Assessment of the Market for COMPRESSED AIR EFFICIENCY SERVICES

Office of Industrial Technologies

Office of Energy Efficiency and Renewable Energy
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Assessment of the Market for COMPRESSED AIR EFFICIENCY SERVICES

Prepared for
Oak Ridge National Laboratory and
Lawrence Berkeley National Laboratory

by XENERGY, Inc.
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EXECUTIVE SUMMARY

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OVERVIEW

The *Assessment of the Market for Compressed Air Efficiency Services,* hereafter referred to as the *Compressed Air Market Assessment,* was commissioned by the U.S. Department of Energy with technical support provided by the Compressed Air Challenge® (CAC). The CAC is a voluntary collaboration of manufacturers, distributors and their associations; industrial users; facility operating personnel and their associations; consultants; state research and development agencies; energy efficiency organizations; and utilities. The mission of the CAC is to develop and provide resources that educate industry on the opportunities to increase net profits through compressed air system optimization.

The objective of this report is to provide a comprehensive and balanced view of the market for engineering and consulting services to improve the energy efficiency of plant compressed air systems. These services include plant assessments or audits to identify opportunities to improve compressed air system operations, preventive maintenance services, such as leak detection and repair that are aimed at reducing energy use, and redesign of controls and other system components to reduce energy use. The report is intended for use by the CAC and other industrial energy efficiency program operators in developing strategies to encourage the growth of the compressed air system efficiency industry and enhance the quality of the services it offers. Compressed air system vendors and designers may also find it useful in charting their own approach to providing energy efficiency services.

COMPRESSED AIR SYSTEM ENERGY USE AND THE BENEFITS OF INCREASED EFFICIENCY

Compressed Air System Electric Use

Compressed air systems account for 10% of all electricity and roughly 16% of all motor system energy use in U.S. manufacturing industries.[1] Seventy percent of all manufacturing facilities in the United States have some form of compressed air system. Most of these systems provide compressed air to drive a variety of equipment within a given plant, including machine tools, painting booths, materials separation, and materials handling.

Benefits of Compressed Air System Efficiency

Recent experience in a variety of "system optimization programs," as well as the experience of consultants in the field, suggests that over 50% of industrial plant air systems harbor opportunities for large energy savings with relatively low project costs. Compressed air system measures identified in energy audits of small- to medium-sized industrial facilities by the Industrial Assessment Centers had average projected

[1] Unless otherwise noted, information in this section is taken from XENERGY, Inc. (1998) *United States Industrial Electric Motor Systems Market Opportunities Assessment.* Washington, D.C.: U.S. Department of Energy, Office of Industrial Technologies, and Oak Ridge National Laboratory. The study is hereafter referred to as the *Motor Market Assessment.*

savings of 15% of compressed air system usage with simple paybacks in less than 2 years. Many case studies conducted for system optimization programs have identified savings in the range of 30 to 60% of initial system usage. The *United States Industrial Electric Motor Systems Market Opportunities Assessment (Motor Market Assessment*) estimated that compressed air system energy use in the typical manufacturing facility could be reduced by 17% through measures with simple paybacks of 3 years or less. In addition to energy benefits, optimization of compressed air systems frequently results in corresponding improvements in system reliability, product quality, and overall productivity.

OVERVIEW OF THE PROJECT AND REPORT

Seventy percent of all manufacturing facilities in the United States have some form of compressed air system.

This market assessment was designed and carried out in consultation with the Ad Hoc Evaluation Committee of the Compressed Air Challenge®. The Committee reviewed the research plan, the assessment interviewing approaches, draft questionnaires, and drafts of the various sections of this report.

Objectives

The project was designed to answer a number of key questions concerning the demand and supply sides of the market for compressed air efficiency services. Among the key research questions to be addressed on the ***demand side*** of the market were the following:

- What extent are customers in key end-use sectors aware of compressed air usage, costs, and savings opportunities?
- What practices do these customers follow to monitor, maintain, and enhance the efficiency of compressed air systems?
- What, if any, services do these customers purchase to maintain or enhance the efficiency of compressed air systems?
- What barriers do customers experience in purchasing such services?

The key research questions on the ***supply side*** of the market were as follows:

- What efficiency services do compressed air distributors, installers, and consultants currently offer?
- What is the current volume of sales for these services (number of customers, number of projects, dollar volumes)? How has volume changed over the past few years? What are vendors' expectations regarding growth?
- What role do these services play in the overall business strategy of manufacturers, distributors, and consultants?
- What barriers do these businesses face in developing and selling compressed air system efficiency services?

Research Activities

The report is based on a combination of primary and secondary research, including:

- An assessment of 91 compressed air equipment distributors. We concentrated our efforts to characterize the supply side on distributors, since these companies have established commercial and service relationships with end users, and are in the best position to serve as a channel for delivering system efficiency services.
- An assessment of 222 industrial end users who have compressed air systems.
- Interviews with 5 veteran compressed air efficiency consultants, designed to capture their perceptions of the current state and recent changes in both the demand and supply side of the market for compressed air system efficiency services.
- Reanalysis of data on compressed air use and maintenance practices collected in 1997 as part of the field inventory for the *Motor Market Assessment*.
- Review of regional studies of the market for compressed air system efficiency services.[2]

KEY FINDINGS

Demand-Side Findings

- ***Customer awareness of and concern for compressed air efficiency is low.*** Only 9% of customers interviewed for the program identified controlling energy costs as the primary objective in compressed air system maintenance and management. Only 17% mentioned efficiency at all as a system management objective. This low level of interest and knowledge was echoed in findings from the regional studies and interviews with compressed air system efficiency consultants.
- ***Maintenance of consistent, reliable compressed air supply is the principal objective of system management.*** Seventy-one percent of customers reported that ensuring adequate air supply is their primary objective in system management. According to consultants interviewed for this project, concern about operating consistency provides an effective route to selling efficiency-oriented services.
- ***A large portion of customers report serious problems in compressed air system operation and maintenance.*** Thirty-five percent of those interviewed reported that they had experienced unscheduled shutdowns of their compressed air systems during the previous 12 months. For 60% of these establishments, or 21% of all establishments, the shutdown had lasted 2 days or more.

  Two-thirds of the customers reported experiencing potentially serious operating problems in their compressed air systems. Excess moisture and inadequate air pressure were the most frequently reported problems.
- ***A significant portion of customers report having service contracts for their compressed air systems, but few of these contracts***

...energy use in the typical manufacturing facility could be reduced by 17% through measures with simple paybacks of 3 years or less.

[2] Including Aspen Systems Corporation, *The Compressed Air Systems Market Assessment for New England,* Compressed Air Baseline Study Group, April 2000; and Customer Opinion Research, *Compressed Air Market Transformation: Quantitative Baseline Research*, prepared for Pacific Gas & Electric, 1999.

address system efficiency. Thirty percent of customers reported that they had service contracts for their compressed air systems. However, only one-third of these (or 10% of all participants) reported that efficiency-oriented services such as leak detection, energy-use monitoring, or assessment of control strategies were included in the service contract. There was no difference in the incidence of unscheduled system shutdowns or operating problems between customers with service contracts and those without such contracts.

- ***Thirty-five percent of customers interviewed reported that they conducted leak prevention programs.***
- ***Reported implementation of compressed air efficiency measures is very low.*** The 1998 *Motor Market Assessment* found that 57% of manufacturing plants had taken *no* action to improve compressed air system efficiency—including repairing leaks—over the 2 years prior to the survey. A 1999 survey of 270 large industrial users served by Pacific Gas & Electric (PG&E) obtained a similar finding.[3]
- ***Seventy-five percent of operators of the systems installed had had no formal training in compressed air system efficiency.***
- ***Seventeen percent of customers reported that they had undertaken a compressed air system audit over the past 7 years.[4]*** Most of the audits had been conducted in the past 6 years; and 6 were underway at the time of the interview. While most of the audits included estimates of energy use and identified potential energy-saving measures, fewer than half included estimated savings and costs for recommended measures. Two-thirds of the customers who conducted system audits reported that they had implemented at least one of the recommended measures.

Seventy-five percent of operators of the systems installed had had no formal training in compressed air system efficiency.

- ***One-third of the customers reported that vendors selling "services specifically designed to reduce energy costs in... compressed air systems" had approached them.*** The nature of these services varied widely. The most frequently mentioned were preventive maintenance for compressors, assessment of control strategies, and identification of energy-saving measures. No one service was mentioned by more than 46% of those interviewed. This result reflects the formative state of the market for compressed air system efficiency services. Vendors have not defined the nature of such services consistently.

  Only 3% of customers reported that they had purchased compressed air efficiency services in response to these sales approaches. The most frequent objections to these services were high cost and the customers' view that they could undertake such activities with in-house staff.

Supply-Side Findings

- ***A large portion of distributors report that they offer compressed air efficiency services.*** Over three-quarters offer system-efficiency measures, while over one-half offer end-use analyses and leak services.

[3] Customer Opinion Research, *Compressed Air Market Transformation: Quantitative Baseline Research*, prepared for Pacific Gas & Electric, 1999.

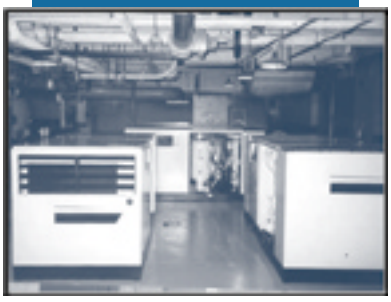
[4] Compressed air system audit was defined in the questionnaire as "a study of how to make your compressed air system as a whole more energy efficient." Field experience of CAC Committee members suggests that audit methods are not uniform and are seldom comprehensive.

- ***However, efficiency services are a very minor portion of distributor revenues.*** An estimated 4% of total revenues are derived from compressed air efficiency services.
- ***Over one-half of vendors feel that the demand for efficiency services has increased over the last year.***
- ***Most distributors that offer efficiency-related services have entered the market within the past 10 years; one-third have entered in the past 4 years.***
- ***Most distributors interviewed consider efficiency services essential to their competitive positions.*** Sixty-seven percent of distributors rate efficiency services as being important to their competitive position. Their major motivation to enter the market is customer retention. With the number of firms that offer efficiency services increasing, vendors believed that they needed to reply in kind to maintain satisfaction among their equipment purchasers. Access to additional revenue streams from consulting was not mentioned at all as a motivating factor.
- ***Most distributors identified customers' lack of understanding of the benefits of compressed air efficiency measures as the major barrier to their increased sale.*** These findings mirror the experience of compressed air efficiency consultants. Forty-five percent of the vendors identified customer perceptions that compressed air efficiency services were already being provided by in-house staff as an objection to sales efforts. This finding, combined with the reported low incidence of specific measure implementation, further reinforces the consultants' observation that customers are largely in the dark about the nature of compressed air system efficiency measures and maintenance practices.

Most distributors identified customers' lack of understanding of the benefits of compressed air efficiency measures as the major barrier to their increased sale.

