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APPENDICES

Appendix A: Technical Experts Interviewed for this Report
Appendix B: Expert Interview Discussion Guide
Appendix C: Equipment Vendors, Engineering Consultants, and Energy Service Companies Interviewed
Appendix D: Distributor Interview Guide
Appendix E: Consultant Interview Guide
The Northwest Energy Efficiency Alliance (the Alliance) contracted with Pacific Energy Associates, Inc. (PEA) and Research Into Action, Inc. (RIA), two independent consulting firms, to conduct a study of the market for compressed air efficiency services in the Northwest. This study was completed in July 1998. The Alliance asked PEA/RIA to explore the current level and character of services in the compressed air efficiency market, and to assess whether opportunities exist to increase the level of service offerings.

To meet these needs, PEA/RIA conducted a literature review and a series of interviews. The intent was to assess the level of market activity in compressed air system retrofit, and describe market barriers, opportunities, and potential solutions. PEA/RIA also explored methods of gathering quantitative data on the compressed air market.

**Research Design**

The literature review included 15 documents, and covered compressed air opportunities, potential savings, program experiences, current initiatives, and market characteristics, focusing on the Northwest but also including leading studies from other regions.

To provide in-depth knowledge of technical opportunities and market structure, and to help define questions and terminology for interviewing market actors. A national compressed air efficiency expert was included in the research team. Then, an initial picture of the market status was drawn through structured, open-ended interviews with 12 additional regional and national experts.

To provide detailed information about baseline activity levels, vendor and customer awareness, and the potential for changes in the market, further interviews were conducted with market actors. These included: 1) Northwest firms who might offer compressed air efficiency services, including consultants, engineering firms, energy services companies, and energy services providers; 2) major compressed air equipment sales organizations in the Northwest; and 3) a few national firms which might be increasing Northwest activity. The intent of these market actor interviews was to assess the scale and focus of compressed air efficiency activity, and
to get the respondents’ ideas of the size of the market, potential segments, barriers, opportunities, etc. In all, we contacted 26 market actors, 23 of which provided data. Respondents included 9 consulting engineers, 4 Energy Service Companies/Energy Service Providers (ESCos/ESPs), 9 compressed air equipment distributors, and one manufacturer’s representative.

The data proved quite useful for understanding market dynamics, but not sufficient for precise quantification of market size or savings potential, due to the modest interview sample and the imprecise, sometimes limited, and overlapping nature of the responses. For strategic planning purposes, approximations of some quantitative market parameters are included in this report. We believe that these are worth considering in that they provide ballpark estimates of the size of the overall market, potential savings, the proportion of the load from systems of various sizes, etc. We further believe that, while these estimates could be incrementally improved, precise data on compressor loads is possible only through an extensive customer survey, and that more precise data on baseline efficiencies are obtainable only through extensive site audits.

**Key Research Findings**

- There are significant opportunities to save energy in the compressed air marketplace.

- Most customers and contractors are not currently acting to optimize the efficiency of compressed air systems.

- Many contractors are considering becoming more active in compressed air system efficiency, but will not move forward until they see changes in customer interest.

- Most customers spend little time thinking about compressed air system efficiency, and have limited faith in their existing contractors to address the issue.

- A combination of recruitment, training, and demonstration could lead to significant market transformation among large systems (over about 500 HP). In this case, market transformation means
Executive Summary

sustainable, increased levels of system retrofit activity independent of any subsidy.

- However, large systems constitute only about half of the horsepower of compressed air systems in the region. The potential for market transformation among smaller systems is less certain and will take larger efforts.

Nature of Opportunities

The largest source of potential Compressed Air efficiency opportunities is in improvements to existing systems. These opportunities differ significantly from site to site, based on system characteristics. While some opportunities are simple and inexpensive to identify (e.g., reduce pressure), many require a significant investment in monitoring to identify the benefits and the appropriate strategy. Technical opportunities include: 1) improved system operations and maintenance; 2) compressor improvements; 3) better compressor unit control; 4) improved cooling and dehumidification systems; 5) controls for sequencing compressors; 6) leak reduction; 7) design and mechanical improvements to distribution piping and system configuration; 8) improved end-use devices (e.g., nozzles); and 9) improved end-use applications of compressed air.

The most prominent national compressed air efficiency consultants focus first on finding some easy, quick savings items to capture the customers' interest. However, once the customer’s attention is captured, they first work to match the needs of end users efficiently with end-use equipment, then to improve distribution, then optimize the controls, and then (only after these elements are considered) look at compressor improvements. This approach often permits downsizing of compressors, or even removing compressors from active operation. By contrast, many consultants and utility programs get most of their savings from compressors and controls. This may reflect differences in local savings opportunities, but may also indicate that many people in the industry have neither the opportunity nor the experience in taking a comprehensive approach.
Potential Energy Savings

A study of national data on savings, applied to Northwest loads, indicates that the Northwest technical potential for energy savings from compressed air system improvements probably exceeds 150 average MegaWatts (AMW), and may be significantly larger. Over half of the potential savings are in the forest products industries: pulp and paper products and wood products. The rest occurs among several industries. Respondents to our interviews confirmed this pattern. A large fraction of the savings are very inexpensive, with savings covering the costs in one year or less. If purchase of a new compressor can be avoided, costs can be negative.

Savings can constitute 30% to 50% of compressed air load and, for some industries, as much as 10% to 20% of plant electric load. While savings of over 10% were found in audits of many forest products industry plants, these audits were probably in smaller plants than are typical in the Northwest. One yet-unpublished national study provides smaller estimates of savings.

Utilizing data from contractors, engineering consultants, and experts, PEA/RIA made an effort to estimate the number of compressors of different sizes in the market, and their concentration by industry. Development of these estimates involved extensive judgement. Systems under 500 HP constitute 47% of total HP using one method of estimation, and 71% of HP using another. Systems under 200 HP constitute 35% and 17% of HP in the two estimates. While these estimates may somewhat overstate the importance of smaller systems (because smaller systems may have fewer load hours), it is clear that a significant fraction of the total compressed air load, and conservation potential, lies outside the very large systems.

Service Delivery

Compressed air services can come from a number of alternative routes. The services industry consists of:

- About five manufacturers. These firms have not traditionally focused on efficiency as a profit center. Some have viewed efficiency as in conflict with their goals of selling compressors.
While their perceptions are beginning to change, their efficiency actions have been limited.

- A few dozen distributors of equipment and services in the Northwest, with perhaps ten of these dominating sales. Some provide customer O&M services, and most provide efficient compressors on request, but their focus on efficiency is limited. Many may have limited capabilities for looking beyond the compressor, at efficiency opportunities in the broader system.

- About a dozen consultants who perform energy audits, meter systems, and/or help design new systems. Other consultants do occasional new system or troubleshooting work. Few of these individuals work on compressed air efficiency full-time, and many are not closely affiliated with organizations that deliver services to customers. Many of the analysis or O&M firms do not provide extensive metering services. Some are affiliated with, and promote, specific products that tend to narrow the focus of recommendations and are not always appropriate. There are only a few firms that can provide advice, and package and manage a comprehensive analysis and installation project. Thus, packaging is often exclusively in the hands of end-users, many of whom do not have the time or interest to take on this task. End-users tend to rely on distributors for information more than consultants, but do not always trust that information.

- A handful of Energy Service Companies (ESCos) and Energy Services Providers (ESPs) who market turnkey or performance-guaranteed compressed air services. For most ESCos and ESPs, these services are offered as part of broader energy services offerings. Only one company appears to be actively pursuing compressed air efficiency in the Northwest, dealing primarily with large systems. Other companies have proposed compressed air services, but either are not selling much of anything or are selling something else.

- A few Compressed Gas companies, who sell a variety of industrial gasses, including compressed air. These companies deal primarily with large manufacturers with diverse industrial gas needs. The one firm we learned the most about is just becoming aware of
compressed air energy efficiency, and has no existing capability in this area.

Our interviews indicate that there is a small volume of compressed air services being offered in the Northwest today (relative to the magnitude of low-cost opportunity), and there are no concrete plans to expand the level of services. While several parties are poised to expand their offerings, they are waiting for evidence of increased customer demand.

PEA/RIA developed estimates of the general magnitude of service offerings in the Northwest (as shown in Table ES-1). These estimates involved significant judgement and should be considered to be useful at assessing the magnitude of activity, but not the precise level.

Table ES-1: Estimated Volume of Compressed Air Services

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>PROVIDER</th>
<th>VOLUME (PROJECTS/YEAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM EFFICIENCY SURVEYS</td>
<td>Engineers, ESCos</td>
<td>20</td>
</tr>
<tr>
<td>SYSTEM LOAD MONITORING</td>
<td>Engineers, ESCos</td>
<td>7</td>
</tr>
<tr>
<td>COMPRESSOR CONTROLS/ SEQUENCING</td>
<td>Engineers, ESCos, some Distributors</td>
<td>9</td>
</tr>
<tr>
<td>COMPRESSOR AUXILIARY ENHANCEMENTS**</td>
<td>Mostly Distributors</td>
<td>59*</td>
</tr>
<tr>
<td>SYSTEM O&amp;M</td>
<td>Engineers</td>
<td>9***</td>
</tr>
<tr>
<td>PIPING DESIGN</td>
<td>Engineers, Distributors</td>
<td>14*</td>
</tr>
<tr>
<td>PROCESS TOOL ASSESSMENT</td>
<td>Engineers</td>
<td>6</td>
</tr>
</tbody>
</table>

* It is unclear whether many of these projects involve efficiency improvements
** E.g., refrigeration, outside air.
*** In addition to distributor services.

We asked whether respondents were hoping to expand business in specific areas. There was moderate interest in expansion of a number of services, including surveys, monitoring, O&M, and compressor and auxiliary
enhancements. In some cases, it was unclear whether the planned O&M and hardware enhancements had an efficiency focus or were focused on other customer objectives.

We also discussed various types of marketing services that might help in “packaging” efficiency for customers in a way that makes it easier to implement. Distributors were most interested in system design, and management of system installation because they now dominate that work. Guaranteed system performance was emphasized by some, but not all ESCos and ESPs. It is important to note that those who had more experience with guarantees were, on average, more equivocal. Unit Pricing (i.e., selling cubic air by the CFM to a plant) was not familiar to most respondents. We heard of six plants in the region where this is used, three of which were contracted to one service firm. Those most familiar said that opportunities were limited largely to new plants by the need of the service firm to own a self-contained space in or near the plant.

Service Provider Perceptions of End-Users

The information we gathered on end-user practices is second-hand because our interviews were with people in the compressed air services business, not the end-users. Nevertheless, the picture they painted was fairly consistent.

Generally speaking, plant personnel try to keep systems working, with pressure up to levels that meet user demands, but compressed air O&M is largely neglected and system efficiency is rarely considered. Many plants have no on-site personnel (contract or staff) who understand maintenance fundamentals. Distributor personnel are called when there is a crisis. A few of the more efficiency-minded customers occasionally perform checks for system leaks, but few customers survey for inappropriate end-use. Fewer maintain a regular program of leak-detection and repair. Among those firms who check for leaks, it is common for identified leaks to go unrepaired. Some larger facilities have undergone efforts to improve compressed air system efficiency, either independently or through utility programs. However, those efforts are rarely comprehensive. New system design is often haphazard, with little consideration of efficiency.

Most customers do not have separate electric meters for compressed air and do not know what the electric costs of compressed air are. As a
consequence, most purchase decisions are based on speed and first cost. The customers do not know how to secure reliable and comprehensive assistance, due to their limited attention to compressed air issues and the fragmented services delivery industry. Many customers hesitate to pay for compressed air studies, yet mistrust recommendations provided for free by vendors.

There is more knowledge, capability, and attention to compressed air efficiency in some large facilities, but even among those with several hundred horsepower of compressed air load, the plant-to-plant variation in focus on compressed air is dramatic.

The limited scale of dollar savings from compressed air energy efficiency can inhibit interest, even if paybacks are attractive. For example, a sawmill might see a one-year payback on a $15,000 investment, but is more worried about where their timber supply will come from next year. As a consequence, when industrial firms pursue compressed air enhancements, it is usually for non-energy reasons. The most common reason is to avoid buying a new compressor or to enhance system reliability. There are other cost savings related to reduced overhead, improved reliability and performance, etc.

**Market Barriers**

The pattern of barriers appears to differ by size class. The following very approximate size breaks are used to clarify the trends by size.

- For 0-100 HP systems, options are limited because the savings can rarely support the cost of a detailed technical study. However, there are still opportunities for efficient compressors, some controls, and in-house O&M improvements. For these options, awareness, knowledge, confidence, and custom (e.g., traditional sales focus of distributors) present significant barriers, but ones that might be influenced by carefully-targeted information from a credible source.

- 100-500 HP systems, from economic and technical perspectives, could benefit from a wide array of technical opportunities. However, there are significant awareness, knowledge, confidence and custom (i.e., traditional practice and market structure) barriers.
Additionally, many customers in this size range may not have the time and knowledge to organize and manage services from separate contractors who offer audits and installation, and are more likely to allocate scarce capital to other needs. The limited number of systems experts and energy service companies offering turnkey services is another significant hindrance.

- In general, the range of technical and project management services currently available is much greater for larger systems (e.g., over 500 HP). While current activity is limited, contractors of many types are eager to provide a package of technical, financing, installation, and guarantee services to large customers. Large customers have the magnitude of potential savings to better afford and attract the few system efficiency experts. While the scale of financial benefits is larger than for smaller plants, it may not be larger in proportion to other expenses and opportunities at the plant. So, even large compressed air opportunities often receive a low priority for internal attention and funding.

**Recommendations**

The following recommendations present a synthesis of our market research finding and our broader knowledge of the market. PEA/RIA does not recommend who should carry out these recommendations. Various recommendations could be addressed by the Alliance, utilities, government entities, or industry alliances.

**Overall Strategy**

- Focus primarily on efficiency improvements to existing compressed air systems.

- There are many types of compressed air service firms who might profit from efficiency. It is premature to preclude any as potential partners for Alliance projects.

- For existing systems, the Alliance should focus on two types of efficiency opportunities:
  - System retrofit or upgrade
Executive Summary

- System operation and maintenance
  - Separate strategies should be developed for different sizes of systems.

