SAV-AIR – A Unique Public/Private Partnership for Industrial Compressed Air Market Transformation

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ABSTRACT

The SAV-AIR market transformation initiative is a unique public/private venture designed to significantly improve the energy efficiency of industrial compressed air systems in the Northwest region, and to maintain that efficiency over time. The project is showing that monitoring and controlling critical systems can not only save energy, but also improve system performance and reduce down time. The paper will discuss the approaches of the initiative in overcoming business development hurdles and barriers in the market.

The partners in this initiative are the Northwest Energy Efficiency Alliance (the Alliance) and SAV-AIR, LLC, a private company. By working together, the Alliance was able to initiate market transformation in the region and SAV-AIR received financial support.

Market transformation effects of the SAV-AIR initiative so far have included implementation of the SAV-AIR system at the sites of four large industrial customers, including one who plans corporate-wide adoption, and broad interest from other industries.

Introduction

The SAV-AIR market transformation initiative is a unique public/private venture designed to significantly improve the energy efficiency of industrial compressed air systems in the Northwest region, and to maintain that efficiency over time. The project is showing that monitoring and controlling critical systems can not only save energy, but improve system performance (often through stable air pressure) and reduce down time through fast problem solving and improved support. This paper discusses the approaches of the initiative in overcoming business development hurdles and barriers in the market. These include time-to-market issues, end-user ignorance of compressed air inefficiencies, and capital decision barriers in large industrial firms.

The partners in this initiative are the Northwest Energy Efficiency Alliance (the Alliance) and SAV-AIR, LLC, a private company. The goal of the Alliance, a private, non-profit consortium of Northwest private and public utilities, is to leverage market transformation in the region. The goal of SAV-AIR is to successfully develop, market, and sell an innovative monitoring and control approach for managing industrial compressed air systems. By working together, the Alliance was able to initiate market transformation in the region, and SAV-AIR received financial support.

Compressed air can be called the "fourth utility" in industrial facilities – after electricity, natural gas, and water. Compressed air is a safe, powerful and flexible resource for operating machinery, cooling, materials handling, and hand tools. However, it is seldom operated to minimize operating costs or optimize productivity, rather it is managed only to maintain production. Table 1 describes the magnitude of the compressed air market in the Northwest region (Xenergy & Easton 1999). For the Alliance, the Northwest includes the states of Oregon, Washington, Idaho, and Montana.

Table 1. Northwest Region Compressed Air Market Size

MOTOR SIZE	TOTAL AIR COMPRESSOR HORSEPOWER	NUMBER OF AIR COMPRESSORS	ENERGY USAGE, GWH	POTENTIAL SAVINGS, GWH
LESS THAN 200 HP	460,500	14,600		
MORE THAN 200 HP	412,500	600		
TOTAL	873,000	15,200	4,490	550

The most important issues concerning industrial compressed air efficiency and management are:

1. Compressed air is a significant industrial end-use in the Northwest region and is often an essential utility in industrial facilities;
2. Compressed air is a fundamentally inefficient energy transformation process where typically ten horsepower of electrical input provides only one horsepower of useful work;
3. Optimal operation of compressed air systems in industrial plants is seldom a priority, and adequate management information is rare, resulting in even less efficiency and often negative impacts on production; and
4. Compressed air systems are often not actively managed. System reliability is most often the primary and sometimes only concern. Risk avoidance and lack of energy cost accounting often leads to over-design of system and complacency in operation.

The Alliance and SAV-AIR Partnership

SAV-AIR was formed in 1997 to develop and implement integrated compressed air management systems that minimize operating costs and increase energy efficiency. The Alliance chose SAV-AIR as an initiative in December 1998 through a competitive bid process that sought innovative approaches to improving industrial compressed air efficiency. SAV-AIR's proposal stood out because of its comprehensive approach, and in particular its continuous, long-term monitoring to maintain efficiency over time which other proposals targeting compressed air did not include. The SAV-AIR market transformation initiative has been undertaken by the Alliance to change the way compressed air end-users and service providers view and manage this "fourth utility," and in doing so achieve not only energy efficiency-related benefits, but also non-energy benefits such as increased system reliability and stable air pressures. A further objective is for SAV-AIR to evolve into a self-sustaining business that will continue this work into the future.

