • magnetic or core losses • windage or friction losses • rewinds
Maintenance and Repairs	• preventative maintenance • planning and preparation	• disregard for regular maintenance • rewinds • competition • low costs of rewinds in relation to replacement motor costs • lack of expertise or time to conduct maintenance properly
Government Policy Components		
	• consistent policy at the Provincial and Federal Government levels • cooperation between government and industry	
Information	• information programs	• information programs without other types of involvement
Incentives	• voluntary industry action • inclining or steady state rate structures • deregulation of electric utilities • rapid increases in electricity prices	• declining electricity price rates • contracted power demand or energy supply

Component	Enhancing Factors	Detracting Factors
Standards	• enforcable, accurate, and applicable standards	• variability of industry and a wide range of energy uses in the industrial sector • inability of governments to set accurate standards • inability of governments to set fines that are commensurate with the offence • changing technologies • deregulation
Utility Components		
	• after installation support by means of close, regular contact • development of commonalties between industry and utilities • elimination of utility risks • tailored assistance to industry	• improper training • lack of after installation support

3. Part B - Empirical Study

3.1 Methodology

The empirical part of the research consisted of a survey that was used to determine the prevalence of savings persistence components in the Albertan industrial market sector.

The survey was conducted in three steps: defining the sample, creating a persistence component questionnaire, and the subsequent analysis of the results.

3.1.1 The Sample

3.1.1.1 The Electric Utility Planning Council (EUPC) Database

The EUPC database was used to identify industrial subsectors that are large consumers of electricity in Alberta. The EUPC was comprised of representatives from Alberta's major electric utilities: Edmonton Power, TransAlta Utilities and Alberta Power Limited. Together, these utilities represent the source of almost 89% of all electricity generated in Alberta (Alberta Department of Energy). In addition to anticipating the electricity demand in Alberta, the EUPC also documents electricity usage in the province.

The major users of electrical energy in Alberta are from the following sectors: oil sands, oilfields, gas processing, refineries, chemicals, forest products, cement, coal, other industrial (EUPC), and electrical utility subsectors. It should be noted that the power use allotted to electrical utilities represents power requirements of draglines only, and not the auxiliary power requirements of generation stations. The sample population is primarily chosen from companies that belong to the subsectors that are significant electricity users (Figure 1). Several sources were used to select respondents.

3.1.1.2 Respondents Obtained From HEMP Participant Lists (Type A)

The names and phone numbers of HEMP participants were requested from Edmonton Power, TransAlta Utilities, Alberta Power Limited, The City of Calgary Electric System, and The City of Red Deer Electric System by means of several letters.

Three of these five electric utility companies initially responded, and indicated that they would seek the permission of the HEMP participants in their jurisdiction before any names would be released. Two of the electric utilities gave their information immediately. Overall, twenty HEMP participants were unwilling; they did not want to participate in this research. The City of Edmonton, TransAlta Utilities, and The City of Red Deer Electric System provided the names of all willing HEMP participants in their areas of service, Alberta Power Limited provided the names of every other willing HEMP participant, and The City of Calgary provided the names of all the willing HEMP 1992 participants.

The names of over 400 HEMP participants were received from Alberta's electric utilities. However, only 84 of these contacts were from the industrial market groupings identified by the EUPC, and therefore only they were included in the sample population.

Although the HEMP was targeted at industrial markets, the majority of the participants belonged to commercial market sectors and not industrial market sectors.

3.1.1.3 Respondents Obtained From Business Directories (Type B)

Industry subsectors identified as significant electricity users by the EUPC were used as guidelines for selecting companies from Business Directories. All companies in The Canadian Key Business Directory and The Alberta Corporate Directory, that were part of the industrial subsectors identified by the EUPC, were contacted by telephone. Respondents employed by companies selected in this manner were classified as Type A respondents if they were included in the list of contact names provided by the utilities.

Data from Statistics Canada was also obtained to compare the sample of the population of industries in Alberta. Statistics Canada's use of Canadian Standard Industrial Classification (SIC) codes complicated matters substantially. The United States also classifies industries according to numerical codes, however, that is where the similarity between Canadian and American SIC codes ends. Conversion of Canadian SIC codes to American SIC codes was time consuming. There is no direct one to one mapping from the Canadian SIC codes to the American SIC codes. Furthermore, different business directories provide different codes for the same companies, and sometimes provide obviously incorrect SIC codes. For example, Alberta Power Limited is not in the business of making trailers, although some business directories would have you believe so.

Data from Statistics Canada included all sizes of industries. To make comparisons more meaningful, only companies with fifty or more employees were compared with the sample. With that in mind, Statistics Canada data indicated that approximately 102 of Albertan companies are involved with the petroleum, gas or oil industries, 26 are in the chemicals industries, 20 are in the forest products industries, 9 are in the cement industries, 14 are in the coal mining industries, and 8 are in the electrical utility industry (Statistics Canada). The distribution of sampled industries did not closely match Statistics Canada data, most notably in the Food Products and Fabricated Metals areas (Figure 2).

3.1.1.4 Respondents Obtained That Were Independent Power Producers

To ensure all companies that generate electricity were included, a list of non-utility power producers (IPPs) was obtained from the ERCB (ERCB). All relatively large IPPs are in the population sample. IPPs account for approximately 9% of all electricity generated in Alberta. Respondents that were employees of companies in the ERCB's list of IPPs were included as Type B respondents if they were not included in the list of contact names provided by the utilities.

3.1.1.5 Respondent Selection

A small pilot survey was conducted to help ensure that respondents would correctly interpret the questions included in the survey. As a result of the pilot survey, several changes were made to the format of the questionnaire.

Respondents in the sample population were all initially contacted by phone, and asked several questions before a survey was mailed to them. The validity of Type A and Type B respondents was verified to ensure that the questionnaires were directed towards qualified individuals; they were asked if they knew about the operation and maintenance of the electric motors at their work location, that their organization had purchased in the last four years. If they did not respond positively, a reference to a more knowledgeable respondent was asked for.

Potential respondents were told the purpose of the research on the phone, and were asked if they would be willing to fill out a questionnaire pertaining to the topic. Those that responded positively were sent a questionnaire, and asked to return it in the mail via a pre-stamped, and addressed envelope.

A total of 84 Type A respondents and 53 Type B respondents were sent a questionnaire.

3.1.2 Limitations

a) Only electricity savings persistence micro factors and components associated with electric motors was researched due to the variability of equipment in use, and lack of the resources required to ascertain the efficiency of all driven equipment throughout the province.

b) Conclusions drawn from examining the electricity savings persistence associated with electric motors may be transferable to other technologies in a qualitative manner only. For example, in general, maintenance practices will help ensure that equipment efficiency does not decay. However, maintenance requirements for optimal long term temporal operation varies according to the types of equipment under consideration.

d) Identification of savings persistence factors and components in the Albertan industrial sector was not based on long term electricity savings persistence measurements. The HEMP commenced approximately only six years ago, so long term electricity savings persistence related to the HEMP cannot yet be determined.

e) The SIC codes offered the best available way of classifying facilities although in some instances, actual company activities are not accurately represented (Rogers).

3.1.3 The Savings Persistence Component Questionnaire

To determine the prevalence of DSM persistence components identified in the literature, a survey was used since it is the recommended measurement technique for persistence related information (Baker and Battle). Due to the potential difficulty respondents could have in accessing required information, and the number of potential respondents in the sample population, a mail survey was selected as the most economical and accurate data collection tool to use.

The mail survey included questions that identified micro persistence components evident in respondents' work locations. In addition to questions about documented persistence components, open ended questions were included to ensure that any persistence components not included in other questions would be identified.

Surveys were mailed to 137 willing participants throughout the fall of 1994 and early 1995, with accompanying stamped and addressed return envelopes. To help ensure a large response rate, reminder letters were faxed to those respondents who took a relatively long time to return their surveys.

3.1.3.1 Measurement Techniques

Nominal, and ordinal measurement techniques were used in the survey. The survey sample population was analyzed using Chi Square analysis.

3.1.3.2 Survey Format

The survey consisted of three sections. A copy of an exemplar survey is located in the appendix for reference.

3.1.3.2.1 Section One

First, the preface of each survey consisted of a letter addressed to the participants. It described the intent of the research, that being the determination of what affects the endurance of electrical savings in the Albertan industrial market sector. Confidentiality of individual responses was assured. The letter also described the sections of the survey which followed the letter: Part I and Part II. Finally, the letter requested that participants respond to each of the questions, and return the completed surveys by mail to the University of Alberta.

3.1.3.2.2 Section Two

Section two, labeled Part II, of each survey was comprised of four questions and was used to obtain relatively personal information from the participants. This information was used to categorize completed surveys according to industrial sectors, and to confirm that the respondents were knowledgeable about the topic.

Question 1 requested the name of the company at which the respondent was employed. This question was necessary to permit analysis which could possibly determine correlations between the type of industry and savings persistence components.

Question 2 requested the work location for two reasons. The location of the company at which the respondent was working helped to confirm the industry category. Secondly, in case the respondent needed to be contacted at a later date, the work location confirmed that the respondent was at the address to which the survey was mailed.

Question 3 requested the respondents position and responsibilities. This was asked to ensure that the respondent was knowledgeable about the use of electric motors at their place of work.

Question 4 requested information about the respondents educational background. Again, this question helped to confirm that the respondent was knowledgeable about the topic.

3.1.3.2.3 Section Three

Section three, labeled Part III, of each survey was comprised of forty two questions and was used to obtain information related to savings persistence components associated with the high efficiency motor program. Question 25 was divided into 25a and 25b. Information obtained from Part III was used to recognize savings persistence components.

This section consisted of questions related to electrical DSM persistence components identified in the literature survey. The questions were either fill in the blank, multiple choice, or long answer.

Questions related to both high efficiency motors and standard motors were asked to determine if the prevalence of savings persistence components depended on the type of motors used.

The HEMP offered rebates primarily for the use of induction motors which ranged from 1 - 500 hp, so therefore all questions were designed with that fact in mind. However, a category of greater than 500hp was also included to permit respondents a very wide range of responses. Motors were grouped together in sizes of 1-20 hp, 21-50 hp, 51-125 hp, 126-500 hp, and > 500 hp.

Question 1 asked respondents what standard and high efficiency motors, which the respondent was familiar with, were installed when the HEMP was in effect. It was designed to gather information related to a savings persistence component called 'installation aspects' that was discussed in Part A.

Question 2 requested from respondents the brand names of the motors identified in question 1. It was designed to gather information related to the savings persistence component called 'Installation Aspects' that was discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 3 asked respondents when the motors identified in question 1 were installed. The survey only considered motors that were installed while the HEMP was active. It was designed to gather information related to a savings persistence component called 'Installation Aspects' that was discussed in Part A.

Question 4 asked respondents if the motors identified in question 1 replaced standard efficiency motors. It was designed to gather information related to a savings persistence component called 'Replacement' that was discussed in Part A.

Question 5 requested from respondents the number of motors identified in question 1 that replaced standard efficiency motors. It was designed to gather information related to a savings persistence component called 'Replacement' that was discussed in Part A.

Question 6 asked respondents if the motors identified in question 1 were still installed. It was designed to gather information related to savings persistence components called 'Installation', 'Lifetime', 'Replacement', 'Failure', and 'Removal' that were discussed in Part A.

Question 7 asked respondents why some motors identified in question 1 were not installed. If respondents previously indicated that all motors were still installed, then respondents were told to skip this question. It was designed to gather information related to savings persistence components called 'Installation' 'Failure', 'Replacement', 'Removal', 'Alterations', 'Maintenance and Repairs', and 'Operational Changes', that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 8 asked respondents what happened after motor(s) indicated by the respondent in question 7, broke down. It was designed to gather information related to a savings persistence component called 'Replacement' that was discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 9 asked respondents why motors identified in question 7 did not live up to their expectations. It was an open ended question and respondents were free to answer in any way they wished. It was designed to gather information related to any of the savings persistence components discussed in Part A.

Question 10 asked respondents what requirements for the motors identified in question 7, changed. It was partly a Yes or No question related to motor size. The second part of the question was open ended. It was designed to gather information related to any of the savings persistence discussed in Part A.

Question 11 asked respondents to identify the reasons behind the selection of the motors identified in question 1. It was designed to gather information related to savings persistence components called 'Lifetime', 'Failure', 'Replacement', 'Efficiency Changes', 'Replacement', and 'Maintenance and Repairs' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 12 asked respondents to rank their responses to question 11 from most to least important. It was designed to gather information related to savings persistence components called 'Lifetime', 'Failure', 'Replacement', 'Efficiency Changes', 'Replacement', and 'Maintenance and Repairs' that were discussed in Part A.

Question 13 asked respondents what had been done with the electricity savings associated with high efficiency motors identified in question 1. It was designed to gather information related to savings persistence components called 'Rebound', 'Surge', and 'Operational Changes' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 14 asked respondents what electrically powered equipment identified in question 13 was purchased, and how often it was operated. It was designed to gather information related to savings persistence components called 'Rebound', 'Surge', and 'Operational Changes' that were discussed in Part A.

Question 15 asked respondents to elaborate about the electrically driven equipment identified in question 13 that was operated for longer periods. It was designed to gather information related to savings persistence components called 'Rebound', and 'Operational Changes' that were discussed in Part A.

Question 16 asked respondents to indicate how often the motors identified in question 1 were operated when they were first installed. The respondents could make an indication on a scale between 'not at all' and 'continuous'. This question was designed to gather information related to a savings persistence component called 'Operational Changes' that was discussed in Part A.

Question 17 asked respondents to indicate how often the motors identified in question 1 were operated when the survey was filled out. The respondents could make an indication on a scale between 'not at all' and 'continuous'. A comparison between the responses of question 16 and question 17 were compared to determine changes in operation duration. This question was designed to gather information related to a savings persistence component called 'Operational Changes' that was discussed in Part A

Question 18 was an open ended question that was designed to provide respondents an opportunity to explain any differences between the operation schedules identified in questions 16, and 17. This question was designed to gather information related to all savings persistence components discussed in Part A.

Question 19 asked respondents to indicate the load at which the motors identified in question 1 were operated when they were first installed. The respondents could make an indication on a scale between '0%' and '100%'. This question was designed to gather information related to the savings persistence component called 'Operational Changes' and 'Efficiency Changes' that were discussed in Part A.

Question 20 asked respondents to indicate the load at which the motors identified in question 1 were operated when the survey was filled out. The respondents could make an indication on a scale between '0%' and '100%'. This question was designed to gather information related to the savings persistence component called 'Operational Changes' that was discussed in Part A. A comparison between the responses of question 19 and 20 were made to determine changes in load.

Question 21 was an open ended question that was designed to provide respondents an opportunity to explain any differences between the loads identified in questions 19, and 20. This question was designed to gather information related to all savings persistence components discussed in Part A.

Question 22 asked respondents if there were changes to the efficiency of the equipment driven by the motors identified in question 1. This question was designed to gather information related to savings persistence components called 'Efficiency Changes', and 'Operational Changes' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 23 asked respondents to indicate how much the efficiency of driven equipment had changed since the time of installation. The respondents could make an indication on a scale between '50% less' and '50% more'. This question was designed to gather information related to savings persistence components called 'Efficiency Changes' and 'Operational Changes' that were discussed in Part A.

Question 24 asked respondents what was changed to affect the efficiency of driven equipment. This question was designed to gather information related to savings persistence components called 'Efficiency Changes'. There was an open answer option to this question that permitted an unlimited range of answers.

Question 25 dealt with the rebates offered during the HEMP. Respondents were asked if they were aware of the rebate, how many rebates were received from Alberta's electric utilities, and if the same purchase decision would be made regardless of the rebate being available. This question was designed to gather information related to savings persistence components called 'Replacement', and 'Surge' that were discussed in Part A.

Question 26 also dealt with the rebates offered during the HEMP. Respondents were asked if the same purchase decision would be made regardless of the rebate being available. This question was designed to gather information related to savings persistence components called 'Replacement', 'Surge', and 'Efficiency Changes' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 27 asked respondents to indicate how many maintenance hours were spent on motors each month. This question was designed to gather information related to the savings persistence components called 'Maintenance and Repairs' that was discussed in Part A.

Question 28 asked respondents to indicate how many motors have been rewound while the HEMP was in effect. This question was designed to gather information related to savings persistence components called 'Lifetime', 'Alterations', and 'Maintenance and Repairs' that were discussed in Part A.

Question 29 asked whether or not the respondent's organization had a written policy about rewinding motors. This question was designed to gather information related to savings persistence components called 'Alterations', and "Maintenance and Repair' that were discussed in Part A.

Question 30 asked respondents to indicate in relative detail what their employer's rewind policy is. This question was designed to gather information related to savings persistence components called 'Alterations', 'Maintenance and Repairs' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 31 was an open ended question that asked respondents why their employer had the rewind policy that was indicated in question 30. This question was designed to gather information related to savings persistence components called 'Alterations' and 'Maintenance and Repairs'.

Question 32 asked whether or not the respondent's organization had a written policy about purchasing electric motors. This question was designed to gather information related to savings persistence components called 'Alterations', and "Maintenance and Repair' that were discussed in Part A.

Question 33 asked respondents to indicate in relative detail what their employer's motor purchasing policy was. This question was designed to gather information related to savings persistence components called 'Alterations', 'Maintenance and Repairs' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 34 was an open ended question that asked respondents why their employer had the purchasing policy that was indicated in question 33. This question was designed to gather information related to savings persistence components called 'Alterations' and 'Maintenance and Repairs'.

Question 35 asked respondents to indicate what maintenance and operation records were recorded while the HEMP was in effect. This question was designed to gather information related to savings persistence components called 'Aspects of

Installation', 'Efficiency Changes', and 'Maintenance and Repairs' that were discussed in Part A.

Question 36 asked respondents how often the maintenance and operation practices indicated in question 35 were done. This question was designed to gather information related to a savings persistence component called 'Maintenance and Repairs' that was discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 37 asked respondents to indicate the type of operational problem(s) indicated in question 36. The question was designed to gather information related to savings persistence components called 'Failure', and 'Efficiency Changes' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 38 inquired about the type of metering used by the electric utility. This question was designed with the idea of determining if each motor's power factor was readily measured. It was designed to gather information related to savings persistence factors called 'Operational Changes' and 'Efficiency Changes' that were discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 39 addressed the issues of motors coming from OEMs, attached to equipment. Respondents were asked how many of the motors identified in question 1 came from OEMs. This question was designed to gather information related to a savings persistence component called 'Replacement' that was discussed in Part A.

Question 40 asked respondents to indicate whether their electric utility contracted a minimum amount of electrical demand or energy with them. This question was designed to gather information related to a savings persistence component called 'Incentives' that was discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 41 asked respondents who made the decisions about what electrical savings were used for. This question was designed to gather information related to a savings persistence component called 'Surge' that was discussed in Part A. Although primarily multiple choice, this question had an open answer component to it.

Question 42 was an open ended question that asked respondents what they believed contributed to the endurance of electricity savings. It was designed to gather responses related to all the savings persistence components identified in Part A.

A table which lists the nominal efficiency thresholds of high efficiency motors was attached to the back of each survey for the respondent reference.

The components referred to by each question are summarized in Table 2.

Table 2, Savings Persistence Components Referred to by Survey Questions

Question Number	Savings Persistence Components Referred To
1	Installation Aspects
2	Installation Aspects
3	Installation Aspects

4	Replacement
5	Replacement
6	Installation Aspects, Lifetime, Replacement, Failure, Removal
7	Installation, Failure, Replacement, Removal, Alterations, Maintenance and Repairs, Operational Changes
8	Replacement
9	all
10	all
11	Lifetime, Failure, Replacement, Efficiency Changes, Replacement, Maintenance and Repairs
12	Lifetime, Failure, Replacement, Efficiency Changes, Replacement, Maintenance and Repairs
13	Rebound, Surge, Operational Changes
14	Rebound, Operational Changes
15	Rebound, Operational Changes
16	Operational Changes
17	Operational Changes
18	Operational Changes

19	Operational Changes, Efficiency Changes
20	Operational Changes, Efficiency Changes
21	Operational Changes
22	Efficiency Changes
23	Efficiency Changes, Operational Changes
24	Efficiency Changes, Alterations
25	Replacement, Surge
26	Replacement, Surge
27	Maintenance Repairs
28	Lifetime, Alterations, Maintenance Repairs
29	Lifetime, Alterations, Maintenance Repairs
30	Lifetime, Alterations, Maintenance Repairs
31	Lifetime, Alterations, Maintenance Repairs
32	Replacement
33	Replacement
34	Replacement
35	Aspects of Installation, Efficiency Changes, Maintenance and Repairs
36	Maintenance and Repairs
37	Failure, Efficiency Changes
38	Operational Changes, Efficiency Changes
39	Replacement

40	Incentives
41	Surge
42	all

3.1.4 Data Entry

The questionnaire was large. Each respondent had 1260 selections to make, from which an enormous number of possible combinations could be chosen. Entering this amount of data manually was considered to be out of the question because of time constraints and the possibility of keying errors into a database. Customizable databases would not easily accommodate the numerous possible answers for each question on individual computer screens. Therefore, an electronic version of the questionnaire was written, that greatly facilitated data entry.

The data entry program consisted of 44 different screens, each of which had separate procedures and code. All screens were linked to a Main Menu, which permitted the user to enter, edit, or download data. Selections made on the screen were converted into a character string, that was stored for later retrieval and analysis (Figure 3).

The program was written in Visual Basic, and was very user friendly. Each page of the survey was represented by a separate screen (Figure 4). To enter the data contained in a completed questionnaire, pointing and clicking the mouse selected the answers which the respondent had chosen (Figure 5). Keying error was greatly reduced, if not eliminated entirely, since after the questionnaire had been entered, the computer monitor looked almost exactly like the questionnaire and therefore a visual check for keying accuracy was inherently provided. The electronic version of the questionnaire had a blank for including the SIC of the respondent's employer. The actual survey that was distributed to respondents did not inquire about the employer's SIC.

Storage of the respondent's answers, in the form of a character string computer memory file, was achieved by clicking a button on the screen with a mouse. The raw data file was comprised of 77 strings (one for each completed survey) connected in series.

After all questionnaires had been entered, the data was electronically converted into a readable format, and downloaded into an Excel spreadsheet that measured 77 cells across, and 1307 cells down. 47 cells of each column represented question number identification codes. Every other cell in each column represented a respondent selection.

4. Part C - Empirical Results

4.1 Returned Survey Distributions

Of the 137 surveys mailed throughout the fall of 1994, 89 surveys were returned, and 77 were completed at least in part, to give a return rate of approximately 65%, and a response rate of 56%. Chi Square test statistics indicated that at the 5% level of significance, the distribution of mailed surveys, according to industry, matched the distribution of returned surveys and answered surveys (Figure 6) All surveyed industries returned and answered questionnaires with comparable frequency.

4.2 Responses to Questions

Some form of answer was given by an average 73% of the respondents to any particular survey question with a response rate standard deviation of 34%, and median of 91% (Figure 7 and Figure 8). Questions which received responses from less than 31% of the respondents included 7, 8, 9, 10, 14, 15, 18, 21, 23, 24, 37. The responses to each question were graphed, and are included in the Appendix.

4.2.1 Part I

Questions 1 through 4 were answered by 100% of the respondents and permitted the collection of relatively personal data related to company names, work locations, respondent position and their responsibilities, and educational background. This data enabled an analysis of subsequent questions according to industry type. Respondents indicated that their education was obtained from several sources, as indicated by the responses to question 4. The quantity of responses for question 4 does not match the number of respondents (Figure 9).

4.2.2 Part II

Question 1 was answered by 100% of the respondents and permitted an indication of the comparison of the numbers of electric motors referred to by respondents (Figure 10). Over 50% of the electric motors referred to by survey respondents were between 1 and 20 hp. More high efficiency motors were referred to than standard efficiency motors.

Question 2 was answered by 100% of the respondents and permitted the collection of data related to brand name preference. Respondents referred most frequently to the installations of Westinghouse, Toshiba, Baldor, and General Electric standard and high efficiency motors (Figure 11). Since all respondents answered this question, it appeared that they knew the brand names of motors which their organization used.

Question 3 was answered by 88% of the respondents. Information related to installation dates was not given precisely by respondents, but approximated in most cases. Data related to this question was therefore graphed according to a yearly basis (Figure 12). Respondents indicated that most of the motors they referred to were installed in 1991. Although the HEMP did not commence until 1991, some respondents indicated motors installed in 1990 or about one year prior to the implementation of the HEMP.

Question 4 was answered by 96% of the respondents, and permitted the collection of data that indicated how many motors, referred to by the respondents, replaced standard efficiency motors (Figure 13). Respondents indicated that standard efficiency motors were replaced more often with high efficiency motors than standard efficiency motors.

Question 5 was answered by 78% of the respondents, and permitted the collection of data that indicated how many motors, referred to by respondents, replaced high efficiency motors (Figure 14). Respondents indicated that high efficiency motors were replaced more often with high efficiency motors than with standard efficiency motors. Also, when considered in conjunction with the results for question 4, the results for question 5 appeared to indicate that fewer high efficiency motors were replaced.

Question 6 was answered by 99% of the respondents, and permitted the collection of data that indicated how many motors, referred to by respondents, were still installed when they answered the questionnaire (Figure 15). Results from this question indicated that the removal percentage of high efficiency motors, referred to by respondents, was lower than that of standard motors.