Key Elements

- It is crucial to provide education, awareness building, and confidence building for efficient approaches, technologies, and service delivery systems. A credible training and (preferably) certification program, such as that planned by the Compressed Air Challenge (CAC),\(^1\) with appropriate follow-through to re-enforce the lessons, may largely serve these ends. The CAC has established a management center to maintain the curriculum and a contractor to organize and hold the classes across the country. It is not necessary to replicate this structure in the Northwest. Through its continued participation in the governance of CAC, the Alliance needs to help assure that the quality and credibility of the training are unimpeachable. Additionally, the Alliance needs to assure that key decision-makers are recruited to attend, and that there is sufficient participation for Northwest training so that CAC’s efforts in the region can expand. This might best be achieved through a series of targeted recruiting efforts aimed at key individuals (compressed air operators and facility engineers). Recruiting aids might include scholarships, or, for far-flung plants, subsidized air fare.

- A very important compliment to the training effort would be case studies to give facility engineers in key industrial “peer groups” (specific plant types and geographic areas) the knowledge and tools to proceed. The case studies should: 1) involve firms who are customary “concept leaders” in the industry; 2) incorporate information on energy, and especially non-energy benefits; and 3) include practical information to help firms with similar plants proceed. The Alliance may also need to encourage facility engineers and plant managers to communicate more with their peers about compressed air efficiency. In our study, we did not study the

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\(^1\) CAC is a national collaborative effort to transform efficiency of compressed air use. Participants include manufacturers, distributors, consultants, government, utilities, end-users, and regional planning groups (including the Alliance).
industry peer groups extensively, and do not know if they are tightly enough knit to act as an efficient vehicle for transmitting innovation.

The above two activities could result in significant transformation of the large customer market and are important for the medium-sized market (e.g., 100-500 HP systems). However, many customers with medium-sized systems need ways of procuring analysis, installation, and management with few players, steps, and risks. While ESCos and ESPs may be ready to work with large customers to address the need for integrated services, more help may be needed to build the service infrastructure to package projects for medium-sized customers. Options for utilities to encourage the development of such packaging include:

- Alliance or utility subsidies for delivery of integrated services (e.g., metering with O&M, or audit/install/guarantee) in a small number of medium-sized plants, to build alliances and experience;

- Alliance or utility help in project administration and oversight; or

- Alliance or utility guarantees and quality control for installations. This would simplify the number of services which contractors would need to provide, thereby making entry into the medium-size market of turnkey contractors, or metering-and-O&M firms more feasible.

For small systems (e.g., <100 HP), targeted educational efforts may have the most impact. These could include mailed information on efficient equipment and a 1-800 line to support customers when they are choosing compressors to match specific circumstances. Significant market transformation in the small system market may be a difficult goal to achieve.
I. Introduction

Compressed air system energy efficiency has been a topic of much discussion and some action for a number of years. Several Northwest utilities and government funded entities (e.g., Energy Analysis and Diagnostic Center at Oregon State) had addressed compressed air efficiency through their energy audit and rebate programs. Some specialized programs had dealt specifically with air leaks and other operations and maintenance issues (e.g., BC Hydro). Consulting engineers had performed a number of compressed air system studies independently of utilities. In addition, BPA developed technical documents describing the efficiency potential in compressed air systems, and several utilities developed AIRMaster, a computer-based analysis tool for identifying efficiency opportunities and estimating potential savings. The results from these efforts indicated the presence of significant and cost-effective energy savings resources.

However, these experiences also raised several questions about how those savings might be achieved:

- Duct leaks tend to recur. How can savings be sustained?
- Vendors of equipment were not highly motivated to promote efficiency.
- Customer knowledge, interest, and focus on compressed air efficiency seemed limited.

These considerations seemed to indicate a market with significant barriers, and the possibility, should these barriers be surmountable, for market transformation.

The Northwest Energy Efficiency Alliance (the Alliance) responded in part with sponsorship of the national Compressed Air Challenge (see section V.C.1). Additionally, the Alliance has been considering options for expanding their initiatives for compressed air system efficiency.

A number of contractors have provided the Alliance with proposals for funding compressed air efficiency activities. To help sort through the options, the Alliance contracted with Pacific Energy Associates, Inc. (PEA) and Research Into Action, Inc. (RIA), two independent consulting firms, to conduct a study of the market for compressed air efficiency services in the
I. Introduction

Northwest. This study was completed in July 1998, and was primarily intended to provide perspective on baseline levels of efficiency activity and market barriers to compressed air efficiency.

Section II presents the goals and objectives for the study. Section III presents the research design and sample. Section IV presents the findings of the research. Section V presents PEA/RIA’s perspective, based on the research on market barriers, opportunities, and options for the Alliance’s interventions into the market.
II. Study Objectives

For purposes of this study, the Alliance and PEA/RIA identified the following primary Alliance objectives in the compressed air market:

1. Transform the regional market for compressed air equipment and related services to practices that increase the efficiency of compressed air systems (not just components). This might include:
   - Improving the capability of facility staff to choose and run more efficient systems, or to bring in outside help who can; and
   - Finding sustainable, profitable ways for maintenance contractors, design engineers, consultants, etc. to provide or enhance their services that increase efficiency.

2. Alliance actions should be such that they complement, rather than duplicate, efforts conducted by non-utility “market players” (e.g., ESCOs, manufacturers, and service companies).

Within this framework of market objectives, the Alliance asked PEA/RIA to:

1. Find out what compressed air efficiency services are currently being offered by various types of service providers, and how much success these efforts are having at penetrating the market;

2. Identify if assistance from the Alliance is needed and would be potentially effective in helping businesses profitably address additional compressed air opportunities; and

3. As part of the overall strategy, assess how the national compressed air training curriculum might be offered and sustained in the Northwest in a way that assures an ongoing focus on technical balance and quality. (This issue is complex because of the fractured delivery system that currently exists for compressed air efficiency services.)

Since prior studies and programs have demonstrated very large, short-payback opportunities that could be accessed through compressed air retrofit (i.e., modifications to existing, operating compressed air systems)
II. Study Objectives

and O&M activities, the research was to focus primarily on retrofit opportunities.

Within the above framework, PEA/RIA set out the following additional research objectives:

1. Assess the level of market activity in compressed air system efficiency retrofit and efficient O&M in the Northwest, considering utility programs, engineering firms, compressed air sales organizations, compressed air service organizations, and energy service companies.

2. Assess market barriers, opportunities, and potential solutions.

3. Explore the feasibility of gathering data from vendors regarding the size of the overall market. If possible, given the project’s very limited timeline, estimate market size.

4. Segment the market to identify customer or technology groups that differ in their likelihood to transform, or that will need different types of help to transform to higher efficiency equipment and practices.

5. Synthesize a perspective on what types of intervention might help transform markets. Assess how existing Alliance-supported efforts (i.e., Compressed Air Challenge) fit into this effort.

It was not an objective of the study to examine or estimate the level of demand for compressed air services from the end-user point of view. Rather, the intent was to examine the market from the service provider perspective. This report includes information on experts’ and service providers’ perspective on customer interests, but there were no surveys performed of end-users.
III. Research Design

The market study relied largely on three information-gathering efforts: a literature review, interviews with compressed air system efficiency experts, and interviews with market players. Each effort is discussed below. A discussion of the analysis strategy follows.

A. Literature Review

PEA/RIA collected technical writings on compressed air opportunities, program descriptions and evaluations, reviews of potential savings, and other documents to help lay the groundwork for the study, and as the basis for the analysis of potential savings. While the primary focus was on the Northwest United States, leading studies and program descriptions from other regions were also reviewed. The literature used in this project is summarized in the bibliography at the end of the report.

B. Expert Interviews

PEA/RIA subcontracted with William Scales to provide expert perspective and advice on the market, on research approaches, on interview questions, and on subsequent PEA/RIA recommendations. Mr. Scales is one of the premier national consultants on compressed air system efficiency. He also owns a major out-of-region compressor sales and service organization.

In addition to Mr. Scales, the project team interviewed twelve national and regional experts in the compressed air market. These included individuals from nonprofit and government organizations and leaders in the industry. Two utility employees who market compressed air programs were also interviewed. The target list of experts to be interviewed was developed based on the knowledge of Alliance and PEA/RIA personnel, and was augmented with referrals we obtained in the course of our research. Our interview list was not intended to be comprehensive, but to provide a reasonable cross-section of knowledge about where the industry is heading nationally and regionally.

We used an open-ended set of questions as a discussion guide for the interviews. The discussion guide is provided as Appendix B to this report. Within the framework of this discussion guide, the emphasis of each
III. Market Status

interview varied significantly, depending on the particular areas of expertise of the respondent.

C. Market Actor Interviews

During the course of the expert interviews, PEA/RIA gathered names of consultants, engineering firms, energy services companies, and providers offering compressed air system efficiency services in the Northwest. Using this extensive list, we endeavored to contact as many individuals as possible in the short time of the study. The intent of these interviews was to assess the scale and focus of their efficiency-oriented activities, and to get their ideas of the size of the market, potential segments, barriers, opportunities, etc.

In addition, PEA/RIA interviewed some national firms who were said to be active in the compressed air services market to assess their efforts in other regions and its implication for future activities in the Northwest. These included energy services companies (ESCos) and energy service providers (ESPs) that might be pursuing any of a variety of services which incorporate compressed air efficiency.

A third set of interviews was conducted with a sample of major compressed air equipment sales organizations (mainly distributors, but also one manufacturer’s representative who works with regional distributors). Questions for the sales firms were similar to those for the consultant and engineering firms, but had a greater focus on equipment volume in the market and the potential for equipment improvements.

Contacts with these individuals were largely based on referrals from experts, from the roster of Compressed Air Challenge participants, and from other respondents. PEA/RIA does not purport to have achieved a statistically defensible sample of any of these groups, but we believe that the research included most of the important regionally active consultants, engineering firms, ESCos, ESPs, and larger regional sales organizations. A list of contacts is provided in Appendix C to this report.

We developed two slightly different survey instruments: one for equipment vendors and one for consultants. The consultant questionnaire was also used, with some variation in emphasis, for interviews with ESCos and ESPs. The two questionnaires are presented in Appendices D and E.
III. Market Status

In all, we contacted 26 market actors, 23 of which provided data. The nonrespondents either were not active in the compressed air market or refused to provide information. Respondents included nine consulting engineers, four ESCos/ESPs, nine compressed air equipment distributors, and one manufacturer’s representative.

D. Analysis

The resulting data proved to be quantitatively imprecise, due to both the nature of the sampling strategy and the ability of respondents to provide reliable estimates. Therefore, we did not engage in extensive quantitative analysis. Interview responses to quantitative questions were variable in detail and credibility. It appeared to the interviewers that some of the respondents knew more about the compressed air efficiency market than others, and that various respondents knew more about its different parts or aspects. Furthermore, some of the most knowledgeable respondents were least willing to divulge details about the size of the market, characteristics of customer systems, etc. Some service vendors appeared to be overstating the extent of their business activity, or interpreting the definition of “efficiency services” liberally.

For this reason, our synthesis of the responses involved not only tallying and totaling, but also comparing results between respondents to assess who we thought knew the most and was providing the most credible information. This inevitably involved considerable judgement on our part. We based our judgement on the plausibility of responses with respect to known facts about the market, the experience and interests of each respondent, and each informant’s apparent interest in selling versus informing.

As a consequence, our quantitative findings should be viewed as estimates only of the range or scale of probable activity, market size, etc. Based on our experience, we believe that it will be quite difficult to obtain precise quantitative estimates of market size, technical potential, or other numerical market parameters from vendors or distributors. We do know that data on the number and size of customer systems have been collected. One distributor informed us that they have conducted surveys of all industrial and commercial establishments in their service area to determine the number and size of compressors in use. However, much of the information is closely held for competitive reasons, and some of the
knowledge about the extent of efficiency improvements simply does not exist in quantitative form.

We are equally skeptical about the prospects of obtaining information on existing efficiency levels from customers without extensive on-site work at a large sample of customers. Compressed air systems are complex, highly variable, and often not well-understood by operators.

For these reasons, we believe that, short of a major investment in end-use research, data on the market for compressed air will always be approximate. However, the data in this study should prove adequate for purposes of market assessment, planning efficiency market transformation efforts, and gauging success over time.
IV. Research Findings

A. Nature of Opportunities

There are several excellent primers available on compressed air savings opportunities (e.g., Maxwell 1994; Vranizan 1993). Consequently, this report only recaps the principles that are important to understanding our assessment of the market.

This study focused on plant compressed air. In some cases, process equipment with very large demand for compressed air has integral equipment for air compression or dedicated equipment close at hand. This is referred to as “process air.” Our research did not specifically examine process air. Our impression is that there are opportunities for efficiency in process air systems, but:

- The technical opportunities are fewer, due to the absence of the facility-wide distribution system.
- Efficiency advances in many cases involve improvements to the manufacturing equipment itself, and may be more difficult to achieve as retrofits.

Plant compressed air systems, which are the primary focus of this study, serve multiple uses from a single distribution loop. Plant compressed air systems can include the following major components and opportunities:

- **Compressors** include motors and many other components. Many systems over 100 HP have multiple compressors.

- All compressors have **basic controls**, such as pressure level controls. Since many systems operate at higher-than-necessary pressure, this presents an efficiency opportunity.

- Some compressors have **unloading controls** that reduce electric use when demand for compressed air decreases.

- Where there are multiple compressors, there is an opportunity for using additional controls to **sequence and stage compressor operation**, to closely match CFM requirements, thus saving energy and reducing electrical demand. Multiple units also increase
IV. Research Findings

reliability. Many plants have backup compressors for use in the event of equipment failure.

- For larger compressors, there are dehumidification and cooling systems. These use energy and present many efficiency opportunities, including the use of cool air sources for cooling, and utilization of desiccant and other advanced dehumidification strategies.

- Variable speed drives are also an option for reducing energy use when equipment is partly loaded, but, due to the low cost of unloading controls, are not always appropriate.

- System operators try to maintain pressure at levels desired by end-users, so that production is not disrupted. Many operators can change their practices to improve efficiency.

- In some cases, air tanks called receivers are used to maintain pressure during short periods of high load. These are analogous to capacitors on electrical systems. One efficiency and cost-saving measure is to add a receiver to meet peak CFM requirements without adding a new compressor to a system. If this allows compressors to operate closer to the loading level where efficiency is greatest, energy savings can be significant.