The partnership between the Alliance, a private non-profit, and SAV-AIR, a private company, is unique. The Alliance took on some of the financial risk by investing in a new, proprietary technology that had been conceptualized and described by SAV-AIR, but had not yet been fully developed. This investment has in turn helped SAV-AIR leverage other sources of venture capital funding. Thus, through this unique business relationship, the Alliance has been able to initiate market transformation in the region, and SAV-AIR has received financial support to launch its venture.

The SAV-AIR approach provides management information on compressed air system performance that verifies savings on an ongoing basis. It also provides a method for diagnosing system problems, and state-of-the-art control capability. The SAV-AIR approach is analogous to viewing a complex system using a video camera for continuous feedback and adjustment rather than making decisions from a few snap shots taken over time.

The SAV-AIR approach takes advantage of three simultaneous trends occurring in the industrial market currently – the availability of high-quality but inexpensive computer control technology, a growing demand for, acceptance of, and capabilities of web-based information systems, and increased end-user interest in energy efficiency.

Compressed Air Systems and Practices

Compressed air can be a significant user of electricity, comprising from 10 to 35 percent of total electrical costs in many industrial sectors. A tool powered by compressed air uses as much as ten times the input energy as one that directly uses electricity (the remaining nine-tenths is waste heat). Yet in most plants, compressed air costs are "invisible" because they are not accounted for or measured. The priority for most firms is simply to avoid loss of air pressure that could bring production to a halt. Most systems are not run to minimize operating costs or to optimize productivity and product quality. In addition, compressed air leaks are generally ignored because they do not create a safety hazard or "mess" as might similar problems with hydraulic fluid, steam, or electrical systems, leaks. However, leaks are prevalent in industrial settings, sometimes as much as fifty percent of airflow goes to leaks rather than productive end-uses. Thus, most industrial compressed air systems operate at a fraction of their potential efficiency – and many owners do not know it. Thus, there are nearly always excellent opportunities for energy savings as well as other benefits from smarter compressed air system operation.

SAV-AIR is not the only firm promoting compressed air system optimization, and their approach is not the only approach. Other consultants are doing system observation, metering, analysis, and improvements. Some firms are also providing ongoing computer monitoring. Some of the approaches that have been used to improve the efficiency of industrial compressed air include audits, leak detection programs, and efficient compressor upgrades.

However, there are a number of important differences between SAV-AIR's approach and these others. The following are some of the key features that distinguish SAV-AIR:

- SAV-AIR's comprehensive, continuous monitoring approach verifies energy savings over time, and provides for long-term energy savings as compared to other approaches.
- SAV-AIR monitoring also provides opportunities for developing non-energy benefits such as improved product quality, increased production throughput, and other improvements on issues pivotal to plant managers and owners.
- SAV-AIR's approach and software streamlines compressed air system modeling, data reporting, and optimization. The software leverages the skills of the core SAV-AIR team, allowing skilled personnel to troubleshoot many disparate plants and locations.
- Since many industrial compressed air systems are under-maintained, implementation of SAV-AIR recommendations may increase O&M costs, but an overall improvement in reliability and productivity will result.

The SAV-AIR approach does have limitations and is not a universal solution for compressed air efficiency. Not every industrial management and maintenance staff will be able to take advantage of the detailed information provided by the SAV-AIR monitoring. Their approach is not suitable for smaller compressed air systems (less that about 300 horsepower) or for systems needing only one compressor. The SAV-AIR control strategy also has the greatest advantage for highly variable compressed air demands rather than for plants with uniform loads.

Other Compressed Air Optimization Approaches

Based on the findings from surveys and secondary sources, the largest source of potential efficiency opportunities is in improvements to existing compressed air systems (Xenergy 2000). 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 long-term monitoring to identify the benefits and the appropriate strategy, and to maintain savings over time. The following represent key technical opportunities in compressed air:

- Improved system operations and maintenance, including leak reduction;
- Compressor improvements;
- Better compressor unit control and sequencing;
- Improved cooling and dehumidification systems;
- Design and mechanical improvements to distribution piping and system configuration; and
- Improved end-use applications of compressed air.

A number of compressed air optimization approaches already offered in the general marketplace address these technical opportunities. The range of approaches includes periodic audits, detailed one-time system measurements, and leak detection and repair programs.