Question 7 was answered by only 29% of the respondents. This question was only answered if respondents referred to an electric motor that was no longer installed. Most respondents indicated that uninstalled motors were either in storage or broken down (Figure 16). If a motor was reported as broken down, respondents indicated that a standard efficiency motor had broken down most frequently.

Question 8 was answered by only 5% of the respondents. Respondents had cause to answer this question only if a motor referred which they had referred to had broken down. No respondents selected multiple choice answers. Two respondents indicated that the motors which broke down would be repaired and put back in service. Other respondents did not indicate what course of action was followed after the motor which they referred to broke down.

Question 9 was answered by 9% of the respondents and provided reasons why some of the motors that had been taken out of service did not meet the expectations of the respondents' organizations. Answers included poor motor quality, premature bearing failures, mechanical overloading during startup, and poor operation procedures.

Question 10 was answered by 12% of the respondents. Although this question was intended to determine whether electric motors were taken out of service because of an increase or decrease in horsepower requirements, responses were not indicative one way or the other. Approximately equal amounts of respondents indicated either increased or decreased horse power requirements.

Question 11 was answered by 99% of the respondents, and permitted the collection of data which indicated the main reasons behind standard or electric motor purchases. Low operation costs and good reliability were the top two most frequently given reasons for purchasing high efficiency motors. Good availability, and low purchase prices were the most frequent reasons given for purchasing standard efficiency motors (Figure 17).

Question 12 was answered by 86% of the respondents, and permitted the collection of data which ranked the reasons for standard or high efficiency motor purchases. To establish an importance ranking order for the reasons that respondents gave for purchasing electric motors, the analysis of responses to question 12 took several steps. A ranking of 1 (most important) was assigned a scale value of 6, a ranking of 2 was assigned a scale value of 5, and so on. A ranking of 7 (least important) was assigned a scale value of 1. First, the frequency of rankings which respondents selected was determined for each 'purchase reason', for both high efficiency and standard efficiency motors. Next, a total scale value of each 'purchase reason' was determined by adding the scaled ranking frequencies together. The scaled values of each 'purchase reason' were then sorted from most important to least important. Low operating costs and good reliability were the top two most important reasons for purchasing a high efficiency electric motor. Good availability and low purchase prices were the top two most important reasons for purchasing a standard efficiency motor (Figure 18). The ranked responses corresponded closely to the results of question 11 (Figure 17), but are not identical, primarily because for question 12, respondents did not always rank the responses they selected in question 11.

Question 13 was answered by 84% of the respondents, and permitted the collection of data that indicated what respondents believed was done with the electricity savings associated with their organizations' use of high efficiency motors. Most respondents indicated that the money realized from the electricity savings was added to the general revenue of their employer, or used to subsidize other operating costs. Few indicated that the savings were used to operate equipment for longer hours, or to purchase equipment that used electricity.

Question 14 was answered by 1% of the respondents. Respondents would have cause to answer question 14 only if they indicated that savings associated with high efficiency motor installations permitted the purchase of equipment that used electricity. Respondents were requested to indicate what electrical equipment was purchased. The one respondent that answered question 14 indicated that the equipment their organization purchased consisted of a computer and related testing devices.

Question 15 was answered by 1% of the respondents. Respondents would have cause to answer question 15 only if they indicated that savings associated high efficiency motor installations permitted the operation of equipment for extended periods. Respondents were requested to indicate what equipment was operated for longer periods. The sole respondent that answered question 15 indicated that 62 electric motors, ranging in size from 1 to 500 hp, operated 48 hours per week more than what they had when first installed.

Questions 16 and 17 were answered by 96% of the respondents, and permitted the collection of data which indicated the operation schedule, and changes to the operation schedule of the electric motors referred to by the respondents. Respondents indicated that the operation schedule of the vast majority of the motors they referred to did not change from the time of installation (Figure 19). Most responses indicated that the motors referred to by respondents operated continuously (Figure 20).

Question 18 was answered by 13% of the respondents. Respondents would have cause to answer question 18 only if a change in the operation schedule of the motors they referred to had occurred. Those that did respond indicated that the reasons for operation schedule changes included seasonal operational scheduling, operations shutdowns, incomplete construction, demand cycle variances, and heat build up.

Questions 19 and 20 were answered by 92% of the respondents , and permitted the collection of data which indicated changes in the load of the electric motors referred to by the respondents. Respondents indicated that the load of the vast majority of the motors they referred to did r[illegible]ge from the time of installation, but the remaining majority reported slight incre[illegible]n load (Figure 21). In addition, the loads at which the electric motors operated was also indicated. Most responses indicated that motors referred to by respondents indicated that they operated between 80% - 90% of full load (Figure 22).

Question 21 was answered by 14% of the respondents. Respondents would have cause to answer question 21 only if a change in the load of the motors they referred to had occurred. Reasons given for changes in load included the variance in materials being processed, and increased production levels.

Question 22 was answered by 95% of the respondents, and permitted the collection of data which indicated if the machinery driven by the electric motors had increased or decreased in efficiency. The vast majority of responses indicated that no changes to driven machinery efficiency had occurred after motor installation (Figure 23).

Question 23 was answered by 27% of the respondents, and permitted the collection of data which indicated how much driven machinery efficiency had changed since motor installation. The majority of responses indicated that no significant changes to driven machinery efficiency had occurred, and the remaining majority of responses indicated that slight improvements to efficiency had occurred (Figure 24).

Question 24 was answered by 19% of the respondents. Respondents would have cause to answer question 24 only if they indicated a change in efficiency had occurred in questions 22 or 23. Respondents were asked what changed the efficiency of the driven equipment. Answers included changes to the drivetrain, the addition of power factor controllers, and speed controls.

Question 25a was answered by 99% of the respondents, and indicated whether or not the respondents were aware of the HEMP when they answered the questionnaire. Answers indicated that 94% of the respondents were, in fact, aware of the HEMP (Figure 25).

Question 25b was answered by 83% of the respondents, and gave an indication of the number of rebates that were received due to the HEMP. Most of the rebates were obtained in the Petroleum Oil and Gas, Chemicals, Lumber and Wood, or Paper and Allied Products industries. In addition, when the results of question 25b were considered in conjunction with results from question 25a, a substantial number of respondents indicated that the available number of motor rebates were not applied for (Figure 26).

Question 26 was answered by 100% of the respondents, and gave an indication of what type of electric motor the respondents' organizations would likely purchase in the absence of a utility rebate. Responses indicated that nearly all surveyed industries would likely purchase a high efficiency electric motor, with the exception of the electric utility industry, food production industry, and cement industry. They would be as likely or more likely to evaluate each purchase separately, or purchase standard efficiency motors before purchasing a high efficiency motor (Figure 27).

Question 27 was answered by 88% of the respondents and provided information which indicated how many hours are spent on motor maintenance per month. Responses were varied (Figure 28), but did not appear to be related to motor size.

Question 28 was answered by 97% of the respondents, and gave an indication of how many rewinds respondents were aware of in their work location. Responses were varied (Figure 29). It appeared that slightly more standard efficiency motors were rewound than high efficiency motors.

Question 29 was answered by 97% of the respondents, and indicated whether the respondents' organizations had written rewind policies or not. 16% of the respondents' organizations had a written rewind policy, and 81% did not.

Question 30 was answered by 95% of the respondents, and indicated the type of rewind policy that respondents' organizations had. Most respondents indicated that rewinds were chosen if the rewind cost was less expensive than the replacement cost (Figure 29). Relatively few respondents indicated their organization's rewind policy dictated that all electric motors should be replaced or rewound. Only one respondent commented that efficiency losses associated with rewinding a motor should be accounted for when doing a cost comparison between a rewind and replacement.

Question 31 was answered by 74% of the respondents, and indicated why their organizations adopted the rewind policies revealed in question 30. Most respondents indicated that replacements were done if a motor falls below a horsepower range, typically 20 hp. Rewinds were typically reported to be done on larger motors.

Question 32 was answered by 97% of the respondents, and indicated if respondents' organizations had written electric motor purchase policies. 29% of the respondents indicated that they were aware that their organization had a written electric motor purchase policy, while 71% of the respondents indicated that they were not aware of such a written policy.

Question 33 was answered by 91% of the respondents, and indicated the type of electric motor purchase policy that respondents' organizations had. Responses indicated that having no policy at all is most common, purchasing only high efficiency motors is next most common, followed by choosing motors based on economic payback (Figure 31). Some corroboration error was present.

Question 34 was answered by 66% of the respondents, and indicated why respondents thought the electric motor purchase policies revealed in question 33 were administered. According to respondents, policies which required the purchase of high efficiency motors existed because of energy savings, reduced maintenance related to lower operating temperatures, rebates, and improved power factors. Policies which stipulated standard efficiency motor purchases existed due to the lower cost, greater availability, and ruggedness of standard efficiency motors. Policies based on economic payback compared purchase prices, operational costs, and availability. Reasons for having no electric motor purchase policy included motor availability requirements, and changing market conditions.

Question 35 was answered by 83% of the respondents, and indicated what motor maintenance practices were recorded by respondents' organizations. The most frequently reported maintenance practices were vibration measurements, current measurements, and insulation resistance measurements (Figure 32).

Question 36 was answered by 69% of the respondents, and indicated how often the maintenance practices identified in question 35 were recorded. Respondents indicated that in most cases maintenance records were taken either on a yearly basis, or whenever a problem occurred (Figure 33).

Question 37 was answered by 31% of the respondents. A respondent would only have cause to answer question 37 if a problem with a motor was identified in question 36. Problems that prompted record keeping included overload trips, vibrations, high bearing temperatures, ground faults, damaged mechanical shieves, and broken shafts.

Question 38 was answered by 90% of the respondents. It provided an indication as to whether electric motors were metered with kW meters, kVA meters, or both. Responses indicated that motors were metered with kW meters about half the time, kVA meters about half the time, and measured with both types of meters about 20% of the time.

Question 39 was answered by 61% of the respondents. It indicated how many of the motors referred to by respondents came to their organization from an OEM, as part of an equipment package. Respondents indicated that, for the most part, motors were supplied by OEM's less than half the time. There appeared to be some ambiguity associated with the question. Respondents indicated with their comments that they were unsure whether the question referred to meters used to monitor each particular motor, or meters used to monitor the entire work location.

Question 40 was answered by 94% of the respondents. It indicated whether a minimum amount of demand or energy was contracted with the respondent's electrical utility. Respondents indicated that there slightly more of the respondents' organizations had power demand or energy contracts.

Question 41 was answered by 96% of the respondents. It indicated the individual(s) that decided what the money associated with electricity savings was used for at respondents' organizations. The vast majority of the responses indicated that the questionnaire respondents did not make decisions related to the use of electricity savings.

Question 42 was answered by 68% of the respondents. It indicated what respondents thought affected the endurance of electricity savings at their work location. The responses were varied, and are tabulated in Table 3. Responses given by two or more respondents included: preventative maintenance and repair of motors and equipment, reduction of peak demands, reduction of operating costs in general, stabilization of process dynamics, more education, teamwork, reducing the costs of high efficiency motors, sizing motors correctly for particular applications, and the installation of power factor controllers.

Table 3, Responses That Indicate What Affects the Endurance of Electricity Savings

preventative maintenance and repair
reduction of peak demands
reduction of operating costs in general
stabilization of process dynamics
more education
teamwork
reducing the costs of high efficiency electric motors
correctly sizing motors for particular applications
the installation of power factor controllers
motor purchase rebates
new technology that would improve process efficiency
ambient temperatures that are close to process temperatures
speed controls
sequential motor starting
acceptable return on energy efficiency investments
full time energy efficiency managers
improved and coordinated operation practices
natural gas prices
energy contracts
load factors
electricity exports
vendors which oversize electric motors

4.3 Error

There were at least three types rot associated with the information obtained from respondents: no response error, con ation error, and interpretive errors.

4.3.1 Non-response error

Non-response error occurs when respondents do not give information they are requested to give. This may occur because of privacy concerns, time pressures, lack of motivation, or simply because the respondent is unable to provide the information (Tull and Albaum, 1973). Respondents which returned uncompleted questionnaires cited a lack of available time, and a lack of information, as reasons for doing so. Comments included in the completed surveys indicated that available time and lack of information were responsible for the non response error which was observed.

Non response error associated with the completed surveys was measured by noting which questions received no responses, and consolidating the results. Microsoft Excel 5.0 Visual Basic was used to analyze the keyed in data.

Questions with substantial non-response included 7, 8, 9, 10, 14, 15, 18, 21, 23, 24, and 37. The median response for all questions was 91%. In other words, half of the questions were answered by more than 91% of the respondents, and half the questions were answered by less. The average response rate per question was 72%, and the standard deviation of question response rate was 32% (Figure 4).

For questions 7, 8, 9, 10, 14, 15, 18, 21, 23, 24, and 37, fewer than 32% of the respondents provided answers. This can be explained by noting that those questions were somewhat specialized, an[illegible] respondents would have no cause to answer them unless they had previously given answers which would oblige them to do so.

However, the non-response error associated with questions other than those listed immediately above, is best explained by comments provided by participants. Many apologized for not having the correct information to answer the questions thoroughly, and some indicated that the survey took too long to complete. It can be concluded that non-response was facilitated by unavailable data, and a lengthy survey.

4.3.2 Corroboration Error

Corroboration error occurs [illegible] the responses given by a respondent are later contradicted by the same respondent (Tull and Albaum, 1973). If the results obtained using two different questions do not agree, invalidity of the data may be present to some extent. The corroborative nature of the questions in the survey, most notably question 1 in conjunction with questions 2, 3, 4, 5, 6, 7, 11, 13, 16, 17, 19, 20, 22, 25b, 35, 36, 38, 39, and 40, permitted a validity analysis of the data.

Corroboration errors or contradictions associated with completed surveys were measured by comparing the categorical responses of question 1 with the categorical responses of questions 2, 3, 4, 5, 6, 7, 11, 13, 16, 17, 19, 20, 22, 25b, 35, 36, 38, 39, and 40. Comparisons could yield three distinct results. If the categories of motors referred to by a respondent in question 1 matched the categories of motors they referred to in other questions, no corroboration error was detected. However, if categorical responses did not match, a corroboration error was detected. Corroboration errors were calculated for each of the above questions in relation to question 1 with the aid of Microsoft Excel 5.0 Visual Basic. The errors were then consolidated and tabulated (Table 4). Corroborative errors were expressed as the ratio between completed surveys which had corroborative errors, and the total number of completed surveys.

For the questions that permitted testing, the corroboration error was substantial and varied from 4 to 57%. The reasons why corroboration errors existed is not entirely obvious. One plausible explanation is that it could have resulted from respondents' annoyance about having to continually reference their answers to question 1.

High corroboration errors indicate that the data associated with these questions may be somewhat invalid. In particular, inferences made about motor sizes are most likely unjustified. In any case, questions with substantial corroborative error can, at best, be considered on their own without reference to the motors respondents listed in question 1.

Table 4, Corroborative Errors Between Question 1 and Questions 2, 3, 4, 5, 6, 7, 11, 13, 16, 17, 19, 20, 22, 25b, 35, 36, 38, 39, 40

Question	Corroborative Error (%)
2	23%
3	27%
4	0%
5	1%
6	0%
7	10%
11	9%
13	11%
16	27%
17	25%
19	23%
20	26%
22	24%
25b	17%
35	57%
36	71%
38	44%
39	4%
40	20%

4.3.3 Interpretive Error

Interpretive error occurs when the underlying assumptions of the questionnaire and respondent differ, or some ambiguity exists (Tull and Albaum).

Ambiguity related to question 38 was discerned by the respondents. Some indicated that the question referred to meters which measured each particular motor. Others indicated that the question referred to plant wide metering.

When drawing conclusions from the study, the results of question 38 were ignored due to the ambiguity associated with it.

4.3.4 Combined Error

Combined error associated with any given question was determined using the non-response error (n%) and the corroboration error (cr%). The combined error (c%) was determined by multiplying the difference between 1 and the non-response error (1-nr%) with the difference between 1 and the corroboration error (1-cr%). If the combined error exceeded 20% for any particular question, the results of the question were ignored when forming conclusions related to the prevalence of savings persistence components. If the corroboration error of a particular question could not be determined, it was assumed that all respondents answered that particular question without contradicting themselves.

In light of the interpretive errors, corroborative errors and low rates of response associated with many questions, in addition to all long answer responses and comments, only the multiple choice components of questions 1 - 4 of Part I, and 1, 4, 6, 12, 24, 25a, 26, 27, 28, 29, 30, 32, 33, 39, and 41 of Part II were analyzed to determine the prevalence of savings persistence components. The total error associated with the multiple choice component of any other question exceeded 20%.

4.4 Identified Savings Persistence Components

4.4.1 Aspects of Installation

High efficiency motors were certainly installed by the Albertan industrial market sector during the HEMP, as evidenced by responses to questions 1 of Part II (Figure 10). Question 6 revealed that, for the most part, few high efficiency motors had to be replaced once they were installed. Respondents referred to more high efficiency motors than standard motors, and therefore implied that high efficiency motors are installed more frequently than standard efficiency motors in the Albertan industrial sector. The above information indicates that enhancers for the savings persistence component called "Aspects of Installation" are evident. Aspects of installation appear to promote savings persistence in the Alberta industrial market sector. Responses to question 1 revealed that respondents referred to 3480 high efficiency motor installations, which added up to a total of over approximately 200,000hp.

4.4.2 Lifetime

Responses from question 6 indicated that, once installed, few high efficiency motors were removed from service (Figure 15). Although the elapsed time between motor installation and this study was short, an enhancer of the "Lifetime" savings persistence component was evident since few high efficiency motors were removed. More standard efficiency motors appeared to be removed than high efficiency motors. The lifetime of high efficiency motors appears to promote savings persistence in the Albertan industrial market sector.

4.4.3 Failure

Few high efficiency motors were removed from service, and therefore few failed (Figure 15). In this sense, an enhancer for the "Failure" savings persistence component, identified in Part A, was evident. Failure rates of high efficiency motors appear to promote savings persistence in the Albertan industrial market sector.

4.4.4 Replacement

More standard efficiency motors were replaced than high efficiency motors (Figure 15). Most respondents would purchase a high efficiency motor even in the absence of a rebate (Figure 27). The above statements indicate evidence of enhancers for the "Replacement" savings persistence component identified in Part A. The replacement of electric motors promotes savings persistence in the Albertan industrial market sector.

4.4.5 Removal

Few high efficiency motors were removed from service (Figure 15). This is indicative of an enhancer for the savings persistence component called "Removal", that was defined in Part A. Removal of electric motors appears to promote savings persistence in the Albertan industrial market sector.

4.4.6 Alterations

A substantial number of high efficiency motor rewinds take place (Figure 29). In addition, rewinding motors is more prevalent than replacing them (Figure 30). Rewinds reduce the efficiency of electric motors, and therefore the results of question 28 - 30 are indicative of a detractor for the savings persistence component called "Alterations", which was defined in Part A. Alterations associated with rewind policies, do not enhance electrical DSM savings persistence in the Albertan industrial market sector.

4.4.7 Rebound

Data indicative of the savings persistence component called "Rebound", defined in Part A, was not evident. The multiple choice components of questions related to "Rebound", namely questions 13, 14 and 15, did not have a significant response due to non response and corroborative errors.

4.4.8 Surge

Data indicative of the savings persistence component called "Surge", defined in Part A, was not evident. Multiple choice components of questions related to "Surge", namely questions 13, 14 and 15, did not have a significant response due to non response and corroborative errors.

4.4.9 Operational Changes

Data indicative of the savings persistence component called "Operational Changes", defined in Part A, was not evident. Multiple choice components of questions related to "Operational Changes", namely questions 13 - 17, 19 - 21, and 23, did not have a significant response chiefly due to corroborative errors.

4.4.10 Efficiency Changes

Data indicative of the savings persistence component called "Efficiency Changes", defined in Part A, was not evident. Multiple choice components of questions related to "Efficiency Changes", namely questions 11, 12, 19, 20, 23, 24, 35, 37 did not have a significant response due to non response and corroborative errors.

4.4.11 Maintenance and Repairs

Data related to the savings persistence component called "Maintenance and Repairs", defined in Part A, was provided by the results of question 12. Question 12 indicated that the importance of high efficiency and standard motor maintenance was about the same when purchasing decisions were made. This implies that the amounts of maintenance required by both motors are about the same in the eyes of motor Albertan industrial market motor purchasers. However, since the rankings of high efficiency and standard efficiency motor maintenance are about the same, the results of question 12 do not indicate what the effect of maintenance and repairs of high efficiency motors on electrical DSM savings persistence is. Similarly, question 27 did not indicate a distinction between the maintenance requirements of standard and high efficiency motors.

4.4.12 Information

Data related to a savings persistence component called "Information", that was defined in Part A, was provided by question 25a. 94% of the respondents had heard of the HEMP before they filled out the survey. This indicates that information about high efficiency motors is well spread in the Albertan industrial market sector. It would appear that some information is enhancing electrical DSM savings persistence in the Albertan industrial market sector.

4.4.13 Incentives

Data related to a savings persistence component called "Incentives", that was defined in Part A, was not evident from the survey results.

4.4.14 Standards

Data related to a savings persistence component called "Standards", that was defined in Part A, was not evident from the survey results.

4.4.15 Utility Components

Data related to a savings persistence component called "Utility Components", that was defined in Part A, was not evident from the survey results.

4.5 Electrical Savings Persistence Factors

Open answer responses provided by respondents to question 42 of the questionnaire, comments provided with other questions, and conversations with respondents, provided insight into several factors that respondents believe affect savings persistence in the Albertan industrial market sector. Factors identified in this manner are summarized in Table 5, with the related savings persistence components.

4.5.1 Reliability of Motors

Increases in high efficiency motor reliability improve savings persistence. The electricity savings associated with the use of high efficient motors is quickly used up if there is a loss of production that results from unreliable equipment. Regardless of how efficient an electric motor is, if it is not reliable, then it will not be installed by industry.

If mistakenly installed, an unreliable motor is replaced, and thus is treated as if it failed. Therefore, a factor related to the 'Failure' component of electrical savings, namely reliability, was identified.

4.5.2 Price of Motors

For new installations, the price of a high efficiency motor is a prime concern. Under this type of circumstance, the premium price of the high efficiency electric motor, and the associated anticipated operating costs, are compared with other potentially viable options such as standard motors, pneumatic, or steam powered drives. Therefore, for new high efficiency motor installations, price was identified as a factor of the 'Replacement' savings persistence component identified in the literature.

4.5.3 Availability of Motors

Availability and reliability of high efficiency motors both contribute to savings persistence when motor replacements are required. Motors are generally purchased under two different sets of circumstances. Either a motor is required for a new installation, or alternatively, a replacement motor is needed. Quotations for initial purchases are often made, and high efficient motors are more likely to be specified under these circumstances. However, if a motor replacement is required when an alternate motor is not in stock, then efficiency and motor cost are not significant considerations. In this set of circumstances, time is of the essence; availability and reliability are the most important considerations since the cost of lost production is of paramount importance. Therefore, for situations which require motor replacements, availability was identified as a factor related to the 'Replacement' component of electrical savings persistence.

4.5.4 Size of Motors

Since motors smaller than about 20 hp are no rewound, the use of smaller motors contributes to savings persistence as long as they are replaced with high efficiency motors. The use of large motors detracts from savings persistence because it is large motors that are usually rewound, since the initial cost associated with rewinding a large motor is less than the cost of purchasing a new one. Motors larger than 20 hp are generally rewound, however, the lower cost of rewinding is a poor investment since rewinding often makes a motor less efficient. Studies conducted by General Electric have indicated that an average rewind increases motor core losses by 40%. For a motor operating at 90% efficiency and 90% of full load, core losses correspond to a 1% efficiency loss for each rewind. That efficiency loss is significant since motors greater than 20 hp in size use about 70% of generated electricity (Nadel and Shepard). In Alberta, where the total electrical capacity is 8991 MW (Government of Alberta), the 1% decrease in efficiency of all motors greater than 20 hp represents about 63 MW of lost capacity. Usually motors larger than 20 hp are rewound, and therefore, motor size was identified as factors of 'Alterations', and 'Maintenance', two components of electrical savings persistence.

4.5.5 Maintenance

Respondents indicated that preventative maintenance of driven equipment enhances savings persistence. Unmaintained equipment does not operate efficiently, and uses more drive power than would be necessary otherwise. Examples of maintenance that were given included replacement of shieves, belts, bearings, bearing packing, and so forth. Maintenance that is planned well before machinery breakdown or inefficient operation was identified as a factor of 'Efficiency Changes' and 'Maintenance', two components of electrical savings persistence.

4.5.6 Electricity Pricing

Contract power or demand of electricity that specifies a minimum use, and declining price structures, do not promote savings persistence. Electricity rates are generally structured in a way that appear to reward users for using more electricity. Generally, electricity costs less per unit if more is used, and contracts that stipulate minimum electricity consumption or demand are also used. Low costs of electricity do not promote investments in energy efficiency. Contracted power and demand which specifies a minimum use, and declining price structures were identified as factors related to 'Incentives", an electrical savings persistence component.

4.5.7 Rebates

Respondents indicated that rebates obtained for the purchase of high efficiency electric motors helped ensure electrical savings persistence. The rebates helped respondents choose to purchase high efficiency motors. Rebates were identified as a factor of 'Incentives', an electrical savings persistence component.