- Piping leads from compressors to end-use equipment. For larger systems, a loop is preferred so that demand at any point can be met from either end of the loop. A variety of fittings and valves help distribute and control compressed air flow through the system. Distribution systems can have leaks, bottlenecks, poor distribution design, inconsistent pipe sizes, and other problems that increase demand for compressed air. Some facilities have two or more loops, which can be combined to allow for staging of compressors. This increases efficiency and has other benefits. Leaks in the distribution system are one of the largest causes of wasted energy and one of the largest potential sources of savings.

- End-use equipment can include a variety of nozzles, controls, etc. for providing the desired amount of air for a particular end-use. Many opportunities come from improving the match between these devices and user needs.
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- It is not uncommon for unrelated end-use devices to require different pressure levels. One efficiency strategy is to either boost pressure through an add-on compressor, or isolate high-pressure loads on a separate system, thus allowing the operator to drop the pressure level on the plant-wide loop.

- Users decide what is an appropriate use of compressed air, how much is needed, and how it will be supplied. This is often done with no thought to system requirements, cost, or efficiency. The users are frequently physically and organizationally separate from the system operators. They often view compressed air as a “free” utility because few companies bill departments for compressed air use.

The most advanced and knowledgeable national compressed air efficiency consultants tend to work their way from the end of the above list to the beginning. That is, they start by assessing whether there are more economical ways of meeting end-user needs, then look at efficiency opportunities in end-use devices, then the distribution system, and finally the controls. Compressor improvements are only considered once demand for compressed air is properly sized and compressors are staged. Through the steps described above, many end-users have found it possible to meet system demand while avoiding purchase of new compressors or retire existing compressors to backup status. Where new compressors are avoided, there are significant capital cost savings.

By contrast, one of the independent consultants with the most experience in the Northwest forest products industry stated that the best opportunities involved control of the compressors. He thought that the system and end-use presented opportunities, but that these were relatively modest. Some other local consultants made similar statements. It is difficult for PEA/RIA to say whether this reflects differences in the opportunities in forest products as compared to other facilities, or differences in knowledge and experience between various consultants.

Utility efficiency programs (e.g., those of New England Electric) get most of their savings from compressors, auxiliaries, and controls, largely because distributors significantly influence what measures are included in the programs and the distributor sales force focuses on these measures.
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It is important to note another aspect of compressed air systems: load patterns and equipment capabilities tend to vary significantly from one site to the next, even within the same industry. This is a result of differences in the equipment being served, the behavior of end-users (including O&M practices), the plant schedules and production levels, the characteristics of the distribution system, and the idiosyncrasies of the compressors, controls, and settings. Leading experts have told us that load monitoring over a period of several days is a critical element in assessing efficiency, particularly for larger systems. One expert argued for some level of monitoring, even for small systems, even if it is simply an ammeter measurement to see if there is a power-factor problem, or a single-channel recording meter.

B. Size of the Compressed Air Services Efficiency Market and Distribution by SIC and System Size

PEA/RIA did not perform an extensive study of the size of the market, but gathered readily available data to help create an idea of how big the market is in terms of savings and customers. First, we reviewed data regarding the magnitude of potential savings per plant, on a percentage basis, and the cost per kWh. Then we collected data from our interviews on the size of the Northwest compressed air market.

1. Secondary Sources of Data on Savings Potential and Cost

PEA/RIA reviewed two existing studies regarding potential savings. One (Battelle PNL 1994) was a summary of savings estimates from across the country using audits performed by Energy Analysis and Diagnostic Centers (EADCs), a Federally-funded, university-based service. The EADC provides one-to-two day industrial efficiency audits, performed by professors and graduate students, focusing on small industry and short-payback measures. This national data from EADC audits was re-weighted by SIC to better represent the industrial base of the Pacific Northwest. We could not determine whether the audits were comprehensive or limited in scope. Also, the data extrapolation to the Northwest used two-digit SIC codes, which may create some errors because the activities within the SIC classification may vary between regions.
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The other source was a series of compressed air system audits performed using the AIRMaster software (Wheeler 1997). The AIRMaster audits were conducted in a variety of medium-sized facilities in the Pacific Northwest. These audits focused on compressor controls, system improvements, and end-use devices, with little attention to compressor efficiency or end-use of the compressed air. Thus, the estimates of savings, while substantial, may not be comprehensive.

In neither case was the data based on measured impacts from installations. Rather, the two sources summarize engineering projections of savings. This is a particular concern in the area of air leaks, because it may be difficult to manage a compressed air system to avoid all leaks on an ongoing basis. Several contacts noted that air leaks easily reappear and require frequent monitoring and maintenance.

The following points summarize our conclusions from reviewing these data sources:

- The EADC study indicates that the technical potential for energy savings from compressed air system improvements in the Northwest probably exceeds 150 average megawatts (AMW), and may be significantly larger.

- The EADC study further indicates that over half of the potential savings are in the forest products industries: pulp and paper products and wood products. Chemicals and allied products account for another 10% of savings (although our field research suggests that there is not much activity in this sector). All other two-digit industrial SIC groups were below 5% of total savings each.

- A large fraction of the savings are very inexpensive, with savings covering the costs in one year or less. There are also some more expensive opportunities, but even these often have paybacks in the range of 18 months to two years. One expert estimated costs at .1 or .2 cents per kWh, plus or minus .5 cents a kWh. The survey databases provided higher costs, but the benefits of deferring a compressor purchase were not considered. One consultant we spoke with claimed that in half the plants he looks at, efficiency helped avoid a compressor purchase or permitted his client to take an existing compressor off-line.
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- Savings can constitute a significant share of facility load. The AIRMaster audits found potential savings averaging 49% of compressor load and 8% of facility load. The EADC audits estimated average savings constituting 38% of plant electric load for rubber and plastics plants, and between 10% and 20% for many industries, including forest products.

Since the research presented in this PEA/RIA report was completed, a national study involving information from 50 compressed air experts developed more modest estimates of savings (Xenergy 1999). That study will be available in January 1999. While these estimates should be considered carefully, one concern we have is whether there are indeed 50 individuals who understand the full range of potential compressed air savings. Several expert sources we spoke with suggested that there are only ten or so consultants in the entire country with sufficient experience to perform a comprehensive compressed air retrofit.

Appendix F provides further detail as to the information provided by these studies.

2. Size of the Market

PEA/RIA made an effort to collect data from contractors, engineering consultants, and experts regarding the number of compressors of different sizes in the market, and their concentration by industry. These data were considered important in particular because, as is discussed later in this report, the size of the compressed air system may be a key market segmentation criteria for delivery of services.

Our method was to ask each respondent to tell us of the number of customers he or she knew of with compressor systems in various size ranges, and then indicate the industries that dominated each size range. Responses varied in their detail, and respondents varied in their expressed confidence in their own answers. The resulting data is presented in Table 1. The standard deviations are provided to show that responses varied significantly, but there was a central tendency.
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Table 1: Reported size of the Air Compressor Market

<table>
<thead>
<tr>
<th>SYSTEM SIZE</th>
<th>NUMBER ESTIMATING</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
<th>MEAN</th>
<th>STANDARD DEVIATION</th>
<th>TEAM JUDGMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREATER THAN 2000 HP</td>
<td>8</td>
<td>2</td>
<td>150</td>
<td>30</td>
<td>4</td>
<td>100+</td>
</tr>
<tr>
<td>1000 TO 2000 HP</td>
<td>8</td>
<td>5</td>
<td>150</td>
<td>35</td>
<td>48</td>
<td>200+</td>
</tr>
<tr>
<td>500 TO 1000 HP</td>
<td>7</td>
<td>10</td>
<td>200</td>
<td>64</td>
<td>67</td>
<td>500+</td>
</tr>
<tr>
<td>200 TO 500 HP</td>
<td>7</td>
<td>20</td>
<td>3000</td>
<td>638</td>
<td>1058</td>
<td>1,500+</td>
</tr>
<tr>
<td>LESS THAN 200 HP</td>
<td>7</td>
<td>100</td>
<td>10,000</td>
<td>2,185</td>
<td>3,502</td>
<td>3,000+</td>
</tr>
</tbody>
</table>

Nine of the 23 respondents were willing to estimate the size of the market based on compressor sizes. One of these was new to the industry and only knew of 15 facilities. His responses were dropped. One of the 8 remaining respondents was unwilling to provide a number for the categories less than 1,000 HP. There was no way to weight the responses and, although some of the customer bases overlap, there was no reasonable way to account for this. Ultimately, reviewing the overall quality of the responses, the higher estimates seem to come from the most knowledgeable individuals. Overall, our most knowledgeable regional respondent estimated that there are at least 10,000 sites in the region with at least one compressor of any size. However, he was unwilling to provide estimates at a finer level of detail.

While the estimates of the magnitude of compressed air load are very approximate, we think that these data are also useful for looking at the distribution of compressed air load by size. In terms of the number of units, it is clear that the majority of compressor systems are under 500 horsepower. To see what this implies on a horsepower basis, Table 2 presents percentages of horsepower by size class, based on the mean and “team judgement” estimates. While the precision of the data used to develop this calculation is weak, the pattern is striking enough that it is probably meaningful; systems under 500 HP are about half of the total HP of compressed air.

It may be possible that this overstates the importance of smaller systems because smaller systems may run for fewer hours, resulting in smaller
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electric loads. Even if the data were adjusted to compensate for this, the overall number of systems under 500 HP and their potential for load impact would be difficult to dispute.

Table 2: Assessment of Percentage of Horsepower by Size Class (based on mean estimates)

<table>
<thead>
<tr>
<th>SYSTEM SIZE</th>
<th>MEAN</th>
<th>MEAN X MEDIAN HP</th>
<th>PERCENT OF HP</th>
<th>TEAM JUDGEMENT</th>
<th>IJUDGEMENT X MEDIAN HP</th>
<th>PERCENT OF HP***</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREATER THAN 2000 HP*</td>
<td>30</td>
<td>75,000</td>
<td>12</td>
<td>100+</td>
<td>250,000</td>
<td>14</td>
</tr>
<tr>
<td>1000-2000 HP</td>
<td>35</td>
<td>52,500</td>
<td>9</td>
<td>200+</td>
<td>300,000</td>
<td>17</td>
</tr>
<tr>
<td>500-1000 HP</td>
<td>64</td>
<td>48,000</td>
<td>8</td>
<td>500+</td>
<td>375,000</td>
<td>21</td>
</tr>
<tr>
<td>200-500 HP</td>
<td>638</td>
<td>223,300</td>
<td>36</td>
<td>1500+</td>
<td>525,000</td>
<td>30</td>
</tr>
<tr>
<td>LESS THAN 200 HP**</td>
<td>2,185</td>
<td>218,500</td>
<td>35</td>
<td>3000+</td>
<td>300,000</td>
<td>17</td>
</tr>
<tr>
<td>TOTAL</td>
<td>617,300</td>
<td>100</td>
<td></td>
<td>1,750,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Systems assumed to average 2500 HP
** Systems assumed to average 100 HP
*** Percentages do not add up to 100 due to rounding

Just as the respondents were unequal in their ability to estimate the sizes of compressor systems, they varied in the apparent credibility of their assessment of the industries dominating each size category. Their stated knowledge typically reflected their geographic or industry focus. For instance, one compressor company that specializes in large systems was primarily familiar with industries using the larger systems. A consultant to a specific industry was unlikely to mention any other industry as having compressors. Several respondents mentioned the same industries in several categories without mentioning other industries at all.

The respondents were more willing to discuss which industries had systems in each size range than they had been to estimate the number of firms in each size range. Twelve of the 23 respondents provided information on the
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industries. Their responses suggest that pulp and paper, aircraft manufacturing, electronics, aluminum, wood products, and food processing are the largest users of compressed air systems of all sizes. Not surprisingly, their responses also suggest that compressed air systems are common in almost every industrial firm, whether large or small, and in some commercial firms as well (see Table 3).

Table 3: Assessment of Industries Using Compressed Air Systems by Horsepower Size Class

<table>
<thead>
<tr>
<th>SYSTEM SIZE</th>
<th>INDUSTRIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-1000 HP</td>
<td>Wood Products (5), Food Processing (5), Mining (2), Foundries (2), Secondary Wood Products, Shipyards, Steel, Glass, Refineries, Electronics, and Cement.</td>
</tr>
<tr>
<td>LESS THAN 200 HP</td>
<td>Secondary Wood Products (2), Small Manufacturing (2), Chemical Plants, food processing, Breweries, Paint Shops, Tire Stores, and Grocery Stores.</td>
</tr>
</tbody>
</table>

C. Delivery Structure

The compressed air services industry consists of:

- A small number of manufacturers.
- A few dozen distributors of equipment and services in the Northwest, with perhaps ten of those (with multiple sites for some distributors) dominating sales.
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- About a dozen consultants who perform energy audits, meter systems, and/or help design new systems. Other consultants do occasional new system or troubleshooting work.

- A handful of Energy Service Companies (ESCos) and Energy Services Providers (ESPs) who market compressed air services, in most (but not all) cases as part of broader energy services offerings.

- Compressed gas companies, who sell a variety of industrial gasses, including compressed air.

Based on interviews with representatives of all of these groups, PEA/RIA believes that there is a small volume of compressed air services being offered in the Northwest today (relative to the magnitude of low-cost opportunity), and there are no concrete plans to expand the level of activity significantly. While several parties are poised to expand their offerings, most do not integrate all the service features that would meet the needs of a broad group of customers (see the discussion of market barriers in the next section). Those who do wish to expand are waiting for evidence of increased customer demand for efficiency services.

The position of each of the group of players with respect to compressed air efficiency services is described below.

1. Manufacturers

Manufacturers sell compressed air equipment through distributors, and also directly to large customers.

To date, manufacturers have not made energy efficiency a major focus of their work. The industry currently lacks standards for published data to rate system efficiency. In the past, some manufacturers have been alleged to engage in design practices that reduce efficiency, such as using the same components for different sized compressors. The primary motivator for manufacturers has been to increase profits by selling more compressors.

Past practices and attitudes notwithstanding, there are clear indications that many of the manufacturers are now viewing efficiency as a potential profit center. Several factors are driving this.
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• Second-hand reports indicate that the volume of compressor sales in the U.S. is decreasing. This may reflect both changes in the American industrial base, and perhaps the early impact of efficiency efforts.