OVERVIEW

The *Compressed Air (CA) Market Assessment* was commissioned by the United States Department of Energy with technical support provided by the Compressed Air Challenge® (CAC). The CAC is a voluntary collaboration of manufacturers, distributors and their associations; industrial users; facility operating personnel and their associations; consultants; state research and development agencies; energy efficiency organizations; and utilities. The mission of the CAC is to develop and provide resources that educate industry on the opportunities to increase net profits through compressed air system optimization. To date, the primary activity of the CAC has been to develop, promote, and present training programs in compressed air system efficiency targeted to equipment vendors and end users. As of December 2000, 2,882 individuals had attended the CAC "Fundamentals of Compressed Air Training" and 843 individuals had attended "Advanced Management of Compressed Air Systems." Other program activities include a sourcebook, a Web site (*www.compressedairchallenge.org*), technical support through the DOE Clearinghouse, technical articles, and conference presentations.



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COMPRESSED AIR SYSTEM ENERGY USE AND THE BENEFITS OF INCREASED EFFICIENCY

Compressed Air System Electric Use

Compressed air systems account for 10% of all electricity and roughly 16% of all motor system energy use in U.S. manufacturing industries.[1] Most of these systems provide compressed air to drive a variety of equipment within a given plant, including machine tools, painting booths, materials separation, and materials handling. Table 1-1 shows the amount of electricity used to drive compressed air systems by major manufacturing industry, as well as the percentage of total electricity consumption accounted for by those systems.

[1] Unless otherwise noted, information in this section is taken from XENERGY, Inc. (1998) *United States Industrial Electric Motor Systems Market Opportunities Assessment.* Washington, D.C.: U.S. Department of Energy, Office of Industrial Technologies, and Oak Ridge National Laboratory. The study is hereafter referred to as the *Motor Market Assessment.*

TABLE 1-1: Compressed Air System Use by Industry Group

SIC	Industry Group	Compressed Air System GWh/Year	Total Motor System GWh/Year	Comp. Air as % of Motor System Use	Comp. Air as % of Total Electric Use
28	Chemicals and Allied Products	39,960	144,362	27.7%	20.1%
33	Primary Metal Industries	12,609	87,935	14.3%	8.3%
29	Petroleum and Coal Products	7,930	51,938	15.3%	15.9%
37	Transportation Equipment	5,519	29,549	18.7%	14.0%
30	Rubber and Miscellaneous Plastics Products	4,767	36,610	13.0%	10.9%
26	Paper and Allied Products	4,533	99,594	4.6%	3.7%
36	Electronic and Other Electric Equipment	3,008	13,243	22.7%	9.1%
20	Food and Kindred Products	2,898	37,797	7.7%	4.5%
22	Textile Mill Products	2,392	16,750	14.3%	7.2%
24	Lumber and Wood Products	1,901	22,946	8.3%	8.7%
34	Fabricated Metal Products	1,777	7,296	24.4%	5.2%
35	Industrial Machinery and Equipment	1,172	7,378	15.9%	3.6%
38	Instruments and Related Products	721	6,487	11.1%	4.9%
32	Stone, Clay, and Glass Products	566	2,231	25.4%	1.6%
25	Furniture and Fixtures	460	3,694	12.5%	6.9%
27	Printing and Publishing	437	5,961	7.3%	2.5%
23	Apparel and Other Textile Products	398	1,168	34.1%	5.1%
31	Leather and Leather Products	1	491	0.3%	0.2%
20-39	Overall Manufacturing	91,050	575,428	15.8%	10.0%

Table 1-1 suggests that electricity used to drive air compressors is heavily concentrated in three manufacturing groups: chemicals, primary metals, and petroleum manufacturing. Particularly in chemicals and petroleum refining, compressed air or other gases are used as feedstocks or are otherwise delivered directly to the production process without going through a plantwide air system. In other industries, such as transportation equipment, air compressors are used almost exclusively to power plantwide systems. We are not aware of any sources that disaggregate energy compressed air usage by plant versus standalone systems. The energy estimates in this section cover all types of air compressors, not just those used to run plantwide systems. This point is important because the kinds of efficiency services assessed in this report, as well as estimates of energy savings from various kinds of measures, are particular to plant air systems.

Table 1-2 shows the percentage of manufacturing facilities that have and use compressed air equipment. Across all manufacturing industries, 70% of facilities have compressed air systems that account for more

TABLE 1-2: Percent of Manufacturing Facilities Using Compressed Air Equipment

SIC	INDUSTRY GROUP	PERCENT OF TOTAL ESTABLISHMENTS WITH		
		No CA System	Small CA System*	Full CA System
20	Food and Kindred Products	13%	34%	53%
22	Textile Mill Products	0%	24%	76%
23	Apparel and Other Textile Products	9%	0%	91%
24	Lumber and Wood Products	8%	10%	82%
25	Furniture and Fixtures	0%	0%	100%
26	Paper and Allied Products	19%	21%	61%
27	Printing and Publishing	95%	0%	5%
28	Chemicals and Allied Products	8%	7%	84%
29	Petroleum and Coal Products	0%	16%	84%
30	Rubber and Miscellaneous Plastics Products	0%	12%	88%
32	Stone, Clay, and Glass Products	0%	0%	100%
33	Primary Metal Industries	5%	13%	82%
34	Fabricated Metal Products	8%	61%	31%
35	Industrial Machinery and Equipment	1%	0%	99%
36	Electronic and Other Electric Equipment	9%	0%	91%
37	Transportation Equipment	0%	8%	92%
38	Instruments and Related Products	11%	0%	89%
20-39	Overall Manufacturing	18%	12%	70%

* CA system accounts for less than 5 percent of motor system energy. Source: *Market Assessment* data; XENERGY, Inc., analysis.

than 5% of total motor system energy use. Eighteen percent have no compressed air systems at all. The figures in Table 1-2 are derived from the results of roughly 2,000 screening interviews conducted to construct the sample for the *Motor Market Assessment.* For some SIC categories, the number of screening interviews were small, and small sample sizes may have led to unrepresentative results. For example, results of the vendor interviews reported in Section 3 suggest that the portion of printing facilities with plant compressed air systems is significantly higher than the 5% identified in the screening interviews.

Benefits of Compressed Air System Efficiency

Recent experience in a variety of "system optimization programs," as well as the experience of consultants in the field, suggests that many industrial plant air systems harbor opportunities for large energy savings with relatively low project costs. Compressed air system measures identified in energy audits of small- to medium-sized industrial facilities by

TABLE 1-3: Compressed Air System Improvement Applicability and Savings

Measure	Applicability			Savings	Net
	Low	Midrange	High	Fraction	Savings
Reduce Overall System Requirements	20%	30%	40%	20%	6.0%
Match Compressor Size to Load	5%	10%	15%	3%	0.3%
Improve Compressor Controls	15%	25%	40%	10%	2.5%
Improve Compressor Components	5%	15%	20%	5%	0.8%
Operation and Maintenance	50%	75%	85%	10%	7.5%
Overall Savings					**17.1%**

the Industrial Assessment Centers had average projected savings of 15% of compressed air systems with simple paybacks in less than 2 years. Many case studies conducted for system optimization programs have identified savings in the range of 30 to 60% of initial system usage.

In developing estimates of energy savings potential for the *Motor Market Assessment,* XENERGY, Inc., interviewed a number of compressed air system efficiency experts to estimate the average level of energy savings available in plant air systems. We asked these experts to identify the most commonly available energy efficiency measures, estimate the percentage of installed systems in which they would be applicable (i.e., be technically feasible and achieve a payback of 3 years or less), and the level of energy savings they generally achieve, expressed as a percentage of initial system energy. Table 1-3 summarizes the findings from this research. A recent study commissioned by utilities in the Northeast estimated potential savings of 30% of compressed air system electric use if the 3-year payback criterion is relaxed.[2] This larger technical potential is significant in areas where utility incentives are available.[3]

Many case studies conducted for system optimization programs have identified savings in the range of 30 to 60% of initial system usage.

The figures in Table 1-3 suggest that, on average, compressed air system usage can be reduced by 17.1% through measures that yield maximum payback of 3 years. Based on conversations with compressed air system consultants, these projects can generally be executed at capital cost ranging from $10,000 to $100,000, with a typical range of $20,000 to $50,000. If all of these projects were implemented, energy savings would total 15,670 GWh per year, or $747 million at current industrial electric rates.

In addition to these attractive energy savings, improvements to the energy efficiency of compressed air systems also yield other important benefits to the end user. Because many of the measures shown in Table 1-3 require significant levels of system monitoring and maintenance for proper implementation, one of their by-products is improved system operation. This in turn leads to reductions in unscheduled downtime and wasted inputs, as well as to improved control over product quality. In many cases, these benefits have value greater than the energy savings.

[2] XENERGY, Inc. (1998) *United States Industrial Electric Motor Systems Market Opportunities Assessment.* Washington, D. C.: U. S. Department of Energy, Office of Industrial Technology, and Oak Ridge National Laboratory, page 61.

[3] Aspen Systems Corporation. *The Compressed Air Systems Market Assessment for New England*, Compressed Air Baseline Study Group, April 2000.

OVERVIEW OF THE PROJECT AND REPORT

This market assessment was designed and carried out in consultation with the Ad Hoc Evaluation Committee of the Compressed Air Challenge®. The Committee reviewed the research plan, the assessment interviewing approaches, draft questionnaires, and drafts of the various sections of this report.

Objectives

The project was designed to answer a number of key questions concerning the demand and supply sides of the market for compressed air efficiency services.

Among the key research questions to be addressed on the ***demand side*** of the market were the following:

- To what extent are customers in key end-use sectors aware of compressed air usage, costs, and savings opportunities?
- What practices do these customers follow to monitor, maintain, and enhance the efficiency of compressed air systems?
- What, if any, services do these customers purchase to maintain or enhance the efficiency of compressed air systems?
- What barriers do customers experience in purchasing such services?
- How and by whom are decisions concerning the purchase and modification of compressed air systems made? What are the key criteria in such decisions?

The key research questions on the ***supply side*** of the market were as follows:

- What efficiency services do compressed air distributors, installers, and consultants currently offer?
- What is the current volume of sales for these services (number of customers, number of projects, dollar volumes)? How has volume changed over the past few years? What are vendors' expectations regarding growth?
- To which kinds of customers (as defined by industry segment, size of system, complexity of system) are these services most often sold?
- What kinds of skills, equipment, and other resources are needed to deliver efficiency services?
- What role do these services play in the overall business strategy of manufacturers, distributors, and consultants?
- What barriers do these businesses face in developing and selling compressed air system efficiency services?

Research Activities

The report is based on a combination of primary and secondary research, including:

- An assessment of 91 compressed air equipment distributors;
- An assessment of 222 industrial end users who have compressed air systems;

If the recommended improvement measures in Table 1-3 were implemented, energy savings would total 15,670 GWh per year or $747 million at current industrial electric rates.