4.5.8 Installation Design

Correct motor and driven machinery selection enhances savings persistence. For example, an oversized pump's flow rate will likely be throttled at the outlet, to reduce output, thereby wasting a lot of energy. An oversized motor will operate at loads lower than those that correspond to optimum efficiency. Although the purchase of a high efficiency motor may be well intentioned, if the motor is oversized for the application, or if it is connected to oversized equipment, savings related to the high efficiency of the motor are small related to the losses associated with oversizing. The design of a motor installation, which includes appropriate sizing of the motor and driven equipment for a particular application, was identified as a factor of "Installation Aspects', a component of electrical savings persistence.

4.5.9 Process Changes

Process changes cause substantial load changes and therefore significantly affect savings persistence. Process changes that increase load detract from savings persistence and vice versa. When they occur, they often are caused by changes in product demand, and operation conditions that are dependent on the materials that are being processed. Process changes were identified as a factor of 'Operational Changes', a component of electrical savings persistence.

4.5.10 Empowerment

Respondents indicated that if personnel at a facility were responsible for the economic health of that facility, and could freely choose methods to make that facility profitable, savings persistence would be enhanced. Empowered facilities that benefit from their economic performance enhance savings persistence. Some companies indicated that energy savings, in conjunction with all profits associated with a facility, determine how much capital a facility is allotted. The more profitable a facility is, the more capital they receive. Empowerment was identified as a factor of 'Surge', a component identified as a savings persistence component.

4.5.11 Natural Gas Prices

Increases in the price of natural gas, a fuel, enhances electrical savings persistence. Respondents from companies which generate their own electricity, indicated that if the price of natural gas rose substantially, electricity use and conservation would become more of a concern. The price of natural gas was identified as a factor of 'Surge', a component of savings persistence.

4.5.12 Education

Although education related to energy efficiency was called a slow process, it apparently leads to the combined efforts of people at work sites. Conveying the importance energy efficiency to everyone at a work site is a difficult task. However, once everyone at a work site is convinced that energy efficiency is worth working towards, respondents indicate that enthusiastic teamwork becomes an important factor of electrical savings persistence. Education was identified as a factor of 'Information', an electrical savings persistence component. Teamwork was identified as a factor of 'Surge', an electrical savings persistence component.

4.5.13 Record Keeping

A significant number of questions were left unanswered, or answered inconsistently. Participants that did not respond or indicated that they could not complete the questionnaire, conveyed that they did not have adequate records to answer all the questions. Record keeping was identified as a factor of 'Aspects of Installation', a component of electrical savings persistence.

Table 5, Identified Factors of Electrical Savings Persistence

Savings Persistence Component	Related Factor
Aspects of Installation	• Design of Installation • Record Keeping
Failure	• Reliability of Motors
Replacement	• Price of Initial Motor Installations • Availability of Replacement Motors • Bill C-41, The Energy Efficiency Act
Alterations	• Motor Size
Surge	• Natural Gas Prices • Empowerment • Teamwork
Operational Changes	• Changes to Process Materials
Efficiency Changes	• Preventative Maintenance
Maintenance and Repairs	• Motor Size • Preventative Maintenance
Incentives	• Rebates • Electricity Pricing

5. Conclusions

Demand Side Management (DSM) in Alberta is intended to act as a substitute for new generation capacity, with reductions in electricity demand and consumption achieved through greater efficiency. The concept of persistence is of paramount importance to this idea. Generation capacity has an economic lifetime. To be comparable, so too should savings associated with DSM.

Literature related to persistence tends to be predictive, anecdotal, and tends to indicate that all savings persistence components are not considered by DSM program administrators. For example, literature indicates that qualitative survey data is used to estimate that high efficiency motor life is about 29.5 years, and after allowing for aspects of savings persistence components such as 'Replacement', 'Failure', and 'Removal', assumes that the lifetime of high efficiency motors is about 20 years (BC Hydro). However, although they appear to be unaccounted for by DSM administrators, savings persistence components such as 'Rebound', 'Surge', 'Alterations', 'Efficiency Changes', 'Operational Changes', and others can affect the benefits associated with high efficiency motor installations.

A substantial pilot survey would have reduced the interpretive error associated with the questionnaire. However, the return rate was high, and the distribution of returned surveys matched the distribution of surveys that were sent out. Enquiries suggested that non-respondents lacked data and records associated with the operation, maintenance, and installed efficiency of their electric motors.

Two aspects of electricity savings persistence are observed: technology and behavior. The technological aspects of the High Efficiency Motor Program (HEMP) are the high efficiency motors. Components related to technology are the efficiency, technical life time, etc., of high efficiency motors. The other aspect of persistence, human behavior, includes factors such as the loads which motors are subjected to, conditions under which they operate, changes made to the mechanical system which they drive, the type and frequency of maintenance they get, records which are taken related to their operation and maintenance, the implementation of government standards, etc. The causes of savings persistence are the underlying factors that influence the technology and the human behavior related to it.

Components and factors of electrical savings persistence are difficult to identify for a variety of reasons. First, aspects related to human behavior are not as predictable as things like the efficiency or the technical lifetime of a piece of equipment. Secondly, to compound the problem, aspects of savings persistence can be dependent on one another; behavior can depend on technology, technology can depend on behavior, behavior can depend on behavior, and technology can depend on other technology. For example, high efficiency motor purchases would not occur if the technology to produce them did not exist, and high efficiency motors would not likely be produced in the absence of a high efficiency motor market. In addition, the implementation of the HEMP by Albertan electric utilities caused some high efficiency motor purchases, and technology related to motor efficiency depends on technology related to metallurgy and heat transfer. 'Root' factors, that determine the developmental sequence and causes of behavior or technology, are difficult to determine. Thirdly, factors related to electrical savings persistence are constantly changing. For example, when HEMP started, the efficiencies of electric motors were not regulated by Bill C-41, the Energy Efficiency Act, and the Electric Energy Marketing Act still averaged the price of all new generation in Alberta. The state of Albertan industry is constantly changing and presents a formidable moving target. However, despite the difficulty associated with identifying components and factors related to high efficiency motor electrical savings persistence, this study identifies several of them.

"Replacement" and "Standards" are the predominant electrical savings persistence components that will affect the HEMP savings persistence the most in the Albertan industrial sector. This can be concluded from the fact that Bill C-41 stipulates the efficiencies of motors that can be imported into Canada or traded interprovincially, and the fact that most respondents indicated that they will purchase a high efficiency motor in the future if a replacement is required. Other identified components are comprised of both aspects of electrical savings persistence: "Aspects of Installation", "Lifetime", "Failure", "Replacement", "Removal", "Alterations", "Maintenance and Repair", "Incentives", "Standards", and "Information".

Identified factors related to the "Replacement" component included the price of initial motor installations, the availability of replacement motors, and the implementation of Bill C-41, the Energy Efficiency Act. The implementation of Bill C-41 is the predominant factor of "Replacement". The other two factors, price and availability, are irrelevant since high efficiency motors are the only motors which will likely be available for purchase in Canada after 1996.

Literature indicates that the main reason why the federal government implemented the Energy Efficiency Act was international pressure pertaining to gaseous emissions, and the international commitments made to reduce greenhouse gas emissions to 1990 levels by the year 2000. The international pressure was fostered by fears that increased CO_2 levels in the atmosphere causes global warming. In addition, the implementation of the HEMP by Albertan utilities likely had an effect on the federal government's decision to create the Energy Efficiency Act.

The survey revealed that industry does not generally appear to collect data that would identify the prevalence of the "Rebound", "Surge", "Operational Changes", or "Efficiency Changes" savings persistence components. After talking with a number of respondents, the predominant impression I received was that data is not collected due to the fact that the relative price of the associated electricity is low when compared with other manufacturing costs, and the reliability of electric motors is too high, to make detailed operational and maintenance records of electric motors worthwhile. Respondents appeared to indicate that if the price of electricity was higher, the efficient use of electricity would be a higher priority. In general, electricity price structures do not appear to promote efficiency.

Respondents did not indicate any "Utility Components" such as after installation support, or customized assistance. After talking to a number of respondents, I was left with the predominant impression that the reason "Utility Components" are not reported, is that industry does not perceive electric utilities as partners, or as sources of support related to energy efficiency.

As shown by this study, important factors of electrical savings persistence related to the HEMP, namely "Surge", "Rebound", "Operational Changes", and "Efficiency Changes" cannot be identified in the Albertan industrial sector. Data related to these components does not exist. Therefore, savings persistence associated with high efficiency motor installations is not certain, and benefits associated with the HEMP are arguable. Without the benefit of Bill C-41, the Energy Efficiency Act, savings persistence associated with the HEMP would be even more uncertain.

Components associated with electrical savings persistence and factors related to it have been identified by this study, thereby increasing the knowledge related to the impact of DSM programs in Alberta. However, other important components of savings persistence have not been identified due to a lack of data records in Albertan industry. The extent of their affects are unknown, and therefore risks associated with future DSM programs still remain. Although the elimination of declining rate structures and contracts that specify minimum amounts of electrical supply may increase the price of electricity to a point where efficiency becomes more important and better records are kept, the related impact on an energy reliant economy such as that of Alberta would be substantial. Increases in electricity prices may cause diversification and net employment in other locales that do not have an intensely energy based economy, but it would likely cause net unemployment in Alberta. Therefore, "Standards" imposed by the government would currently appear to be the best way to ensure that electrical savings persist in the future, although government standards are generally very sweeping, do not usually target specific segments of industry, currently address the "Replacement" component, and generally do not enhance other savings persistence components.

As such, industrial DSM programs in Alberta with the least risk will be those that can be targeted by legislation. However, few pieces of equipment other than high efficiency motors are used as consistently by all sectors of industry. Most other industrial technologies that have potential for increased efficiency have characteristics that are specific to industrial subsectors, and characteristics that depend substantially on particular applications within specific work locations. In addition, government may not be willing or able to institute more regulations associated with energy efficient technology. In lieu of these considerations, it is doubtful that "Standards" can be applied in conjunction with future Albertan industrial DSM programs. Therefore, future industrial DSM programs in Alberta, if any, will likely target specific segments of industry without the support of impending legislation. However, without detailed, temporal records of the operation, maintenance, and efficiency of the equipment targeted by future industrial DSM programs in Alberta, that address all components of electrical savings persistence, benefits claimed by the administrators of such programs should be greeted with skepticism.

Recommendations For Further Research

Research that explores why different companies in the same industrial subsectors record the efficiency, operation, and maintenance of their electric motors with varying degrees of detail would be valuable. More factors related to savings persistence would likely be determined in this manner.

6. Figures

Figure 1
Distribution of Distributed Surveys and Alberta Energy Consumption, According To Industry Type

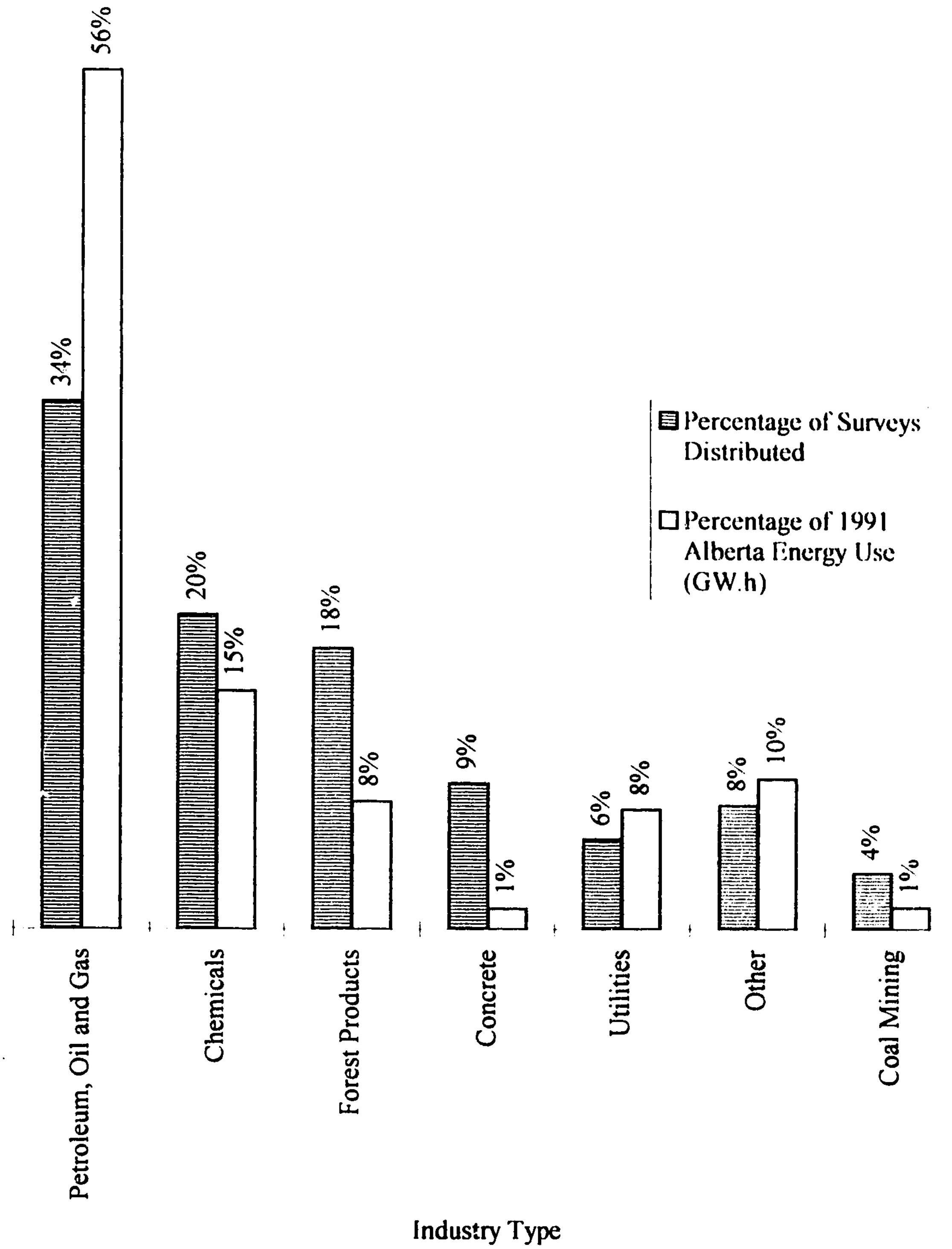


Figure 2
Distribution of Delivered Surveys and Number of Corresponding Industries In Alberta With More Than 50 Employees

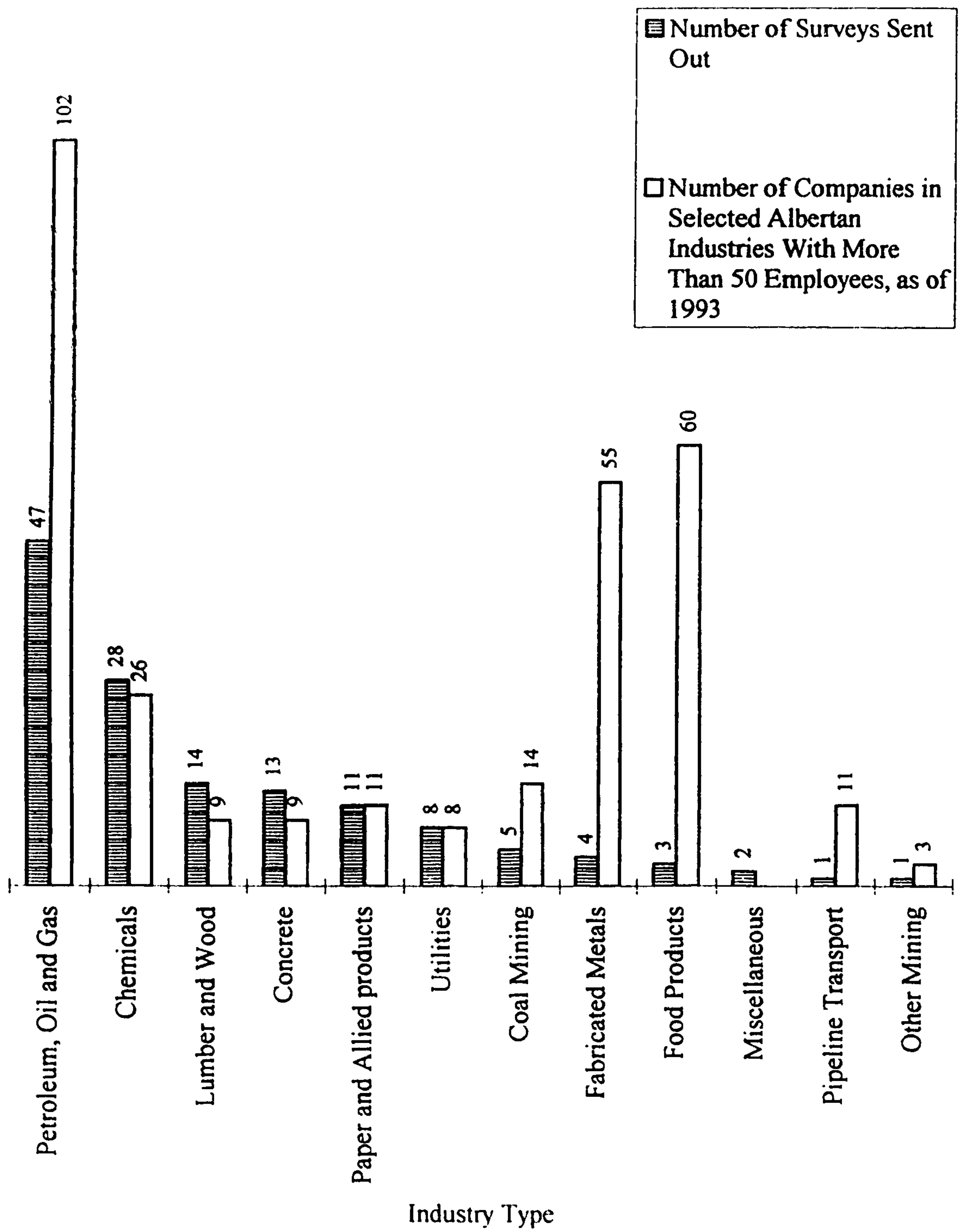


Figure 3
Flowchart of the Data Entry Program

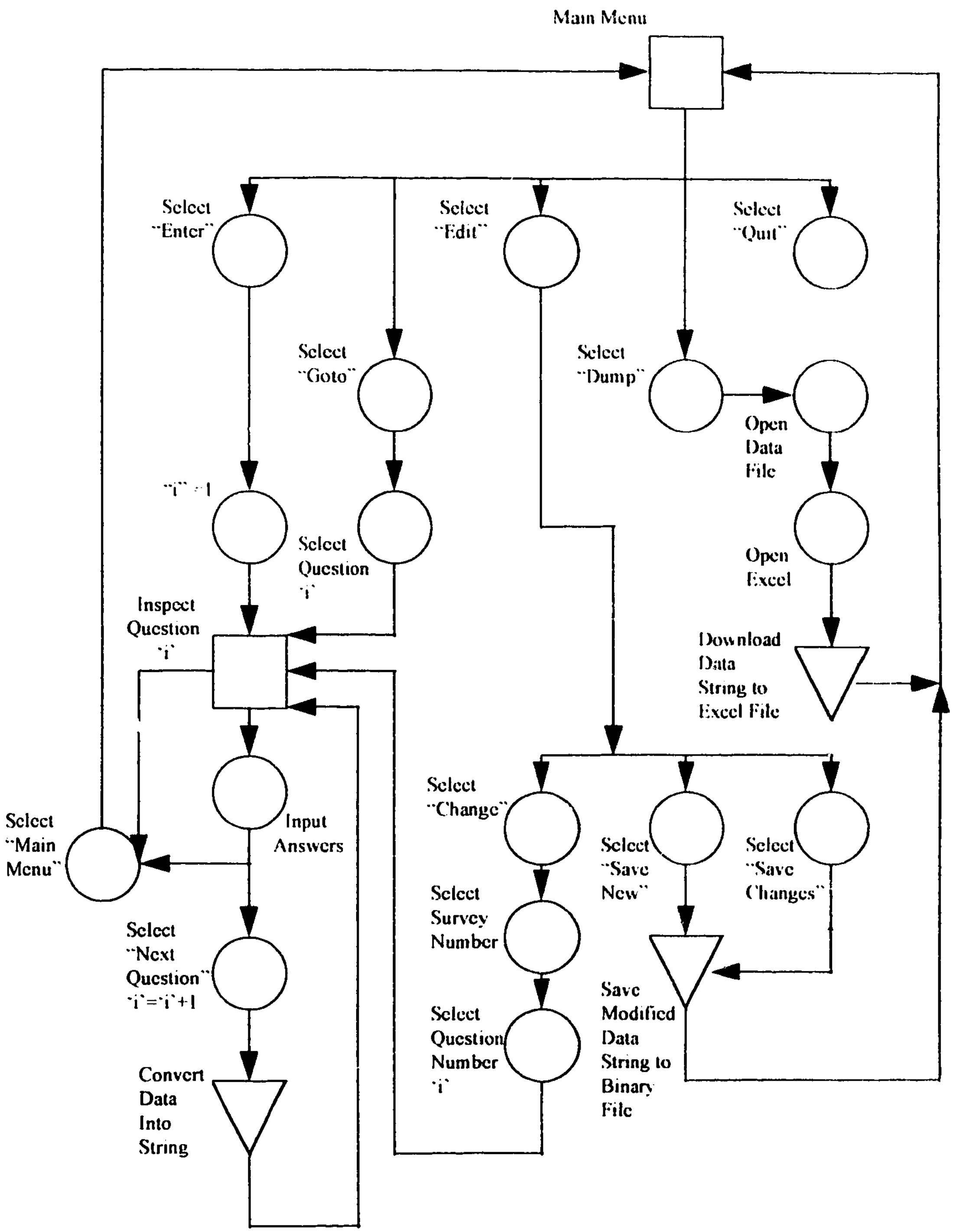


Figure 4
Sample Screen From Data Entry Program

Question 25

25a). Are you aware of a High Efficiency Motor Rebate Program offered by Alberta's electric utilities? (circle one)

Yes No

25b). Please indicate the number of rebates that were received from Alberta's electric utilities via the High Efficiency Motor Program for the high efficiency motors identified in question 1. (for each category in the table below, please circle the appropriate number)

High Efficiency Motors	
Quantity	*Motor Size Range (hp)*
0 1 2 3 4 5 6 7 8 9 10+	1 - 20 hp
0 1 2 3 4 5 6 7 8 9 10+	21 - 50 hp
0 1 2 3 4 5 6 7 8 9 10+	51 - 125 hp
0 1 2 3 4 5 6 7 8 9 10+	126 - 500 hp
0 1 2 3 4 5 6 7 8 9 10+	> 500 hp

next question main menu

Figure 5
Sample Screen From Data Entry Program With Some Answers Selected

Question 25

25a). Are you aware of a High Efficiency Motor Rebate Program offered by Alberta's electric utilities? (circle one)

Yes No

25b). Please indicate the number of rebates that were received from Alberta's electric utilities via the High Efficiency Motor Program for the high efficiency motors identified in question 1. (for each category in the table below, please circle the appropriate number)

High Efficiency Motors	
Quantity	*Motor Size Range (hp)*
0 1 2 3 4 5 6 7 8 9 10+	1 - 20 hp
0 1 2 3 4 **5** 6 7 8 9 10+	21 - 50 hp
0 1 2 3 4 5 6 **7** 8 9 10+	51 - 125 hp
0 **1** 2 3 4 5 6 7 8 9 10+	126 - 500 hp
0 1 2 3 4 5 6 7 8 9 10+	> 500 hp

next question. main menu

Figure 6
Numbers of Delivered, Returned, and Answered Surveys, According To Industry