Periodic audits can identify and correct the cumulative problems in industrial compressed air systems. These are typically done through a system inspection and one-time measurements of performance. A compressed air system audit usually provides a technical and economic analysis of the compressed air system and also an evaluation of end-uses.

For plants with smaller total system horsepower, and stable production and air usage, an audit can be a reasonable way to identify more limited approaches to compressed air efficiency with short-term paybacks. However, some customers may benefit from a longer-term, comprehensive approach that provides diagnostic and performance feedback over time to improve practices or correct production problems.

Another approach is to provide more detailed measurement of compressor and system performance on an occasional basis. The measurement equipment might be utilized by in-house staff, allowing performance testing as needed. Some equipment can also be used to quantify air leaks, understand air consumption rates, and troubleshoot compressor and system controls. This approach is often suited to assessing the performance of air treatment systems such as dryers and filters, and to identify problems with air piping.

Another common element in other approaches is a leak detection program, while such a program is necessary, it is not sufficient for optimal system maintenance. Some utilities and equipment distributors have promoted compressed air efficiency through upgrades to more efficient compressors. Modern screw compressors can have much better full-load performance than older equipment, and it is considered straightforward to determine the savings and economic benefits of such an equipment upgrade. However, a systems approach that looks at compressed air demands and leak repair as well as supply, will sometimes negate the need for a new compressor, no matter how efficient.

The Compressed Air End-User and Services

The Compressed Air End-User

Surveys of end-users in the Northwest indicate a need for compressed air optimization and management information, but most end-users do not perceive that they have this need (Scott, Stout & Gordon 2000b). Although the vast majority think that compressed air is expensive, only about one-fourth have any idea what their own plant's compressed air costs are. Thirty percent of respondents have some kind of service contract for compressed air, but only one-third of those contracts included efficiency services.

Several other regional and national studies showed the top objectives of end-users in managing their compressed air systems were maintaining continuous operation, ensuring adequate supply of air, and maintaining air quality. Inadequate budgets, a focus on maintaining production, insufficient staff time, and lack of training were considered the top four barriers to effective operation of a compressed air system (Xenergy 2000, Scott, Stout & Gordon 2000b).

Altogether, the end-user surveys and other information sources suggest that:

- End-user awareness and action to comprehensively address and optimize compressed air efficiency are relatively rare, so there are significant savings opportunities.
- In prioritizing action for their plants, personnel are not necessarily focused on those that can provide the most energy savings.
- There is a real need for optimization and monitoring services, but this need may not be perceived by end-users themselves. Most end-users spend little time thinking about compressed air system efficiency.
- End-users value information on system performance, and there are problems with efficiency efforts that do not provide measurement.
- Compressed air system problems lead to significant and frequent production interruptions.
- Only about one-third of end-users say that they have leak prevention programs.

Compressed Air Services

Secondary sources also revealed important information about the national market for compressed air services (Xenergy 2000). These include:

- End-users have limited faith in their existing service providers to address compressed air efficiency.
- Only the top national compressed air efficiency consultants approach systems in a truly comprehensive way. By contrast, many other service providers, including other

consultants, vendors, and even utility programs achieve most of their savings from compressor equipment and controls.

- Many service providers say they are doing "system optimization," but at the same time do not offer the key service elements of true system optimization. In general, compressed air services remain fragmented, while customer needs are integrated.
- Many service providers are considering becoming more active in compressed air system efficiency, but indicate they will not move forward until they see definitive increases in customer interest.

Overview of SAV-AIR's Approach and Services

SAV-AIR provides integrated compressed air management systems and engineering services. The SAV-AIR approach includes remote monitoring and control of compressed air systems involving sensors, computers and software. They have expertise and specialized technology to evaluate existing equipment, engineer upgrades, and provide ongoing monitoring and control of an entire compressed air system. The result is increased compressed air system reliability, decreased compressed air costs, and management information for verification and decision-making. The SAV-AIR service approach is comprised of three delivery phases, described below.

Phase I – Performance Evaluation

A SAV-AIR Performance Evaluation is a comprehensive, accurate evaluation of an industrial compressed air system. The Performance Evaluation uses computer simulation of various operational scenarios to provide the basis for recommendations. The Performance Evaluation includes a walk-through inspection, and installation of monitoring equipment. Monitoring is conducted over a period of one to three weeks so as to be representative of normal plant operating cycles. Monitoring points include power and flow for each compressor, as well as selected pressures and temperatures.