- Interviews with 5 veteran compressed air efficiency consultants, designed to capture their perceptions of the current state and recent changes in both the demand and supply side of the market for compressed air system efficiency services;
- Reanalysis of data on compressed air use and maintenance practices collected in 1997 as part of the field inventory for the *Motor Market Assessment*;
- Review of regional studies of the market for compressed air system efficiency services. The two principal studies used in this regard were[4]:
  - *The Compressed Air Systems Market Assessment and Baseline Study for New England* (2000) by Aspen Systems Corporation for the New England Study Group. This was a comprehensive study of the market for compressed air efficiency services in New England. Research included interviews with 56 individuals, including utility company representatives, service providers, equipment vendors, consultants, and end users. This original research was supported by review of existing literature and local energy use studies commissioned by the utilities that formed the study group.
  - *Compressed Air Market Transformation: Quantitative Baseline Research* (1999) prepared by Customer Opinion Research for PG&E. The research for this study consisted primarily of a telephone survey of 270 of PG&E's industrial customers with compressed air systems of at least 50 horsepower. The primary purpose of the study was to establish a baseline for compressed air system operation and maintenance practices and to quantify the market potential for compressed air system efficiency services.

STRUCTURE OF THIS REPORT

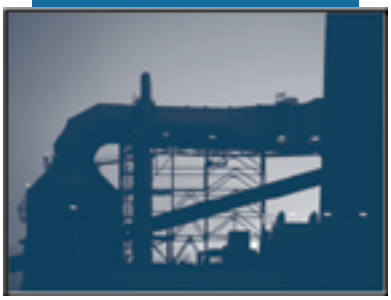
The remainder of this report is divided into the following sections:

- ***Section 2: The Demand Side of the Market.*** This section presents findings from the sources discussed above concerning the demand side of the market. In particular, we focus on descriptors of compressed air system design and use, customers' current practices in regard to compressed air system management and maintenance, customers' current use of compressed air system efficiency services, as well as barriers and motivations to greater use of such services.
- ***Section 3: The Supply Side of the Market.*** This section presents findings from the sources discussed above concerning the supply side of the market. We concentrate primarily on distributors' current offerings, their perceptions of trends on the demand side of the market, and barriers and motivations they perceive to developing their efficiency offerings further.

[4] Aspen Systems Corporation, *The Compressed Air Systems Market Assessment for New England*, Compressed Air Baseline Study Group, April 2000; and Customer Opinion Research, *Compressed Air Market Transformation: Quantitative Baseline Research*, prepared for Pacific Gas & Electric, 1999.

INTRODUCTION

This section presents findings from the various sources discussed in Section 1 concerning the demand side of the market for compressed air system efficiency services. The analysis draws principally from the findings of an assessment of 222 plant engineers undertaken for this study. We bring in findings from the regional studies, the *Motor Market Assessment*, distributor survey, and consultant interviews to provide perspective on the findings of the plant engineer evaluation.



METHODS: THE COMPRESSSED AIR MARKET ASSESSMENT

Objectives

The objectives of the customer assessment were to characterize and quantify customer awareness and use of compressed air efficiency services in key end-use sectors. This portion of the study also characterized the purchase and maintenance practices for compressed air systems.

The key research questions addressed were as follows:

- To what extent are customers in key end use sectors aware of compressed air usage, costs, and savings opportunities?
- To what extent are these customers aware of the costs and benefits of compressed air efficiency measures?
- What practices do these customers follow to monitor, maintain, and enhance the efficiency of compressed air systems?
- What barriers do customers experience in implementing compressed air system efficiency measures?
- What, if any, services do these customers purchase to maintain or enhance the efficiency of compressed air systems?
- What barriers do customers experience in purchasing such services?
- To what extent are these customers receptive to various potential services to increase compressed air system efficiency?

Research Activities

The Interviews. The names of the customers interviewed for this study were extracted from the list of subscribers to *Plant Engineer* magazine. This publication focuses on the management of industrial equipment. The subscription list does not represent a random listing of individuals for compressed air system management since subscribers are likely to have a high interest in operational efficiency issues. However, in previous studies, XENERGY, Inc., had encountered very high levels of non-response on listings that did not contain contact names. Therefore, we elected to use the subscriber list because we believed that the bias imparted to the results would be no worse than the non-response bias encountered using random lists that did not contain contact names. Also, given the technical content of the assessment, we believed that data collection efforts would be more productive if we focused on individuals

who had indicated some interest in the topics covered.

This strategy did have the intended effect of increasing response rates. The overall response rate for this assessment was in the 40-50% range. In comparison, for a study we recently conducted with end users of industrial motor systems in the Northeastern U.S., where the sample contained few contact names, the response rate was in the 10-20% range.

The *Plant Engineer* subscription list was narrowed down to establishments in 11 2-digit SIC codes, as shown in Table 2-1. These 11 SIC codes represent industries that are either ranked in the top nine industries in motor energy usage of compressed air systems or have at least 20% of their motor energy usage accounted for by compressed air systems (See Table 2-1). Twenty interviews were initially allocated to each SIC group for a target of 220 total assessments. An additional 2 were completed with SIC 29 customers for a total of 222 completed assessments.

Implementation

XENERGY employees designed the evaluation with the assistance of the Compressed Air Challenge®. It was then programmed into a CATI system and administered by Atlantic Marketing Research of Boston, Massachusetts. The questionnaire was pretested and XENERGY staff continually oversaw the interviewing process. The interviews were fielded in July and August, 1999.

FINDINGS

Characteristics of Customers

Table 2-2 presents the distribution of the 222 establishments interviewed by a measure of size, the number of employees. The majority of the interviewed establishments (71%) fell into the medium range of 100 to 500 employees. By contrast, 83% of manufacturing establishments employ fewer than 100 persons. This result reflects the selection of the *Plant Engineer* subscription list as a starting point. We cannot determine the extent to which the list reflects the population of all manufacturing establishments with compressed air systems. However, the objective of the approach was to identify customers with significant compressed air systems who could respond knowledgeably to fairly technical questions concerning system management. We believe this objective was achieved.

Characteristics of Compressed Air Systems

Number of Compressors. Table 2-3 shows the distribution of customers by number of air compressors in their facility for both this study and the PG&E customer survey. Both studies found that almost all customers had 2 or more compressors in the facility. Findings from the New England study suggest that, in most cases, at least one of the compressors was used for back-up capacity. On the whole, it appears that those interviewed for this assessment had larger compressed air systems: 68% had 3 or more compressors versus 45% in the California sample.[1]

[1] Personal communications with PG&E staff suggest that their industrial customers fall into the small/medium categories.

TABLE 2-1: Distribution of Interviewed Customers by SIC

SIC	Industry Group	# Assessments
20	Food and Kindred Products	20
22	Textile Mill Products	20
23	Apparel and Other Textile Products	20
26	Paper and Allied Products	20
28	Chemicals and Allied Products	20
29	Petroleum and Coal Products	22
30	Rubber and Miscellaneous Plastics Products	20
32	Stone, Clay, and Glass Products	20
33	Primary Metal Industries	20
34	Fabricated Metal Products	20
36	Electronic and Other Electric Equipment	20
	Total	222

TABLE 2-2: Distribution by SIC and Number of Employees

SIC	NUMBER OF EMPLOYEES					
	<100	100 to 499	500 to 999	>1000	Unknown	Total
20 Food and Kindred	3	8	4	5	0	20
22 Textile Mill Products	2	13	5	0	0	20
23 Apparel and Other Textile	0	19	1	0	0	20
26 Paper and Allied	2	12	3	2	1	20
28 Chemicals and Allied	2	16	1	1	0	20
29 Petroleum and Coal	4	13	2	2	1	22
30 Rubber and Miscellaneous Plastics	0	17	1	2	0	20
32 Stone, Clay, and Glass	0	16	1	3	0	20
33 Primary Metal	2	14	2	2	0	20
34 Fabricated Metal	3	14	2	1	0	20
36 Electronic and Other Electric Equipment	0	16	1	2	1	20
Total	18	158	23	20	3	222
Percent of Distribution	8%	71%	10%	9%	1%	100%
Percent of Population*	83%	8%	1%	0%	8%	100%

** Source: Annual Survey of Manufactures: 1997.*

TABLE 2-3: Number of Compressors in Customer Facilities

Number of Compressors	CA Market Assessment (n = 218)	PG&E Survey (n= 268)
1	7%	18%
2	25%	37%
3	21%	20%
4	19%	12%
5	9%	5%
6+	19%	8%

TABLE 2-4: Distribution by SIC and Total Horsepower of Compressors

SIC	TOTAL HORSEPOWER OF AIR COMPRESSORS					
	100	100 to 499	500 to 999	1000	Unknown	Total
20 Food and Kindred Products	5	10	4	1	0	20
22 Textile Mill Products	1	11	2	3	3	20
23 Apparel and Other Textile Products	12	6	0	0	2	20
26 Paper and Allied Products	1	10	1	6	2	20
28 Chemicals and Allied Products	3	4	2	3	8	20
29 Petroleum and Coal Products	2	7	1	4	8	22
30 Rubber and Miscellaneous Plastics	1	13	3	2	1	20
32 Stone, Clay, and Glass Products	1	8	2	5	4	20
33 Primary Metal Industries	2	11	3	3	1	20
34 Fabricated Metal Products	3	11	3	0	3	20
36 Electronic and Other Electric Equipment	4	11	2	1	2	20
Total	35	102	23	28	34	222

TABLE 2-5: Hours of Compressed Air System Operations

Hours of Operation/Week	CA Market Assessment (n = 218)	PG&E Survey (n= 268)
40 hours or less	12%	19%
41 - 80 hours	25%	36%
81 -120 hours	21%	22%
121 - 167 hours	18%	6%
168 hours/week (7 days x 24 hours per day)	24%	17%

This finding is consistent with the distribution of the national list by number of employees. The relatively large size of the companies should be kept in mind when interpreting other evaluation results.

Total Compressed Air System Horsepower. Table 2-4 displays the distribution by SIC and another measure of size, self-reported compressor horsepower. Again, most interviewed establishments fall into the medium range here as well.

Hours of System Operation. The findings from both this study and the PG&E survey indicate that compressed air systems generally have very heavy hours of operation. Table 2-5 shows self-reported hours of operation from customers to the *Compressed Air Market Assessment* and the PG&E survey. Sixty-three percent of the customers to this assessment reported that they run their compressed air systems more than 80 hours per week, as did 45% of the respondents to the PG&E survey. Nearly a quarter of those interviewed during this assessment reported that their compressed air systems run continually, as did 17% of the PG&E respondents. This high level of use suggests the importance of the compressed air systems in supporting overall manufacturing operations, as well as the importance of high-quality system management and maintenance in realizing energy savings.

Sixty-three percent of the customers to this assessment reported that they run their compressed air systems more than 80 hours per week....

Incidence of Compressed Air Systems. In an effort to learn more about the presence or absence of compressed air systems in different industries, the assessment research firm recorded the number of establishments that were screened out because they did not use compressed air systems in their facilities. This screening question was posed to the contact from the subscription list or, if that person no longer worked at the facility, the plant manager, plant engineer, or maintenance manager. We are therefore confident that the customer could accurately answer whether the facility had a compressed air system. Table 2-6 displays the results of this screening. Given the small size in each industry, the results cannot be extrapolated to the population. However, the results closely resemble those of the *Motor Market Assessment*, which found that 18% of all manufacturing plants have no compressed air systems.

Compressed Air System Management

Position of Person with Responsibility for Compressed Air System Management. Maintenance Managers are responsible for the management of compressed air systems in nearly two-thirds of the establishments assessed (See Table 2-7). Plant engineers and plant managers are responsible in most of the remaining establishments. This suggests that compressed air system management is considered more as a maintenance function and is not generally tied to decision-making on capital improvements.