• Efficiency efforts are becoming more visible, money is being made (nationally) on efficiency, and the manufacturers want a piece of the action. The old sales philosophy that “any compressor performance problem can best be addressed by installing more compressors” is becoming more difficult to sell. Several utilities have worked with customers for years to improve compressor system performance, and have impressive, evaluated results. A small number of consultants are making significant amounts of money advising and helping customers improve system efficiency. Other firms are selling performance contracts and/or proprietary control systems to improve system efficiency.

• The Compressed Air Challenge program (described Section V) essentially provides an opportunity for manufacturers to get on the bus or watch it leave without them. By marshalling a major, multiparty national effort to educate customers about compressed air, the U.S. DOE and the other supporters are providing a catalyst for manufacturers to refocus their efforts on efficiency.

At the same time, our contacts did not indicate that manufacturers are developing major service organizations in the Northwest to address efficiency opportunities. One manufacturer’s representative has developed a service network with distributors of his firm’s products. They co-market services. The distributors address basic efficiency opportunities, and experts from the manufacturer’s organization address more complex situations. However, this respondent described the market barriers as daunting and the efficiency business as slow. As a result, his firm has put limited resources into pursuing efficiency.

While nobody quite said so, our sense was that the manufacturers were essentially hanging back and waiting for the demand for efficiency services to become clearer, particularly in the low-power-rate Pacific Northwest.
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2. Distributors

Compressed air equipment distributors are generally independently owned firms. Many are closely affiliated with one manufacturer, and sometimes with manufacturers of control devices or other auxiliary equipment. Some distributors sell equipment from multiple manufacturers, but most favor one brand, at least for a certain type of system. We found several large distributors with multiple locations in the Northwest. One distributor has a significant portion of the forest products industry sales and service work in at least one state. Distributors tend to specialize in particular types of customers and equipment. Some firms specialize in air compressor systems only, and others sell varieties of industrial equipment.

Distributors perform or subcontract for most new system design work. Some distributors also work with customers to maintain and service equipment. In this respect, they have existing relationships that could evolve into work on efficiency-oriented operations and maintenance. For example, one distributor has its service customers send in post cards that periodically report on key system settings. This information is used to assess whether equipment is significantly misbehaving. However, the focus of these services appear to be to “keep it running” not “keep it running

Distributors usually sell equipment to the plant engineer or manager.

Some distributors have limited understanding of the equipment they sell. Others are very knowledgeable about compressors and compressors controls. At least one firm has worked closely with one utility program to help market control systems to stage compressors. However, distributor expertise typically focuses on the compressors and compressor controls, not on the distribution system or end-use devices. Many distributor respondents claimed to sell efficiency services, but, based on their statements, it was difficult to discern whether their “services” extended beyond basic maintenance and selling higher-efficiency compressors when customers demanded them.

Leading distributors in the Northwest consider themselves capable of managing system optimization work for efficiency and, if a market develops, might organize to more actively pursue that line of business. However, nationally, some manufacturers privately state that they consider many of their distributors to be woefully undereducated about how to
manage compressed air efficiency. These manufacturers feel that without further training and a change in business philosophy, the distributors are poorly positioned to do well in a market where efficiency is a major profit opportunity. This is at least partially confirmed by our distributor responses. Many distributor respondents had little experience or knowledge of system monitoring and measurement, and many considered the customer system to be a “black box” that their equipment was plugged into.

The primary motive for distributors to get into the efficiency business may be that it is getting more and more difficult to make money on compressor sales. As the forest products industry shrinks in the Northwest, the primary client base is diminishing. Competition is reducing profits and it may be necessary to find new profit centers to survive. The biggest impediment to success is that distributors have trained their staff to make money selling more compressors. The institutional change to selling more services and fewer compressors may be difficult for many firms, unless they start entirely new business units to handle efficiency services.

Distributors provided us with estimates of the sales volume of “high-efficiency compressors.” This term was not precisely defined (nor does the industry agree on a definition). PEA/RIA’s synthesis of responses is that the market may be for about 300 compressors per year. All distributors would like to increase high-efficiency sales, but several noted that most buyers still have a first-cost focus.

Based on distributor’s responses, we would also estimate that there are about 300 or more projects a year where distributors assist with operations and maintenance. It is not clear how energy-efficiency focused these projects are. Only about half of the respondents expected to increase business in this area.

Most or all distributors offer financing, primarily for compressor sales. Recently, some have offered lease financing. However, financing is and has been a very limited part of their business. The distributors reported that most customers find other sources of capital to buy compressors. Distributors did not tell us that they currently finance efficiency measures, although some allowed that it might be a possibility.
3. Consultants

The Northwest has a wealth of consultants performing a variety of engineering services related to compressed air. This probably reflects the historic industrial base in the Northwest and the historically strong role of energy efficiency programs in this region. The services offered vary; some firms focus primarily on measurement of efficiency, while others focus on energy audits and efficiency recommendations. Many analyze compressed air as part of their general analysis work in industrial facilities. Within the industrial plant, consultants usually market to the plant engineer and work with the plant maintenance foreman or their equivalent.

What was striking to us in our review is that services tended to be fragmentary, while customer needs (as discussed in the next section) tend to be integrated.

- Some firms provide measurement but do not offer to help customers perform operations and maintenance improvements (e.g., fix leaks, adjust system pressure, look for inappropriate end-uses) in response to an indicated decrease in system efficiency or effectiveness.

- Some firms provided engineering recommendations for system improvements but were generally not allied with implementation or financing firms to provide turnkey assistance. Thus, they rely on the customer to pull together various contractor resources and manage a project. This is a reasonable expectation for the most highly-motivated large customers, but many plant personnel who might pursue efficiency improvements do not have the time, contacts, or understanding of contract options to put the pieces together.

- Many of the audit firms do not have extensive monitoring capability, so estimates of load and savings are approximate and difficult to prove to customers.

The result is that most of the consultants are doing little work in compressed air and many of the utility-sponsored studies that these firms do sit on the shelf without implementation. Many of the firms previously depended, and some still depend, on utility audit programs for much of their work in compressed air. However, as utility funding of audits
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diminishes, so does their compressed air work. Others work with an existing client base of industrial firms, usually in a niche market in which they offer the client all manner of consulting engineering services.

There are exceptions. One firm appears to be focusing on a combined metering/engineering study strategy. Some engineering firms work occasionally for ESCOs and ESPs, or for distributors who package technical, financial, and implementation services. However, this is not yet common and it does not appear from our research that these services have reached the self-sustaining level in response to market demand.

4. Energy Service Companies and Energy Service Providers

Energy Service Companies are firms that offer technical, financing, and implementation services for efficiency, and sometimes use a performance contract (guaranteed or shared savings) as a way of assuring profitability to customers. Energy Service Providers are firms that offer “integrated energy service packages.” ESPs have emerged as a result of utility deregulation. Integrated energy service packages usually include the commodity energy (gas and electric), as well as various energy-related project services that ESCos provide. ESCos and ESPs do not finance all transactions with a performance contract. Sometimes they perform turnkey services on a cash basis, or use conventional financing. The distinguishing characteristic of both ESCos and ESPs is the ability to bundle technical analysis, financing, forms of warrantee, technical services, and project delivery. In the case of ESPs, it also includes the ability to meet all the customer’s energy-related needs.

There are a wide variety of ESCos and ESPs operating in the Northwest. Many are utility subsidiaries, some of which are using energy services as a “door-opener” to sell power. Some are affiliated with controls manufacturers (e.g., Honeywell, Johnson Control), and still others are independent firms.

Based on ESCo and ESP interviews, their energy services business strategies have become diverse, and thus ESCos and ESPs are approaching the compressed air market from a number of different directions. For example:
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- One firm is selling a variety of energy efficiency and related power system and plant management services. Compressed air efficiency is considered to be “part of the mix.” This firm generally uses guaranteed savings as part of their sales approach. The firm has performed compressed air audits, but has not yet sold any implementation services.

- Another firm is largely in the business of buying the utility plant within very large industrial concerns and then selling power, water, etc. on a per-unit basis. This firm has an office in the Northwest, but has not entered into any such transactions in the area.

- Another firm engages in large-scale guaranteed savings contracts, focusing on all fuels and large government facilities. This firm does not do much work in compressed air.

Most ESCos and ESPs appear to have a financing and contract-management business focus and are looking for something to sell and someone to buy a product involving their financial and contract tools. For these firms, compressed air is “another product,” but it has not sold well, so it doesn’t get exceptional attention. Many ESCos and ESPs are simply not focusing on industrial customers. Others are focusing on other end-uses and would focus on compressed air if the customer demanded it or if they could be certain the service would be profitable.

While we did not survey every ESCo or ESP, we think that very little compressed air efficiency is coming through ESCo or ESP sales channels, with the possible exception of one firm. This firm has developed a business plan, a technical resource base, and corporate delivery system specifically for compressed air efficiency. They have a nationwide staff of about 50 working on compressed air, and have also engaged two of the leading national consultants to help. Furthermore, they have engaged in a marketing alliance with a firm offering a proprietary compressed air controls approach.

Most of the ESCos and ESPs we talked to said that they are currently targeting only Fortune 50 companies or very large plant sites (e.g., greater than 10 AMW). However, the one firm specializing in compressed air claims to be working with systems as small as 300 HP.
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One interesting difference between ESCos and ESPs and other service providers is that ESCos and ESPs are more likely to approach financial officers within the industrial firm, and more likely to do so at the highest levels in the corporation. This reflects their marketing orientation, which is to sell large projects with guaranteed cash-flow benefits. This approach would not make much sense for firms who are marketing only compressed air efficiency. Compressed air, by itself, is not a large financial issue in most firms, and without the financial guarantee, improvements are viewed more as a technical management problem than a financial opportunity.

5. Compressed Gas Companies

These are the newest players in the compressed air market, and their role is least-defined. They do business with industries that have extensive need for in-plant delivery of various industrial gases. In some cases, the compressed gas companies manufacture the gas in the plant, using their own equipment. In other cases the gas is delivered. We encountered one electronics industry plant where the compressed gas company also provides compressed air. We were told that the compressed gas company did not know much about compressed air efficiency, and that efficiency is not a major business driver at this time. However, during the period of our field work, this compressed gas company brought in a consulting engineer to help them better understand the opportunities.

D. Overall Volume of Baseline Services Delivery

The following estimates should be used to judge the magnitude of activity, but not the precise level. This caution reflects the limited nature of PEA/RIA’s survey and the equivocal responses from some firms. Total estimated volume of compressed air efficiency services is provided in Table 4. This is in addition to the distributor-only services discussed above.
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Table 4: Estimated Volume of Compressed Air Services

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>PROVIDER</th>
<th>VOLUME (PROJECTS/YEAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM EFFICIENCY SURVEYS</td>
<td>Engineers, ESCos, ESPs</td>
<td>20</td>
</tr>
<tr>
<td>SYSTEM LOAD MONITORING</td>
<td>Engineers, ESCos, ESPs</td>
<td>7</td>
</tr>
<tr>
<td>COMPRESSOR CONTROLS/SEQUENCING</td>
<td>Engineers, ESCos, ESPs, some Distributors</td>
<td>9</td>
</tr>
<tr>
<td>COMPRESSOR AUXILIARY ENHANCEMENTS**</td>
<td>Mostly Distributors</td>
<td>59*</td>
</tr>
<tr>
<td>SYSTEM O&amp;M</td>
<td>Engineers</td>
<td>9***</td>
</tr>
<tr>
<td>PIPING DESIGN</td>
<td>Engineers, Distributors</td>
<td>14*</td>
</tr>
<tr>
<td>PROCESS TOOL ASSESSMENT</td>
<td>Engineers</td>
<td>6</td>
</tr>
</tbody>
</table>

* It is unclear whether many of these projects involve efficiency improvements
** E.g., refrigeration, outside air.
*** In addition to distributor services.

We also asked whether respondents were hoping to expand business in specific areas. With the caution that the results may reflect desires as much as expectations, the results are presented in Table 5. We presume that those who did not plan to expand business in certain areas either did not see much potential profit or were not well-positioned or structured for certain types of work.
Table 5: Estimated Volume of Compressed Air Services

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>NUMBER WHO WANT TO EXPAND BUSINESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Efficiency Surveys</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>System Load Monitoring</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Compressor Controls/Sequencing</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Compressor Auxiliary Enhancements**</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>System O&amp;M</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Piping Design</td>
<td>12</td>
<td>4*</td>
</tr>
<tr>
<td>Process Tool Assessment</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

* It is unclear whether many of these projects involve efficiency improvements

** E.g., refrigeration, outside air.

We also discussed various types of marketing services that might help in “packaging” efficiency for customers in a way that makes it easier to implement:

- **System Design:** Distributors were most likely to see this as an opportunity. In all, 6 of 13 respondents to this question saw this as a significant market.

- **Guaranteed System Performance:** 5 of 8 respondents, primarily consultants, saw this as a significant opportunity. Some ESCo/ESPs emphasized it while other did not. It is important to note that those who had more experience with guarantees were on average more equivocal.

- **Management of System Installation:** 5 of 8 respondents to this question, primarily distributors, saw a large-scale, potential market for this service. Distributors now are the players who most frequently assist with this service.

- **Unit Pricing (i.e., selling cubic air by the CFM to a plant):** Only 5 interviewees responded to this question. Four other respondents...
were interested but did not know how it worked. One firm saw this as a significant opportunity and 2 reported activity in the region. One of these 2 (a distributor) indicated that his firm has 3 of 6 plants in the region where unit pricing is being used. Those most familiar, said that opportunities were limited because it was necessary for the service firm to own a self-contained space within the plant, or right outside it, to address liability and other contract issues. This requirement limits unit pricing primarily to new facilities where the need can be designed into the plant layout.

E. Customer Management Of Compressed Air

The information we gathered on customer practices is second-hand because our interviews were with people in the compressed air services business, not the customers. Nevertheless, the picture they painted was fairly consistent.

Respondents consistently described compressed air as a low priority among plant management issues. Generally speaking, plant personnel try to keep systems working, with pressure up to levels that meet user demands. Operation and maintenance of equipment is poor in many plants, even from a perspective of reliability and system wear and tear. Some firms have competent on-site or contract maintenance. However, many plants have no on-site personnel who understand maintenance fundamentals and call in help only when there is a crisis. Many firms can sustain this level of neglect because they have backup compressors or multiple compressors that can keep service coming until a unit is repaired. Some compressed air systems are difficult to access physically and are therefore never maintained.