Based on the measured compressed air "demand profile" and different operating scenarios, a simulation is performed that results in a calculation of total energy consumption for each scenario, including differences in energy demand and improvements in air delivery and pressure variations.

Phase II – System Optimization

In Phase II, the SAV-AIR Compressed Air Management System is installed along with other recommended system improvements. The Management System is an integrated control and monitoring system, customized for a specific industrial compressed air system. The SAV-AIR Compressed Air Management System's flow-based logic offers configuration flexibility and control stability that is often better than that provided by products that generally use pressure only. The system allows for local and remote monitoring and retains more than two-weeks of 10-second interval data.

Other recommended improvements may include repair, renovation, or upgrade of ancillary equipment including dryers, receivers, and individual compressor control systems where they are not compatible with the SAV-AIR Compressed Air Management System.

When implemented in an integrated improvement project, SAV-AIR controls can reduce energy costs by 25 to 50 percent and increase reliability. Its monitoring function verifies savings, and when integrated with SAV-AIR Ongoing Services, it can facilitate maintaining and improving those savings over time.

Phase III – Ongoing Services

The Ongoing Service Agreement is a comprehensive set of services to maintain the reliability and energy savings gained in a compressed air system upgrade project. Without it, the improvements gained could deteriorate because of increased leakage, control drift and operational and maintenance compromises, but mostly because of ongoing plant modifications and changing air requirements. The SAV-AIR Basic Remote Monitoring Service includes the ongoing maintenance of a detailed database on compressed air system operation and energy efficiency and Internet-based reporting.

Along with the monitoring, SAV-AIR offers engineering analysis on an as-needed basis, based on customer requests, alarms, and reports that indicate an issue of concern. Further, the energy savings associated with these services can be directly measured with the monitoring.

Industrial Market Transformation

The Alliance and Market Transformation

SAV-AIR is one of many initiatives that comprise the Alliance's market transformation approach to helping sustain energy efficiency initiatives as new market forces reshape the electric industry. This market transformation approach has been formally endorsed by the Alliance's Regional Review steering committee as a key demand-side strategy. Northwest utilities provide about $20 million in annual funding for the Alliance.

The Alliance is not intended to supplant all other conservation efforts undertaken by utilities, governments, the private sector, or others. The $20 million annual allocation represents only about one-seventh of suggested regional electric utility spending on energy conservation, renewable energy, and low-income energy services. In addition, some local market transformation ventures will occur outside the auspices of the Alliance.

Nevertheless, the Alliance's regional orientation to market transformation makes sense in several ways. From an economic standpoint, markets for products and services don't necessarily respect political or utility boundaries. A market transformation example: a major manufacturer is unlikely to be much interested in providing specific energy-efficient products for a single city or a single utility service territory – no matter how large the area or how enticing the incentive. Through collaboration and resource pooling, however, a region can enhance its influence over market practices. That influence can be strengthened even further through joint initiatives with other regions or nationally; the Alliance plans to take advantage of these opportunities where appropriate.

SAV-AIR and Market Transformation

Market transformation will sometimes use existing market players to influence the way things are done, and sometimes require supporting the development of new players. In the case of SAV-AIR, the Alliance had to create a new player as none existed that offered comprehensive, ongoing maintenance of savings in industrial compressed air systems. There may have been some companies that offered ongoing monitoring and diagnostics at the time the Alliance was looking for compressed air opportunities, but none of these firms were operating in the Northwest, nor did they submit a proposal.

SAV-AIR was selected in a competitive solicitation primarily because it had a comprehensive rather than piecemeal approach, and it offered ongoing services to maintain efficiency over time. Also part of the Alliance's market transformation objectives was that SAV-AIR's success would increase demand from customers for these types of services and so bring in additional service providers. As additional support for the decision to select SAV-AIR as the Alliance initiative to promote industrial compressed air efficiency, market research that predated the SAV-AIR project supported these conclusions. The overall direction for both the market and technical opportunities was that SAV-AIR was a reasonable choice to fulfill the market transformation needs for the Alliance.

Overcoming Barriers To Business Development

The most significant barrier to compressed air system efficiency is the tendency for industry to run compressed air systems only to drive production, rather than consider it as a utility that can be operated for both lowest cost and best productivity. General ignorance of compressed air inefficiencies, costs, and the benefits of improved management of compressed air systems leads to indecision and inaction.