Objectives of Compressed Air System Management. Table 2-8 shows customers' responses to open-ended questions regarding their objectives in managing compressed air systems. Control of energy costs ranks very low among the objectives for managing compressed air systems. Without prompting, just 9% of customers mentioned energy efficiency as their primary system management objective; only 22% mentioned efficiency at all as a system management objective.

TABLE 2-6: Customers Screened Out by SIC

SIC/Industry Group	Number Screened Out	% Screened Out per Contact Reached
20 Food and Kindred Products	3	13%
22 Textile Mill Products	3	13%
23 Apparel and Other Textile Products	6	23%
26 Paper and Allied Products	6	23%
28 Chemicals and Allied Products	2	9%
29 Petroleum and Coal Products	7	24%
30 Rubber and Miscellaneous Plastics Products	3	13%
32 Stone, Clay, and Glass Products	3	13%
33 Primary Metal Industries	1	5%
34 Fabricated Metal Products	3	13%
36 Electronic and Other Electric Equipment	3	13%
Total	40	15%

Maintaining continuous operation and ensuring an adequate supply of air were the objectives mentioned most frequently by customers (71% of first mentions). This finding indicates the importance of system reliability as a customer value in promoting system efficiency services.

Incidence of Compressed Air System Problems. Despite the orientation of compressed air system management activities towards the maintenance of continuous operation, most companies reported incidents of unscheduled downtime. Thirty-five percent of customers reported that their systems had experienced unscheduled downtime during the previous 12 months. For 60% of these establishments, or 21% of all establishments, the system was down for 2 or more workdays.

Two-thirds of customers reported experiencing potentially serious problems in compressed air system operations during the past year. The most often cited problems were excess moisture in the compressed air and inadequate pressure, both within the system as a whole and at specific points (See Table 2-9).

Customer Knowledge of Compressed Air System Energy Use and Efficiency Opportunities

The survey conducted for this report did not probe customers' knowledge about specific operating attributes of their compressed air systems. However, the survey conducted for PG&E did cover this topic. That study found that operators' knowledge of fundamental aspects of compressed air system operations was very low. For example:

- Over one-half of survey respondents did not know the discharge capacity of their compressor(s). Additionally, over 40% of respondents

TABLE 2-7: Position of Person with Responsibility for CA System Management

Position	Percent
Maintenance Manager	63%
Plant Engineer	18%
Other	6%
Contractor	4%
Plant Manager	4%
Compressed Air Specialist	1%
General Manager	1%
Manufacturing Manager	1%
Mechanic	1%
Supervisor/ Team Leader	1%
Don't Know	1%
Number of customers	222

TABLE 2-8: Objectives of CA System Management

System Management Objective	Percent Mentioning as Primary Objective	Percent Mentioning as Objective
Maintain continuous operation	41%	57%
Ensure adequate supply of air	30%	50%
Maintain quality of air	12%	37%
Preventive maintenance	7%	19%
Control or reduce energy use	9%	22%
Other	0%	1%
Don't know	1%	2%
Number of customers	222	222

TABLE 2-9: Reported Problems in Compressed Air Systems

Problems	Percent
Excess moisture in compressed air	50%
No problems reported	33%
Inadequate pressure in whole system	27%
Inadequate pressure at points in the system	26%
Excess oil in compressed air	12%
Frequent fouling of air filters	11%
Don't know	1%
Number of responses	222

TABLE 2-10: Regularly Scheduled Maintenance Activities

Maintenance Activity	Percent
Check lubricant level and filter	71%
Clean or replace inlet air filter cartridges	58%
Clean air line filters	38%
Verify operating temperature per manufacturer specification	22%
Clean drain traps	21%
Check cooling water quality, replace cooling system	19%
Check belts for wear and replace	14%
Check for system leaks	13%
Number of customers	222

TABLE 2-11: Number of Maintenance Procedures by Compressor Size

NUMBER OF MAINTENANCE PROCEDURES	HORSEPOWER OF AIR COMPRESSORS			
	Up to 100 HP	100 - 500 HP	>500 HP	All
0	9%	9%	10%	9%
1 - 2	43%	49%	44%	46%
3 - 8	49%	43%	46%	45%
Number of customers	35	101	52	188

did not have a clear understanding of the relationship between compressor discharge pressure and the largest pressure requirement for a single piece of equipment.

- There were large gaps between individual respondents' reported compressor discharge pressure and the largest pressure requirement for a single piece of equipment.
- Based on "rule of thumb" calculations, nearly 60% of respondents should have between 501 and 2000 gallons of air storage. There is a significant difference in the recommended amount of air storage compared to the actual amount installed. Only 19% of respondents have between 501 and 2000 gallons of air storage.
- Only 10% of respondents reported that they kept track of the energy cost of their compressed air systems.

Interviews with 4 consultants with national experience in providing compressed air system audits and efficiency services confirmed that current levels of system knowledge among plant engineers and system operating personnel is low. However, 3 of these consultants report that awareness of the benefits of increased efficiency among plant engineers is increasing. This perception is consistent with findings from the PG&E study that over two-thirds of compressed air system mangers believe that they can substantially reduce the costs of operating the system.

Consultants attribute the increase in awareness of efficiency opportunities to a number of factors, including the efforts of the Compressed Air Challenge®, increased coverage of compressed air efficiency issues in trade and industry publications, and utility programs. One consultant noted that his customers tend to be aware of efficiency opportunities available from upgrades to compressed air system components—dryers, air storage, controls, as well as the compressors themselves. However, awareness of measures to reduce air demand is still virtually non-existent. By way of contrast, 44% of the customers interviewed for this study reported that they periodically assess whether their end uses of compressed air are appropriate.

There is no correlation between size and the number of maintenance activities implemented.

Current System Management and Maintenance Practices

Maintenance Practices. The assessment asked customers to name the maintenance activities they perform on a regular basis. Ninety percent of them reported undertaking at least one of the common maintenance activities identified in Table 2-10. Checking lubricants was mentioned by almost three-quarters of all customers with over half citing air filter maintenance. In-house staff performs these maintenance activities for over 75% of the customers with vendors and consultants doing so for the rest.

Generally, we would have expected that facilities with large compressed air systems would expend greater resources on their maintenance. However, we found that there was no correlation between size, as measured by the compressed air system horsepower, and the number of maintenance activities implemented (See Table 2-11). The New England study found that there was no relationship between system or facility size and staff hours spent on system maintenance.

One of the consultants interviewed expressed the opinion that the level of system maintenance efforts was declining due to trends in outsourcing and assignment of maintenance personnel to production positions occasioned by historically high levels of production.

Leak Prevention Programs. Identification and repair of leaks in the air distribution system and end-use tools can often reduce system energy use by 10 to 15%. The value of leak prevention seems intuitively obvious, given the exposed nature of air lines and the audible hiss of leaks. However, only 35% of those interviewed during this assessment regularly conducted leak prevention programs in their facilities. There was no consistent pattern of association between the implementation of leak prevention programs and either SIC or size of the establishment. The primary activities included in these leak prevention routines are checking for leaks near compressors/dryers and repairing leaks (See Table 2-12). For almost 90% of the customers with leak prevention programs, in-house staff performs these routines.

The percentage of customers who have made capital improvements to their compressed air systems to reduce energy consumption is very low.

System Monitoring and Management. The assessment contained a number of questions concerning customers' efforts to monitor compressed air system performance. They were asked if they had made a variety of operating measurements over the past 2 years. Table 2-13 displays the different quantities that were measured by those interviewed. One-quarter of them had made no measurements at all. Measuring pressure levels was cited most often, by almost two-thirds of the customers. Forty percent of them mentioned making operating measurements related to energy use: demand on compressor motors, energy use by compressor motors, leak loads, and load profiles (defined as periodic demand measurements over the course of one or more days). The high proportion of customers who report measuring pressure levels is consistent with the high proportion of customers who are concerned with reliability of air supply.

In-house staff carried out the above measurements for almost three-quarters of the establishments that performed such measures.

TABLE 2-12: Leak Prevention Activities

Leak Prevention Activity	Percent Included in Leak Prevention Programs
Check for leaks around compressors and air dryers	77%
Repair leaks	67%
Check joints for leaks	49%
Check regulators and tools for leaks	45%
Tag leaks	41%
Check for open bleed valves	39%
Check bypass valves	37%
Number of customers	75

Capital Improvements to Increase Compressed Air System Efficiency. All of the studies consulted for this report found that the percentage of customers who have made capital improvements to their compressed air systems to reduce energy consumption is very low. The *Market Assessment User Practices Survey,* conducted in 1997 for the *Motor Market Assessment*, found that *57% of all customers with compressed air systems had made no efficiency-related capital improvements to their system— including leak repair—in the 2 years prior to the survey*.

TABLE 2-13: Quantities Measured

Operating Parameters Measured	Percent
Pressure levels	65%
Demand on the compressor motors (KW)	39%
Weekly or monthly compressor motor electric use	21%
Leak loads	19%
Load Profiles	16%
None of the above	25%
Number of customers	222

TABLE 2-14: Reported Improvements in Two Years Prior to the 1998 *Motor Market Assessment*

EFFICIENCY MEASURE	SIZE CATEGORY*					
	Large	Large/Med	Medium	Small/Med	Small	Total
Replace 1-stage rotary screw units with more efficient models	7%	16%	29%	2%	4%	7%
Use parallel compressors to respond to variations in load	23%	12%	10%	13%	8%	9%
Reconfigure piping and filters to reduce pressure drops	14%	25%	5%	13%	1%	5%
Add multi-unit controls to reduce part load consumption	23%	10%	6%	0%	4%	4%
Reduce size of compressors to better match load	10%	6%	1%	2%	1%	1%
Fix leaks	42%	41%	34%	36%	17%	22%
No improvements	39%	45%	37%	63%	58%	57%

** Size categories are based on percentile breaks in the distribution of establishments by size within each SIC. Thus there is no set number of employees for each category.*

The PG&E study found that 63% of its customers had made no attempts to upgrade their system's efficiency in the 3 years prior to the study. Table 2-14 provides details of the findings from the 1998 *Motor Market Assessment*. Leak repair accounts for most of the measures implemented. Larger facilities were more likely than average to implement these measures. However, this pattern was not entirely consistent across size or measure categories.

Purchase of System Maintenance Services

Service Contracts. Overall, 30% of customers to the *Compresssed Air Market Assessment* reported that they had service contracts for their compressed air systems. The proportion of establishments with service contracts for CA systems did not vary substantially by industry nor by size of establishment. Among establishments with service contracts, 83% purchased those services from compressed air equipment vendors. The remaining 17% were serviced by consultants and contractors other than the company's principal compressed air equipment vendor.

The study's questionnaire asked customers to name the specific services provided under their service contracts. Table 2-15 shows the results of this set of questions. The results indicate that most compressed air system service contracts are oriented primarily towards preventive maintenance of the compressors and auxiliaries. Only one-third of customers with service contracts (10% of the total list) reported that they received efficiency-oriented services such as leak detection, leak repair, assessment of control strategies, energy use monitoring, and load profiling.

Only one-third of customers with service contracts reported that they received efficiency-oriented services.