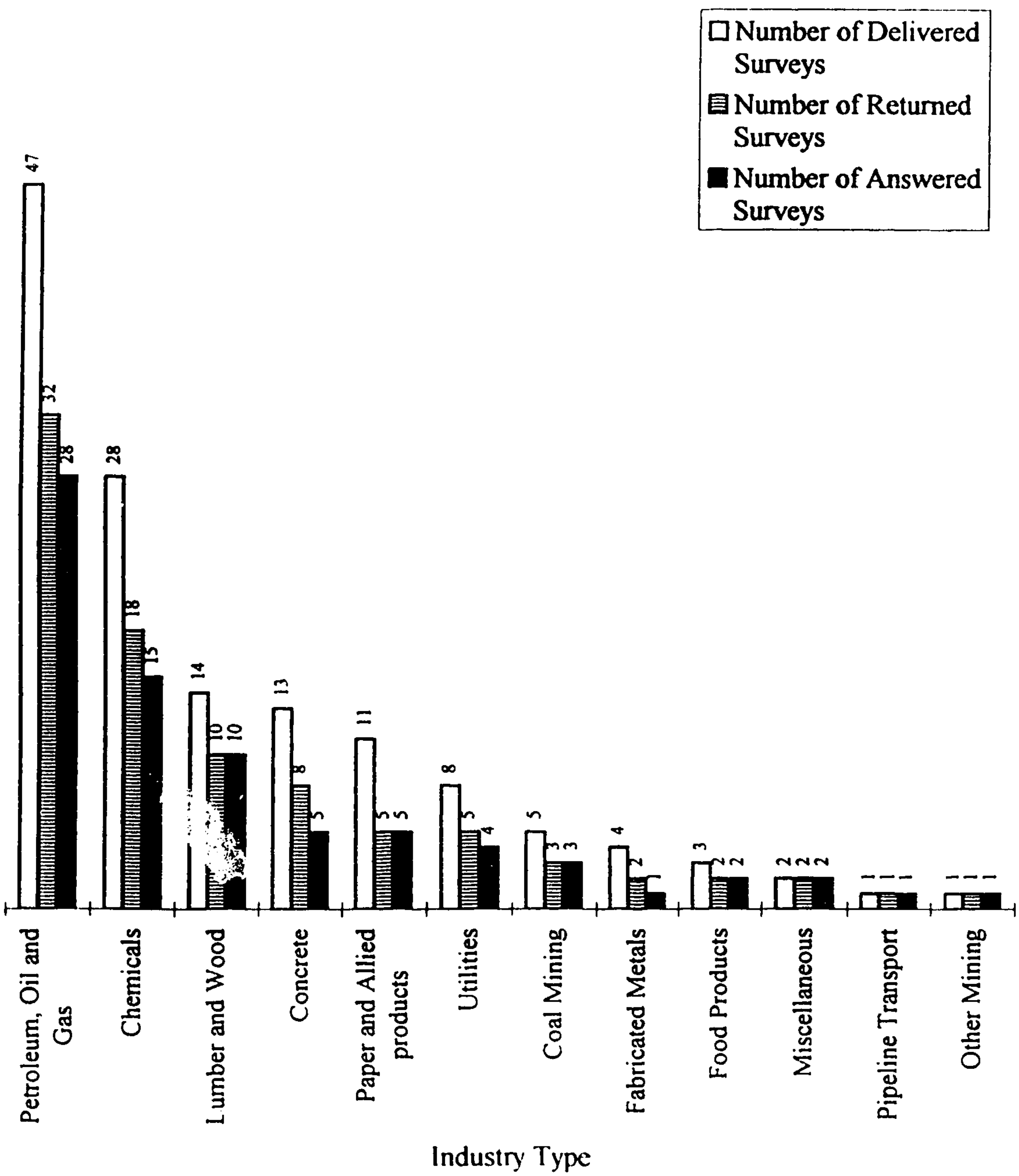


Figure 7
Percentage of Part II Responses, According to Question Number

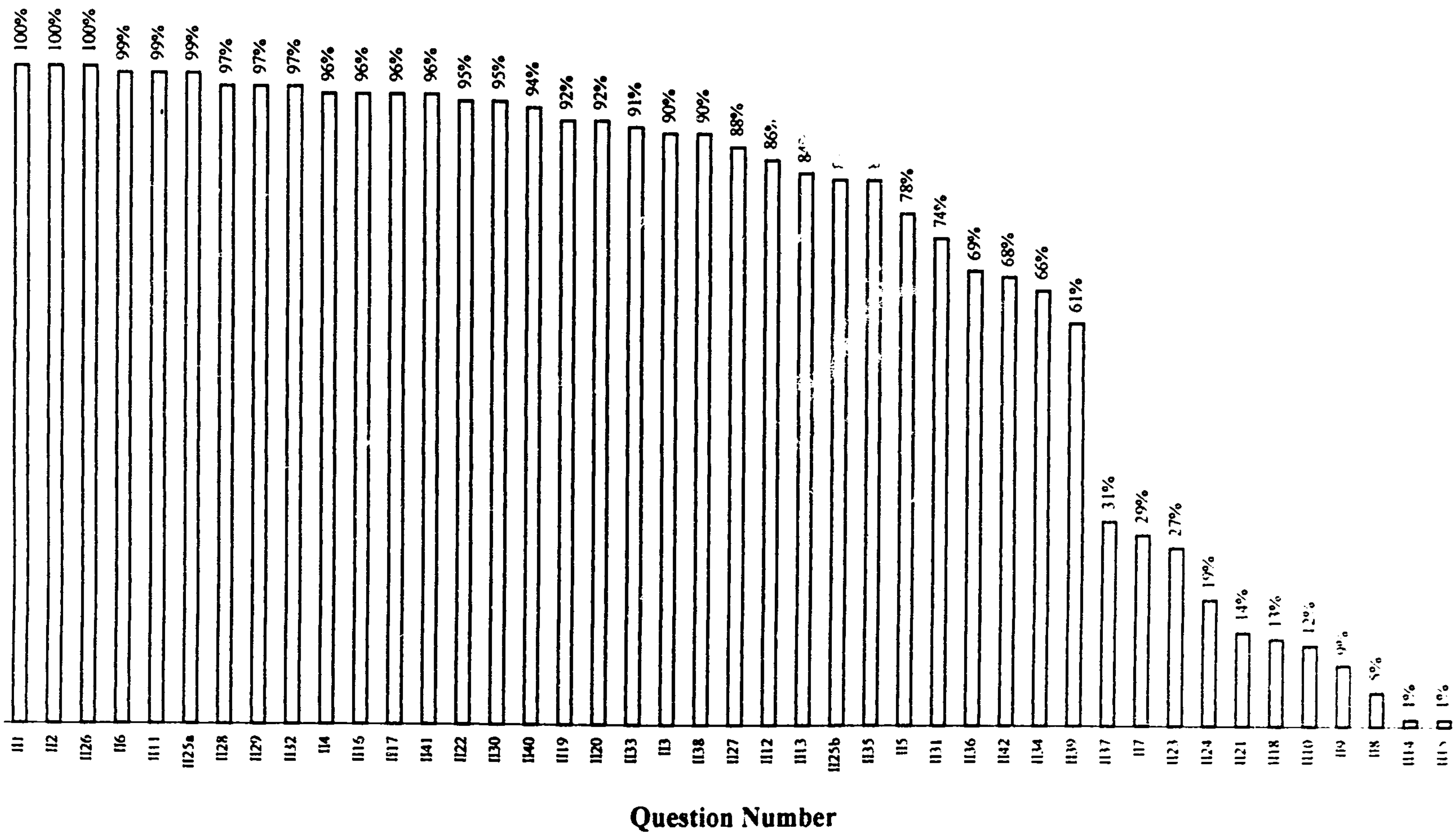


Figure 8
Frequency Distribution of Part II Question Response Percentages

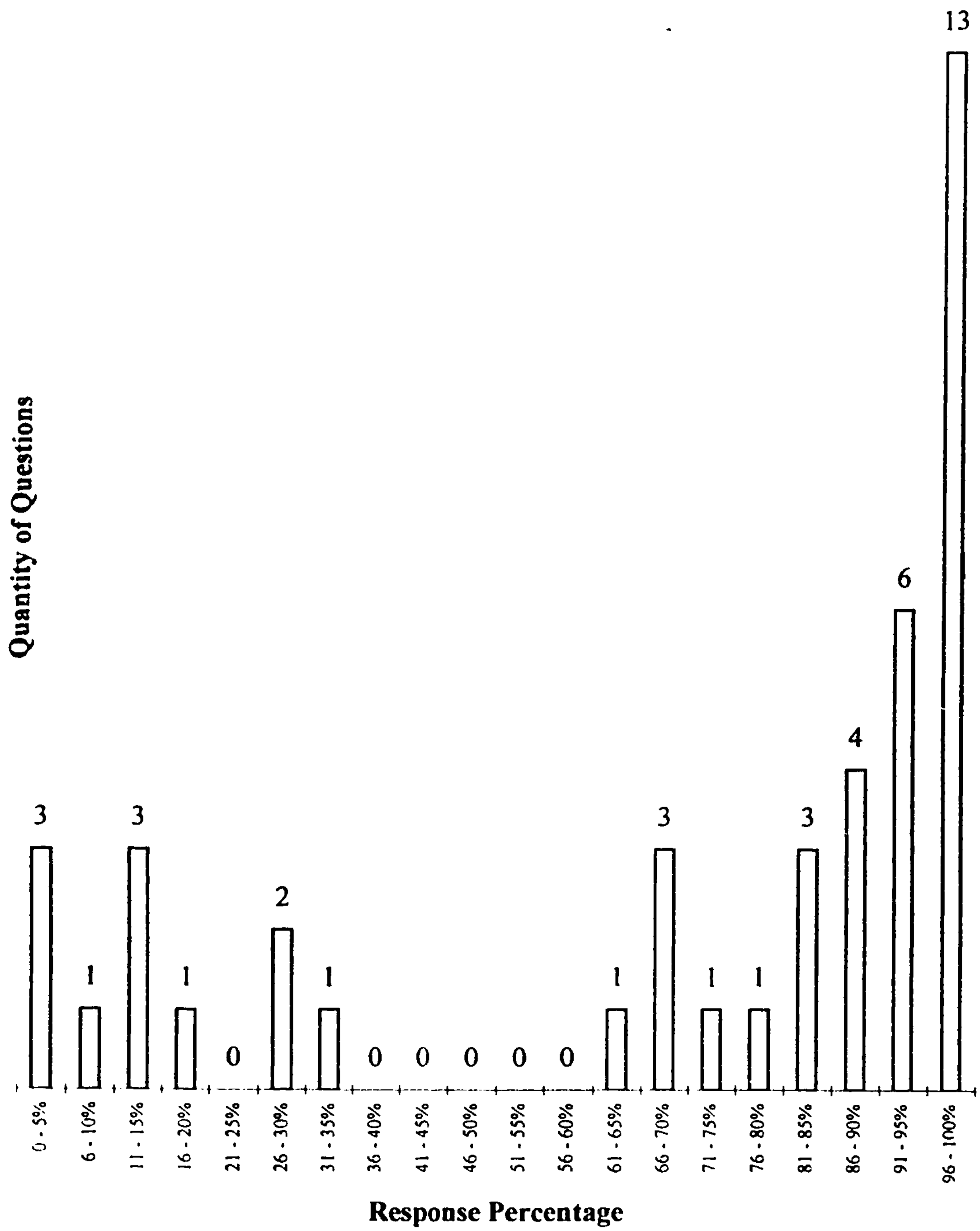


Figure 9
Education of Respondents

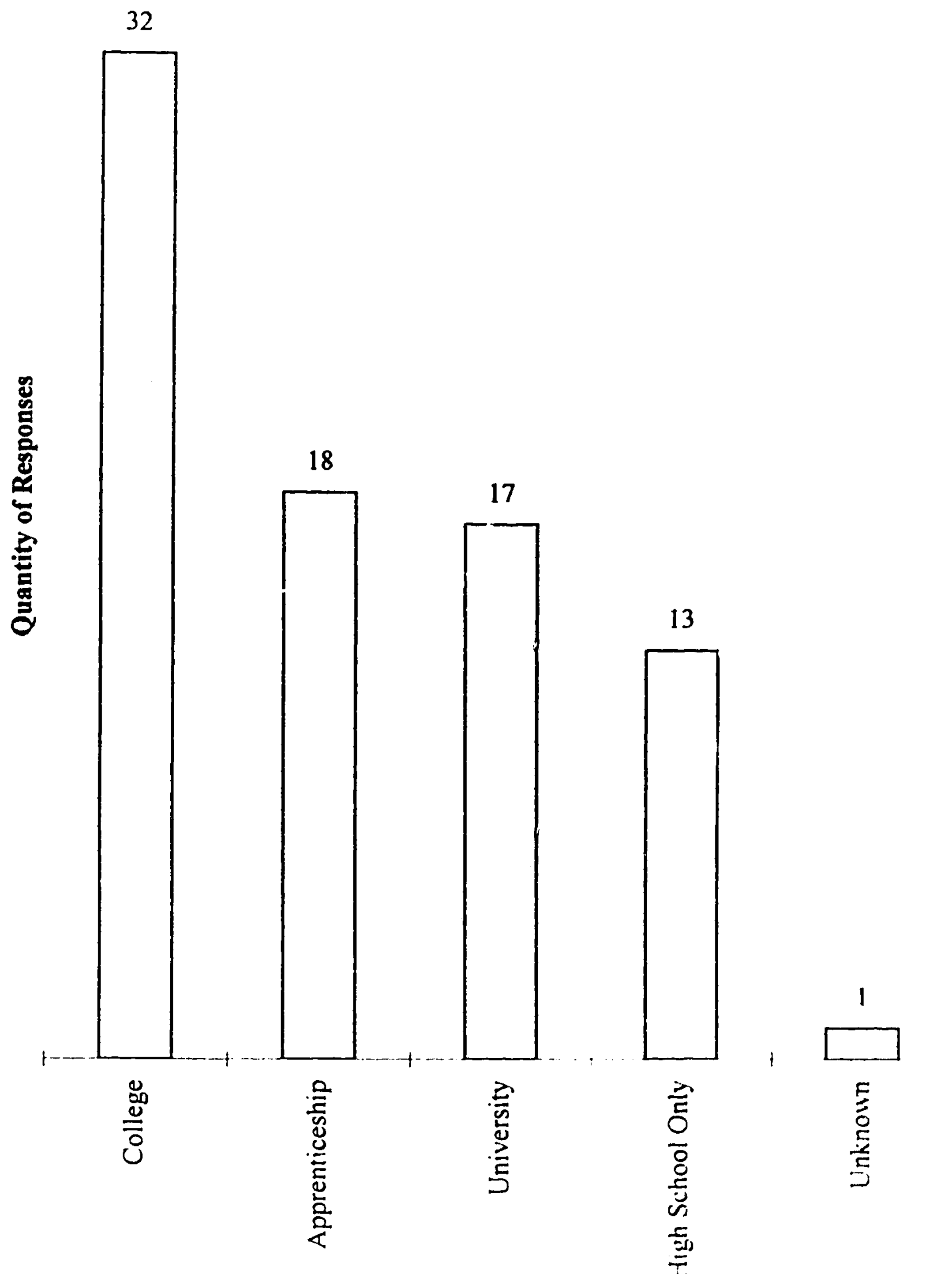


Figure 10
Electric Motors Referred to By Respondents

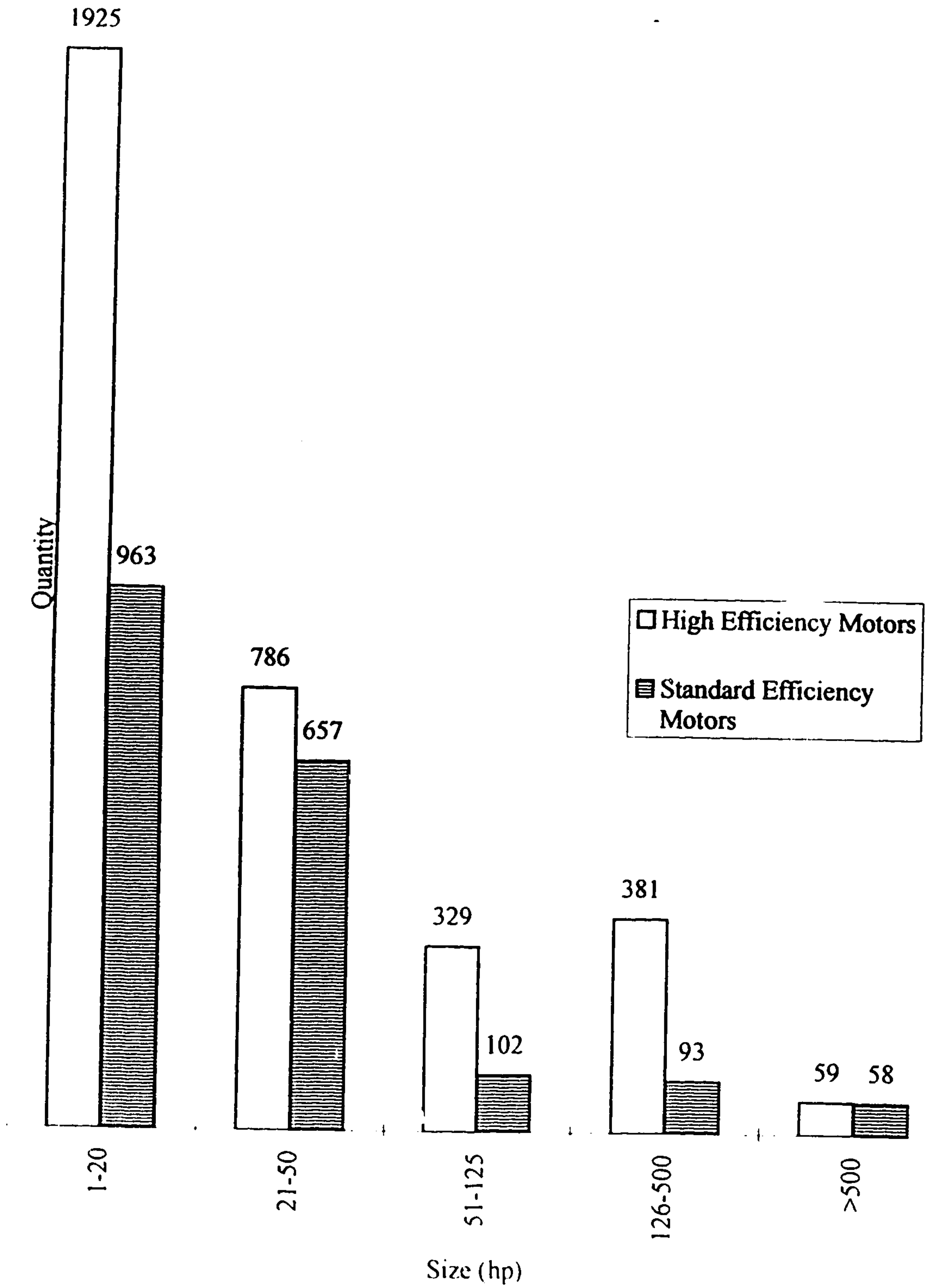


Figure 11
Number of Motors Referred to By Respondents In Terms of Brand Name

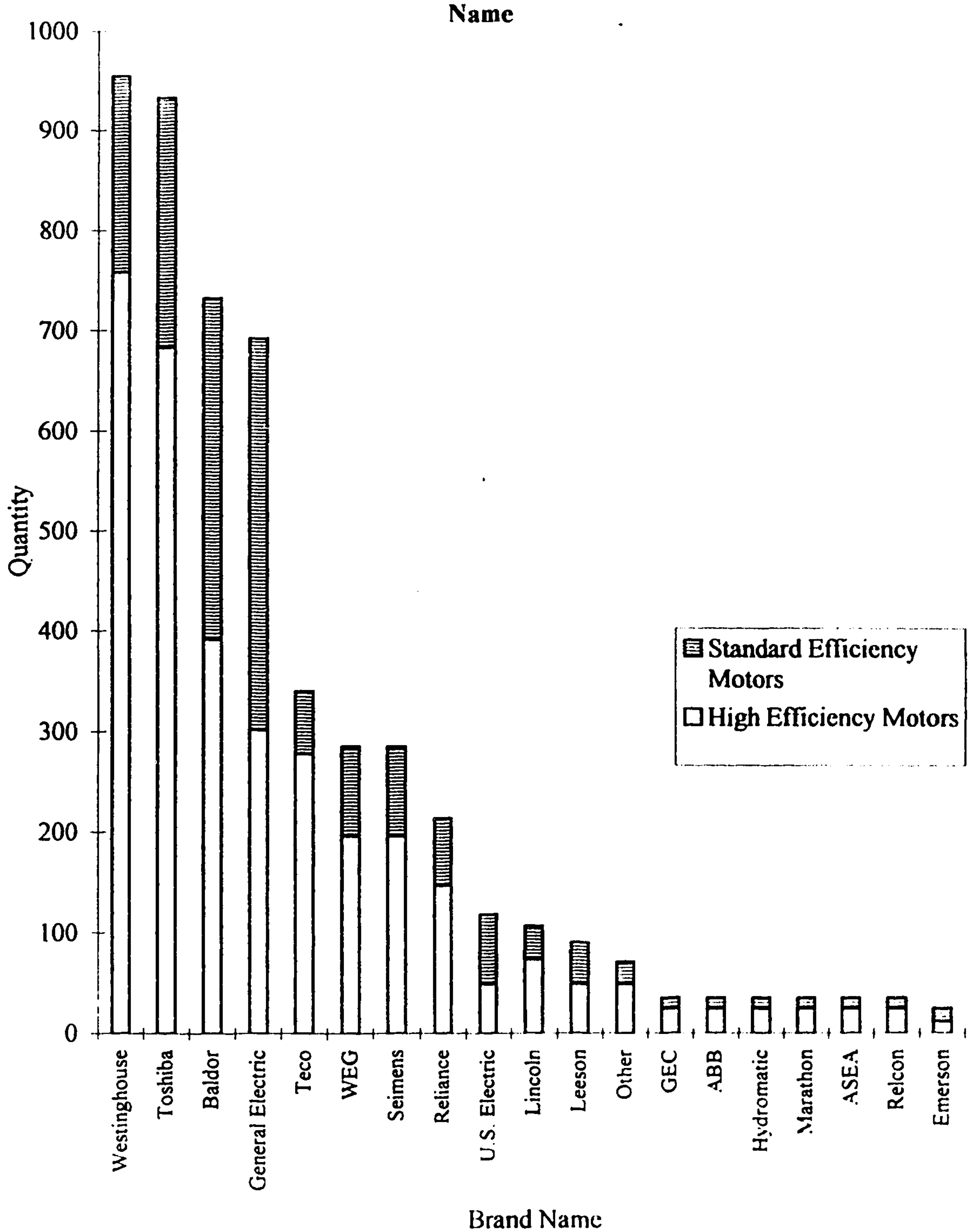


Figure 12
Approximate Installation Years of Motors Referred to by Respondents