Capital decision barriers are more of a problem for compressed air system optimization because compressed air costs are typically unknown and therefore no investments can be justified. The general tendency is to add compressors when system pressure drops, rather than consider any other solution. Compressed air investments need to compete against many other maintenance and production improvements and do not often fare well because it is difficult to justify them either economically or operationally without monitoring information.

For a start up organization like SAV-AIR, time-to-market is critical. Initial sales are essential, and delays in any sale can result in cash flow difficulties that a fledgling organization may have problems overcoming. Time-to-market issues are a typical result of the above two barriers and thus have been a problem for SAV-AIR. The SAV-AIR initiative is working to overcome this and other business development hurdles by broadening their marketing approach, being flexible in where they serve potential customers, and in looking to work with smaller compressed air systems than they might otherwise. For example, they have implemented their approach with compressed air systems as small as 200 horsepower rather than their initial target of systems larger than about 400 horsepower.

SAV-AIR Demonstration Projects

SAV-AIR has implemented four projects to date for various industries, each with quite different compressed air needs and system configurations. Three installations of the SAV-AIR approach are described below.

Mineral Processing Plant

A recent SAV-AIR project is a mineral processing facility in Montana. The goal of the processing plant was to obtain a more reliable compressed air system with lower operating costs. The existing compressed air system consisted of a total of 375 horsepower of plant compressors and a very inefficient desiccant dryer.

Before the SAV-AIR compressed air management was implemented, the compressed air operating cost were $175,000 per year, not including significant maintenance costs. In addition, the system was difficult to manage, contributing to unreliable operation, randomly fluctuating plant pressure (varying between 78-113 psig), poor air quality (wet air), and a complete lack of a unified control system. The plant operators had no system information and had little technical support for keeping the system running properly.

SAV-AIR not only installed its integrated compressed air management system, but also designed and specified a completely new compressor house with three new oil-flooded screw compressors – one with variable frequency drive and two standard machines, all of 150 horsepower. They also specified a new heated regenerative air dryer and appropriate air storage capacity. With this new configuration the measured annual energy costs are $77,000 per year, with much reduced maintenance costs. The measured energy savings are $92,000 annually. A graph showing before and after compressor energy use is shown in Figure 1. This comprehensive change also provides the processing plant with reliable equipment, stable air pressure (within 3 psig), uniform air quality, and access to real-time and historical performance data. A graph showing the impact of the improved system control on air pressure is shown in Figure 2.

Figures 1 and 2 respectively also represent the energy benefits and the non-energy benefits of the SAV-AIR approach. The first figure describes significantly reduced requirements for compressor power over a two-week period while delivering the same airflow. The second figure shows clearly a significant benefit to industrial plant operation in closely controlled system pressure as compared to the large fluctuations before improvements.

The changes to the plant's compressed air system required a new compressor building along with the other equipment described above, for a total cost of approximately $395,000. Because of the comprehensive nature of work needed at this plant it is not possible to determine a payback for the SAV-AIR compressed air control system alone. The overall payback based on reduced operating costs is about 4.3 years. However, the benefits to plant operation from stable air pressure and improved reliability are as important to this customer as operating costs.