Effectiveness of Service Contracts. Given the emphasis of service contracts on preventative maintenance, one potential index of their effectiveness would be the incidence of compressed air system breakdowns and operating problems. We examined the association between the use of service contracts and reported system problems. The proportion of customers reporting unscheduled system downtime was virtually the same for those with and without service contracts: 38%. Table 2-16 displays the percent of customers in both groups who experienced various system operating problems. While there are small differences between the 2 groups in the portion of customers who experienced compressed air system operating problems, these differences are not statistically significant.[2]

Awareness and Use of Compressed Air System Efficiency Services

Interest in Efficiency Services. Part of this assessment was designed to capture information from customers on the extent to which vendors are marketing their efficiency services and the content of those offers. Thirty-four percent of those interviewed reported that they had been approached by vendors selling "services specifically designed to reduce energy costs in your compressed air systems." Fifty-eight percent of the customers who were offered efficiency services were approached by compressed air equipment vendors. Another 39% were approached by

[2] Applied the Chi-square test.

consultants and 15% by OEM vendors. Only 3% of all customers reported purchasing such services.

Table 2-17 lists the activities included in the offers for energy efficiency services. Among the 50 customers who could recall the services offered, the most often mentioned services were preventative maintenance on compressors and assessment of control strategies and equipment. While assessment of control strategies is clearly an efficiency-oriented service, preventative maintenance of compressors has been a staple of conventional service contracts. It is also interesting to note that not one service was mentioned as being offered by more than one-half of the customers. This finding suggests that vendors are trying to work out the content of efficiency services, and that individual companies are each coming up with their own concepts of what these services should include.

TABLE 2-15: Services Provided under CA System Service Contract (Percent of those with Contracts)

Services	Percent Mentioning
Preventive maintenance on compressors	67%
Preventive maintenance on auxiliaries	44%
Emergency repair	33%
Leak repair	20%
Assessment of control strategies and equipment	14%
Leak detection	13%
Load profiling	5%
Energy use monitoring	3%
Number of customers	64

TABLE 2-16: Number of Operating Problems by Service Contract Group

Number of Operating Problems Reported	Have Service Contract	No Service Contract
0	47%	35%
1	19%	29%
2	22%	13%
3	5%	14%
4	3%	6%
5	5%	3%
Number of customers	64	150

TABLE 2-17: Activities Included in Efficiency Service Offers

Compressed Air Efficiency Services Offered	Percent of Customers Receiving Service Offers
Preventive maintenance on compressors	46%
Assessment of control strategies and equipment	46%
Identification of energy-saving measures	42%
Leak detection	38%
Energy use monitoring/load profiling	36%
Preventive maintenance on auxiliaries	36%
Assessment of compressed air end-uses	30%
Financial analysis of energy-saving measures	28%
Leak repair	24%
Installation of energy-saving measures	22%
Number of customers	50

TABLE 2-18: Main Reason for Not Purchasing Efficiency Services

Reason	Percent
Too costly	28%
Can do it ourselves	23%
No budget	13%
Skeptical of estimated energy savings	10%
Don't know	10%
Still considering	8%
Not approved by management	7%
Number of customers	60

TABLE 2-19: Sources of Compressed Air System Efficiency Study Services

Source of Efficiency Study Services	Percent of Those who Had System Audit
A compressed air system consultant	43%
Your compressed air equipment vendor	24%
Your own staff	13%
Some combination of the above	11%
Number of customers	38

Of those interviewed who purchased energy efficiency services, almost one-half did so because they believed they would save a substantial amount of energy. Other reasons cited include improved production control, improved production efficiency, the reputation of the vendor, and a lack of staff time. Among the reasons for *not* purchasing efficiency services, the most frequently mentioned were that it was too costly or because it could be performed by in-house staff (See Table 2-18).

Of those customers who were not approached to purchase energy efficiency services, 58% reported that they would be interested in such services. Among customers who were not interested in these services, the most common reason for their lack of interest was their ability to perform the services in-house (32%) or the small size of their systems (39%).

Fifty-eight percent of customers who were not approached to purchase energy efficiency services reported that they would be interested in purchasing such services.

Training. Slightly over one-quarter of all customers reported that someone in their staff had been trained in compressed air system efficiency. In roughly half of these instances, their compressed air equipment vendor had sponsored the training. Only 6% of all customers were aware of the Compressed Air Challenge® program. **The key finding from this series of questions reveals that operators of 75% of the systems had had no formal training.**

Compressed Air System Efficiency Studies. Almost 20% of all customers reported undertaking energy-efficiency studies of their compressed air systems over the past 7 years.[3] For those establishments that did undertake efficiency studies, most used a specialized compressed air system consultant (37%) or an equipment vendor (24%) to perform the study (See Table 2-19).

There is no uniform set of procedures or protocols for conducting compressed air system efficiency study. There are a number of computerized study programs currently available which call for extensive measurements of compressor power and operating parameters under various load conditions. Other protocols are somewhat less rigorous. Many consultants have developed their own procedures that they modify to meet the particular requirements of the site. Table 2-20 lists the activities included in these system studies. While most contained the full complement of technical assessments, it is interesting to note that fewer than half of the studies estimated cost and energy savings for the recommended measures. This information is often necessary to motivate customers to implement recommendations.

Twenty-five of the 38 establishments (66%) that undertook an efficiency study reported that they implemented measures recommended in those studies. Twelve of these companies reported implementing two or more measures. A variety of efficiency measures were implemented due to the efficiency study (See Table 2-21). Among those 13 customers who had not implemented any measures, 7 reported that their study was not yet complete. A number of these customers reported that they intended to implement the recommended measures.

Twenty-five of the 38 establishments (66%) that undertook an efficiency study reported that they implemented measures recommended in those studies.

[3] The relevant question read: "Have you undertaken or contracted for a study of how to make your compressed air system as a whole more energy efficient?"

TABLE 2-20: Activities Included in the Efficiency Study

Compressed Air Efficiency Study Services	Percent of Those who Had System Study
Estimate of compressed air system energy use	79%
Recommendations for improvements	74%
Assessment of auxiliary equipment such as dryers and separators	68%
Load profile based on system measurements	63%
Estimation of losses due to leaks	63%
Assessment of control system and alternate strategies	63%
Identification of inappropriate uses of compressed air	61%
Assessment of the distribution system for pressure drops and efficiency	61%
Assessment of air storage capacity	61%
Estimates of costs and energy savings for recommended measures	47%
Number of customers	38

TABLE 2-21: Measures Implemented from Efficiency Study

Measures	Percent of Those who Implemented Measures
Improvements to system auxiliaries	40%
Changes to piping, distribution system	40%
Leak reduction	32%
Added air storage capacity	28%
Changes to compressor controls	24%
Reduced unnecessary compressed air uses	16%
Installed heat-recovery equipment	16%
Number of customers	25

Barriers to the Purchase of Compressed Air System Efficiency Services

The compressed air system efficiency consultants interviewed for this report repeatedly stressed that the major barrier to increased demand for compressed air efficiency services is lack of customer understanding of potential benefits: energy savings and improved control over production processes.

Other barriers mentioned included:

- Lack of time among maintenance and facilities engineering staff to deal with problems that are not directly related to short-term production needs.
- A lack of communication and shared goals between the maintenance department—which typically is responsible for system operation—and plant engineers, who are focused on meeting the needs of production departments.

These observations are consistent with the findings from this assessment and the PG&E customer survey.

In light of these findings, the consultants believed that training and information strategies such as those currently pursued by the Compressed Air Challenge® will be the most effective. The consultants stressed that, to be most effective, the training programs must:

- Be kept relatively simple;
- Focus the trainee's attention on "the low-hanging fruit," measures that are relatively easy to implement and are likely to yield appreciable savings;
- Provide a step-by-step road map regarding how to use information gained through the training;
- Equip the trainee to advocate for the expenditure of resources.

INTRODUCTION

This section presents findings from the various sources discussed in Section 1 concerning the supply side of the market for compressed air system efficiency services. The analysis draws principally from the findings of an assessment of 91 distributors of compressed air equipment manufactured by Gardner Denver, Inc., and Quincy. We supplemented the findings from this evaluation with information taken from regional market studies, interviews with consultants, interviews with managers of 3 Ingersoll-Rand air centers (manufacturer-owned sales and distribution centers), and the customer interviews.

METHODS

Objectives

The objectives of the distributor assessment were to characterize and quantify the compressed air efficiency services offered by distributors.

- What efficiency services do compressed air distributors and consultants currently offer?
- What is the format in which these services are sold: as part of equipment sales effort, as "free-standing" consulting services, as part of a service contract?
- What specific measures or components are covered by these services?
- What is the current volume of sales for these services? How has volume changed over the past few years? What are vendors' expectations regarding growth?
- To which kinds of customers (as defined by industry segment, size of system, complexity of system) are these services most often sold?
- What kinds of skills, equipment, and other resources are needed to deliver efficiency services?
- What role do these services play in the overall business strategy of manufacturers, distributors, and consultants?
- What barriers do these businesses face in developing and selling compressed air system efficiency services?

Selection of Interviewees

The selection group for the assessment consisted of membership lists for two distributor associations: the Industrial Compressor Distributors Association (ICDA), which represents Gardner Denver distributors, and the Association of Independent Compressor Distributors (AICD), which represents Quincy distributors. These two lists provided a total of 204 contacts. Nationally, there are 6 compressor manufacturer associations who represent approxmately 700 affiliated distributors. The remaining associations did not provide mailing lists of members. According to the president of the Compressed Air Distributors Associations, the umbrella group for the individual associations, Gardner Denver, Inc., and Quincy supply a full line of equipment but tend to specialize in rotary screw

compressors. These machines are generally used to drive small- and medium-sized systems. Other manufacturers control large shares of the market for centrifugal compressors, which are more often used to power larger systems. The fact that the selection group did not contain distributors for manufacturers with varying specialties and target markets should be kept in mind when interpreting the findings of the distributor assessment.

Assessment Implementation

To pretest the effectiveness of the assessment, 6 samples were distributed to dealers at an early project meeting. The assessment was then mailed out to all 204 distributors by XENERGY, Inc., with a cover letter from Compressed Air Challenge® describing the research project. However, only 42 completed assessments were received. Therefore, the evaluation was converted to telephone format and administered by XENERGY staff to the remaining vendors. XENERGY staff also conducted telephone interviews with representatives of 3 Ingersoll-Rand air centers, which are manufacturer-owned distributorships. Another reason to add the Ingersoll-Rand air centers to the interviewing group was to capture the experience of distributors for larger capacity equipment, including centrifugal compressors. The patterns of response from the Ingersoll-Rand centers were not entirely consistent with one another and followed the distribution of responses from the larger group of independent distributors. The results of the Ingersoll-Rand assessments were therefore combined with those from the larger group for the analysis. A total of 94 evaluations were completed, including 46 via telephone. This work was carried out over the summer of 1999.

FINDINGS

Characteristics of Vendors

Organization. Interviewed vendors were located in 36 of the 50 United States. Forty-five percent of organizations operate at multiple locations, while 55% have only one location. All vendors classified their organizations primarily as compressed air distributors. Eight of the vendors also claimed to provide consulting services as a major line of business. The companies employed between 2 and 100 people, with a mean of 25 and a median of 18 employees.