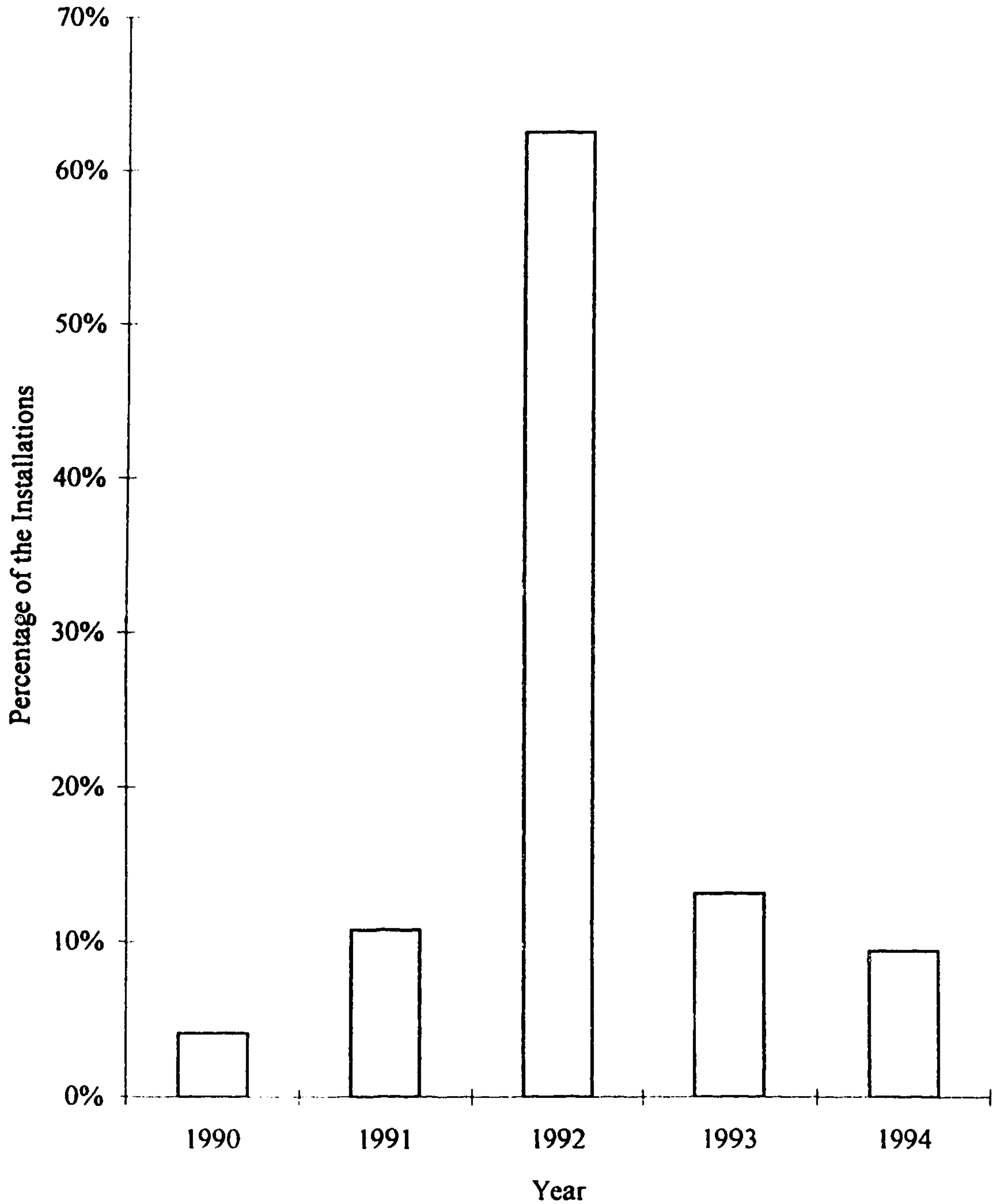


Figure 13
Replacement of Standard Efficiency Motors

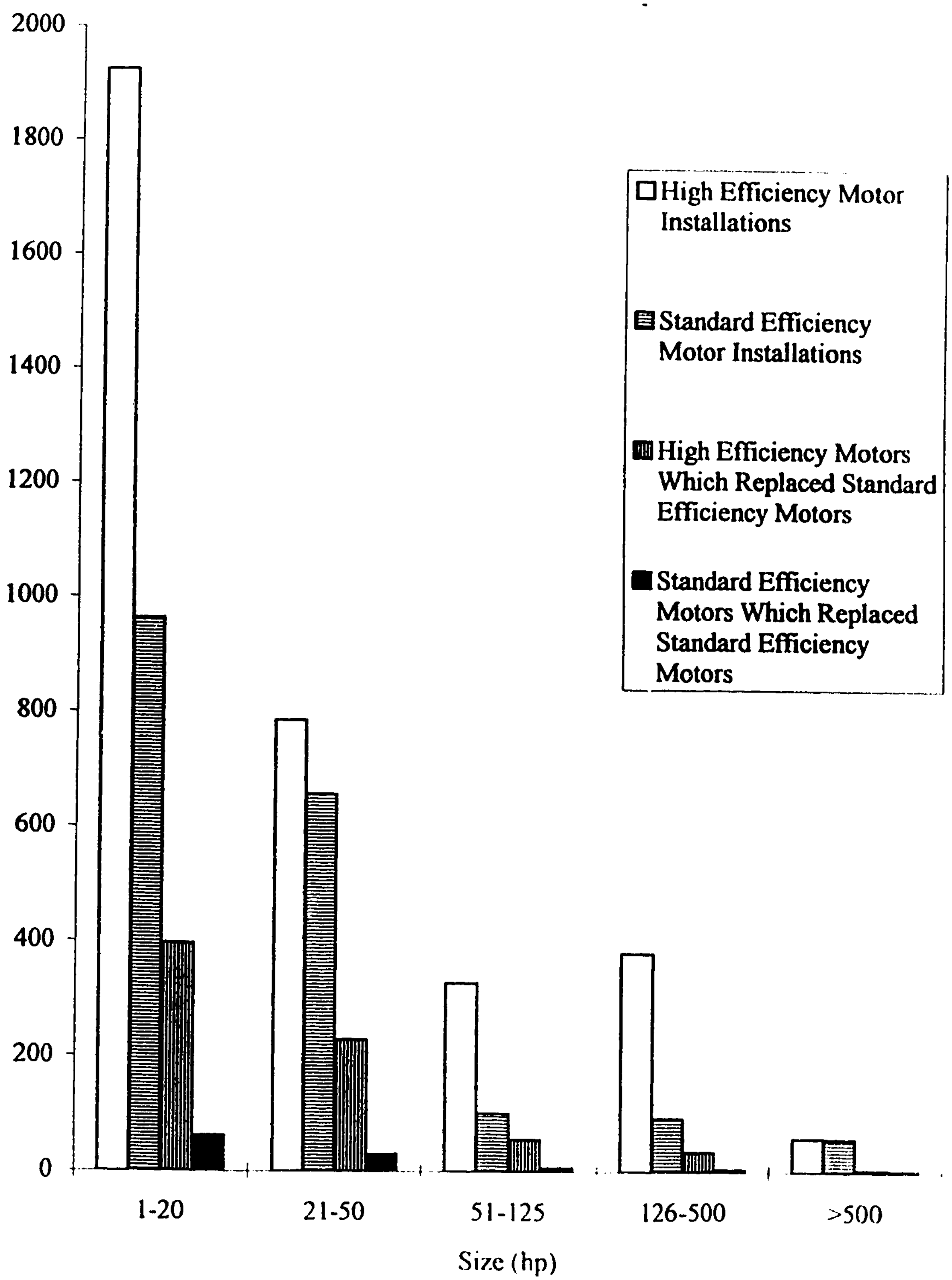


Figure 14
Replacement of High Efficiency Motors

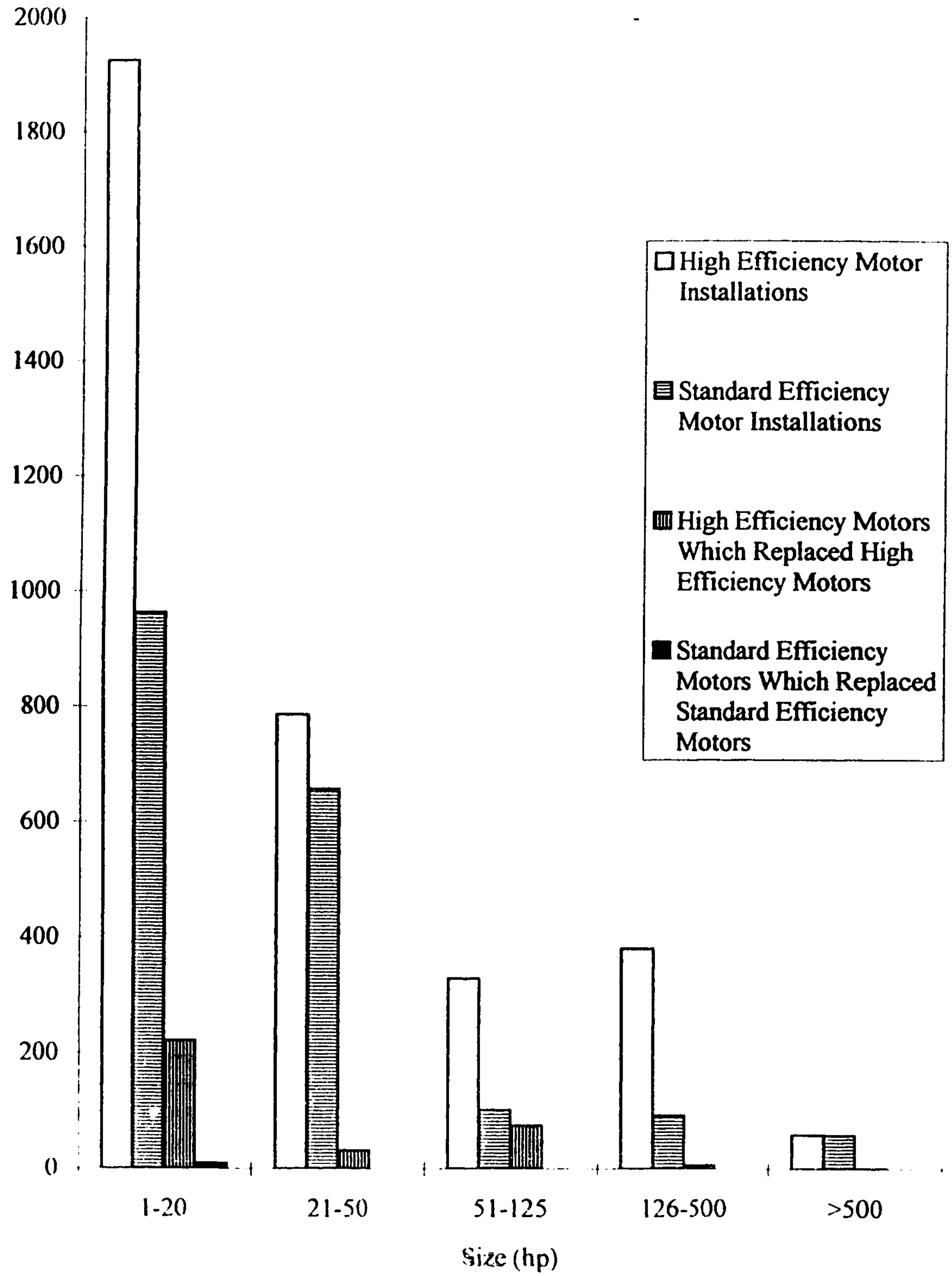


Figure 15
Motors That Were Still Installed Near the End of the HEMP

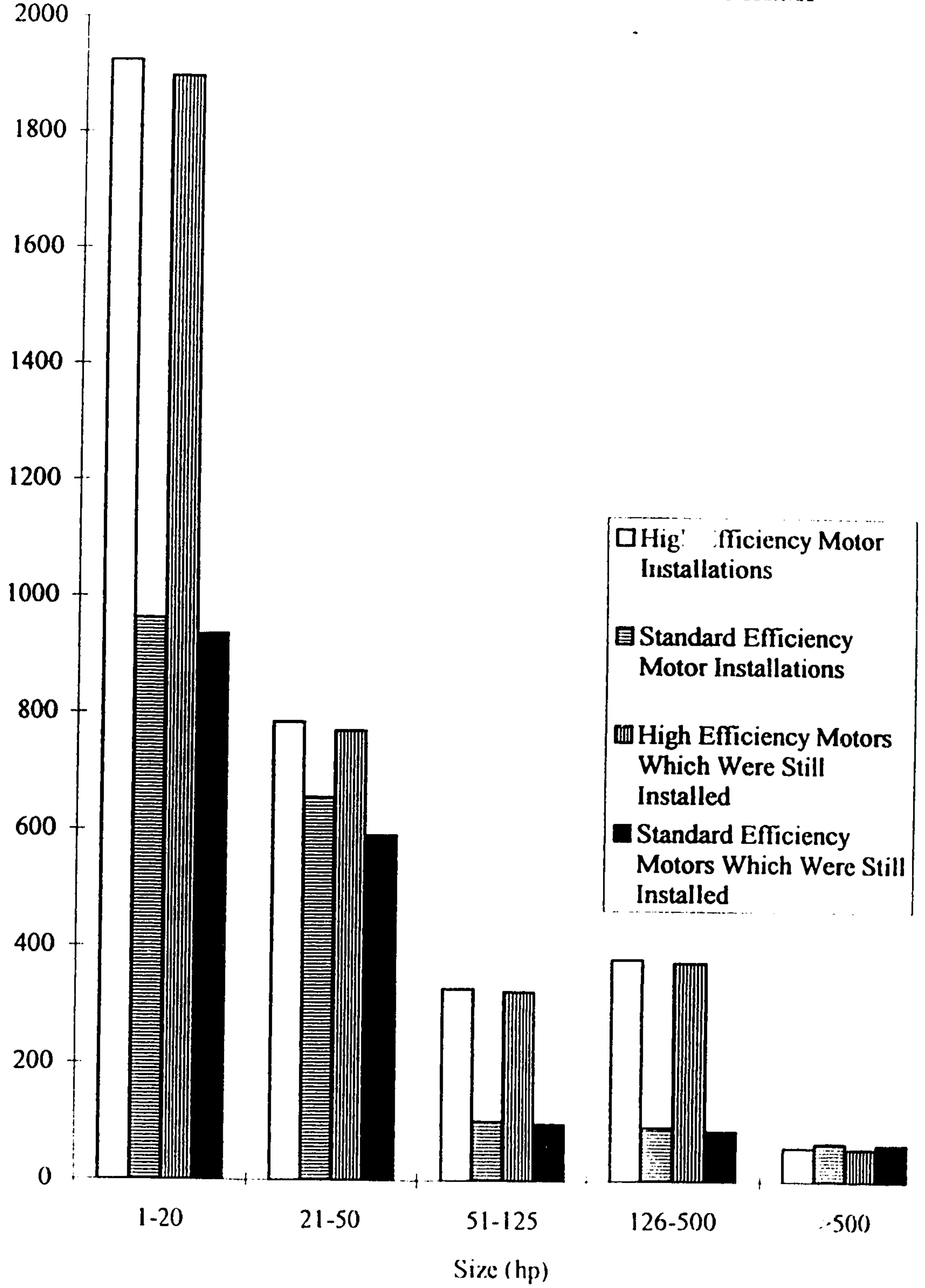


Figure 16
Reasons Why Some Motors Were Not Still Installed Near the End of the HEMP

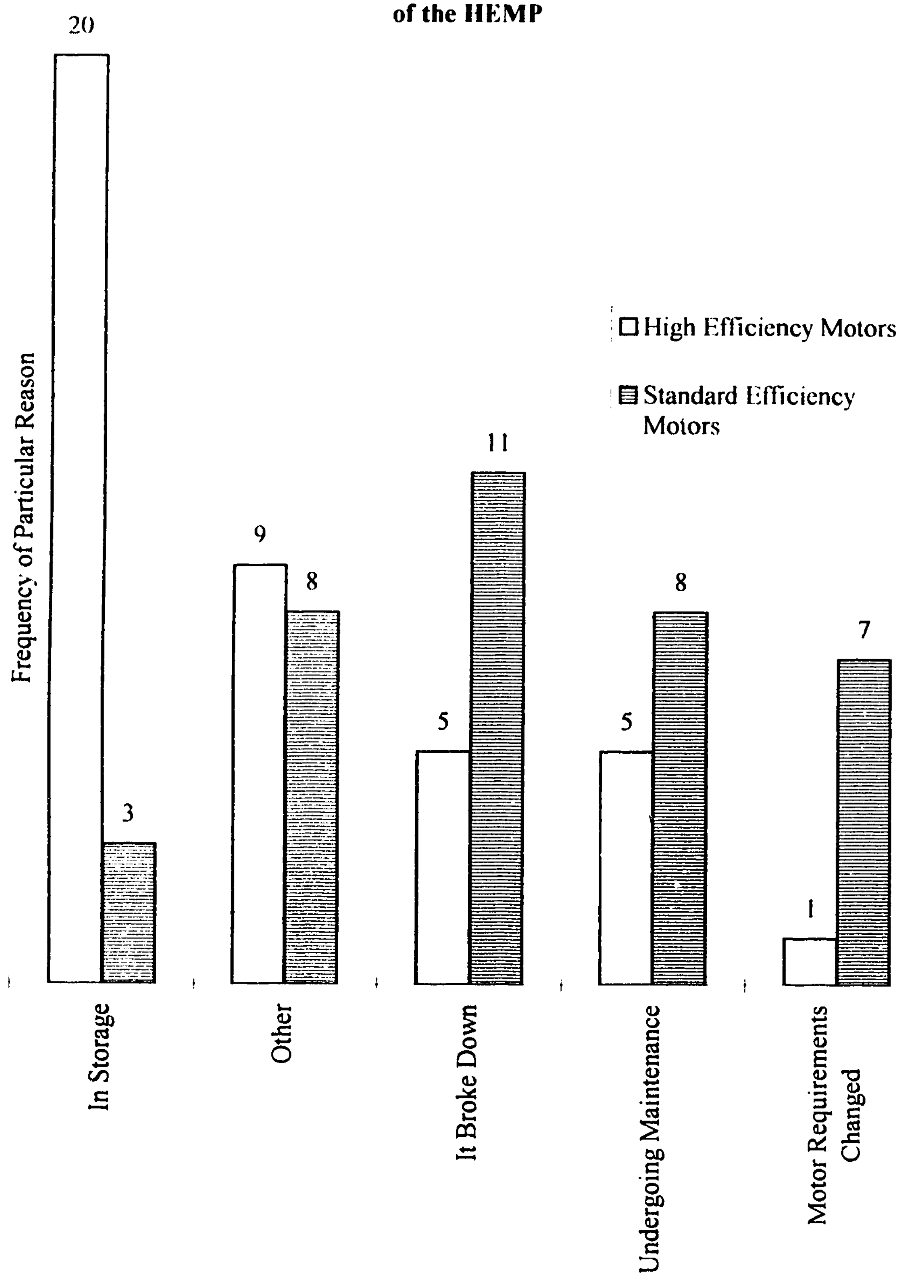


Figure 17
Reasons Given For Motor Purchases

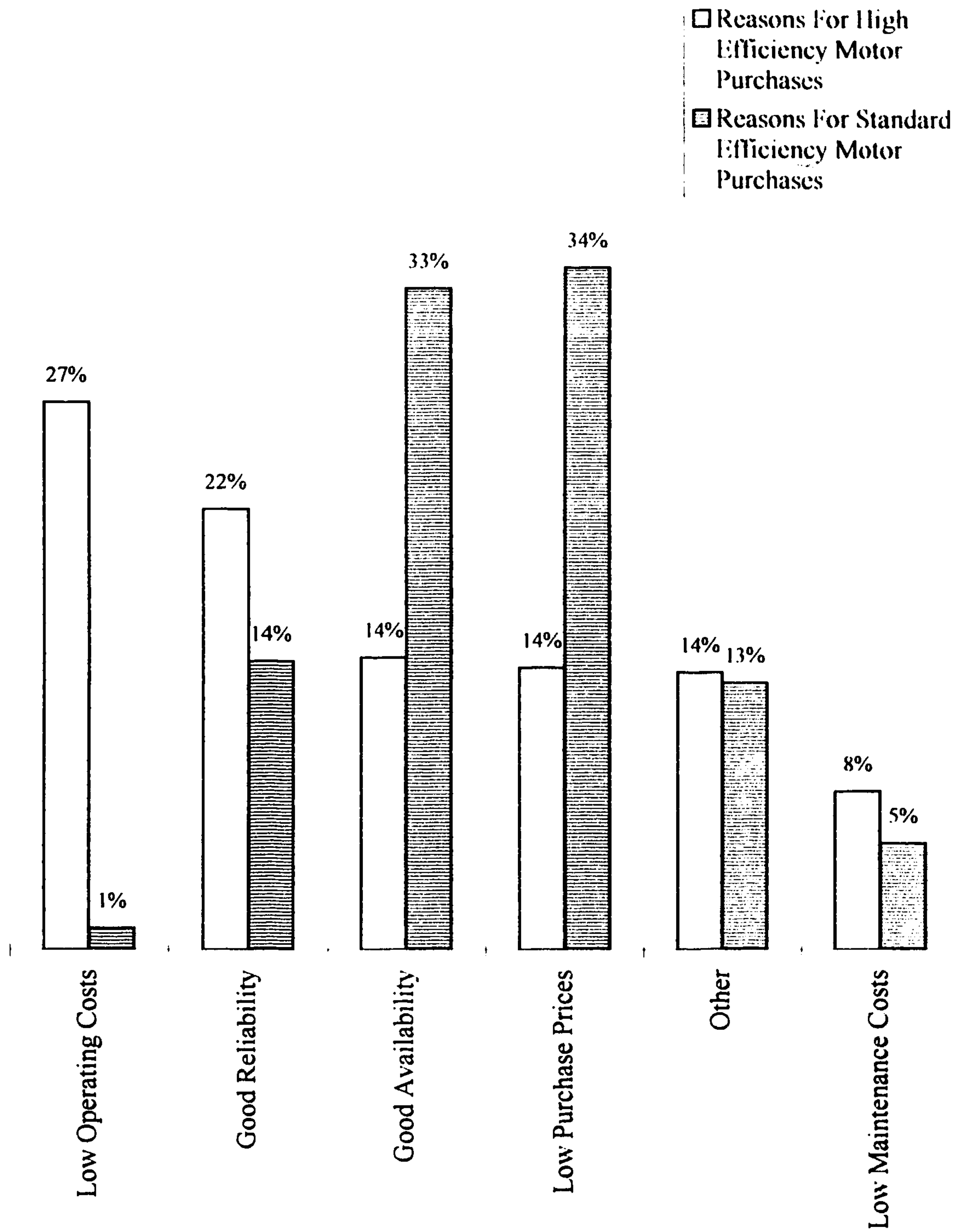


Figure 18
Ranked Reasons For Motor Purchases

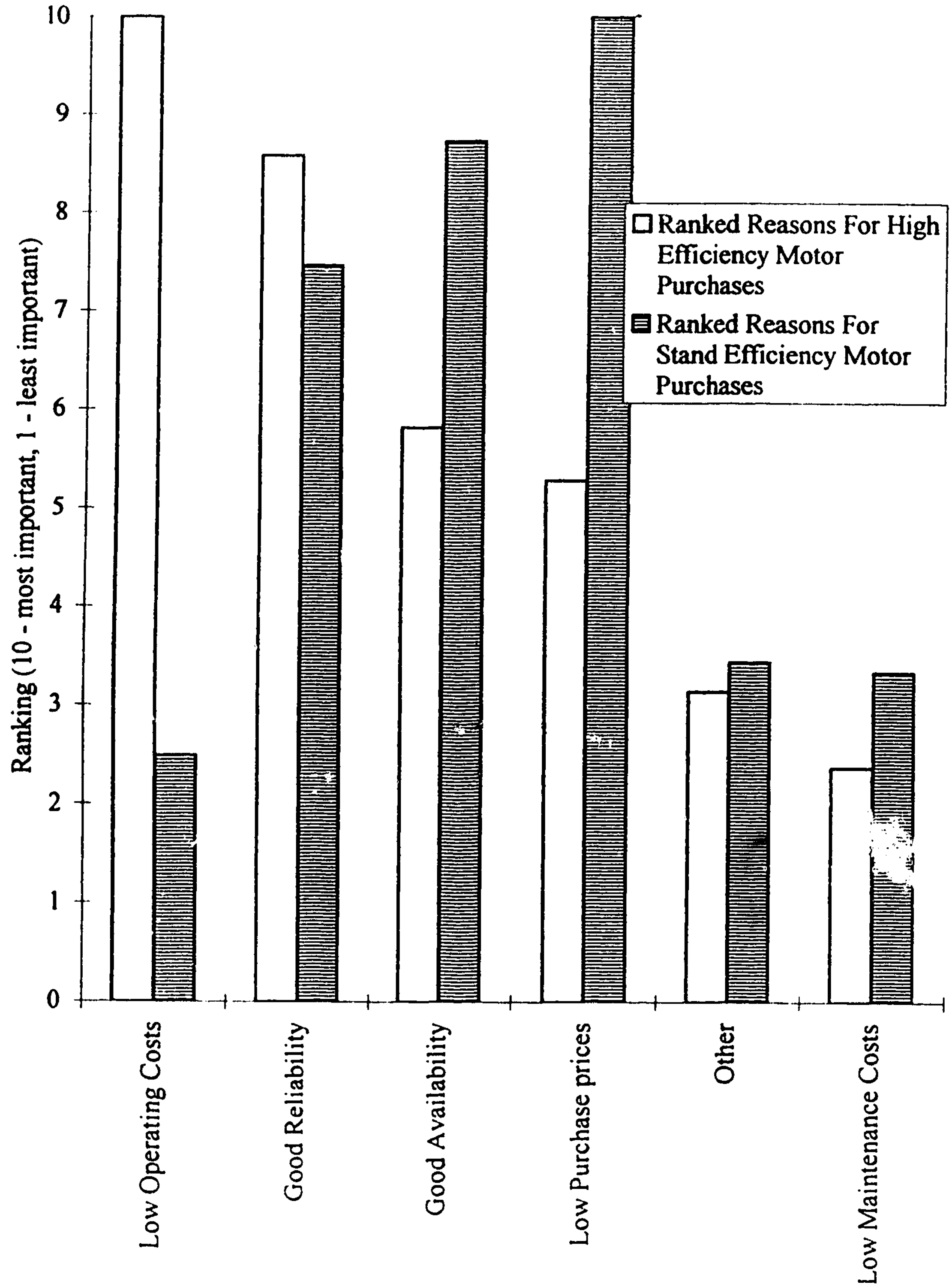
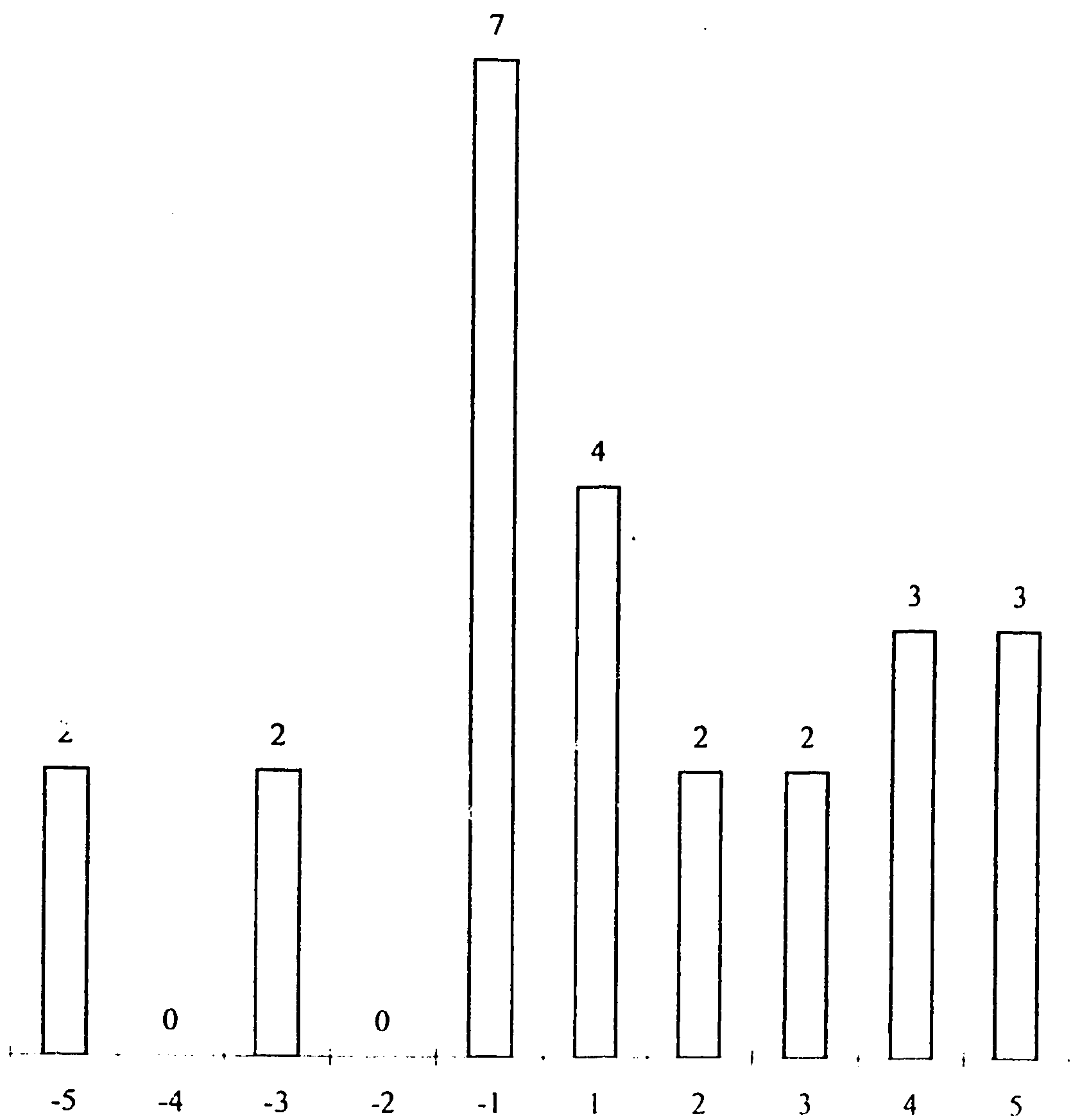