More efficiency-minded customers occasionally perform checks for system leaks, but few customers survey for inappropriate end-use. Fewer maintain a regular program of leak-detection and repair. Among those firms who check for leaks, it is common for identified leaks to go unrepaired. This is sometimes because there is nobody in the organization with the responsibility and time to do the work, and sometimes because “management doesn’t believe it.” One consultant described an experience in a major out-of-region manufacturing plant where staff had identified leaks constituting 60% of air volume, but management had not directed or staffed actions on the issue for many months. The staff hired the consultant...
IV. Research Findings

to write a report documenting the issue because management refused to believe their own staff.

Some larger facilities have undergone efforts to improve compressed air system efficiency. However, those efforts have often been fragmentary, focusing on buying efficient compressors, staging controls, checking leaks, or perhaps improving a loop that is no longer well-designed for changing plant needs. Rarely does a customer survey the options, decide on the logical sequence, and proceed to optimize a compressed air system. Also, utility programs in the Northwest have often been limited in the scope of measures considered due to limited access to metered data, budgetary constraints on studies, limited customer interest, or the limited knowledge of the consultants hired.

System design is often haphazard. Systems are designed by in-house staff, vendors, or occasionally by consulting engineers. Compressed air systems are often designed with thought only to the length and width of pipe and the pressure and CFM needed to meet all plant uses. Little consideration is given to system efficiency. For many of the individuals who design systems, the issue is not even considered.

Most of our respondents view customers as unaware of the energy costs associated with compressed air. The individuals who buy new equipment focus mainly on issues of first-cost and equipment reliability. In most large plants, there is no sub-metering and there has never been a compressed air audit, so energy use has not come up as an issue.

Internal operations and concerns can influence buying decisions in strange ways. For example, one manufacturer’s representative mentioned a situation where he convinced a customer that a set of efficiency measures would make it unnecessary to buy a new compressor. The customer bought a new compressor anyway, because the money was in his budget, and it was not clear that the money would be available should a compressor be needed later.

Larger facilities (e.g., at least several Average Megawatts) are: 1) more likely to have engineering personnel involved in equipment management; 2) more likely to have taken steps to make compressed air systems more efficient; and 3) more likely to be interested in further improvements. However, that likelihood is not strong. Even in big plants, the compressed air system is considered a “detail” to be managed with as little time and
IV. Research Findings

effort as possible. Manufacturing issues (product volume, quality, and reliability of production) dominate the scarce time of manufacturing engineers and maintenance personnel. Even in relatively efficient plants, with efficient lights, HVAC, and process control, compressed air is often ignored.

Many industrial plant personnel do not know who can provide reliable information, advice, consulting help, equipment, or installation for compressed air system efficiency. In the motors customer survey conducted by PEA for the Alliance (Gordon et al. 1998), one customer noted that he was dissatisfied with the distributor his firm had used for years but could not find another firm with the experience in their industry. For many customers, distributors are not considered to be reliable sources of recommendations (although there are exceptions).

Plant personnel are often hesitant to pay for engineering studies when the payback is unclear at the outset. Since compressed air systems differ significantly, walk-through studies are often unreliable except for the simplest of fixes. Metering and analysis to understand system loads can be a significant investment. One manufacturer’s representative told us that “customers are unwilling to pay for energy audits, and don’t trust free information from us.” Utilities have, at times, helped break this deadlock by funding energy studies and by providing credibility for the analysis.

The scale of dollar savings from compressed air can inhibit interest, even if paybacks are attractive. One expert cited the example of a sawmill that could save $15,000 a year with a compressed air retrofit that might have an analysis cost of $5,000 and installation and capital costs of $10,000. A one-year payback may look attractive, but mill personnel are more concerned with million-dollar issues, such as where they are going to get wood next year. The future of the plant is in question, and fixing the compressed air system will not save the plant.

Compressed air experts told us that when industrial firms pursue compressed air enhancements, it is usually for non-energy reasons. The most common reason is to avoid buying a new compressor or to enhance system reliability. A list of non-energy benefits that have proven useful in selling system improvements is shown in Table 6.
IV. Research Findings

Table 6: Non-Energy Benefits for Compressed Air System Efficiency Improvements

- Reduced capital costs
- Reduced interest cost on capital investments
- Reduced floor-space requirements from fewer compressors
- Reduced maintenance costs from fewer compressors and better system operation
- Reduced insurance costs from fewer compressors
- Reduced backup compressor requirements due to lower CFM requirement
- Reduced labor costs for equipment attendance
- Increased reliability of compressed air service; fewer consequent production disruptions
- Improved system performance (pressure levels, consistency of pressure, ability to address spikes in usage).\(^2\)
- Reduced worker safety issues (where inappropriate uses of compressed air are eliminated).\(^3\)
- Improved ease of system operation

\(^2\) One consultant encountered a large system where design problems caused turbulent flow, reducing effective pressure. Distributors had addressed this with a series of added compressors. The system finally reached the point where an added compressor actually resulted in reduced system pressure due to increased turbulence.

\(^3\) In one plant, employees were using high-pressure compressed air to cool themselves near a furnace, in violation of OSHA requirements.
IV. Research Findings
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

A. Market Structure

As discussed in the previous section, there are a variety of market actors selling compressed air services to end-users in the Pacific Northwest. Figure 1 diagrams the service flows between market participants in the Pacific Northwest.
As is apparent from this diagram, there are multiple actors approaching end-users during the course of each year. This variety is certainly one of the key factors that makes it difficult for end-users to discern who is the appropriate provider of efficiency services, if they should have an interest in such services. The variety of potential providers also means that end-users are less likely to shop around and, as has been noted above, frequently stick with a trusted provider with whom they have experience, without necessarily having any certainty (or concern) that they are getting the maximum services that could be provided.
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

B. Barriers

Based on the research findings, Table 7 summarizes the key barriers to compressed air system efficiency. The table indicates the importance of each barrier for different sized compressed air systems.

Table 7: Market Barriers

<table>
<thead>
<tr>
<th>MARKET BARRIERS</th>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEGEND</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*** = Very Significant Barrier</td>
<td>** = Moderately Significant Barrier</td>
<td>* = Not A Significant Barrier</td>
<td></td>
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</tr>
</tbody>
</table>

**AWARENESS**

1. CUSTOMERS ARE UNAWARE OF THE COST OF ENERGY EFFICIENCY  
   
<table>
<thead>
<tr>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
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<tbody>
<tr>
<td>***</td>
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</tbody>
</table>

2. CUSTOMERS ARE UNAWARE OF/ LACK CONFIDENCE IN EFFICIENCY OPPORTUNITIES  
   
<table>
<thead>
<tr>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
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<tbody>
<tr>
<td>***</td>
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</tbody>
</table>

**KNOWLEDGE**

3. COST OF ENERGY STUDY WITH NO ASSURED SAVINGS  
   
<table>
<thead>
<tr>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
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<tbody>
<tr>
<td>*</td>
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</tbody>
</table>

   Energy studies are impractical for small systems

**CONFIDENCE**

4. COMPRESSED AIR EFFICIENCY IS NOT A TRADITIONAL FOCUS OF STAFF ATTENTION  
   
<table>
<thead>
<tr>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
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<tbody>
<tr>
<td>***</td>
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</table>

**BUSINESS STRUCTURE, MARKET STRUCTURE, AND MARKET CONDITIONS**

5. CUSTOMERS DO NOT KNOW WHERE TO GO FOR RELIABLE HELP (ANALYSIS, FINANCING, INSTALLATION, O&M)  
   
<table>
<thead>
<tr>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
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<tbody>
<tr>
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</table>

Continued
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

<table>
<thead>
<tr>
<th>MARKET BARMERS</th>
<th>0-100 HP</th>
<th>100-500 HP</th>
<th>500+HP</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEGEND</td>
<td>*** = Very Significant Barrier ** = Moderately Significant Barrier * = Not A Significant Barrier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. DISTRIBUTORS HAVE LIMITED EFFICIENCY KNOWLEDGE AND MOTIVATION TO SELL MORE EQUIPMENT</td>
<td>**</td>
<td>***</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>7. BUSINESS INSTABILITY IN FOREST PRODUCTS INDUSTRY</td>
<td>**</td>
<td>**</td>
<td>**</td>
<td>A show-stopper, but not for all plants</td>
</tr>
<tr>
<td>SCALE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. COMPRESSED AIR IS NOT BIG ENOUGH A FINANCIAL ISSUE TO WARRANT IN-HOUSE PROJECT MANAGEMENT AND TURNKEY GUARANTEED SERVICES ARE NOT AVAILABLE</td>
<td>*</td>
<td>***</td>
<td>**</td>
<td>Less attention needed for small systems, given more limited options</td>
</tr>
<tr>
<td>9. COMPRESSED AIR EFFICIENCY IS LOW PRIORITY FOR FINANCIAL RESOURCES DUE TO LIMITED SCALE OF BENEFITS</td>
<td>*</td>
<td>***</td>
<td>**</td>
<td>Capital options fewer in small; money more available in large</td>
</tr>
<tr>
<td>RESOURCES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. SHORTAGE OF ANALYSTS WHO CAN LOOK AT THE WHOLE SYSTEM</td>
<td>*</td>
<td>***</td>
<td>**</td>
<td>Impractical for small; more help is available for large systems</td>
</tr>
<tr>
<td>11. LACK OF TURNKEY/GUARANTEED SERVICES</td>
<td>*</td>
<td>***</td>
<td>*</td>
<td>Available for large; impractical for small</td>
</tr>
</tbody>
</table>

While there are commonalities, the pattern of barriers appears to differ by size class:

- For the 0-100 HP systems, it may necessary to deal with a more limited range of options because the cost of a detailed technical

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4 This segmentation analysis uses different size criteria than were presented previously in the analysis of horsepower by system size. The horsepower analysis reflects the breakpoints used in the PEA/RIA survey. Reflection on the responses led us to use different breakpoints for market segmentation.
study will often not be worth the savings. However, there are equipment choices and O&M opportunities that may be practical for small systems. For these options, awareness, knowledge, confidence, and customs present significant barriers, but ones that might be influenced by carefully targeted information from a credible source.

- 100-500 HP systems, from economic and technical perspectives, could benefit from a wide array of technical opportunities, excluding only improvements to some forms of compressors and auxiliaries that are common only on larger systems (e.g., centrifugal compressors, desiccant dehumidifiers). However, there are significant awareness, knowledge, confidence and custom barriers. Additionally, many customers in this size range are unlikely to have the time and knowledge to organize, procure, and manage separate contractors who offer audits and installation. While many firms “would” finance internally, funds are likely to go to production improvements first, so compressed air projects will tend to go unfunded. The limited number of systems experts and ESCos offering turnkey services is another significant hindrance. ESCos and ESPs, in particular, are not now interested in this size of customer (with the exception of one firm).

- In general, the range of technical and project management services currently available is much greater for larger systems, variously described by our respondents as Fortune 50 firms, very large plants, and systems over 500 HP. While current activity is limited, firms are eager to provide a variety of integrated compressed air efficiency, technical, financing, installation, and guarantee services to large customers. Large customers have the system size and magnitude of potential savings to better afford and attract the few system efficiency experts. While the scale of financial benefits is larger than for smaller plants, it may not be larger in proportion to other expenses and opportunities at the plant. So, even large compressed air opportunities often receive a low priority for internal attention and funding.
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

C. Opportunities

This section reviews trends and projects that may provide openings for change in the compressed air system efficiency market.

1. Compressed Air Challenge

This is a national collaborative, funded in part by the Alliance, which is dedicated to change in the compressed air market. Though federally initiated, the board and active membership includes representatives from the major manufacturers (represented in some cases individually, and collectively by the Compressed Air and Gas Institute), some large distributors, several leading consultants, national advocates, government agencies, utilities, regional efficiency consortia (i.e., the Alliance) and some large customers.

The Compressed Air Challenge (CAC) is working to standardize criteria for efficiency ratings for compressors, and has published a technical sourcebook. However, their main project is a curriculum for training and (perhaps) certifying compressed air experts. Their initial training program, a one-day class targeted at system operators and distributor personnel, will go through a series of shake-down presentations early in 1999. CAC is developing a faculty of experts with the intent of offering 50 classes nationwide in 1999, but it is not yet clear if that goal is achievable. Classes will likely be offered through two channels:

- The Association of Facilities Engineers (AFE) is planning to organize classes which are open to the public and targeted at operators. AFE and CAC are currently seeking co-sponsors to help fund and assure that classes are attended. AFE’s level of effort depends largely on the success of early classes. AFE has three chapters in the Northwest, and several hundred members. Their core membership is facilities personnel.

- The manufacturers will probably hold separate classes for their distributors and their own personnel, probably in association with compressed air industry meetings. The intent is to train their sales force in an environment separate from the customers, largely to avoid acknowledging how little their personnel already know.
CAC has also developed a second, more intensive curriculum for trainers, to assure that they have a consistent and comprehensive knowledge of compressed air system opportunities. This may someday evolve into a second-tier “consultant” level of training.

Certification is being discussed within CAC but has proven to be a contentious issue. This stems from differences between consultants. Privately, experts noted that many consultants do not base their recommendations on the details of specific systems, or lack the knowledge to troubleshoot systems. Those consultants, who are considered to be more accomplished by the expert respondents, are not eager to get into a fight with the consultants they accuse of being biased or limited. Furthermore, the value of certification based on the current curriculum may be limited. So, whether CAC incorporates certification remains to be seen. Another possibility is for a consultants’ association to develop its own certification criteria.

Quality control processes for CAC training is another area of contention. Many consultants fear that manufacturers will twist the training in a way to promote compressor sales, or that owners of proprietary controls systems will distort the training to promote their products. The Energy Center of Wisconsin has been assigned to manage and maintain the curriculum. How they will assure consistency remains to be seen. There will be requirements that certain topics be covered for training to receive CAC approval. One good sign is that manufacturers appear eager to use CAC curriculum as a sign of credibility. Also, there is much discussion of joint sponsorship of specific sessions by competing parties to assure credibility and neutrality.