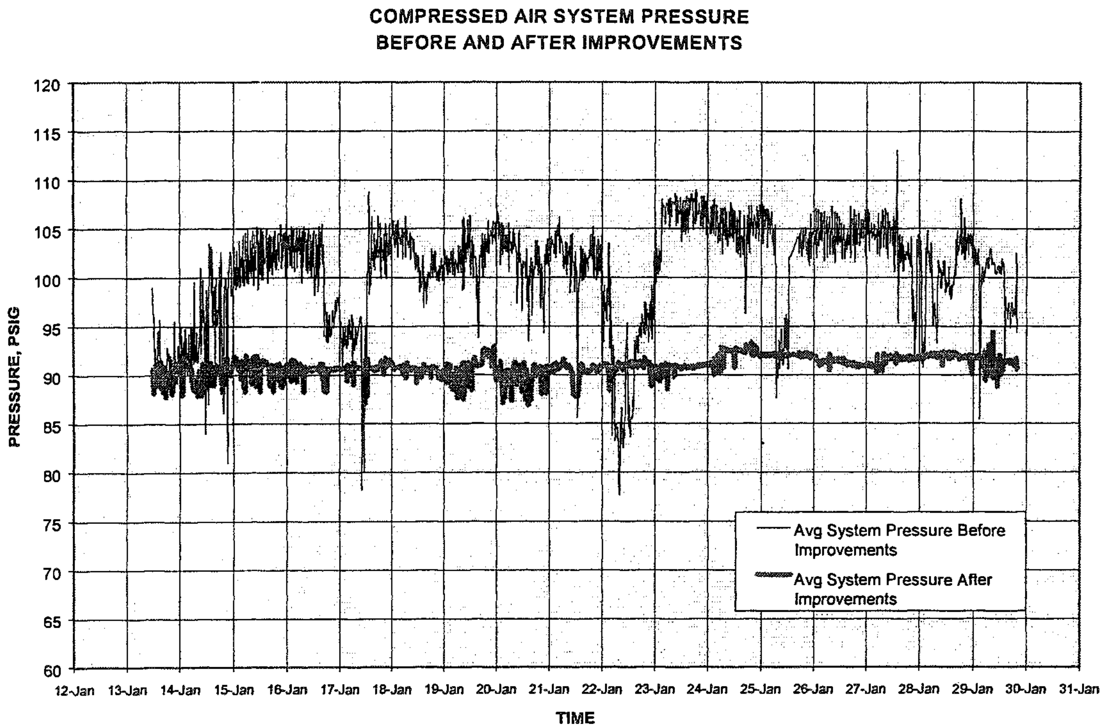

Figure 1. Compressed Air Power Before and After Improvements

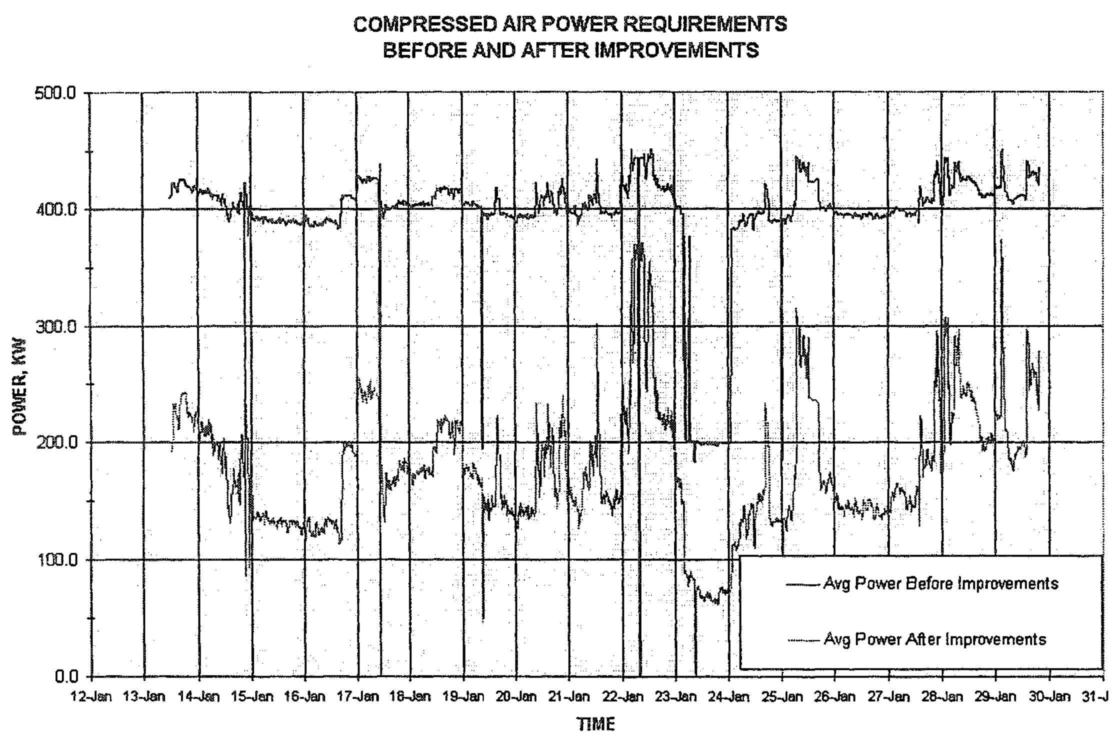

Figure 2. Compressed Air Pressure Before and After Improvements

Wood Products Plant

The first SAV-AIR demonstration project was a large wood products plant in Oregon with three air compressors totaling 550 horsepower. Existing problems with the air system included large fluctuations in pressure, poor air dryer performance, and no system operating information. The implemented measures included permanent comprehensive metering and new controls managed by the SAV-AIR system. The measured annual electricity cost for compressed air dropped from $175,000 to $120,000 with the SAV-AIR system, an annual savings of $55,000. Plant management now has accurate and ongoing information on compressed air system operation that was never available before. In addition to cost savings, non-energy benefits are improved pressure control, fully automated operation that reduces operator attention, and a new "no worries" attitude about management of compressed air.

The SAV-AIR compressed air management system provided networked control and monitoring capabilities for the three compressors located in different parts of this large plant. The project also involved correcting maintenance problems with the plant air dryers, and installing appropriately sized air storage. The total cost of all the SAV-AIR recommended modifications and equipment was $110,000. The simple payback based on these comprehensive system improvements was 2.0 years.

Specialty Cable Manufacturer

A demonstration of the SAV-AIR system in a smaller facility was with a fiber optic cable manufacturer in Oregon. The plant operates year-round, 24 hours a day. Their existing air system consisted of two 100 horsepower oil-flooded screw compressors, and a dual tower desiccant dryer. Operating problems with their existing controls included fluctuating system pressure (varying between 100-110 psig), no back up compressor, poor compressor performance (a SCFM to kW ratio of 4.5), and average annual compressed air energy costs of $53,300. Lack of compressor back up was a problem as the plant operates continuously and down-time is very costly.

The SAV-AIR management system was installed, along with other recommendations that included adding a new 150 horsepower air compressor for new capacity and system back up. The new system now has stable air pressure (within 1 psig) and much improved overall compressor performance (a new SCFM to kW ratio of 5.3). The plant with the SAV-AIR compressed air management system now has an average annual measured energy cost of $28,200, for savings of $25,100 per year. The project cost for the SAV-AIR equipment and installation, including the new compressor, was $52,000, resulting in an overall simple payback of 2.1 years.