Figure 19
Frequencies of Responses That Indicated Changes in Operation Duration Had Occurred Since Motor Installation



(-5 : substantial decrease in operation duration, +5 : substantial increase in operation duration)

Figure 20
Frequency of Responses Which Indicated the Duration of Electric Motor Operation

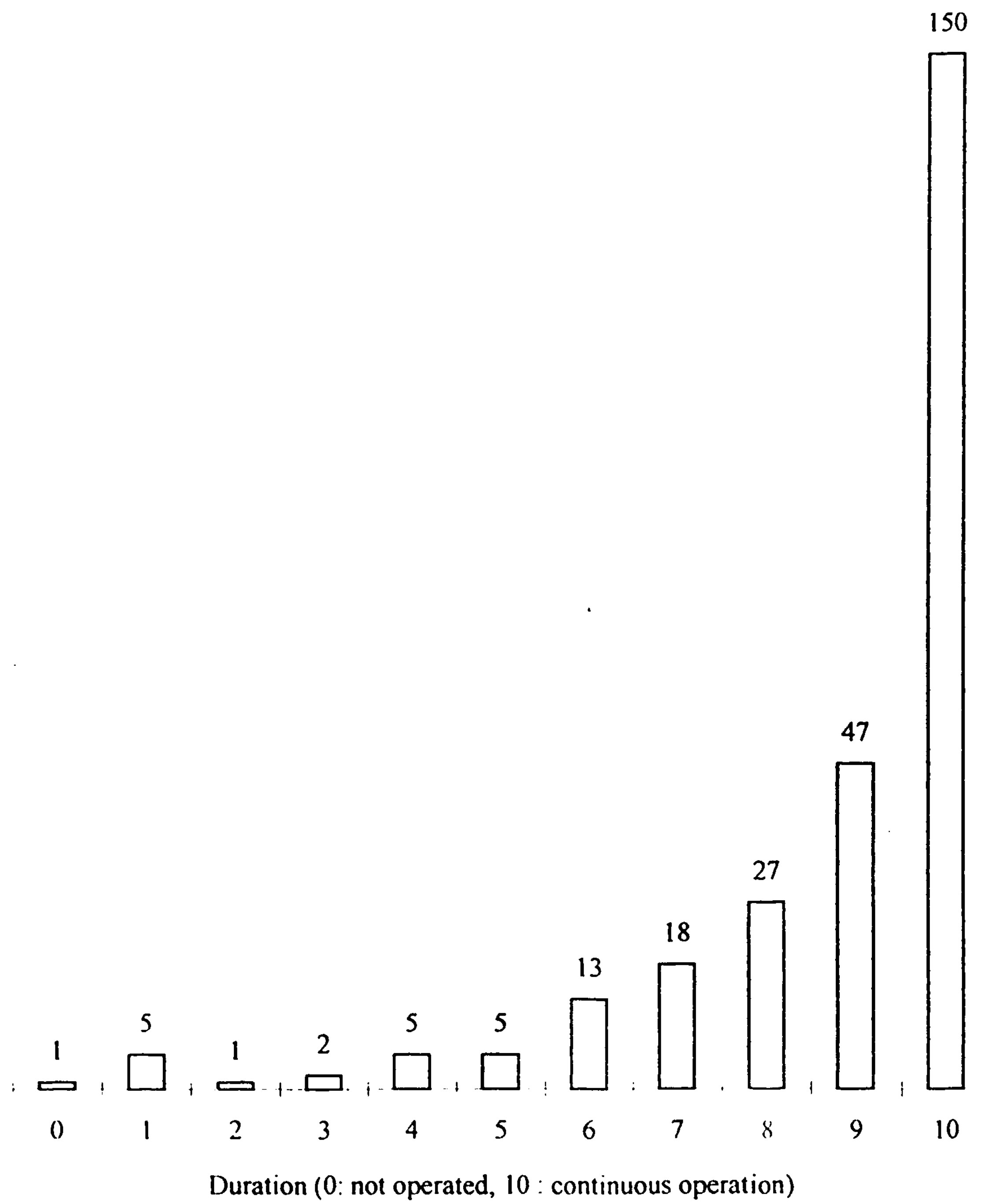
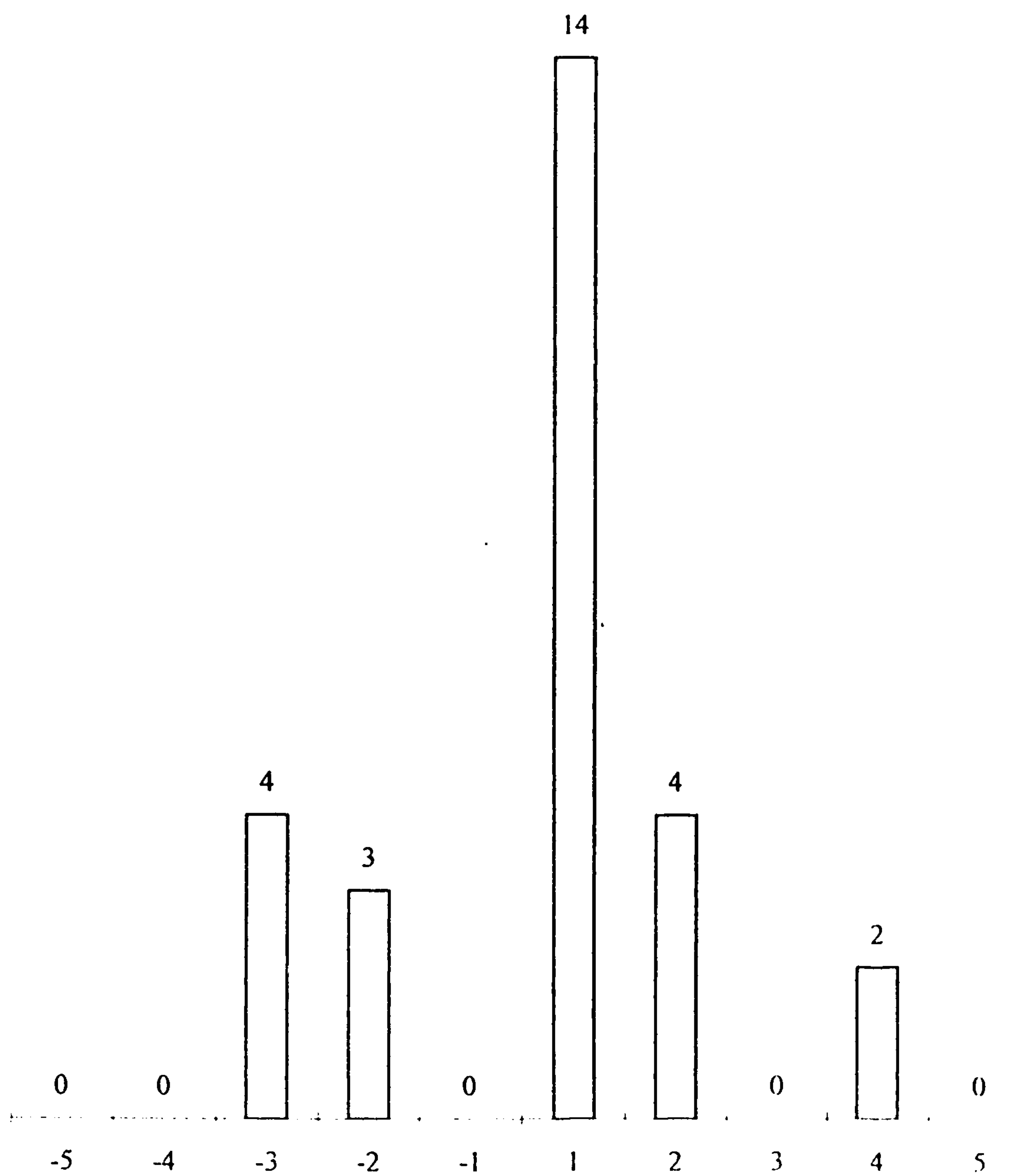


Figure 21
Frequencies of Responses That Indicated Changes in Load Had Occurred Since Motor Installation



(-5 : substantial decrease in load, +5 : substantial increase in load)

Figure 22
Response Percentages Which Indicated Electric Motor Loads

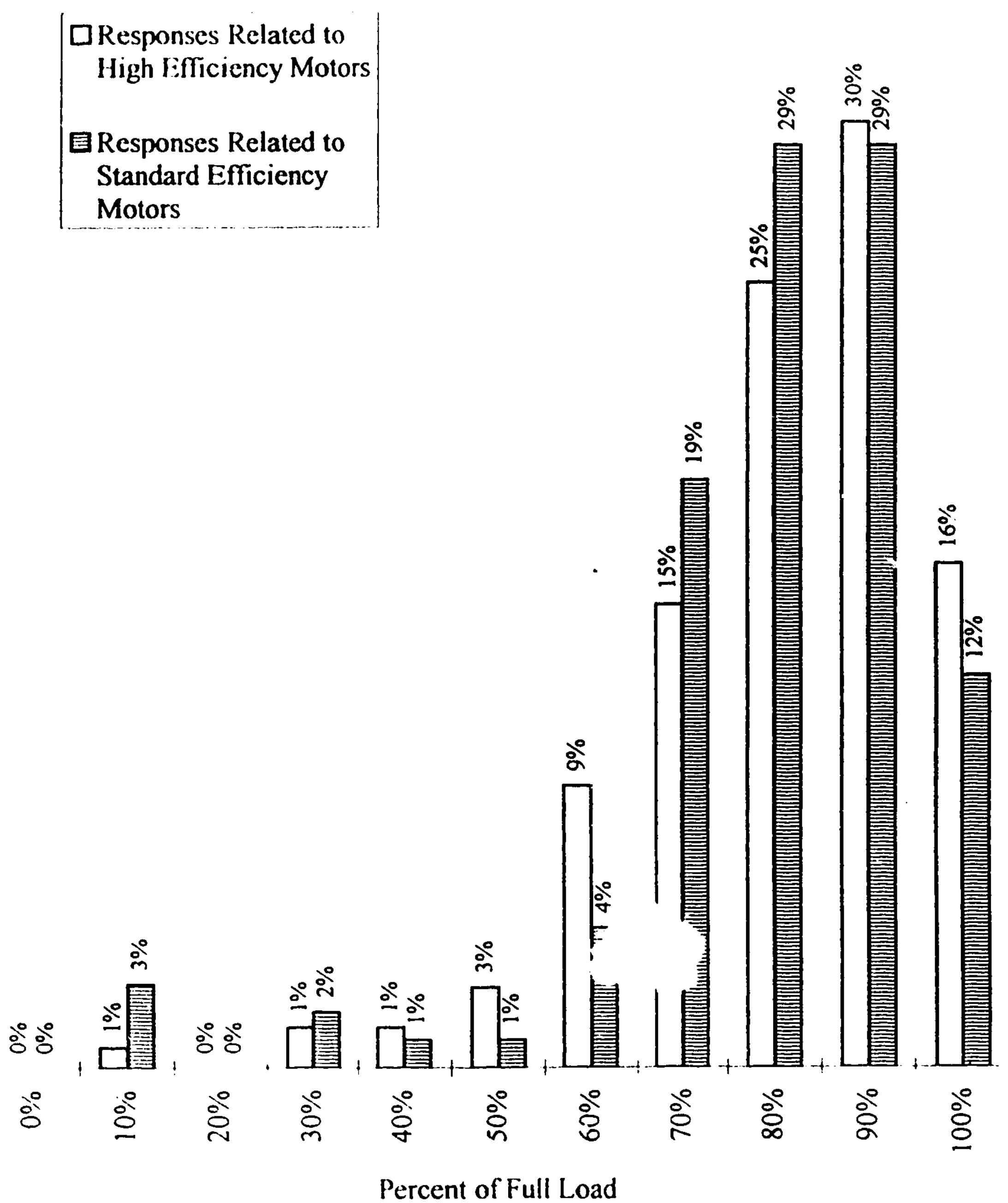


Figure 23
Frequencies of Responses That Commented About Driven Machinery Efficiency Changes

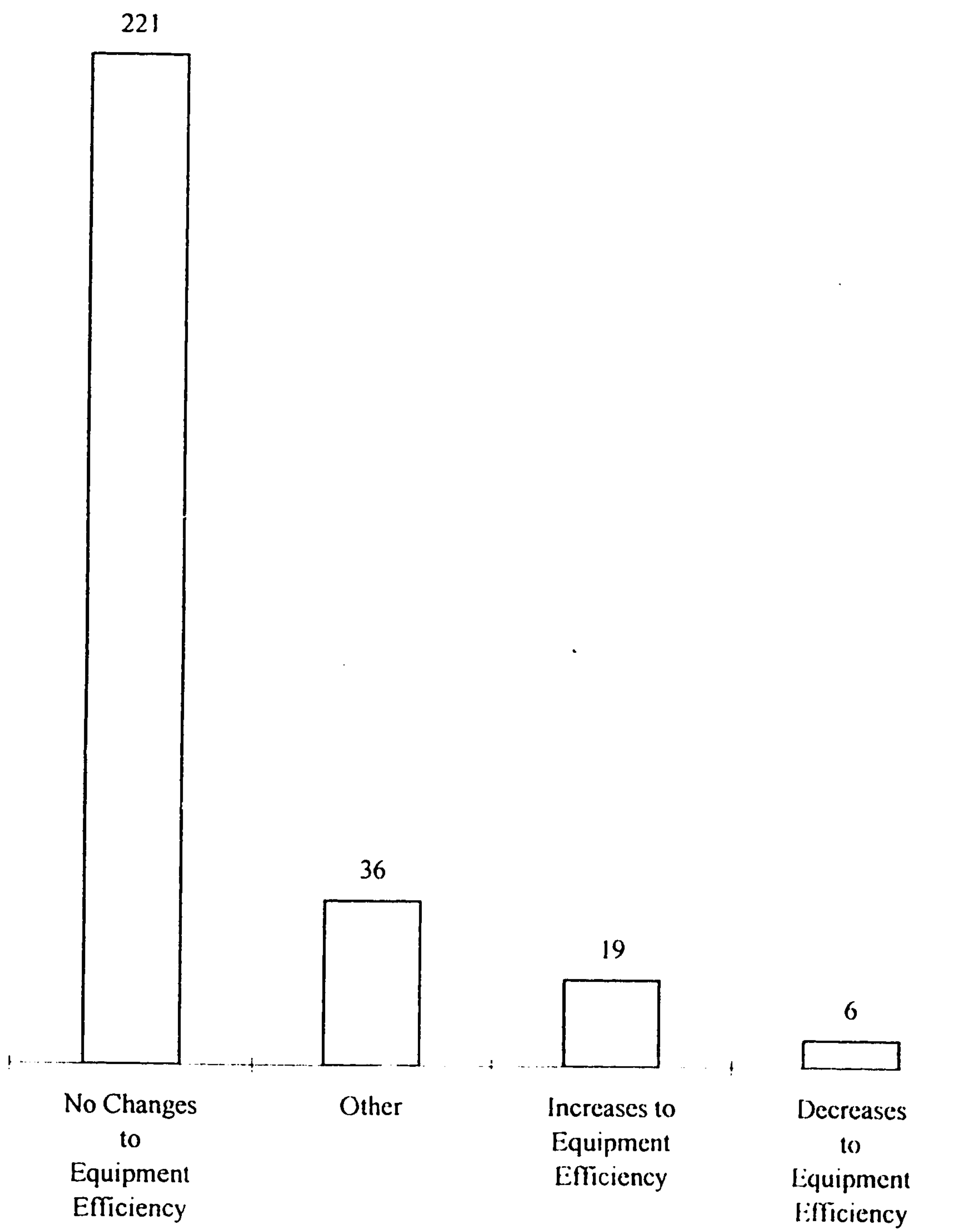
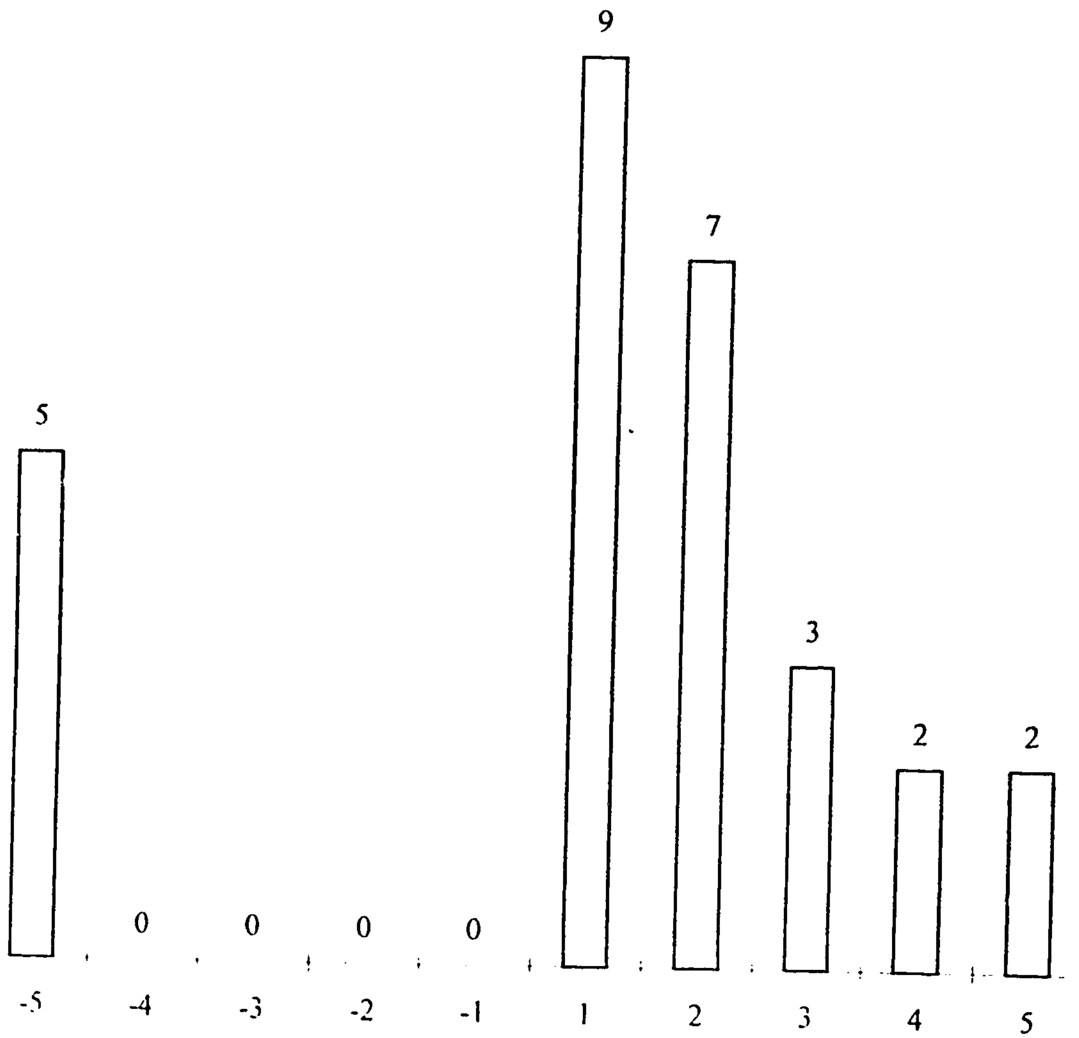


Figure 24
Frequencies of Responses That Indicated Driven Equipment Efficiency Changes



(-5 : substantial decrease in efficiency, +5 : substantial increase in efficiency)

Figure 25
Frequency of Responses Related to Awareness of the HEMP,
According To Industry

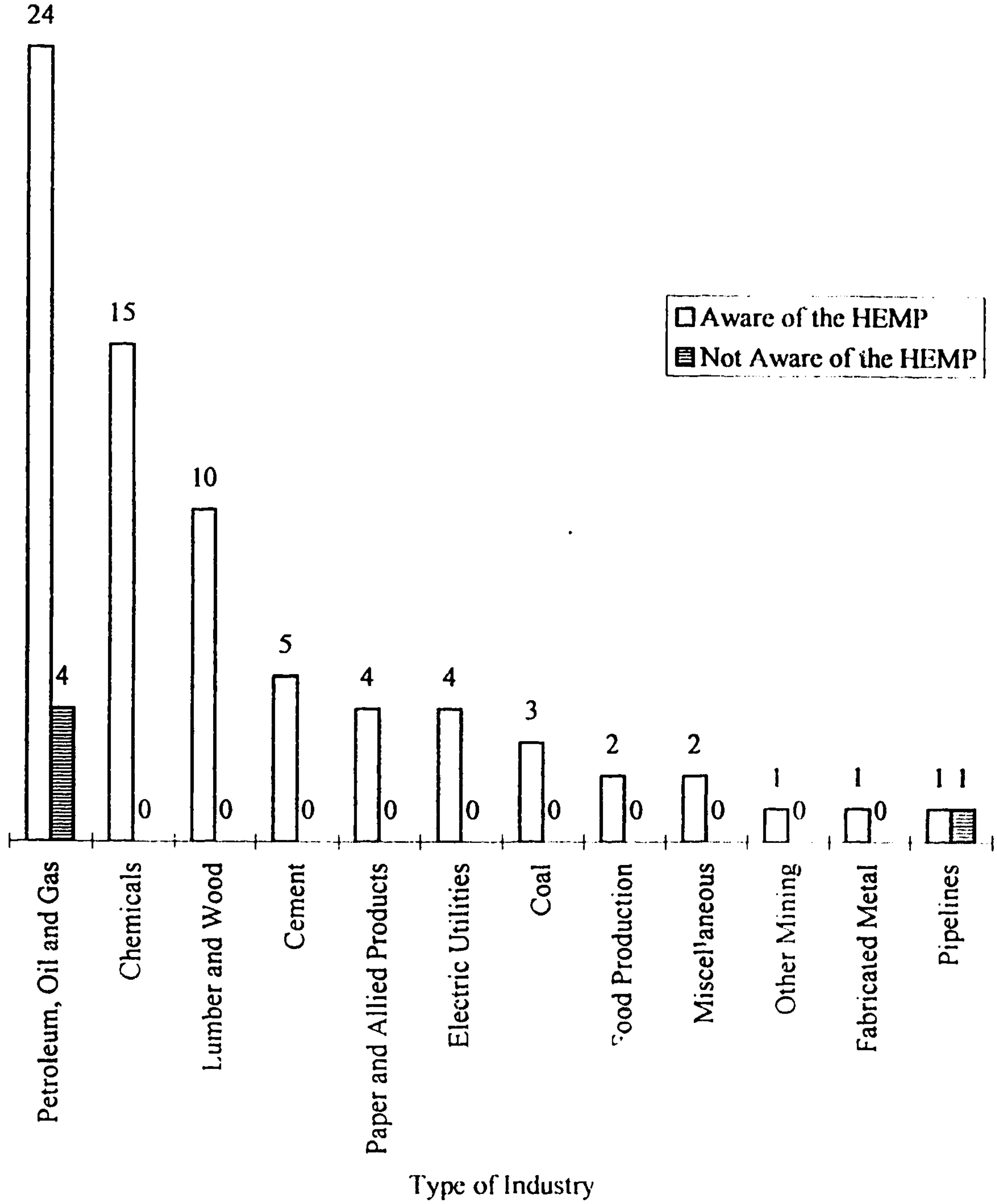


Figure 26
Quantities of Surveys Which Indicated Respondents were Aware of HEMP, But Did Not Apply For Available Rebates, According To Industry