A further concern is whether “trained” distributor staff or consultants will be obligated to offer a full range of efficiency alternatives, or whether they may use the training as a pretext to push sales of high-margin products. This issue will be difficult to resolve until certification is instituted.

A few things are remarkable about the CAC. The first is that manufacturers, distributors, and consultants who traditionally are at war with each other are all at the same table, and largely agree on the curriculum. The second is that there appears to be serious interest in developing a way to keep the process and product neutral. The third is that the CAC is either the product of, or process whereby, manufacturers and some distributors are beginning to see efficiency as a potential profit
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

center. Our respondents indicated that, though manufacturers are limiting their investment in efficiency today, their business strategies may change quickly if CAC creates an educated populace. At least some people from manufacturer organizations who participate in the CAC see it as a tool to open up markets for efficiency through education and credibility-building, and they want to be poised to jump on that opportunity. Others are more passive, not wanting to miss the train, but not yet convinced it is going anywhere.

The individuals we talked to who were involved in CAC were almost unanimous in thinking that, if the training is well-executed, and widely attended by plant compressed air personnel and distributors, it will significantly accelerate the market for compressed air system efficiency. They differed significantly, and expressed some uncertainty, about how much impact the CAC could have without additional support efforts, and on the breadth of the market that the CAC could impact.

2. Market Momentum

CAC is creating market momentum, but this may be partly due to the momentum already created nationally by the multi-year, evaluated success of several utility programs (including those in the Northwest), and of several consultants, in achieving compressed air system efficiency. The U.S. Department of Energy Motor Challenge program has also publicized compressed air success stories.

Additionally, the politics of greenhouse gasses have created pressure for industrial firms to find ways to cut source emissions. Small, but short-payback, efficiency measures are one of the least disruptive ways to “look like we’re doing something.” Programs such as ClimateWise (sponsored by U.S. DOE and EPA) have included compressed air improvements and then publicized them widely among large corporations.

Even the decline in compressor sales creates market momentum of a different kind. Distributors are driven to find new ways of making money. System efficiency may be an attractive target for technically-sophisticated distributors, once customer demand for the services improves.
3. Developments in the Energy Services Industry

A few years ago, ESCos specialized primarily in institutional retrofits, or in subsidized projects through utility bidding or rebate programs. Generally speaking, these ESCos were not well-structured or financed to make extensive investments in efficiency studies prior to an assured contract.

Now, many ESPs and ESCos are owned by utility companies who are looking at energy efficiency as a way to make inroads into potential power sales markets, or who are trying to parlay their expertise in utility plant management into an on-site power business. While compressed air has not yet been a focus for these firms, they are positioned to organize turnkey compressed air services once customers are more motivated. The modest nature of compressed air opportunities makes compressed air attractive as a trial transaction for an ESP or ESCo trying to prove themselves to a new industrial client. On the other hand, ESCos or ESPs who are trying to prove themselves may be more motivated to help customers with issues that are higher on the customer’s priority list.

4. Developments in Industrial Management

Over the past decade, “lean management” and “outsourcing” have increased in popularity among large manufacturing firms. There is no question but that the “lean management” movement has resulted in a decline in operations and maintenance activities in many firms, to the detriment of compressed air efficiency. However many firms, including some forest products firms PEA interviewed in the motors market research for the Alliance (Gordon et al. 1998), have reached a point where they need to either staff up, shut down, or outsource major functions. This provides a number of possible paths for increasing attention for compressed air, including turnkey system improvements, contract O&M, and unit pricing.

5. AIRMaster

AIRMaster is a program for auditing compressed air systems that was developed, in part, with Northwest utility market transformation funding at about the time of the Alliance’s inception. The objective was to provide a
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

standardized, relatively simple, but fairly comprehensive tool for compressed air efficiency audits by plant staff or auditors. Washington State University (WSU) currently manages AIRMaster sales and distribution.

WSU staff report that they have not seen the tool extensively used. Our contact guessed that there are about 50 copies distributed in the Northwest. Sales have not been heavily concentrated in this region. Most of the users appear to be engineering consultants. One of the authors has established a consulting business built around the tool, but much of his business is training others how to use it, primarily outside of the Northwest. Two training sessions on Version 1.4 were held in Portland and Seattle. Trainees included distributors and plant personnel. Many appeared interested in “finding out what’s going on,” but it wasn’t clear that they were planning to use the tool.

PEA/RIA’s conclusion is that AIRMaster, in itself, has not addressed the primary market barriers to compressed air system efficiency. However, it may prove to be a useful tool once these barriers are addressed.

D. Recommendations

These recommendations are based on PEA/RIA’s synthesis of the market research reported in this document. These recommendations do not represent Alliance policy. Alliance staff have received other information through CAC membership, proprietary proposals to the Alliance, and other sources. PEA/RIA has also explicitly not made recommendations about who should provide certain services. That issue is beyond the scope of PEA/RIA’s assignment. Many of the recommendations could be addressed by the Alliance, utilities, government entities, or industry alliances.

1. Overall Strategy

PEA/RIA makes the following recommendations:

a. While there are significant savings in new compressed air system design, PEA/RIA supports the Alliance’s preference to focus primarily on efficiency improvements to existing compressed air
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

systems. Existing systems have huge, inexpensive opportunities. These provide a better opportunity for service firms to profit from efficiency (thus creating a sustainable business) than does new system design.

b. Market transformation is most likely and easiest for large customers, yet there are enough barriers that the Alliance could make a difference – start there! Success with large customers will make transformation of the medium and small markets easier. Significant market transformation in the small system market may be a difficult goal to achieve.

c. Among the many types of compressed air service firms who are potential service delivery channels for system optimization, it would be premature to preclude any as potentially significant players in these markets as partners for Alliance projects. It is possible that consultants, ESCos/ESPs, distributors, industrial gas companies, manufacturing organizations, or others may fill the gaps in the market.

d. For existing systems, the Alliance should focus on two types of efficiency opportunities:

- **System Retrofit or Upgrade**: This includes opportunities for efficiency when customers are considering expansions to systems, when systems are not performing adequately, or when customers are dissatisfied with system operation or efficiency.

- **System Operation and Maintenance**: System O&M includes compressor maintenance, controls and settings, and leak detection and management. While intervention can begin at the same time as retrofit/upgrade, it often takes a different organizational and contract approach to assure the long-term follow-up needed for improved O&M.

e. Separate strategies should be developed for three market segments, which we have delineated based on the horsepower of compressors at the site:
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

- One hundred horsepower or less (small)
- One hundred to five hundred horsepower (medium)
- Over five hundred horsepower (large)

It is important to note that the boundary between these segments has not been set with precision. Also, the boundary between medium and large, in terms of which customers will benefit from which approaches, may shift downward if customer motivation increases and ESCos or others find smaller systems profitable.

f. For all customers, but especially the large, education, awareness and confidence building for efficient approaches, technologies, and service delivery systems are crucial. Credible education (such as CAC is planning), with appropriate follow-through to re-enforce the lessons, may largely serve these ends.

g. To increase market activity, given the limited attention most customers are willing to pay to compressed air, it is important that customers be able to contract from one or two actors for analysis, installation, and management in a way with few steps and perceived risks. Some industrial firms may want to manage the integration of services themselves, and some may want to perform their own system O&M. However, many industrial firms are unlikely to pay enough attention, or dedicate enough money and staff time, to achieve major savings. ESCos and ESPs that offer guaranteed or shared savings arrangements can help reduce the decision load on staff, once the substantial complexities of a performance contract and verification protocol are settled. Even firms with very large compressed air loads may need to see more successful examples of performance contracting for compressed air efficiency optimization before they are willing to make the effort to engage in such a contract.

h. While ESCos and ESPs may be ready to work with large customers, more Alliance or utility help may be needed to build the infrastructure to serve medium-sized clients. It is not certain that performance or guaranteed savings contracting is economically viable for medium-sized systems. Specific strategies for moving
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

this market ahead are detailed below. They focus on different ways to make the transaction simpler and more viable for potential service providers while making it also simple and low risk for industrial firms.

i. Small systems are not an attractive market for consultants, ESPs, or ESCos, and never will be. The practical technical options involve better in-house O&M (e.g., pressure level, compressor maintenance, basic controls) and better selection of equipment. Targeted educational efforts may help promote these ends.

Each element of this strategy is discussed further below.

2. Education

The Compressed Air Challenge is primed to offer a nationally-consistent, vendor-neutral program of basic education for system operators and distributors. The Alliance’s primary objective in market transformation should be to assure that the rollout is effective and that there are several well-attended workshops in the Northwest. Key tasks include the following:

a. Quality Oversight for Training: Work within CAC to assure that the quality oversight process for training is effective. Ideally, this should include some level of monitoring to assure that sessions follow the curriculum.

b. Get the Right People to Training: Assure that early Northwest public sessions are well-attended, and attended by the most important people: system operators, the engineers who plan and manage system improvements, and, in some cases, their managers. This may not be as simple as it appears. The evaluation of the training aspects of the Alliance’s motors programs indicates that industrial-sector efficiency training can be well-attended, well-regarded, but still of limited influence because the critical individuals do not attend (Gordon, Jennings et al. 1998). For compressed air, one-to-three hundred operators and plant engineers may control decisions for a large proportion of the horsepower in the region. Classes can fill up with “interested parties” who do not
have control over critical decisions. One solution is to make a list of key individuals within large firms, and then directly mail and call those individuals to invite them to training. Mail alone tends to be less effective than a phone call from a knowledgeable individual. Peer, corporate, vendor, and association marketing channels may also be important, but do not substitute for direct contact. System operators and plant engineers tend to be very busy, so selling the classes to these critical individuals may be very difficult.

- Until the profile of compressed air efficiency is enhanced, availability of corporate funding to pay the tuition for CAC classes may be a barrier to participation. The Alliance could address this by offering scholarships to firms with limited training budgets or, for widely dispersed firms, offering to cover air-fare to classes.

- The need for financial co-sponsorship for the training sessions is unclear. During our interviews we were told that tuition should cover session costs. At a later date, we heard that CAC was looking for financial co-sponsorship. The Alliance can best resolve this issue through direct contact with CAC.

c. **Assure that There Are More Training Sessions:** Success of the early sessions is critical to assuring that more training is planned for the Northwest. CAC also is looking for “co-sponsors” for more sessions. These could include the Alliance and utilities, as well as Northwest industrial firms and compressed air businesses. The Alliance could help coordinate marketing to assure that co-sponsorship is as broad as possible. It will likely take ongoing Alliance and utility marketing to key individuals to assure that participation remains high, and that critical people attend.

How far will an education-focused strategy go in transforming the market for compressed air? One expert quoted Peter Drucker as saying “Knowledge must degenerate into work.” This expert distinguished between lessons that the operator could take back to the plant and implement quickly (e.g., turn down the pressure to match user needs), and actions that required investment, risk, arrangement of contracts, etc. As previously noted, the firms best organized to package services and provide
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

turnkey help are targeting only the largest customers. Furthermore, the low cost of Northwest power will make the Northwest a low-priority area for investing in efficiency for multi-site firms, and will reduce the interest of local firms. Based on the feedback we received, we think that more than training is needed to assure widespread success, even for customers with large systems. The following items address options for enhanced services.

3. For Large Customers: Develop Demonstration/Case Studies to Support Compressed Air Challenge

Several respondents noted that plant personnel are more likely to act if a peer in their geographic area has had a positive experience with an efficiency opportunity. The Alliance can “turbocharge” the effect of CAC by first encouraging CAC training participants to form mutual support groups to explore compressed air efficiency, and then sponsoring case studies that are carefully designed to maximize leverage of successful customer experience. The following elements are important to case studies:

a. Select industrial “peer groups” with large enough compressed air loads to warrant significant attention, and common enough processes and close enough geography that success might foster imitation within the group. For example:

- Finished paper plants and rough paper product plants (e.g., craft mills) might be treated as distinct types.\(^5\)

- For each plant type, two peer groups might be defined: one East of the Cascades and one West of the Cascades.

- For some very large multi-site firms, a case study within the particular firm may be important to achieving progress

- In some cases, the Alliance may wish to actively support the formation of closer peer ties among industrial customers.

Our research did not extensively explore the nature of

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\(^5\) These categories are examples, which could be refined with industry input.
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

industrial peer relationships for specific types of customers. We cannot say whether these relationships are now well-enough established to act as a vehicle for transmission of innovation. Based on our discussions with industrial personnel over several Alliance studies, we would expect them to be best-established inside large multi-site firms, and within geographic subregions with several similar plants, therefore similar compressed air systems.

b. Within each peer group, **identify a firm and plant manager or engineer** who are acknowledged innovators and leaders. These are the people who are willing to try something first, and to share their knowledge, at least at the conceptual level.

c. **Market the idea of a case study** directly to these peer group leaders.

d. **Design the case studies** to involve a comprehensive approach to efficiency. In some cases this may require that the Alliance provide the technical contacts, project facilitation, incentives, and quality control assistance to achieve that end. Case studies should focus on system hardware and control improvements, on O&M, or both.

- In addition to incorporating a comprehensive measure approach, hardware-oriented case studies should help demonstrate the value of metered information in providing feedback to technical studies, and for demonstrating to customers that savings are “real.”

- O&M-oriented case studies should help demonstrate sustainable, affordable systems for organizing either staff or consultants to perform ongoing compressed air O&M. Metering may also be an important part of O&M case studies.