Position of Vendors. The assessments were generally completed by the contact for the distributor association. According to staff of the distributor organizations, these individuals are primarily owners, with some senior staff as designated representatives.

Market. Thirty-five percent of the vendors describe their company's market area as local and 57% describe it as regional. The remaining 8% describe their market as national or global. The industry that provides the most customers was food processing, cited by 52% of vendors. This was followed by the chemical industry, mentioned by 45% of distributors, then fabricated metals, with 41%, and printing, with 37%.

Revenue. Annual revenues in 1998 varied between $500,000 and $35 million, with a mean of $7.3 million, and a median of $5 million. This finding indicates that most distributorships are small businesses. Distributors were then asked to break out their revenues for different compressed air products and services. Table 3-1 displays the mean value, weighted by annual revenue, and maximum value for each category. Given the large difference between the mean and maximum values, it is apparent that different shops focus on different areas in the compressed air market.

Sales of compressed air parts and equipment comprise 59% total revenue for a typical distributor. Servicing equipment represents another 19%, while all other services, including design and efficiency services, comprise only 16%. Efficiency services, such as leak detection and system audits, appear to play a very minor role in overall business, accounting for only 4% of total revenue. The types of services offered under the category "other compressed air related services" include the sale and rental of various equipment, such as pumps, blowers, and dryers. None of the vendors derived more than 40% of revenues from services other than equipment sales, parts sales, and equipment service.

Efficiency services, such as leak detection and system audits account for only 4% of total revenue.

Efficiency Service Offerings

Current Status. Table 3-2 displays the percent of vendors who reported offering particular efficiency services and the pricing structure or format under which they were offered. The 3 choices in format include: as part of a service contract, as part of equipment sales, or as a freestanding engineering service. Seventy-eight percent of the distributors interviewed reported that they deliver system efficiency assessments; 75% offer measurements of system flow and pressure. Surprisingly, over one-half of the vendors reported that they offer ultrasonic leak detection services, a fairly new technology. Table 3-2 also suggests that distributors frequently package energy efficiency services with more traditional lines of business, such as equipment sales and service. It appears that the 2 system efficiency services, efficiency assessment and measurement, and the

TABLE 3-1: Reported Sources of Business Revenues

SERVICE	PERCENT OF 1998 REVENUES	
	Mean	Maximum
Compressed air equipment sales	37%	75%
Compressed air parts sales	22%	50%
Compressed air equipment service	19%	70%
Compressed air system design	5%	30%
Compressed air efficiency services[1]	4%	16%
Other compressed air related services	9%	45%

[1] Compressed air efficiency services were enumerated in the assessment form as measurement of system flow and pressure, assessment of system efficiency, leak management services, ultrasonic leak detection, and analysis of end-use reduction opportunities.

TABLE 3-2: Efficiency Services Offered

SERVICE	FORMAT OF SERVICE			
	Offer	Equipment Sales	Service Contract	Freestanding Engineering Service
Assessment of system efficiency	78%	50%	31%	46%
Measurement of system flow and pressure	73%	55%	34%	46%
Analysis of end-use reduction opportunities	63%	39%	25%	41%
Leak management service	60%	26%	40%	39%
Ultrasonic leak detection	54%	24%	29%	33%
Other	5%	4%	2%	2%

TABLE 3-3: Dates When Efficiency Services Were First Offered

SERVICE	YEAR FIRST OFFERED		
	Since 1995	Since 1990	Total
Assessment of system efficiency	25%	51%	78%
Measurement of system flow and pressure	26%	49%	73%
Analysis of end-use reduction opportunities	30%	53%	60%
Leak management service	35%	53%	54%
Ultrasonic leak detection	32%	51%	63%

TABLE 3-4: Frequency of Compressed Air Needs Assessments as Part of Equipment Sales Efforts

Frequency of Compressed Air Needs Assessments	Percent of Distributors
In all sales situations	10%
In most sales situations	29%
In some sales situations	47%
In only a few sales situations	14%

TABLE 3-5: Customer Objections to Efficiency Service Offers

Objections	Percent
Customer is skeptical about savings	75%
Customer thinks the service costs too much	72%
Customer believes internal staff already performs service	45%
Other	10%

end-use analysis are more likely to be offered as part of equipment sales and engineering services. In contrast, the 2 leak control services are more likely to be offered as part of a service contract or engineering service.

Dates of Service Initiation. The distributors were asked when they began delivering the energy efficiency services they claimed to offer. As Table 3-3 shows, the development of these services is relatively recent for those distributors who offer them. Roughly one-third of the distributors who reported offering assessments of system efficiency and measurement of operating parameters began offering this service after 1995; two-thirds had been offering the service since 1990. This pattern holds for the other efficiency services offered.

The compressed air system efficiency consultants interviewed for this project all reported that the percentage of distributors offering various kinds of efficiency-oriented services had increased in the past 2 years. However, these consultants felt that far fewer distributors offered efficiency services than the results of the assessment would suggest. In particular, it was the consultants' opinion that distributors would seldom offer efficiency-oriented services if doing so would interfere with or complicate the sale of compressors and ancillary equipment.

Fifty-five percent of distributors interviewed reported that demand for system-efficiency services had increased over the past year.

For their part, the distributors reported that they frequently undertook compressed air needs assessments—analyses of compressed air requirements based on an inventory of end uses—as part of their equipment sales effort. Thirty-nine percent of the vendors reported that they conducted such needs assessments in all or most of their equipment sales situations (See Table 3-4). These findings are at odds with the observations of consultants in the field. On the other hand, the questionnaire was not specific about what procedures should be included in a compressed air needs assessment.

Trends in Demand for Efficiency Services. Despite the fairly low level of reported sales of efficiency-oriented services, distributors generally found that the demand for them increased over the past year. Fifty-five percent of distributors interviewed reported that demand for system-efficiency services had increased over the past year; 38% reported that demand had remained steady, while 7% believed it had dropped. Several of the distributors interviewed reported a significant upturn in interest among customers, with one claiming a 75-80% closing rate for proposed efficiency-related products. Others were more frustrated with the lack of customer response they encountered, "We've had 22 years of experience in this field, during which our many air systems surveys have not resulted in significant changes nor implementation of recommendations by our customers."

The distributor questionnaire did not probe distributors' observations regarding the factors leading to changes in demand for efficiency services. Consultants interviewed for the project reported that the Compressed Air Challenge® and utility-sponsored programs appeared to be contributing to increased demand, as had increased attention to compressed air system efficiency in major industry and trade publications. The New England baseline study also found evidence that CAC and utility programs had an effect on participating customers' knowledge and

understanding of the benefits of efficiency measures. However, the sample of end users for this study was very small (30 facilities) and higher awareness may have resulted from extensive utility demand-side management activity.

Barriers and Motivations to Sales of Compressed Air Efficiency Services

Identification of Barriers. The distributors interviewed for this study identified customers' skepticism concerning energy-savings claims and resistance to service costs as the primary barriers to greater sales of compressed air efficiency services (See Table 3-5). These findings mirror the experience of compressed air efficiency consultants who identified customers' lack of understanding of the benefits of compressed air system efficiency measures as the main obstacle to greater market penetration. Forty-five percent of the vendors identified customer perceptions that compressed air efficiency services were already being provided by in-house staff as an objection to sales efforts. This finding, combined with the reported low incidence of specific measure implementation, further reinforces the consultants' observation that customers are largely in the dark about the nature of compressed air system efficiency measures and maintenance practices. Objections included under the "other" category focus on lack of time for staff to handle efficiency projects, low regional energy costs that reduce the return to investment, and customers' lack of understanding. One contractor noted: "The air compressor industry is to blame for not educating customers over the years [in energy efficiency benefits]. They are more interested in moving product than in customers' needs."

Thirty-six percent of vendors feel that efficiency services are very important to the competitive position of their business.

The consultants interviewed for this project mentioned that many distributors experience conflicting motivations in offering efficiency services. Customers most often call distributors and consultants when they are experiencing problems with the operation of their systems. These problems usually involve interruptions in service, inconsistent air pressure, or contaminated air. Very often, the solutions to these problems involve increased system efficiency, which may obviate the need to purchase new or larger equipment. In these cases, the distributor may feel most comfortable in following established business procedure, which is to sell the larger equipment. It should be noted that not all distributors follow this pattern. In fact, 2 of the consultants interviewed are principals in large distributorships. Interestingly, only one of the distributors interviewed for the study identified the potential for perceived conflict of interest as a barrier to entering the market. This individual believed that any engineering advice he would provide to his customers would be viewed as biased.

Costs. The major costs involved in offering compressed air efficiency services are labor-oriented. They include diversion of sales or system engineering staff from other potential revenue-generating activities and training. Other key costs involve the accumulation of technical materials on diverse lines of equipment for easy reference and acquisition of test equipment. Experienced consultants maintain that technically-oriented sales staff in many distributorships can be trained to perform system

diagnostics and efficiency-oriented specification within a reasonable period. The most effective training for this kind of work consists of hands-on mentoring at live customer sites.

Findings from the distributor assessment suggest that the training aspect of developing consulting capabilities may not constitute a major barrier to entering the market. Over two-thirds of vendors reported that they have implemented a training program in energy-efficient system design for their sales staff. The majority of these training programs have been implemented since 1995 and the programs are held, on average, 5 times per year, although this figure varies between 1 and 12 times per year. The questionnaire did not probe the source of this training. However, contacts in the industry report that most of the training currently available is provided by manufacturers.

Motivations to Enter the Market. Thirty-six percent of vendors felt that efficiency services are very important to the competitive position of their business. In addition, another 31% felt that the services are important. Their major motivation to enter the market was customer retention. Of the 73 vendors who gave reasons as to why system efficiency services were (or were not) important to their businesses, 16 mentioned customer retention as a key motivation for promoting those services. As one dealer noted, “The world is changing. Energy efficiency is very important. To stay in the marketplace, we will have to be trained to understand what the customer does not understand and what our competition does understand in order to be a player.”

Interviewed distributors mentioned the need to differentiate themselves from their competitors next most frequently (12 of 73) as a reason for offering efficiency-related services. One distributor noted, “[Offering efficiency services] is the key factor in convincing the customer that we are a professional business.”

"[Offering efficiency services] is the key factor in convincing the customer that we are a professional business."

Other important business motivations for offering efficiency services included:

- Enhancing the distributor’s credibility in making equipment sales;
- Providing value added services to the customer (closely related to customer retention); and,
- Opening up a relatively high-margin business line for the distributor.

Key Markets. Based on their experience in the field, the distributors believed that the market for compressed air system efficiency services was *not* highly segmented by industry type. Their answers to inquiries probing the most receptive industries for these services were fairly evenly distributed over the industries the individual firms served. For example, distributors identified electronics and high tech manufacturing (13%), food processing (12%), and chemicals, especially pharmaceuticals (15%), as the most receptive industries for purchase of compressed air efficiency services. Fifteen percent of vendors replied that there are no particular industries that are especially receptive to compressed air efficiency services.

Overwhelmingly, the interviewed distributors believed that larger businesses are more receptive than are smaller-sized businesses. Customers with large and complex compressed air systems, especially with multiple

compressors, appear to be most receptive to efficiency services. Consultants who have served as instructors in the CAC training programs report that most end users who have attended the programs represent mid-sized facilities—those with compressor horsepower in the range of 100 to 500 hp. They believed that larger facilities often have somewhat experienced operating personnel, even though many of their own clients were extremely large manufacturing facilities.