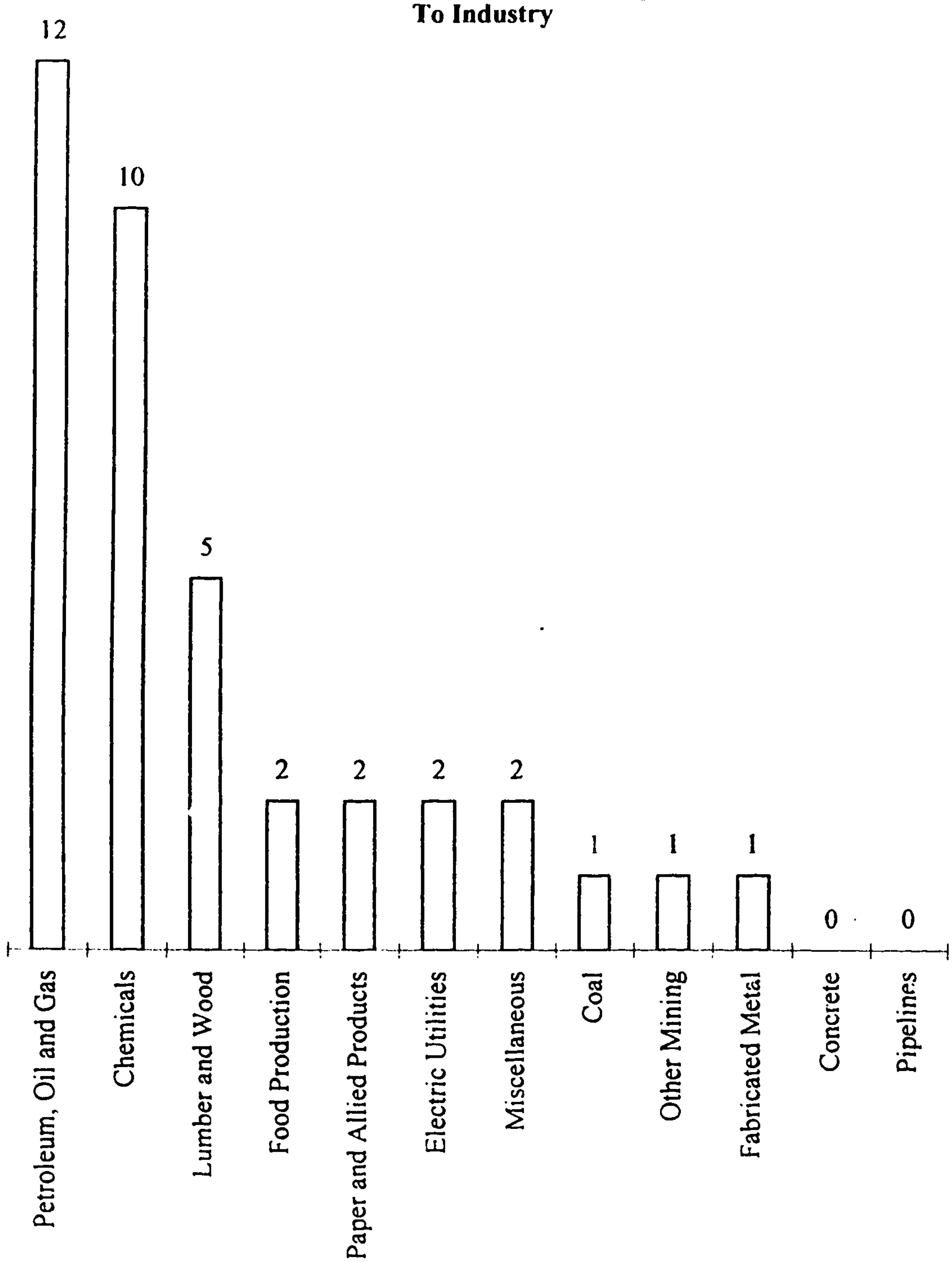


Figure 27
Likely Action of Respondents' Organizations if a Motor Rebate is Not Offered But a Motor is Needed