Case studies should help promote integrated teams to provide customers with combinations of services which can lead to a complete installation (e.g., analysis, installation, and monitoring) or sustainable O&M (e.g., monitoring, leak checking and repair).
e. **Evaluate** carefully from an energy perspective, and using a full spectrum of non-energy benefits. Perform pre- and post-monitoring and analysis to clearly show savings. Develop rules-of-thumb and report formats for incorporating non-energy benefits into the studies. Since many of the consultants performing studies in the Northwest have traditionally focused only on energy benefits, developing a new set of analysis procedures to consider other benefits may be important.

f. **Write case study documents** that focus on the situation, the economics of the change, and specific changes to equipment or management practices. These are the elements that most survey respondents told us were most important to plant managers. A flashy one-pager may attract upper management, but engineers want to know the following:

   - “Here’s what we did.”
   - “The company benefited and we proved it.”
   - “Staff was appreciated.”
   - “Here’s how to do it.”
   - “Here’s how to avoid mistakes.”


g. **Work with CAC to integrate case studies into CAC training.** The combination of education and carefully selected, executed, and documented demonstrations may accelerate compressed air system efficiency business with at least some of the largest firms and systems. The impacts are likely to reach few medium-sized firms, at least for the first few years, because services businesses are not focusing on those firms. The next recommendation directly addresses how to accelerate market transformation for medium-sized systems.
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

4. Accelerating Development of Integrated Services for Medium-Sized Systems

If the Alliance wishes to address medium-sized systems, it will be important to take steps with private enterprise to encourage the development of services targeted to this market. Several options are discussed below. Of these options, PEA/RIA believes that the most effective package would be a combination of demonstrations, subsidized projects, guarantees paired with quality control, and bill financing. This would constitute a significant effort. It might be prudent to begin medium-sized demonstrations immediately and pursue the other options after efforts for the large system market are established and the response from service businesses and customers can be gauged.

a. **Sponsor demonstrations for medium-sized systems** consistent with the outline described above for large systems. Focus on integrated services, providing quality control, and creating experience to help form teams of businesses that can address the requirements for medium-sized firms. The experience and track record of an “endorsed and evaluated” project may also help these or existing firms improve their marketing effectiveness with customers.

b. **Follow up with more subsidized projects.** While the large system market may take off after training and a few demonstrations, it may take more subsidized comprehensive jobs with the Alliance or utility-sponsored quality control for the medium-sized system market to mature. This is because the systems and business types are more diverse and customers have fewer technical, management, and financial resources on-site.

c. **Offer contract administration services.** The Alliance or utilities could provide what the construction industry calls “contract administration” services to the customer. This involves advising customers regarding bid documents, proposals, scope of technical studies, study and installation review, etc. The customer retains contract management authority and responsibilities, but much of the labor burden is relieved. We think that, in the absence of financial support (as discussed below), contractor-arranger services will have
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

only a limited effect. This is because many customers who lack the time to manage the project will still lack the time to sort out respective roles between the industrial firm, the contract assistant, and themselves. In short, it is a pretty complicated system for modest transactions. The simplest system for delivering this type of service is for utility field representatives who are already working with specific customers to provide help.

d. Offer guarantee backing to contractors pursuing efficiency for medium-sized businesses. Many smaller consultants and distributors lack experience with performance contracting. Medium-sized customers also tend to lack the experience and/or contract sophistication to understand how to enter into a performance contract while protecting their interests. Furthermore, the scale of the transaction may be too small for performance contracting to make sense. One alternative is for the Alliance, preferably in cooperation with specific utilities, to offer performance guarantees for jobs that undergo their quality control regime (including, presumably, technical review of plans and installation, plus metering). Since customers often trust their utility as a source of efficiency expertise, this option would give consultants and distributors considerable credibility.

e. Utilities should consider offering financing on the electric bill for medium-sized projects. While access to capital has not been identified as a key barrier, experience with other industrial program areas indicates that it may be. Industrial firms tend to invest in spurts when they reach a certain point in their own capitalization and improvement cycle. Money for support system improvements can be hard to find at other times. Other interests tend to be funded more readily than efficiency projects. Bill financing, if structured to provide a positive cash flow, can make the job of selling the improvement within the industrial firm simpler, more direct, and quicker. If packaged with a guarantee, it will simplify the private-sector job of offering turnkey services to medium-sized customers. Private-sector firms would only have to package analysis, installation, and O&M services.
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance

f. Consider rebates, but only as a fallback option. PEA/RIA did not find evidence that rebates help transform compressed air service markets, but neither was it clear that they do not. Generally speaking, compressed air rebates have focused on equipment or other limited options, not on system improvements. Thus, it is difficult to say what their ultimate impact could be. Respondents expressed a variety of views about rebates. All respondents who volunteered comments on the issue believed that rebates helped make savings transactions happen, or at least happen faster, and, with appropriate technical services to assure quality resulted in cost-effective savings. Many wished rebates were still around, but there was considerable skepticism regarding whether they durably change market behavior. One manufacturer stated that rebates help sell high-efficiency compressors, the operator is likely to revert to buying lowest-cost equipment next time unless the high-efficiency unit has significant advantages in terms of ease of operation or reliability. He noted that equipment operators never see an electric bill, so they don’t care about energy savings. Another respondent thought that rebates close a sale by preventing customers from having to think about the benefits, and this acts against the interests of market transformation.

It will probably be important for the Alliance to help pay for measures for some demonstrations, to assure comprehensiveness. However, beyond demonstrations, we are not convinced that rebates are the best market transformation tool. At the same time, we recognize that guarantees and bill financing, which would be more effective in moving the medium-sized market toward a pattern of investing in efficiency, may be difficult for the Alliance and utilities to do. Rebates may therefore be a second-choice fallback strategy, offered due to their relative simplicity for the offeror.

5. Education and Quality Control for Small Systems

Smaller systems (<100 HP) present the most limited technical opportunities with the lowest odds for market transformation. Yet, these systems include about a third of the region’s compressed air horsepower, so it may be important to at least explore opportunities.
Rebates excepted, the strategies outlined in the four prior sections are unlikely to be effective for small systems. Customers will not take the time to obtain all-day compressed air training. These smaller systems are very low-priority for consultants and of no interest to ESCos and ESPs. Given the scale of potential savings, it is not practical for the Alliance to provide extensive on-site technical consultation. Therefore, the primary contact will continue to be with distributors at those times when a new compressor purchase is being considered.

The efficiency options may be largely limited to those that distributors will promote to small customers and those that can be explained on the telephone and implemented by staff. This limits the options to high-efficiency compressors, some simple controls, and basic operations and maintenance. To encourage these measures, we suggest the following initiatives:

a. **Promote Sales of Efficient Compressors** through bill stuffers, promotional information mailed to customers and distributors, and a 1-800 telephone service to help advise customers at the time of purchase. The 1-800 service is particularly important because selection of efficient small systems is not as simple as it would appear. For example, some two-stage small compressors are less efficient than their one-stage counterparts unless loads vary significantly.

b. **Encourage good basic O&M** through the same channels, with an emphasis on development and use of a written checklist.

Efficiency improvements in the small system market are feasible. We know of one utility in the Northeast that processes a significant number of rebates on efficient small compressors because the distributors have recognized the sales value of the rebate. This same utility recommends some basic controls improvements on systems over about 50 HP. However, we have little evidence to argue that there is any certainty about transformation of this market.
V. Market Structure, Market Barriers, Opportunities, and Options for the Alliance


VI. Bibliography


Appendix A: Technical Experts Interviewed for this Report

Appendix B: Expert Interview Discussion Guide

Appendix C: Equipment Vendors, Engineering Consultants, and Energy Service Companies Interviewed

Appendix D: Distributor Interview Guide

Appendix E: Consultant Interview Guide

Appendix F: Estimates of Compressed Air Energy Savings Potential
Technical Experts Interviewed for this Report
Technical Experts Interviewed for this Report

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization and Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrew DeLaski</td>
<td>Consortium for Energy Efficiency, Boston, Massachusetts</td>
</tr>
<tr>
<td>Neal Elliott</td>
<td>American Council for and Energy Efficient Economy, Washington, D.C.</td>
</tr>
<tr>
<td>Nikhil Gandhi</td>
<td>Strategic Energy Technologies, Acton, Massachusetts</td>
</tr>
<tr>
<td>Steve Kidwell and Tom Phinney</td>
<td>Union Electric</td>
</tr>
<tr>
<td>Gil McCoy</td>
<td>Washington State University, Pullman, Washington</td>
</tr>
<tr>
<td>Bruce Medaris</td>
<td>Association of Facilities Engineers, Cincinnati, Ohio</td>
</tr>
<tr>
<td>Aimee McKane</td>
<td>Lawrence Berkeley Laboratories, Washington, D.C.</td>
</tr>
<tr>
<td>Tim Newcomb</td>
<td>Seattle City Light, Seattle, Washington</td>
</tr>
<tr>
<td>John Vranizan</td>
<td>Carroll, Hatch and Associates, Portland, Oregon</td>
</tr>
<tr>
<td>Lyle Wells</td>
<td>Retired from Rogers Machinery</td>
</tr>
<tr>
<td>Greg Wheeler</td>
<td>Oregon State University, Corvallis, Oregon</td>
</tr>
<tr>
<td>Bob Zdebski</td>
<td>Electric League of the Pacific Northwest, Bellevue, Washington</td>
</tr>
</tbody>
</table>
Technical Experts Interviewed for this Report
Expert Interview Discussion Guide
1. Where do you see significant opportunities for savings?
   ___ Leak detection and management
   ___ Compressor efficiency
   ___ Compressor auxiliaries (e.g., refrigeration)
   ___ Individual compressor controls (e.g., loading, component shutoff)
   ___ Compressor sequencing and coordination
   ___ Improvements to the loop design
   ___ Compressor O&M (beyond controls upgrades)

2. What’s the relative opportunity for savings during:
   ___ New system design
   ___ System expansion
   ___ System troubleshooting due to poor performance
   ___ Compressor failure
   ___ System optimization

3. To what extent has your utility’s program been able to take advantage of each type of opportunity?

4. How do savings differ for large vs. small systems? Where are the break points? What are the implications for program and market development?
5. What sort of market activities have you seen re: compressed air efficiency?

6. To what extent do they focus on:
   ___ Leak detection and management
   ___ Compressor efficiency
   ___ Compressor auxiliaries (e.g., refrigeration)
   ___ Individual compressor controls (e.g., loading, component shutoff)
   ___ Compressor sequencing and coordination
   ___ Improvements to the loop design
   ___ Compressor O&M (beyond controls upgrades)

7. What do you see as the major barriers to creating a sustainable improvement in compressed air efficiency?
   A. Internal
   B. In terms of consultant services?
   C. How important are A vs. B?

8. Yes, yes, rates and interest are barriers. Do you see them as insurmountable? What would get the attention of building managers? What would make it easier for them to say “yes”? 
9. Any data on resource potential? (Supply curves, etc.) What publications are most useful in describing the resource and the market?

10. Who is selling compressed air services? What type of services?


12. Who knows the most about this market?
Appendix C

Equipment Vendors, Engineering Consultants, and Energy Service Companies Interviewed
# Equipment Vendors, Engineering Consultants, and Energy Service Companies Interviewed

## Equipment Vendors and Distributors

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben Richards</td>
<td>R&amp;R Compression,</td>
<td>Seattle, Washington</td>
</tr>
<tr>
<td>Bob Wilson</td>
<td>Portland Compressor,</td>
<td>Portland, Oregon</td>
</tr>
<tr>
<td>John Savoy</td>
<td>Ingersoll-Rand,</td>
<td>Vancouver, Washington</td>
</tr>
<tr>
<td>Mike Smeltzer</td>
<td>Rogers Machinery,</td>
<td>Portland, Oregon</td>
</tr>
<tr>
<td>Lyle Wells</td>
<td>Retired, formerly with Rogers Machinery</td>
<td>Portland, Oregon</td>
</tr>
<tr>
<td>Robert Harder</td>
<td>Misco,</td>
<td>Boise, Idaho</td>
</tr>
<tr>
<td>Bruce Odegaard</td>
<td>Dickinson Equipment,</td>
<td>Seattle, Washington</td>
</tr>
<tr>
<td>Rob Logsdon</td>
<td>Compressed Air Products,</td>
<td>Vancouver, Washington</td>
</tr>
<tr>
<td>Dave Jolly</td>
<td>Beckwith &amp; Cuttel,</td>
<td>Vancouver, Washington</td>
</tr>
<tr>
<td>Gary Beckwith</td>
<td>Beckwith &amp; Cuttel,</td>
<td>Seattle, Washington</td>
</tr>
<tr>
<td>Harry Walp</td>
<td>Mitchell, Lewis &amp; Staver,</td>
<td>Redmond, Washington</td>
</tr>
<tr>
<td>Jan Osterburg</td>
<td>Air Equipment,</td>
<td>Boise, Idaho</td>
</tr>
</tbody>
</table>
Equipment Vendors, Engineering Consultants, and Energy Service Companies Interviewed

Engineering Consultants and Energy Service Companies

Rick Bell  Pneumatech
Scott Stroup  Braco Energy Services
Eric Bessey  Self-employed
Greg Page  Abacus Engineering
John Shinn  Self-employed
Marcus Wilcox  Cascade Energy Engineering
Dick Wilson  Self-employed
Dave Vanderbeek  AirLogic
Bruce Poulin  Self-employed
John Vranizan  Carroll, Hatch and Associates
Jim Volkman  PG&E Energy Services Northwest
Curt Thieldmann  Duke Solutions
Michael Rohen  Honeywell
Chris Galati  Enron Energy Services
Appendix D

Distributor Interview Guide
Distributor Interview Guide

Interview Guide

DISTRIBUTORS

ALLIANCE COMPRESSED AIR SERVICES MARKET ASSESSMENT

Name ______________________________________________________

Phone Number/Address ______________________________________

____________________________________________ ________________

Date Time Response

Is this ________________________?
   If yes go to Introduction.
   If no, ask to make an appointment and call back
   If no, and no longer there, ask for another contact number

Introduction: I am _____________ of RIA. RIA is a market research firm in Portland, Oregon. We are conducting a research project for the Northwest Energy Efficiency Alliance, a consortium of Northwest utilities and public energy agencies. We are asking consulting engineers who provide services for compressed air systems questions about services they are providing and might be providing in the near future. Your responses will be confidential. The questions take about 15-20 minutes. Is now a good time to talk?

Alternative description of the Alliance: a not for profit corporation interested in investing in energy efficiency opportunities.

RESEARCH IN THE MARKET FOR COMPRESSED AIR EFFICIENCY
1. Do you are someone in your firm provide services for compressed air systems?
   1. Yes
   2. No - Ask if they know anyone who does, and terminate once confirmed they really do not. Follow-up with references.

3. How would you describe the geographical area for sales and service covered by your shop? (That is by which states, cities, counties?)

4. When you talk with customers and clients about compressed air services, what is the job title of the person at the plant who is most likely to be interested?
   1. Plant Engineer/Facilities Manager/Plant Manager
   2. Facilities Planner
   3. Plant Maintenance Manager/Supervisor
   4. Plant Maintenance staff
   5. Financial Officer/Purchasing Agent/CFO
   6. Other
5. We have developed a list of possible service activities compressed air consulting engineers might offer, which ones do you currently provide to your customers. We would like to know whether your are providing each of these types of service and whether you think there is potential for this type of service.