COMPRESSED AIR EFFICIENCY SERVICES
BASELINE END-USER ASSESSMENT

CUSTOMER IDENTIFICATION

Contact Name: [from list] .....

Company: [from list] .....

Address: [from list] .....

City, State, Zip: [from list] .....

Telephone: [from list] .....

4-Digit SIC Code: [from list] .....

Industry Description (SIC Name): [from list] .....

Employment Category: [from list] .....

ID Number: .....

Lead-in

Hello, this is _____ calling from _____. We're conducting an assessment of compressed air system management practices for the Compressed Air Challenge, a partnership of government and industry organizations.

Identification of Customer

May I speak with [CONTACT NAME].

IF CONTACT IS NOT AVAILABLE, ASCERTAIN BEST TIME TO CALL.

IF CONTACT NO LONGER WORKS AT THE LOCATION, ASK:

May I speak with the plant manager or maintenance manager. IF NO SUCH POSITION, ASK FOR INDIVIDUAL WHO MANAGES THE COMPRESSED AIR SYSTEM.

ENTER NAME OF CONTACT: _____

IF CONTACT IS NOT AVAILABLE, ASCERTAIN BEST TIME TO CALL.

Lead-in for Customer

Hello, this is _____ calling from _____. We're conducting an assessment of compressed air system management practices for the Compressed Air Challenge®, a partnership of government and industry organizations that supports programs to improve industrial compressed air system performance. The Compressed Air Challenge® is a non-profit organization, and is not seeking to sell products or services. The information you provide will help the Compressed Air Challenge® refine programs to help companies such as yours. The assessment will take just a few minutes. In return for your participation we will send you a copy of the book *Improving Compressed Air System Performance*. This book normally sells for $19.95. It provides a practical guide to reducing the costs of compressed air in your facility.

Screener

First, I'd like to get a little information about you and your firm.

SC1 Is there a compressed air system that supplies energy for one or more production processes in your facility?

Yes 1
No 2
Don't know 3

IF SC1=1, CONTINUE. ELSE THANK AND TERMINATE.

SC2 What is your title?

Plant Manager 1
Maintenance Manager 2
Purchasing Manager 3
Plant Engineer 4
Chief Electrician 5
President/CEO 6
General Manager 7
Other(Specify)_____ 8

SC3 What is the principal product produced or service provided at your facility?

Food product 1
Textile product 2
Lumber or wood product 3
Paper or allied product 4
Chemicals 5
Petroleum 6
Stone, Clay, Glass 7
Primary metals (e.g. Steel, aluminum) 8
Metal fabrication or machinery 9
Other 10

SC4 How many full-time employees work at this location. This includes clerical and professional employees as well as production workers.

ENTER NUMBER OF EMPLOYEES . . . . . .____

SC5 How many days per week are your production facilities currently operating?

ENTER NUMBER OF DAYS PER WEEK . . . . . .____

SC6 And how many hours per day, on average?

ENTER NUMBER OF HOURS PER DAY . . . . . .____

Compressed Air System Description

SD1 How many compressors are there in your compressed air system?

ENTER NUMBER OF COMPRESSORS;
97 FOR DON'T KNOW . . . . . ___

SD2 Approximately what is the total horsepower of these compressors?

ENTER HORSEPOWER; 97 FOR DON'T KNOW . . . . . ___

SD2 What is the principal type of compressor-control strategy used in you compressed air system?
PROMPT IF NECESSARY.

Start/Stop 1
Load/Unload 2
Modulating controls 3
Multi-step controls 5
Variable speed drives 6
Variable Displacement 7
Dual control system 8
Other (Specify) _____ 9
Don't know 0

IF SD1>1, ASK SD5. ELSE SKIP TO SD6

SD5 Do you use a system-control scheme such as single master sequencing or multimaster network controls?

Yes 1
No 2
Don't know 3

Compressed Air System Management

AM1 Who in your organization has primary responsibility for management and maintenance of your compressed air system?

You 1
Plant engineer (if other than you) 2
Maintenance manager (if other than you) 3
Compressed air specialist 4
Contractor 5
Other (Specify) _____ 6

AM2a What would you say is the primary objective in the way you manage your compressed air system? [PROMPT IF NECESSARY. ROTATE PROMPTS.]

AM2b Are there other objectives?

	AM2a Main Reason	AM2b Other Reasons
No other objectives		0
Maintain continuous operation	1	1
Ensure adequate supply of air to end uses	2	2
Maintain quality of air supplied	3	3
Preventive maintenance	4	4
Control or reduce energy costs/energy use	5	5
Other (Specify)	7	7
Don't know	8	8

AM3 Do you have a service contract for your compressed air system or components of that system?

Yes 1
No 2
Don't know 3

IF AM3 = 1 ASK AM4. ELSE SKIP TO MA1.

AM4 Who provides this service? [PROMPT IF NECESSARY.]

Compressed air equipment vendor 1
Independent service contractor or consultant 2
Other (Specify) _____ 3
Don't know 4

AM5 Can you tell me what services are provided under the contract? [CIRCLE ALL MENTIONED.]

Leak detection 1
Leak repair 2
Energy use monitoring 3
Load profiling 4
Preventive maintenance on compressors 5
Preventive maintenance on auxiliaries 6
Assessment of control strategies and equipment 7
Emergency repair 8
Other (Specify) _____ 9
Don't know 0

Maintenance Practices

MA1 What maintenance activities are carried out on your compressed air equipment on a regular basis? DO NOT READ. MARK ALL MENTIONED.

- Clean or replace inlet air filter cartridges. 1
- Clean drain traps 2
- Check lubricant level and filter 3
- Check belts for wear and replace 4
- Verify operating temperature per manufacturer specification 5
- Clean air line filters 6
- Check cooling water quality, replace cooling system filters 7
- Check for system leaks 8
- Other (Specify) _____ 9

MA2 In general, how often do you perform these maintenance activities? Would you say it is...

- Once per year 1
- Once every six months 2
- Once per quarter 3
- Once per month 4
- Once per week 5
- Or more frequently 6
- Don't know 7

MA3 Are these activities carried out by...

- Your own staff 1
- Your compressed air equipment vendor 2
- An independent service contractor or consultant 3
- Some combination of the above 4
- Don't know 5

MA4 Do you have a leak-prevention routine or program in place at your facility?

- Yes 1
- No 2
- Don't know 3

IF MA4 = 1, ASK MA5. ELSE SKIP TO SM1.

MA5 Can you tell me what you do as part of your leak-prevention routine? [CHECK ALL ELEMENTS MENTIONED.]

- Check for leaks around compressors and air dryers 1
- Check for open bleed valves 2
- Check bypass valves 3
- Check joints for leaks 4

Check regulators and tools for leaks 5
Tag leaks 6
Repair leaks 7
Other (Specify) _____8
Don't know 9

MA6 Is this activity carried out by...

Your own staff 1
Your compressed air equipment vendor 2
An independent service contractor or consultant 3
Some combination of the above 4
Don't know 5

MA7a Over the past 12 months, has your compressed air system been down for unscheduled repairs or maintenance?

Yes 1
No 2
Don't know 3

IF MA7a = 1, ASK MA7b. ELSE SKIP TO MA8.

MA7b How many work days was the system down?

ENTER NUMBER OF DAYS, 97 FOR DON'T KNOW _____

MA8 Over the past 12 months, have you experienced any of the following operating problems in your compressed air system? [READ AND MARK ALL THAT APPLY].

Inadequate pressure in the whole system 1
Inadequate pressure at specific points in the system 2
Excess moisture in the compressed air 3
Excess oil in the air 4
Frequent fouling of air filters 5

System Monitoring and Management

SM1 Over the past 2 years, have you measured any of the following quantities in regard to your compressed air system?

Demand on the compressor motors 1
Weekly or monthly compressor motor electric use 2
Pressure levels 3
Leak loads 4

SM3 Have you developed a load profile for your compressed air system? That is, have you prepared an analysis of how demand for compressed air varies over a typical week.

Yes 1
No 2
Don't know 3

IF SM1 NOT NULL OR SM3 = 1 ASK SM4, ELSE SKIP TO SM5.

SM4 Who carried out these measurements? Was it...

- Your own staff 1
- Your compressed air equipment vendor 2
- An independent service contractor 3
- A compressed air system consultant 4
- Some combination of the above 5
- Don't know 6

SM5 Have you evaluated the effectiveness of your compressor control system in the past 2 years?

- Yes 1
- No 2
- Don't know 3

SM7 Do you periodically assess whether end-uses of compressed air in your plant can be eliminated or replaced by motor-driven equipment?

- Yes 1
- No 2
- Don't know 7

System Audit

SA1 Have you undertaken or contracted for a study of how to make your compressed air system as a whole more energy efficient?

- Yes 1
- No 2
- Don't know 3

IF SA1 = 1, ASK SA2. ELSE SKIP TO ES1.

SA2 In what year was this study undertaken?

ENTER YEAR, 9999 FOR DK _____

SA3 Was this study performed by...

- Your own staff 1
- Your compressed air equipment vendor 2
- An independent service contractor 3
- A compressed air system consultant 4
- Some combination of the above 5
- Don't know 6

SA4 Please tell me which of the following elements were included in the study.
[READ AND CIRCLE ALL ELEMENTS MENTIONED.]

Estimate of compressed air system energy use 1
Load profile based on system measurements 2
Identification of unnecessary or inappropriate uses of compressed air 3
Estimation of losses due to leaks 4
Assessment of control system and alternate strategies 5
Assessment of the distribution system for pressure drops and efficiency 6
Assessment of auxiliary equipment such as dryers and separators 7
Assessment of air storage capacity 8
Recommendations for improvements 9
Estimates of costs and energy savings for recommended measures 10
Other (Specify) _____ 11

SA5 Have you implemented any of the measures recommended in the compressed air system audit?

Yes 1
No 2

IF SA5 = NO, ASK SA5a. ELSE SKIP TO SA6.

SA5a What is the main reason you have not implemented any of these measures?

SA5b Are there other reasons?

	SA5a Main Reason	SA5b Other Reasons
Too busy; no time	1	1
No personnel in the plant to manage implementation	2	2
Skeptical of energy-savings estimates	3	3
Plan to do it; haven't gotten around to it	4	4
No budget; can't afford it	5	5
Management did not approve	6	6
Other (Specify)	7	7
Don't know	8	8

SA6 What measures have you implemented? [DO NOT READ. CHECK ALL THAT APPLY.]

- Leak reduction 1
- Changes to compressor controls 2
- Improvements to system auxiliaries (air dryers, coolers, separators) . . 3
- Reduced unnecessary compressed air uses 4
- Changes to piping, distribution system 5
- Added air storage capacity 6
- Installed heat recovery equipment 7
- Other (Specify) _____ 8

Interest in Efficiency Services

ES1 Have any vendors approached you or your company to sell services specifically designed to reduce energy costs in your compressed air systems?

- Yes 1
- No 2
- Don't know 3

IF ES1 = 1 ASK ES2, ELSE SKIP TO ES7.