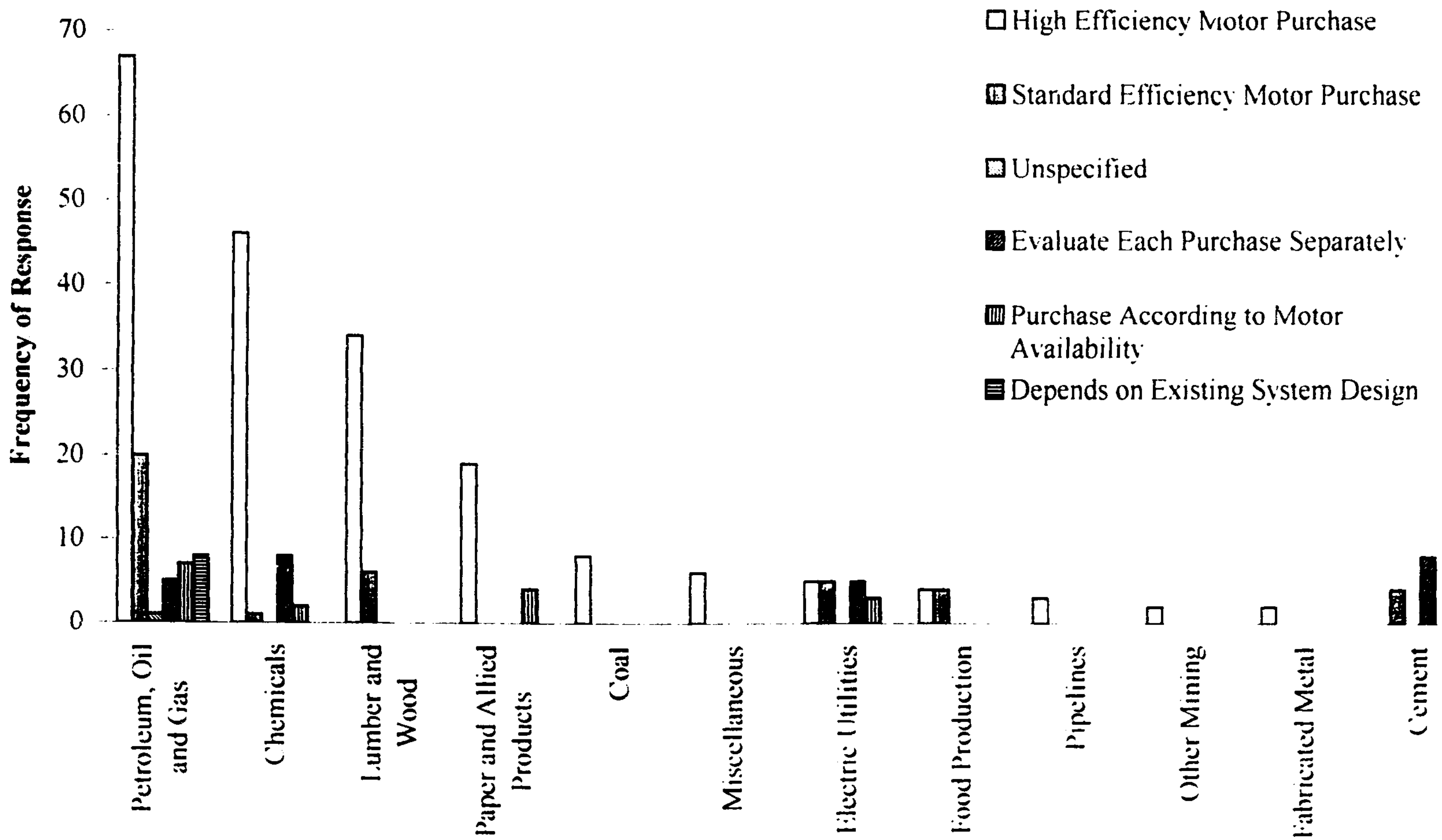


Figure 28
Hours Used To Maintain Electric Motors per Month

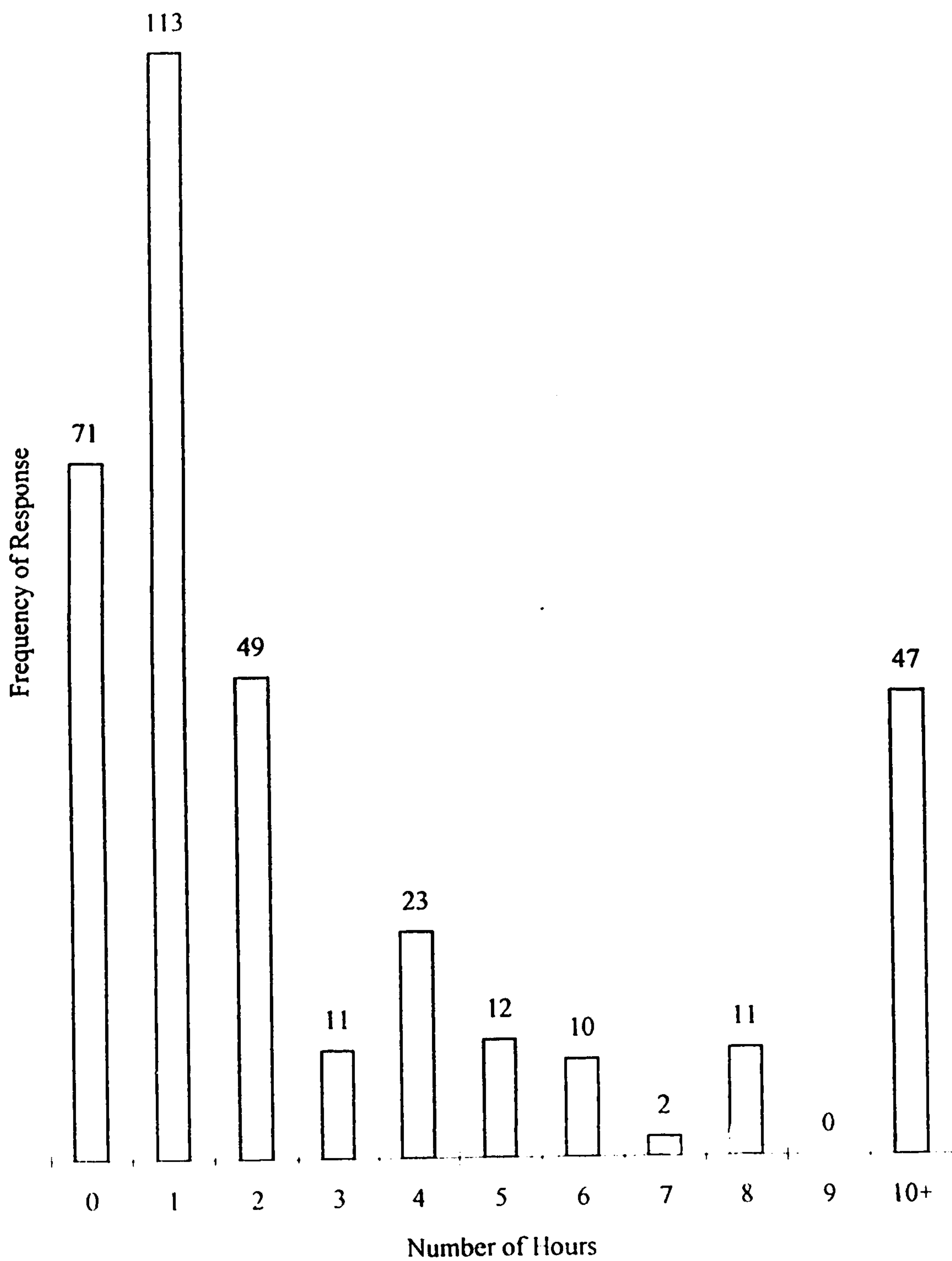


Figure 29
Number of Rewinds Respondents Were Aware of in Their Organizations

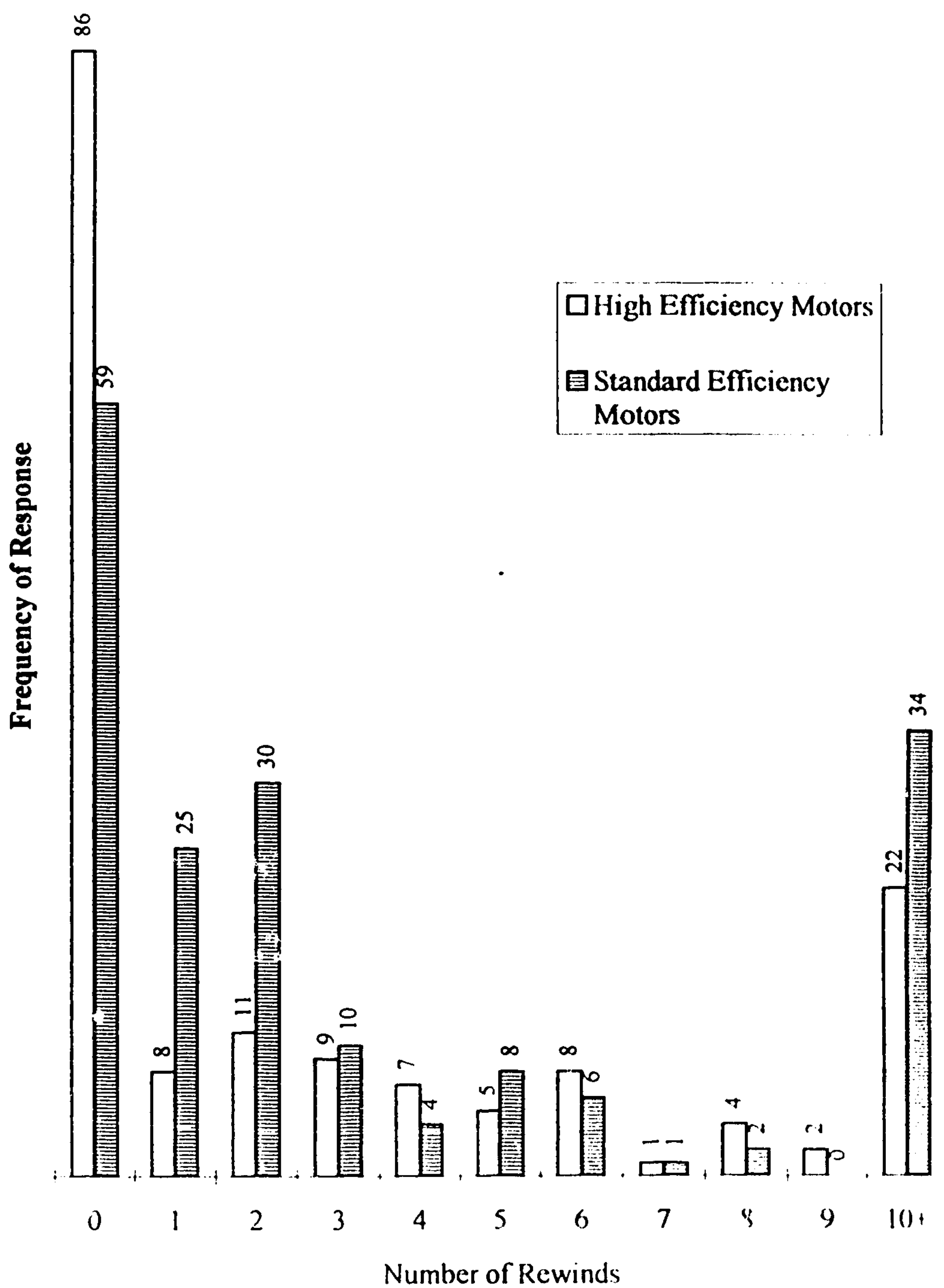


Figure 30
Frequencies of Responses Related To Rewind Policies

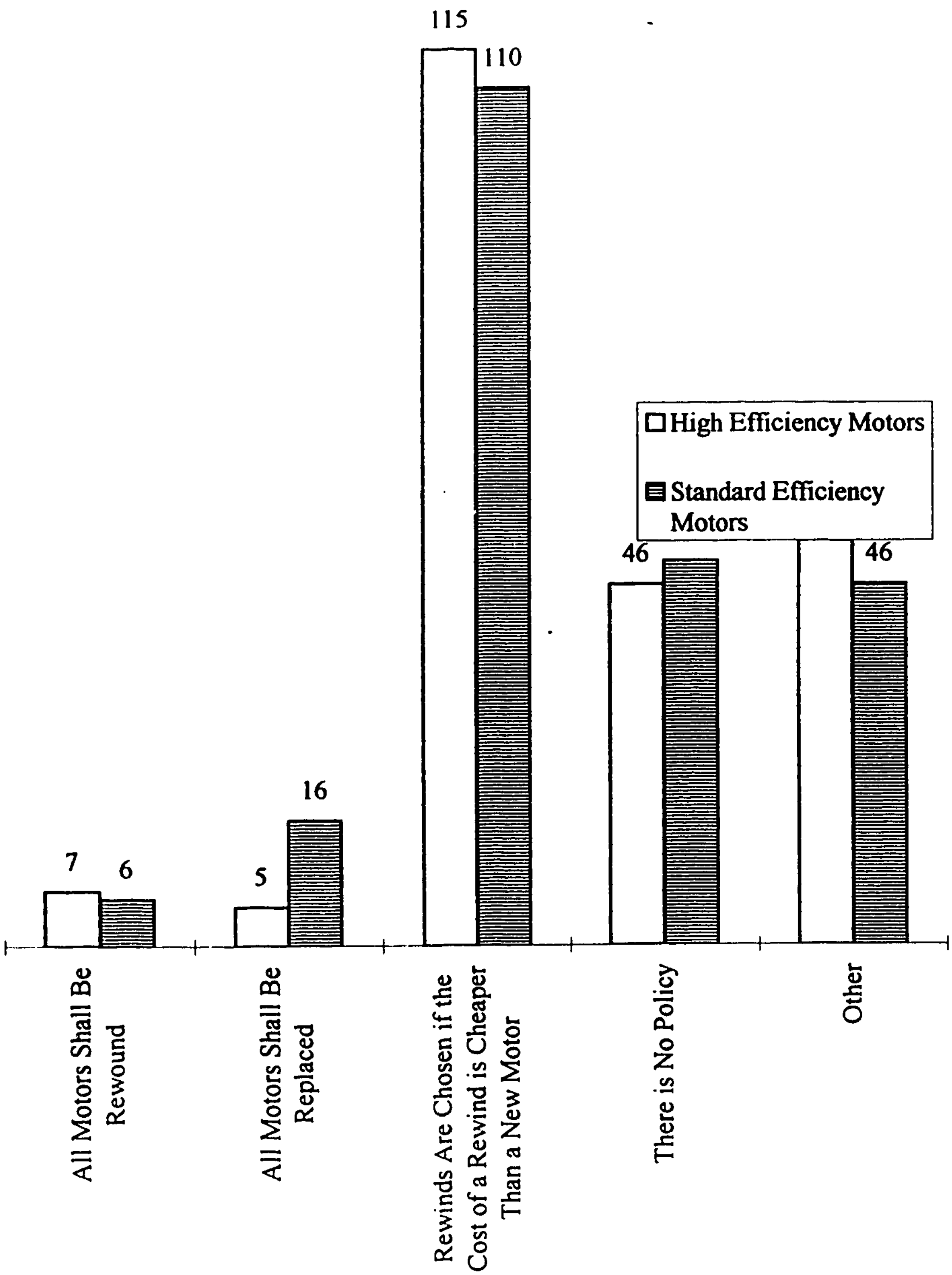


Figure 31
Frequencies of Responses Related to Purchase Policies

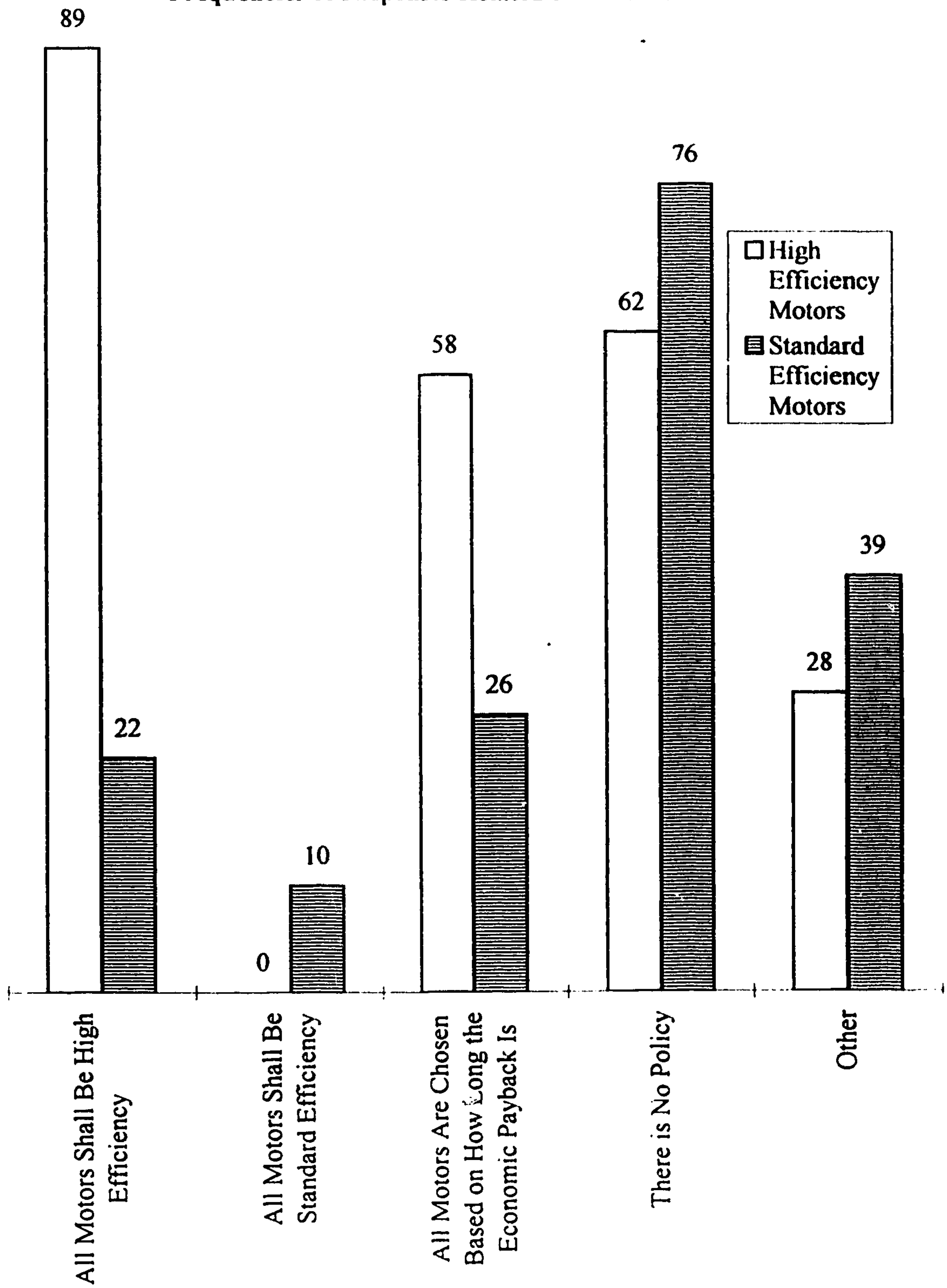


Figure 32
Frequencies of Responses Related to Maintenance Practices

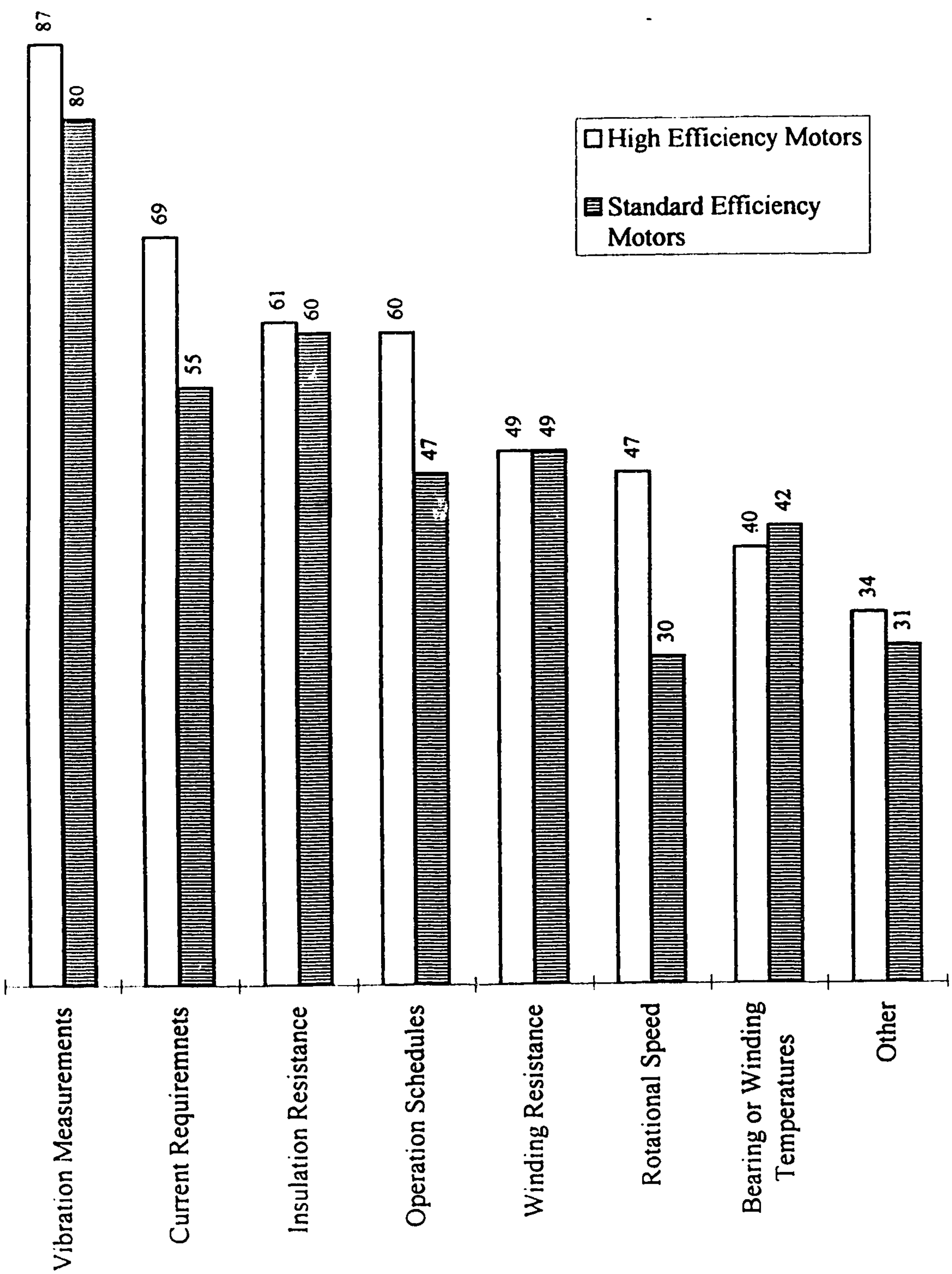
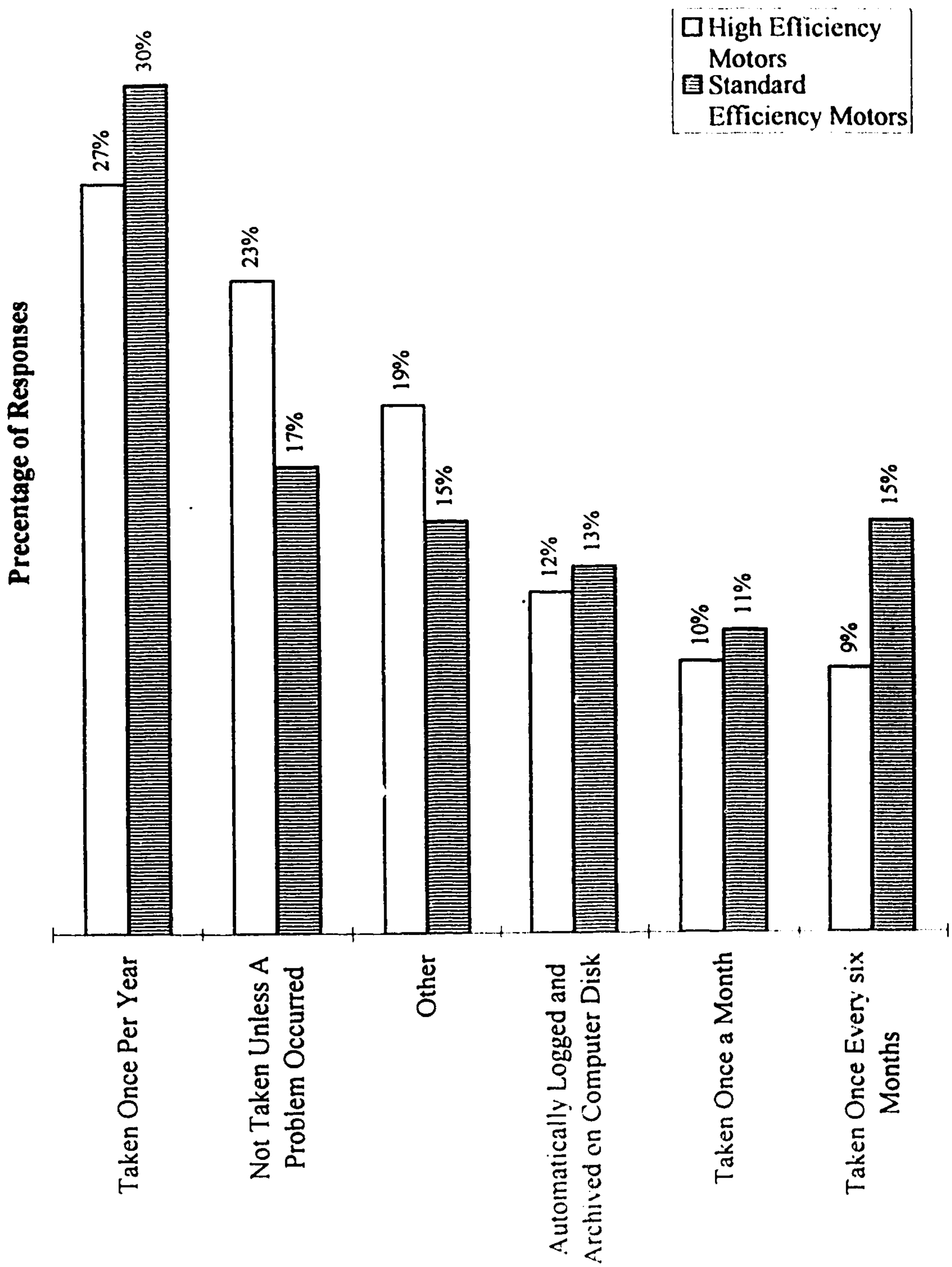


Figure 33
Maintenance Record Frequency



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[79] Zwicky, L. Energy Conservation: A Goal For Albertans? ECA88-PA/CS-S5, Environment Council of Alberta, Edmonton, 1988.

8. Appendix - Questionnaire

Dear Participant:

I am a M.Sc. candidate at the University of Alberta.

This questionnaire is designed to help determine what affects the endurance of electrical savings in the Albertan industrial market sector. It will be used to obtain data for a thesis entitled "Persistence Factors for Electrical Demand Side Management Savings in the Albertan Industrial Market Sector". This thesis will be completed in partial fulfillment of a M.Sc. degree in Engineering Management at the University of Alberta.

Responses will be held *strictly confidential*; data will only be reported in an aggregate manner. Copies of the aggregate results will be made available to those organizations participating in the study.

Part I consists of some questions which will help categorize all responses according to industry sector. **Part II** consists of questions about high efficiency and standard efficiency electric induction motors. For the purposes of this study, high efficiency motors are defined to be any induction motors that equal or exceed the efficiencies listed on the last page. Standard efficiency motors are defined to be any motors that have efficiencies less than those listed on the last page.

Please answer all questions. There are no right or wrong answers. Instructions are included with each question. The questionnaire should take approximately **½hr** to complete.

Please return your completed questionnaire in the enclosed stamped and addressed envelope to

Cameron Sterling
Department of Mechanical Engineering
Room 4-9 Mechanical Engineering Building
University of Alberta
Edmonton, AB T6G 2G8

Additional comments are welcome.

Thank you *for your participation.*

Sincerely,

Cameron Sterling

Start of Questionnaire

Part I

1. **Company Name**______________________________

2. **Location**______________________________

3. **Your Position and Responsibilities** (please elaborate):

____
____
____
____

4. **Your Educational Background** (please check the appropriate boxes):

❐ High School

❐ College Diploma

❐ University Degree

❐ Other (please elaborate):

____

Part II

1. How many electric motors do you know of that your organization has installed in the past four years? (please fill in the appropriate blanks below)

High Efficiency Motors		Standard Motors
Quantity	*Motor Size Range (hp)*	*Quantity*
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

2. What are the brand names of the motors identified in question 1? (please circle the appropriate letter*(s)* in the table below that correspond to the following brand names)

High Efficiency Motor		Standard Motor
Brand Names	*Motor Size Range (hp)*	*Brand Names*
a b c d e f g h i	1 - 20 hp	a b c d e f g h i
a b c d e f g h i	21 - 50 hp	a b c d e f g h i
a b c d e f g h i	51 - 125 hp	a b c d e f g h i
a b c d e f g h i	126-500 hp	a b c d e f g h i
a b c d e f g h i	> 500 hp	a b c d e f g h i

a) General Electric
b) Baldor
c) Leeson
d) Emerson
e) U.S. Electric
f) Teco
g) Toshiba
h) Westinghouse
i) other:_______________

3. Approximately when were the motors identified in question 1, installed? (please fill in the appropriate blank*(s)*)

High Efficiency Motor		Standard Motor
Installation Dates (Month / Year)	*Motor Size Range (hp)*	*Installation Dates* (Month / Year)
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

4. How many of the motors identified in question 1, *replaced* standard efficiency motors? (please fill in the appropriate blank*(s)* below)

High Efficiency Motor		Standard Motor
Quantity	*Motor Size Range (hp)*	*Quantity*
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

5. **How many of the motors, identified in question 1, *replaced* high efficiency motors?** (please fill in the appropriate blanks below)

High Efficiency Motor		Standard Motor
Quantity	*Motor Size Range (hp)*	*Quantity*
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

6. **How many of the motors identified in question 1 are currently installed?** (please fill in the appropriate blanks below)

High Efficiency Motors		Standard Motors
Quantity	*Motor Size Range (hp)*	*Quantity*
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

- **IF YOUR ANSWERS TO QUESTIONS 1 AND 6 WERE IDENTICAL, PLEASE PROCEED TO QUESTION 11.**

7. **Why are some of the electric motors identified in question 1 not currently installed?** (*for each* category in the table below, please circle the appropriate letter*(s)* that correspond to the following statements)

High Efficiency Motors		Standard Motors
Reasons	*Motor Size Range (hp)*	*Reasons*
a b c d e f	1 - 20 hp	a b c d e f
a b c d e f	21 - 50 hp	a b c d e f
b c d e f	51 - 125 hp	a b c d e f
a b c d e f	126-500 hp	a b c d e f
a b c d e f	> 500 hp	a b c d e f

a) it is in storage
b) it broke down
c) it did not meet your organization's expectations
d) it is undergoing maintenance
e) motor requirements changed
f) other (please elaborate):

8. **For any motor range in question 7 that you selected explanation b), indicate what happened after the motor*(s)* broke down** (*for each* category in the table below, please circle the appropriate letter, that corresponds to the following statements)

High Efficiency Motors		Standard Motors
Explanation	*Motor Size Range (hp)*	*Explanation*
A B C D	1 - 20 hp	A B C D
A B C D	21 - 50 hp	A B C D
A B C D	51 - 125 hp	A B C D
A B C D	126-500 hp	A B C D
A B C D	> 500 hp	A B C D

A) a high efficiency motor *replaced* it
B) it was *not* replaced
C) a standard motor *replaced* it
D) other (please elaborate):

9. For any motor range in question 7 that you selected explanation c), why did the motor*(s)* not live up to your organization's expectations? Please elaborate:

standard efficiency motors:

____
____
____
____
____
____

high efficiency motors:

____
____
____
____
____
____

10. For any motor range in question 7 that you selected explanation e)....

i) Was a larger motor required? (circle one) Yes No

ii) Was a smaller motor required? (circle one) Yes No

Why did motor requirements change? Please elaborate:

____
____
____
____
____
____

11. What are the main reasons that the electric motors identified in question 1 were purchased? *(for each* category in the table below, please circle the appropriate letter*(s)*, that correspond to the following statements)

High Efficiency Motors							Standard Efficiency Motors					
Reasons for Purchase						*Motor Size Range (hp)*	*Reasons for Purchase*					
a	b	c	d	e	f	1 - 20 hp	a	b	c	d	e	f
a	b	c	d	e	f	21 - 50 hp	a	b	c	d	e	f
a	b	c	d	e	f	51 - 125 hp	a	b	c	d	e	f
a	b	c	d	e	f	126-500 hp	a	b	c	d	e	f
a	b	c	d	e	f	> 500 hp	a	b	c	d	e	f

a) good reliability
b) low maintenance costs
c) low operating costs
d) good availability
e) low purchase prices
f) other (please elaborate):

12. Please rank the reasons you indicated in question 11 *for each* motor category, from most important to least important, *by placing a number from 1 to 7 beside the letters you selected in the table above.*

13. With regards to the <u>high efficiency</u> motors identified in question 1, what has been done with the electricity savings associated with higher efficiency? (circle the appropriate letter*(s) for each category* in the table below, that correspond to the following statements)

Explanations	*Motor Size Range (hp)*
a b c d e f	1 - 20 hp
a b c d e f	21 - 50 hp
a b c d e f	51 - 125 hp
a b c d e f	126-500 hp
a b c d e f	> 500 hp

a) Some money was used to purchase equipment that *does not* require electric power for operation.
b) Some money was used to purchase equipment that *does* require electric power for operation.
c) They were used to help operate electrical motors for more hours per week than before
d) They were used to subsidize other operating costs, in the department responsible for the savings.
e) They were added to the general revenue of your organization.
f) Other (please elaborate):________________________

14. If you selected b) for any motor range in question 13, please elaborate about what equipment was purchased, and how often it is operated. (please fill in the appropriate blanks):

Description of Purchased Equipment	*Quantity*	*Operating Schedule of Equipment (hrs/week)*	*Size of Equipment (hp)*
			1 - 20 hp
			21 - 50 hp
			51 - 125 hp
			126-500 hp
			> 500 hp

15. **If you selected c) for any motor range in question 13, please elaborate about what equipment is operated for longer periods.** (please fill in the appropriate blanks)

Description of Equipment	*Quantity*	*Increased Operation of Equipment (hrs week)*	*Equipment Size Range (hp)*
			1 - 20 hp
			21 - 50 hp
			51 - 125 hp
			126-500 hp
			> 500 hp

16. ***Soon after*** **your organization installed the motor*(s)* indicated in question 1, how often did your organization operate it(*them*)?** (please circle the appropriate tick *for each category*)

High Efficiency Motors		Standard Efficiency Motors
Operation Schedule — *Not At All* … *Continuous*	*Motor Size Range (hp)*	*Operation Schedule* — *Not At All* … *Continuous*
├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤	1 - 20 hp	├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤
├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤	21 - 50 hp	├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤
├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤	51 - 125 hp	├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤
├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤	126-500 hp	├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤
├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤	> 500 hp	├─┴─┴─┴─┴─┼─┴─┴─┴─┴─┤

17. How often does your organization *now* operate the motor(s) indicated in question 1? (please circle the appropriate tick *for each category*)

High Efficiency Motors		Standard Efficiency Motors
Operation Schedule *Not At All* … *Continuous*	*Motor Size Range (hp)*	*Operation Schedule* *Not At All* … *Continuous*
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

18. If your answers to questions 16 and 17 differ, please elaborate about why the number of hours per week the motors operate has changed from time of installation:

19. ***Soon after*** **your organization installed the motor*(s)* identified in question 1, what percentage of full load did it*(they)* operate at most often?** (please circle the appropriate tick *for each category*)

High Efficiency Motors		Standard Efficiency Motors
Percentage of Full Load 0% 100%	*Motor Size Range (hp)*	*Percentage of Full Load* 0% 100%
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

20. **What percentage of full load does your organization** ***now*** **operate the motor*(s)* identified in question 1 at** ***most often*****?** (please circle the appropriate tick *for each category*)

High Efficiency Motors		Standard Efficiency Motors
Percentage of Full Load 0% 100%	*Motor Size Range (hp)*	*Percentage of Full Load* 0% 100%
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

21. **If your answers to questions 19 and 20 differ, please elaborate about why the mode of operation has changed since time of installation:**

____
____
____
____
____
____
____
____
____
____

22. **On average, has the efficiency of machinery driven by the motors identified in question 1, changed since motor installation?** (*for each category* in the table below, please circle the appropriate letter that corresponds to the following statements)

High Efficiency Motors		Standard Motors
Responses	*Motor Size Range (hp)*	*Responses*
a b c d	1 - 20 hp	a b c d
a b c d	21 - 50 hp	a b c d
a b c d	51 - 125 hp	a b c d
a b c d	126-500 hp	a b c d
a b c d	> 500 hp	a b c d

a) the driven equipment's efficiency has *increased*
b) the driven equipment's efficiency has *decreased*
c) there have been no changes
d) other....please elaborate: ______________________

(IF YOU DID NOT SELECT a) OR b) FOR ANY MOTOR RANGE, GO TO QUESTION 25)

23. ***How much*** **has the efficiency of the driven machinery changed from the time of installation?** (please select the appropriate tick *for each category*)

High Efficiency Motors				Standard Efficiency Motors		
Machinery Efficiency			*Motor Size Range (hp)*	*Machinery Efficiency*		
50% less	*no change*	*50% more*		*50% less*	*no change*	*50% more*
			1 - 20 hp			
			21 - 50 hp			
			51 - 125 hp			
			126-500 hp			
			> 500 hp			

24. ***What*** **was changed to affect the efficiency of the driven equipment?** (*for each category* in the table below, please circle the appropriate letter(s) that correspond to the following statements)

High Efficiency Motors						Standard Efficiency Motors				
Changes Affecting Efficiency					*Motor Size Range (hp)*	*Changes Affecting Efficiency*				
a	b	c	d	e	1 - 20 hp	a	b	c	d	e
a	b	c	d	e	21 - 50 hp	a	b	c	d	e
a	b	c	d	e	51 - 125 hp	a	b	c	d	e
a	b	c	d	e	126-500 hp	a	b	c	d	e
a	b	c	d	e	> 500 hp	a	b	c	d	e

a) the drivetrain (shaft couplings, gears, belt drives, chains)
b) piping or duct changes
c) speed control (variable frequency drives, electronic soft starters, multi speed motors, fluid couplings)
d) power factor controllers
e) other (please elaborate): ___

25a). Are you aware of a High Efficiency Motor Rebate Program offered by Alberta's electric utilities? (circle one)

Yes No

25b). Please indicate the number of rebates that were received from Alberta's electric utilities via the High Efficiency Motor Program for the high efficiency motors identified in question 1. (*for each category* in the table below please circle the appropriate number)

High Efficiency Motors	
Number of Rebates	*Motor Size Range (hp)*
0 1 2 3 4 5 6 7 8 9 10+	1 - 20 hp
0 1 2 3 4 5 6 7 8 9 10+	21 - 50 hp
0 1 2 3 4 5 6 7 8 9 10+	51 - 125 hp
0 1 2 3 4 5 6 7 8 9 10+	126-500 hp
0 1 2 3 4 5 6 7 8 9 10+	> 500 hp

26. What would your organization likely do <u>today</u> if a rebate is not offered and you need an electric motor? (*for each category* in the table below, please circle the appropriate <u>letter</u> that corresponds to the following statements)

Purchase Decision	*Motor Size Range (hp)*
a b c	1 - 20 hp
a b c	21 - 50 hp
a b c	51 - 125 hp
a b c	126-500 hp
a b c	> 500 hp

a) purchase a high efficiency motor
b) purchase a standard motor
c) other...(please elaborate):______________________________

27. **On average, how many hours are spent on motor maintenance each month?** (please circle the appropriate number *for each category* in the table below)

High Efficiency Motors		Standard Efficiency Motors
Maintenance Hours per Month	*Motor Size Range (hp)*	*Maintenance Hours per Month*
0 1 2 3 4 5 6 7 8 9 10+	1 - 20 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	21 - 50 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	51 - 125 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	126-500 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	> 500 hp	0 1 2 3 4 5 6 7 8 9 10+

28. **How many motors in your organization are you aware of that have been rewound over the past four years?** (please circle the appropriate number *for each category* in the table below)

High Efficiency Motors		Standard Efficiency Motors
Number of Rewinds	*Motor Size Range (hp)*	*Number of Rewinds*
0 1 2 3 4 5 6 7 8 9 10+	1 - 20 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	21 - 50 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	51 - 125 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	126-500 hp	0 1 2 3 4 5 6 7 8 9 10+
0 1 2 3 4 5 6 7 8 9 10+	> 500 hp	0 1 2 3 4 5 6 7 8 9 10+

29. **Does your organization have a written policy about *rewinding* electric motors?** (circle one)

Yes　　　　No

30. Describe the policy your organization has about *rewinding* electric motors?
(*for each category* in the table below, please circle the appropriate letter that corresponds to the following statements)

a) all motors shall be rewound
b) all motors shall be replaced
c) rewinds are chosen if the cost of a rewind is cheaper than a new motor
d) there is no policy
e) other (please elaborate): ______________________________

High Efficiency Motors		**Standard Efficiency Motors**
Rewinding Policy	*Motor Size Range (hp)*	*Rewinding Policy*
a b c d e	1 - 20 hp	a b c d e
a b c d e	21 - 50 hp	a b c d e
a b c d e	51 - 125 hp	a b c d e
a b c d e	126-500 hp	a b c d e
a b c d e	> 500 hp	a b c d e

31. Please elaborate about *why* your organization has the policy described in question 30:

____
____
____
____
____
____
____
____

32. Does your organization have a written policy about the *purchase* of electric motors? (circle one)

Yes No

33. **Describe the policy your organization has about the *purchase* of electric motors.** (*for each category* in the table below, please circle the appropriate letter, that corresponds to the following statements)

High Efficiency Motors		**Standard Efficiency Motors**
Purchasing Policy	*Motor Size Range (hp)*	*Purchasing Policy*
a b c d e	1 - 20 hp	a b c d e
a b c d e	21 - 50 hp	a b c d e
a b c d e	51 - 125 hp	a b c d e
a b c d e	126-500 hp	a b c d e
a b c d e	> 500 hp	a b c d e

a) all motors shall be *high* efficiency
b) all motors shall be *standard* efficiency
c) all motors are chosen based on how long the economic payback is
d) there is no policy
e) other (please elaborate):

34. **Please elaborate about *why* your organization has the policy described in question 33:**

____
____
____
____
____
____
____
____

35. **Please indicate the motor maintenance and operation records your organization has had *recorded* over the past four years for the motors identified in question 1.** (*for each category* in the table below please circle the appropriate letter*(s)*, that correspond to the following statements)

High Efficiency Motors	Motor Size Range (hp)	Standard Efficiency Motors
Maintenance and Operation Practices		*Maintenance and Operation Practices*
a b c d e f g h	1 - 20 hp	a b c d e f g h
a b c d e f g h	21 - 50 hp	a b c d e f g h
a b c d e f g h	51 - 125 hp	a b c d e f g h
a b c d e f g h	126-500 hp	a b c d e f g h
a b c d e f g h	> 500 hp	a b c d e f g h

a) operation schedules
b) current requirements
c) rotational speed (revolutions per minute)
d) temperatures of bearings orwindings
e) vibration measurements
f) winding resistance
g) insulation resistance
h) other (please elaborate):

36. **Please indicate <u>how often</u> your organization recorded the maintenance and operation practices, identified in question 35, *for each motor category*.** (*place the appropriate capital letter, that corresponds to the following statements, in the table above beside the letters you just circled*)

A) records were automatically logged and archived on computer disk
B) records were taken once a month
C) records were taken once every six months
D) records were taken once per year
E) records were generally not taken unless a problem occurred
F) other (please elaborate): ______________________

37. **If you selected E) for any motor range in question 36, please elaborate about what type of problem(s) occurred.**

____

____

38. **How is the electricity demand, used by the motors identified in question 1, *metered by the corresponding electric utility?*** (*for each category* in the table below, please circle the appropriate letter(s) that correspond to the following statements,)

a) kW meters
b) kVA meters
c) other (please elaborate):

____

____

High Efficiency Motors		**Standard Efficiency Motors**
Metering Methods	*Motor Size Range (hp)*	*Metering Methods*
a b c	1 - 20 hp	a b c
a b c	21 - 50 hp	a b c
a b c	51 - 125 hp	a b c
a b c	126-500 hp	a b c
a b c	> 500 hp	a b c

39. **Which of the motors identified in question 1, if any, came to your organization already attached to the driven equipment?** (*for each category* in the table below, please fill in the blanks)

High Efficiency Motors		**Standard Efficiency Motors**
Quantity	*Motor Size Range (hp)*	*Quantity*
	1 - 20 hp	
	21 - 50 hp	
	51 - 125 hp	
	126-500 hp	
	> 500 hp	

40. Is a minimum amount of electrical demand and / or energy contracted with the electrical utility for the accounts corresponding to the motors identified in question 1? (*for each category* in the table below, please circle the appropriate letter(s), that correspond to the following statements)

High Efficiency Motors		Standard Efficiency Motors
Demand Contract?	*Motor Size Range (hp)*	*Demand Contract?*
a b c	1 - 20 hp	a b c
a b c	21 - 50 hp	a b c
a b c	51 - 125 hp	a b c
a b c	126-500 hp	a b c
a b c	> 500 hp	a b c

a) Yes
b) No
c) Other (please elaborate):

41. Who decides what money associated with electricity savings is used for, when electricity savings, if any, are achieved at you work location? (*for each category* in the table below, please circle the appropriate letter(s), that correspond to the following statements)

High Efficiency Motors		Standard Efficiency Motors
Demand Contract?	*Motor Size Range (hp)*	*Demand Contract?*
a b c d	1 - 20 hp	a b c d
a b c d	21 - 50 hp	a b c d
a b c d	51 - 125 hp	a b c d
a b c d	126-500 hp	a b c d
a b c d	> 500 hp	a b c d

a) you do
b) people, *who work at your location*, do
c) people, *who work outside of your location*, do
d) other (please elaborate):

42. Please comment on what you believe *affects* the endurance of electricity savings that your organization may achieve:

____
____
____
____
____
____
____
____
____
____
____
____
____

Thank you.

High Efficiency Motor Nominal Efficiencies

HP	900 RPM	1200 RPM	1800 RPM	3600 RPM
1	74.0%	80.0%	82.5%	75.5%
1.5	77.0%	85.5%	84.0%	82.5%
2	82.5%	86.5%	84.0%	84.0%
3	84.0%	87.5%	87.5%	85.5%
5	85.5%	87.5%	87.5%	87.5%
7.5	85.5%	89.5%	89.5%	88.5%
10	88.5%	89.5%	89.5%	89.5%
15	88.5%	90.2%	91.0%	90.2%
20	89.5%	90.2%	91.0%	90.2%
25	89.5%	91.3%	91.7%	90.5%
30	90.7%	91.4%	91.9%	90.8%
40	90.6%	92.3%	92.5%	91.4%
50	91.3%	92.3%	92.7%	91.9%
60	91.6%	92.9%	93.2%	92.4%
75	92.8%	93.1%	93.5%	92.5%
100	92.7%	93.5%	93.7%	93.0%
125	93.4%	93.6%	93.9%	93.6%
150	93.4%	94.2%	94.3%	93.8%
200	93.9%	94.6%	94.5%	94.3%
250-500	95.0%	95.0%	95.0%	95.0%
> 500	95.0%	95.0%	95.0%	95.0%

(Nadel and Shepard et al.)