<table>
<thead>
<tr>
<th>Service Activity</th>
<th>Are you selling X at this time?</th>
<th>How many projects per year?</th>
<th>HP Size appropriate for A=&lt;100 B=100-500 C=&gt;500 D=all</th>
<th>Plan to increase business in this area?</th>
<th>If “no or not sure”, What is the primary reasons you are not sure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Efficiency compressors</td>
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<tr>
<td>Compressor O&amp;M (e.g. other than controls upgrades)</td>
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<tr>
<td>Air compressor System surveys</td>
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<tr>
<td>System O&amp;M including leak detection and management services</td>
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</table>
## Distributor Interview Guide

<table>
<thead>
<tr>
<th>Service</th>
<th>Selling service?</th>
<th>Projects per year?</th>
<th>A=&lt;100</th>
<th>B=100-500</th>
<th>C=&gt;500</th>
<th>D= all</th>
<th>Plan to increase business?</th>
<th>If “no or not sure”, What is the primary reasons you are not sure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressor sequencing and individual compressor controls services to operate compressor at most efficient mode</td>
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<tr>
<td>Compressor auxiliaries (e.g., dryers, filters) optimization</td>
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<td>System monitoring (kW, kWh, CFM, PSI)</td>
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<tr>
<td>Improved piping design to minimize pressure drop.</td>
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<tr>
<td>Process tool assessment and optimization</td>
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<td>Other</td>
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</table>
6. For each of the following, I’d like to know about whether your firm offers the capability and how your customers value the service.

1=Yes  2=No  3=Not sure

<table>
<thead>
<tr>
<th>Service</th>
<th>do you offer X at this time?</th>
<th>Could your firm offer?</th>
<th>Would customers benefit?</th>
<th>Do customers want service?</th>
<th>Is there a large scale market?</th>
<th>If “no or not sure”- What is the primary reasons you are not sure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Design</td>
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<td>System Financing</td>
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<td>Guarantee System Performance</td>
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<tr>
<td>Manage System Installation</td>
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<tr>
<td>Unit Pricing contracts</td>
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<tr>
<td>(note if energy or air, for air if to facility or to tools and what type, PSI &amp; flow or CFM, or ???)</td>
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</table>

Just a few last questions
7. The NW Energy Efficiency Alliance is trying to find a means to permanently improve the prospects for firms such as yours to make money selling more services for compressed air systems. They are not interested in offering rebates forever, but might make some investments in the short term. What do you think the Alliance could do to improve the conditions for selling services for compressed air systems?

8. What other air services companies in the Pacific Northwest region (Montana, Idaho, Oregon, Washington) are selling compressed air services? (Probe for a contact name and phone number if possible - city and state at a minimum)

9. Approximately how many of firms that you know of have compressed air horsepower?  (What industries? is to get top of mind view not detailed probing.)
   ______ Greater than 2000 HP, what Industries _________________________________
   ______ from 1000-2000 HP, what Industries _________________________________
   ______ from 500-1000 HP, what Industries _________________________________
   ______ from 200-500 HP, what Industries _________________________________
   ______ less than 200 HP, what Industries _________________________________
Appendix E

Consultant Interview Guide
Interview Guide
CONSULTING ENGINEERS
ALLIANCE COMPRESSED AIR SERVICES MARKET ASSESSMENT

Name _________________________________________________________________
Phone Number/Address ________________________________________________________________________________________________

Date __________ Time __________ Response

Is this _______________________?
If yes go to Introduction.
If no, ask to make an appointment and call back
If no, and no longer there, ask for another contact number

Introduction: I am ________________ of RIA. RIA is a market research firm in Portland, Oregon. We are conducting a research project for the Northwest Energy Efficiency Alliance, a consortium of Northwest utilities and public energy agencies. We are asking consulting engineers who provide services for compressed air systems questions about services they are providing and might be providing in the near future. Your responses will be confidential. The questions take about 15-20 minutes. Is now a good time to talk?

Alternative description of the Alliance: a not for profit corporation interested in investing in energy efficiency opportunities.
1. Do you or someone in your firm provide consulting engineering for compressed air?
   1. Yes
   2. No - Ask if they know anyone who does, and terminate once confirmed they really do not. Follow-up with references.

2. What proportion of your total business revenues are from consulting engineering for compressed air services, including everything from design to troubleshooting to optimization or redesign.

3. How would you describe the geographical territory covered by your company? (PROBE: That is by which states, cities, counties?)

4. When you talk with customers and clients about compressed air services, what is the job title of the person at the plant who is most likely to be interested?
   1. Plant Engineer/Facilities Manager/Plant Manager
   2. Facilities Planner
   3. Plant Maintenance Manager/Supervisor
   4. Plant Maintenance staff
   5. Financial Officer/Purchasing Agent/CFO
   6. Other
5. We have developed a list of possible service activities compressed air consulting engineers might offer, which ones do you currently provide to your customers. We would like to know whether you are providing each of these types of service and whether you think there is potential for this type of service.

1=Yes  2=No  3=Not sure

<table>
<thead>
<tr>
<th>Service Activity</th>
<th>Are you selling X at this time?</th>
<th>How many projects per year?</th>
<th>HP Size appropriate for A=&lt;100 B=100-500 C=&gt;500 D=all</th>
<th>Plan to increase business in this area?</th>
<th>If “no or not sure”, What is the primary reasons you are not sure?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air compressor System surveys</td>
<td></td>
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</tr>
<tr>
<td>System monitoring (kW, kWh, CFM, PSI)</td>
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<tr>
<td>Compressor sequencing and individual compressor controls services to operate compressor at most efficient mode</td>
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<tr>
<td>Compressor auxiliaries (e.g., dryers, filters) optimization</td>
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<tr>
<td>Service</td>
<td>Selling service?</td>
<td>Projects per year</td>
<td>A=&lt;100 B=100-500 C=&gt;500 D= all</td>
<td>Plan to increase business?</td>
<td>If “no or not sure”, What is the primary reasons you are not sure?</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
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<tr>
<td>System O&amp;M including leak detection and management services</td>
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<tr>
<td>Improved piping design to minimize pressure drop.</td>
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<tr>
<td>Process tool assessment and optimization</td>
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<tr>
<td>Other</td>
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</tbody>
</table>
6. For each of the following, I’d like to know about whether your firm offers the capability and how your customers value the service.

<table>
<thead>
<tr>
<th>Service</th>
<th>do you offer X at this time?</th>
<th>Could your firm offer?</th>
<th>Would customers benefit?</th>
<th>Do customers want service?</th>
<th>Is there a large scale market?</th>
<th>If “no or not sure” - What is the primary reasons you are not sure or say no?</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Design</td>
<td></td>
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<tr>
<td>Guarantee System Performance</td>
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<tr>
<td>Manage System Installation</td>
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<tr>
<td>Unit Pricing Contracts (note if energy or air, for air if to facility or to tools and what type, PSI &amp; flow or CFM, or ???)</td>
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</tbody>
</table>
7. The NW Energy Efficiency Alliance is trying to find a means to permanently improve the prospects for firms such as yours to make money selling more services for compressed air systems. They are not interested in offering rebates forever, but might make some investments in the short term. What do you think the Alliance could do to improve the conditions for selling engineering services for compressed air systems?

I have just a few last questions

8. What other consulting engineering firms in the Pacific Northwest region (Montana, Idaho, Oregon, Washington) are working on compressed air systems? (Probe for a contact name and phone number if possible - city and state at a minimum)

9. Approximately how many of firms that you know of have compressed air horsepower? (What industries? is to get top of mind view not detailed probing.)
   ____ Greater than 2000 HP, what Industries _________________________________
   ____ from 1000-2000 HP, what Industries _________________________________
   ____ from 500-1000 HP, what Industries _________________________________
   ____ from 200-500 HP, what Industries _________________________________
   ____ less than 200 HP, what Industries _________________________________
Appendix F

Estimates of Compressed Air Energy Savings Potential
Estimates of Compressed Air Energy Savings Potential

Battelle Pacific Northwest Labs Study

In 1994, Battelle Pacific Northwest Labs conducted an analysis of data from the national Energy Analysis and Diagnostic Center (EADC) energy audit survey (PNL, 1994). This analysis summarized potential savings on a percentage basis by two-digit SIC. The data was then adjusted to reflect the proportions of each SIC in Northwest U.S. loads.

It is important to recognize several caveats when using this data:

1. The audits primarily focused on short-payback and operations and maintenance improvements; major hardware enhancements are not commonly included in EADC audits.

2. Based on eligibility for the EADC program, there may be biases toward smaller facilities and those measures that can be analyzed and recommended quickly.

3. EADC audits often do not involve extensive load monitoring, which may limit the accuracy of savings projections.

4. The analysis excluded the primary metals industry due to lack of data. We know of at least one consultant who is focusing primarily on energy efficiency opportunities for compressed air in the Northwest primary metals industry, and many others mentioned this industry has having compressor systems of 1000 HP or more. So we know that this is a significant gap.

5. The industrials plants within a two-digit SIC may differ between the national sample included in the PNL study and the firms in the Northwest. This may be particularly true for the chemicals industry. The PNL study showed great economic potential, but we heard little from distributors about significant chemicals industry compressor use or purchase.

With these caveats in mind, the EADC audits still provide significant information about potential savings.
Estimates of Compressed Air Energy Savings Potential

It is notable that, among the industrial end-uses studied in the EADC audits, compressed air provided the largest source of savings. The primary types of measures for compressed air recommended in the study were fixing leaks, relocating air intake to take advantage of cooler air, and reduced pressure. Thus, the emphasis was not on complex staging controls, loop enhancements, or end-use fixes. The study estimated that the total technical potential in the northwest US was 1.4 MkWh/year, or 169 Average Megawatts.

The share of potential compressed air savings in the northwest US by industrial SIC is shown in Figure F-1.

Average compressed air savings potential as a percentage of facility load, by SIC code, is shown in Table F-1. It is striking that the savings is above 10% for the two most important SICs in the Northwest: Pulp and Paper (SIC 26) and Lumber and Wood Products (SIC 24). Savings are even higher for Rubber and Plastics (SIC 30) and Machinery, excepting Electrical (SIC35). This savings potential may be accurate, or may reflect conditions at smaller plants. SIC 26, in particular, is dominated by very large plants. It is also PEA’s experience that the scale and operation of pulp and paper plants differ by geographic region. Thus, these results should be interpreted with caution.
Estimates of Compressed Air Energy Savings Potential

Table F-1 Savings As A Percent Of Facility Load

<table>
<thead>
<tr>
<th>SIC CODE</th>
<th>CATEGORY</th>
<th>PERCENT OF SAVINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIC 30</td>
<td>Rubber and Plastics</td>
<td>38%</td>
</tr>
<tr>
<td>SIC 35</td>
<td>Machinery, Except Electrical</td>
<td>22%</td>
</tr>
<tr>
<td>SIC 26</td>
<td>Pulp and Paper</td>
<td>17%</td>
</tr>
<tr>
<td>SIC 25</td>
<td>Furniture and Fixtures</td>
<td>15%</td>
</tr>
<tr>
<td>SIC 34</td>
<td>Fabricated Metals</td>
<td>15%</td>
</tr>
<tr>
<td>SIC 24</td>
<td>Lumber and Wood Products</td>
<td>14%</td>
</tr>
<tr>
<td>Misc</td>
<td>Others</td>
<td>Between 5% and 12%</td>
</tr>
</tbody>
</table>

The PNL study estimated costs for specific measures as between $.016 and $.057/kWh (not levelized). Less expensive measures dominated.

Oregon State University Case Studies

Oregon State University (OSU) did seven case study audits for BPA using AIRMaster. As with the Battelle PNL study, it is important to note several limitations of the data set:

- These plants were selected for the presence of multiple compressors and for leak problems.

- Medium-sized facilities with compressor capacity between 150 and 500 HP were targeted.

- The AIRMaster software, and the users, focus on using and staging compressors more effectively through controls, and on improvements to the loop and end-use devices. For example, OSU defined some end-uses as “leaks to be fixed.” Compressor and compressor component replacement were not considered and limited attention was paid to the appropriateness of end-uses.

- The analysis appeared to assume that perfect leak management is possible. As discussed elsewhere in this report, ongoing leak
management is a significant dilemma and perfection does not appear to be a reasonable goal.

The selected facilities included a bakery, a sawmill, a secondary wood process plant, a metals fabrication plant, two foundries, and a small electronics plant.

For these plants, the kWh-weighted average projected savings were 49% of compressor electric load with a range of 30-71% of compressor electric load. Savings averaged about 8% of facility electric load. Costs averaged $13,000 per plant, with a weighted average projected payback, based on electric savings, of half a year. Paybacks varied from plant to plant between .1 and 1.3 years. The average cost was projected as $.023 per annual kWh saved.  

Context for These Estimates

While the savings estimates from these studies appear to be quite dramatic, they are borne out at least anecdotally by the experience of the compressed air efficiency experts that we interviewed, and by the expert included in our research team. It is commonplace for the better consultants to recommend removing a compressor from the system, or deferring purchase of a new compressor due to reduced load after system improvements.

Furthermore, experience with programs for compressed air efficiency (HEC 1995) indicate that some audits may be conservative in relation to actual savings. New England Electric generally finds in their evaluations, that compressed air savings exceed the engineering estimates developed to qualify measures. This could be an artifact of New England Electric’s program rules, which pay incentives only on measures with a payback of longer than 18 months. This may prompt vendors to “lowball” savings. Many of the measures were close to the 18-month payback level even though they often involved significant hardware improvements. New England Electric’s experience points to the possibility that audits projecting high savings and low costs may be reasonable. It also indicates that even

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6 In other words, $.023 per kWh saved in the first year. If the typical measure life was three years for savings, the cost per kWh would be a third of this amount.

7 New England Electric’s evaluations did not include an estimate of the percent of facility load saved.
measures involving significant hardware improvements may be relatively inexpensive.

While the data available are flawed and limited in scope, they clearly point to the potential for significant savings and low costs from compressed air system efficiency improvements.
Estimates of Compressed Air Energy Savings Potential