ES2 What kind of company or companies have approached you to sell this service? [PROMPT IF NECESSARY.]

- Compressed air equipment vendor 1
- Independent consultant or contractor 2
- OEM equipment vendor 3
- Other (Specify) 4
- Don't know 5

ES3 Can you tell me what services were offered as part of this service? [CIRCLE ALL MENTIONED.]

- Leak detection 1
- Leak repair 2
- Energy use monitoring/load profiling 3
- Preventive maintenance on compressors 4
- Preventive maintenance on auxiliaries 5
- Assessment of control strategies and equipment 6
- Identification of energy-saving measures 7
- Financial analysis of energy-saving measures 8
- Installation of energy-saving measures 9
- Assessment of compressed air end-uses 10
- Other (Specify) _____ 11

ES4 Did you purchase this service?

Yes 1
No 2
Don't know 3

IF ES4 = YES, ASK ES 5. ELSE SKIP TO ES6.

ES5a What was the most important factor in your decision to purchase this service?

ES5b Were there other important factors?

	ES5a-Main Factor	ES5b-Other Factors
No other factor		0
Believed energy savings would be substantial	1	1
Improved control over production	2	2
Improved efficiency in production	3	3
Increased safety	4	4
Good for the environment	5	5
Reputation of vendor/Good experience with vendor	6	6
Other (Specify)	7	7
Don't know	8	8

GO TO CC1.

ES6a What is the main reason you decided not to purchase this service?

ES6b Are there other reasons?

	ES5a Main Reason	ES5b Other Reasons
No other reason		0
Too costly	1	1
No budget	2	2
Skeptical of energy-savings estimates	3	3
Can do it ourselves, in-house	4	4
Presented to management; management did not approve	5	5
Still considering	6	6
Other (Specify)	7	7
Don't know	8	8

GO TO CC1

ES7 Would you consider purchasing such a service?

Yes 1
No 2
Don't know 3

IF ES7 = 2, ASK ES8. ELSE GO TO CC1.

ES8a What is the main reason you would not be interested in this kind of service?

ES8b Are there other reasons?

	ES8a Main Reason	ES8b Other Reasons
No other reason		0
No budget	1	1
Skeptical of energy-savings claims	2	2
Already doing it	3	3
Can do it ourselves, in-house	4	4
Compressed air system is too small; not enough savings potential	5	5
Other (Specify)	6	6
Don't know	7	7

CC1 Prior to this interview, had you ever heard of the Compressed Air Challenge® Program?

Yes 1
No 2
Don't know 3

CC2 Have you or your staff participated in training on compressed air system efficiency?

Yes 1
No 2
Don't know 3

CC3 Who provided that training?

Utility 1
Government program 2
University or college 3
Compressed air equipment vendor 4
Compressed air system consultant 5
Other (Specify): _____6
Don't know 7

CC4 Would you like to receive the sourcebook *Improving Compressed Air System Performance?*

Yes 1
No 2

IF CC4 = 1, Confirm name and address.

Name: .....

Title: .....

Company: .....

Address: .....

Street Address: .....

City: .....

State: .....Zip: .....

END: THANK YOU VERY MUCH FOR YOUR TIME AND COOPERATION.

BARCODE:

ID:

ZIPCODE:

MARKET FOR COMPRESSED AIR SYSTEM EFFICIENCY SERVICES

The Compressed Air Challenge® Program is conducting an assessment of compressed air system distributors and consultants to help guide its program efforts and establish a baseline for evaluation of its efforts. Please take a few minutes to complete this questionnaire. All answers are strictly confidential. Assessment results will be made available publicly in a few months.

COMPANY CHARACTERISTICS

1. LOCATION(S) OF YOUR COMPANY

CITY	STATE	

2. TYPE OF COMPANY (Check most appropriate).

- ❑ Compressed air equipment distributor
- ❑ Compressed air system consultant/designer
- ❑ Mechanical engineering
- ❑ Other (Specify_____)

3. MARKET AREA FOR YOUR COMPANY

❑ Local ❑ National ❑ Regional ❑ Global

4. NUMBER OF EMPLOYEES: ____ ____ ____ ____

5. ANNUAL SALES: $___ ___ ___ , ___ ___ ___ , ___ ___ ___

6. PLEASE WRITE PERCENT OF 1998 REVENUES ACCOUNTED FOR BY SERVICES LISTED BELOW IN THE SPACE PROVIDED. If you are unsure of share of revenues, simply check those services that you provide.

Service	Percent of 1998 Revenues
Compressed air equipment sales	
Compressed air parts sales	
Compressed air equipment service	
Compressed air system design	
Compressed air efficiency services (leak detection, compressed air system audits, system optimization, controls)	
Other compressed air related services	
(Specify)_____	

7. PLEASE CHECK THE INDUSTRIES THAT ACCOUNT FOR MOST OF YOUR CUSTOMERS. Check a maximum of four.

- ❑ Food Processing
- ❑ Textile Mill Products
- ❑ Paper & Allied Products
- ❑ Printing
- ❑ Chemicals
- ❑ Petroleum Products
- ❑ Rubber and Plastics
- ❑ Primary Metals
- ❑ Fabricated Metals
- ❑ Industrial Equipment
- ❑ Electronic Equipment
- ❑ Transportation Equpt
- ❑ Other _____
- ❑ Other _____
- ❑ Other _____

EFFICIENCY SERVICES

Use the grid below to mark your answers to the next three questions.

1. WHICH OF THE EFFICIENCY SERVICES LISTED IN THE GRID BELOW DO YOU OFFER?
2. IN WHAT YEAR DID YOU FIRST OFFER THE SERVICE?
3. IS THE SERVICE OFFERED AS:
   - PART OF A SERVICE CONTRACT (Serv)?
   - A FREESTANDING ENGINEERING SERVICE (Eng)?
   - PART OF EQUIPMENT SALES (Eqpt)?

Check all that apply.

	1	2	3		
			Format of Service		
Service	Offer? (Check for Yes)	Year First Offered	Serv.	Eng.	Eqpt.
Example	***X***	***1996***	***X***	***X***	
Measurement of system flow and pressure					
Assessment of system efficiency					
Leak management service					
Ultrasonic leak detection					
Analysis of end-use reduction opportunities					
Other (please specify)					

4. HAS THE VOLUME OF EFFICIENCY SERVICES YOU SELL INCREASED, DECREASED, OR REMAINED ABOUT THE SAME OVER THE PAST YEAR?

- ❑ Increased
- ❑ Decreased
- ❑ Remained the same

5. HOW OFTEN DO YOU CONDUCT A COMPRESSED AIR NEEDS ASSESSMENT AS PART OF A SYSTEM SALES ORDER OR BID RESPONSE?

- ❑ In **all** sales and bid situations
- ❑ **Never**
- ❑ In **relatively few** sales and bid situations
- ❑ In **some** sales and bid situations
- ❑ In **most** sales and bid situations

BARCODE:

ID:

ZIPCODE:

6. HAVE YOU IMPLEMENTED A TRAINING PROGRAM IN ENERGY-EFFICIENT SYSTEM DESIGN FOR YOUR SALES STAFF?

❑ Yes → In what year? 19_____ _____

→ How often do you hold training sessions?

❑ No

7. WHAT KIND OF SPECIAL SKILLS, EQUIPMENT, AND OTHER RESOURCES ARE NEEDED TO DELIVER THESE SERVICES EFFECTIVELY? Enter one skill, piece of equipment, or other resource in each response box.

Skills:		
Equipment:		
Other resources:		

8. WHAT KIND OF BUSINESSES APPEAR TO BE MOST RECEPTIVE TO PURCHASING COMPRESSED AIR SYSTEM EFFICIENCY SERVICES?

Types of Industries	*Example: Textile mills*
Types of Industries:	1.
	2.
	3.
Size **Large, Medium, Small**	*Example: Medium and large*
Size	1.
	2.
	3.
Size or complexity of CA system	*Example: Over 200 HP*
	1.
	2.
	3.

9. WHAT OBJECTIONS DO YOU ENCOUNTER MOST FREQUENTLY IN TRYING TO SELL COMPRESSED AIR SYSTEM EFFICIENCY SERVICES?

Objections	**Check if Applicable**
Customer thinks the service costs too much	
Customer is skeptical about savings	
Customer believes service is already performed by internal staff	
Other (please specify)	

10. HOW IMPORTANT DO YOU THINK EFFICIENCY SERVICES ARE IN ESTABLISHING THE COMPETITIVE POSITION OF YOUR COMPANY?

1	2	3	4	5
❑	❑	❑	❑	❑
Not Important		Somewhat Important		Very Important

11. WHAT ARE YOUR REASONS FOR THIS ASSESSMENT?

_____

_____

_____

_____

ABOUT THE OFFICE OF INDUSTRIAL TECHNOLOGIES

The U.S. Department of Energy's (DOE) Office of Industrial Technologies (OIT), through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution-prevention technologies for industrial applications. OIT is part of DOE's Office of Energy Efficiency and Renewable Energy.

OIT encourages industry-wide efforts to boost resource productivity through the Industries of the Future (IOF) strategy. The industry-led IOF strategy focuses on these energy- and resource-intensive industries:

Agriculture	Aluminum	Chemicals
Forest Products	Glass	Metal Casting
Mining	Petroleum	Steel

These nine industries account for more than 80% of the manufacturing sector's energy use. In addition, they account for over 80% of the volume of all waste and pollution generated in manufacturing, and about two-thirds of all pollution-control expenditures in manufacturing.

To help industries begin saving energy, reducing costs, and cutting pollution right away, OIT offers a comprehensive portfolio of emerging technologies, practices, tools, information, and resources in a variety of application areas. Visit our Web site at ***www.oit.doe.gov*** to find out more about OIT and how your company can get involved.

ABOUT OIT'S BESTPRACTICES PROGRAM

BestPractices is part of OIT's Industries of the Future strategy. BestPractices brings together the best-available and emerging technologies and practices to help companies immediately begin improving energy efficiency, environmental performance, and productivity.

In addition to bringing emerging technologies closer to commercialization, BestPractices focuses on plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. The Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-sized manufacturers.

BestPractices also works with an extensive network of Allied Partners to help deliver energy efficiency information to industry. Allied Partners enhance the IOF strategy by working with these industries to adopt proven technologies and best energy management practices.

BestPractices offers a wide range of resources—including software, training, tip sheets, case studies, sourcebooks, and a bi-monthly newsletter—to industry on how to take advantage of energy- and cost-saving opportunities in their facilities.

To learn more about BestPractices, visit our Web site at ***www.oit.doe.gov/bestpractices***.

ABOUT THE COMPRESSED AIR CHALLENGE®

The Compressed Air Challenge® (CAC) is a non-profit corporation that is a collaboration of industrial users of compressed air and their associations; equipment manufacturers, distributors and their associations; the U.S. Department of Energy; state research and development agencies; utility companies, and energy efficiency organizations. The purpose of the CAC is to educate both users and suppliers of industrial compressed air systems on the benefits of taking a "systems approach" as set forth in training materials, publications, software, and other media. The CAC takes a strict "solutions neutral" approach as an unbiased source of information. For more information, visit our Web site at ***www.compressedairchallenge.org***.

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Visit our Web site at
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