Market Transformation Results

At the time this paper was prepared there are some clear market transformation outcomes as a result of the activity of the SAV-AIR initiative. In general, hoped for indicators of market transformation are that SAV-AIR becomes a viable and sustainable business, that competitors offering similar products and services enter the market, and that industrial end-users increasingly demand these services. The first two of these outcomes will only be established over time, while the latter seems to be occurring to some extent.

In terms of corporate-wide adoption, the owner of the plant where the first SAV-AIR project was installed is having SAV-AIR perform a Phase I Performance Evaluation and implement the Phase II Compressed Air Management System at a number of facilities nationwide.

In addition to these market transformation indicators, there is a general increase in awareness of SAV-AIR and it's merits among regional and national compressed air experts. Another indicator that SAV-AIR has a unique product in demand in the marketplace is the fact that several Northwest companies considered a SAV-AIR proposal and then turned around and publicly rebid the SAV-AIR approach. These companies were looking for other firms that could provide a similar product and service as SAV-AIR, perhaps at a more competitive price. In neither case did the companies receive responsive or competitive bids and therefore they selected SAV-AIR to provide comprehensive compressed air control and monitoring.

Market Transformation Next Steps

Next steps for market transformation are for SAV-AIR to increase sales and develop a distribution network for their approach. Some of this may be implemented through partnerships with energy service companies and utilities. The path for market transformation diffusion for SAV-AIR in the Northwest region may include projects outside of the region – as demonstrations for large corporations in other locations are used to justify implementing this approach locally. Adoption by additional plants of existing customers is expected, and diffusion across a broader range of industries will need to be part of market transformation.

About the Authors

Steven Scott, PE and Jennifer J. Stout are the team evaluating the market transformation impacts of SAV-AIR under contract to the Northwest Energy Efficiency Alliance. Dr. Philipp Degens is the Evaluation Coordinator and Blair Collins is the Project Coordinator for the SAV-AIR initiative for the Northwest Energy Efficiency Alliance.

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(Note that Northwest Energy Efficiency Alliance documents are published on their web site http://www.nwalliance.org/.)