Why Is the Treasure Still Buried?
Breaching the Barriers to Compressed Air System Efficiency

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ABSTRACT

The authors conducted a literature review and market player interviews to assess the level of activity and potential for market transformation to efficient compressed air systems in the Northwest United States. Potential savings in the Northwest are large, perhaps 150 Average MW. Savings are sometimes a significant share of plant electric use. Paybacks can be less than a year and, where the number of compressors is reduced, total capital costs can be reduced.

In spite of this, knowledge of efficiency and current activity is limited. Many customers are not aware of the cost of compressed air. Most of the local service and equipment providers deal with limited aspects of the compressed air system, even though a system-wide approach provides a much better financial reward.

For all but the largest customers, the size of annual dollar benefits limits the interest in developing customer expertise. Therefore, customers must outsource planning or turnkey installation of system enhancements to a trusted contractor. Yet contractors are positioned to offer this service only for the largest customers.

Education and demonstration efforts (featuring non-energy benefits) may by themselves accelerate activity among the largest systems – those over 300-500 HP. However, about half of the horsepower is in smaller systems. For 100-300 HP systems, the focus should be on building business alliances which offer integrated services to customers of that scale. This may require significant and sustained support. For systems under 100 HP, market transformation may be difficult. The best approach may involve hotline advice and mailings.

Introduction

The Northwest Energy Efficiency Alliance (the Alliance) is a regional organization in the Northwest United States dedicated to transforming energy product and services markets in ways that enhance efficiency. The Alliance contracted with 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 the consultants to identify if assistance from the Alliance could help businesses profitably and sustainably address more compressed air efficiency opportunities than are currently being met.

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

Research Design

The literature review 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.

A national compressed air efficiency expert was included in the research team, and structured, open-ended interviews were conducted with twelve additional regional and national experts.

Additional interviews were conducted with: 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 that 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, the research team contacted 26 market actors, 23 of which provided data. Respondents included nine consulting engineers, four Energy Service Companies/Energy Service Providers (ESCos/ESPs), nine compressed air equipment distributors, and one manufacturer's representative.

The data proved quite useful for understanding market dynamics, but was not sufficient for precise quantification of market size or savings potential, due to limitations of the sample and the imprecise, sometimes limited, and overlapping nature of the responses. *Approximations* of some quantitative market parameters are included in this report. The research team believes that more precise data on compressor loads is attainable only through an extensive customer survey, and that more precise data on baseline efficiencies is possible only through extensive site audits.

Research Findings

The key finding is that there are significant opportunities to save energy in the compressed air marketplace, and that a combination of recruitment, training, and demonstration could lead to significant transformation (i.e., sustainable, increased levels of system retrofit activity) among large systems (over about 500 HP). 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 easy 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 (Maxwell 1994; Vranizan 1993).

The most prominent national compressed air efficiency consultants focus first on establishing a baseline for hourly loads and compressed air pressure and volume. Then they may perform low-cost control adjustments to capture easy savings and show the customer some success. Next they work sequentially to optimize the system, starting with matching the needs of end users efficiently with end-use equipment, then on improving distribution, and finally readjusting the controls. Only after these elements are considered do they 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 (HEC, Inc. 1995; Skumatz 1998) get most of their savings from compressor and control changeouts. 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 to take a comprehensive systems approach.

Size of Market

A study of national data on savings, applied to Northwest loads (Parker1993), 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 estimated to be 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 (Parker 1993; Wheeler, 1997). Savings of over 10% of plant load were found in audits of many forest products industry plants (Parker 1993). Forest products is a key compressed air-using industry in the Northwest. However, we suspect that many of these audits were in smaller plants than are typical in the Northwest, so it is not clear that this level of savings is achievable in the Northwest forest products industry as a whole. One yet-unpublished national study provides smaller estimates of savings, so the estimates provided above might be considered an "upper bound" on achievable savings.

Utilizing data from contractors, engineering consultants, and experts, the consultants 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

The services industry consists of:

- A small number of **manufacturers** who have not traditionally focused on efficiency as a profit center. While their perceptions are beginning to change, their efficiency actions are limited.
- A few dozen **distributors** of equipment and services in the Northwest, with perhaps ten of these dominating sales. Some provide O&M services, and most provide efficient compressors on request, but their focus on efficiency is limited. Many have limited capabilities for assessing system efficiency opportunities.
- 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. Few of the analysis or O&M firms provide extensive metering services. Some are affiliated with, and promote, specific products that tend to narrow the focus of recommendations and may not always be appropriate. Thus, packaging and managing a comprehensive analysis and installation is often exclusively in the hands of customers, many of whom do not have the time or interest to take on this task.
- 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.

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

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.

Table 1. Estimated Volume of Compressed Air Services

Service	Provider	Volume (Projects/Year)
System Efficiency Surveys	Engineers, ESCos	20
System Load Monitoring	Engineers, ESCos	7
Compressor Controls/ Sequencing	Engineers, ESCos, some Distributors	9
Compressor Auxiliary Enhancements**	Mostly Distributors	59*
System O&M	Engineers	9***
Piping Design	Engineers, Distributors	14*
Process Tool Assessment	Engineers	6

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

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 air by the total cubic feet consumed 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.

Customer Perspective

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 and was partly supported by a parallel study of the motor market that included customer interviews (Gordon et al. 1998a, 1998b).

Generally speaking, plant personnel try to keep systems working, with pressure set to levels that meet user demands. However 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 compressed air 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 of purchase 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. Others are listed in Table 2.

There are other cost savings related to reduced overhead, improved reliability, reduced staff time to attend and maintain systems, better performance, etc.

Market Barriers

The pattern of barriers appears to differ by size of compressor system. 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.

Table 2. 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)[1]
- Reduced worker safety issues (where inappropriate uses of compressed air are eliminated)[2]
- Improved ease of system operation

Recommendations

Overall Strategy

1. Focus primarily on efficiency improvements to existing compressed air systems.
2. The Alliance should pursue projects that: a) create opportunities by raising the awareness and comfort level of the large facility owners; b) help develop and demonstrate success for model service provider agreements with the facility owners; and c) make that information available to a variety of service providers.

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[1] 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.

[2] In one plant, employees were using high-pressure compressed air to cool themselves near a furnace, in violation of OSHA requirements.

3. For existing systems, the Alliance should focus on two types of efficiency opportunities:
   - System retrofit or upgrade; and
   - System operation and maintenance.
4. Separate strategies should be developed for different sizes of systems.
5. Work to establish mechanisms that allow facility owners to quantify the cost to operate and maintain the compressed air 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),[3] (CAC 1997a, 1997b) 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 complement 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 customarily "concept leaders" in the industry; 2) incorporate information on energy and, especially, non-energy benefits; 3) show how measurement and metering can help demonstrate energy benefits; and 4) include practical information to help firms with similar plants proceed.

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 and managing compressed air system improvements which are relatively simple. They need a single source for services, few procurement steps and limited and understandable 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;

[3] 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).

- 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 that 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), the goal should be to encourage purchase of appropriate compressors and controls. 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.

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