

# **THE COMPRESSED AIR CHALLENGE: MAKING A DIFFERENCE FOR US INDUSTRY**

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## **ABSTRACT**

In 1997, the Compressed Air Challenge<sup>®</sup> (CAC) was developed as an outgrowth of the US Department of Energy's (USDOE) Motor Challenge program. The Challenge began as a voluntary collaboration managed by a sponsor, the Energy Center of Wisconsin, that included 15 sponsors from equipment manufacturers and distributors' associations, utilities, state research and development agencies, energy efficiency organizations, and the USDOE. The mission of the CAC is to develop and provide resources that educate industry on the opportunities and benefits attainable through compressed air system optimization.

In 2000, the CAC became an independent not-for-profit organization that continues a development and deployment model based on shared interests and shared costs among public, private, and not-for-profit organizations that serve industrial customers. Since the first CAC training session in 1999, approximately 3900 people have been trained by CAC qualified instructors- both end users and suppliers. Using the CAC cost-share model has allowed sponsors to offer a very high-quality training product at a relatively low cost. For instance, USDOE typically spends \$1 for each \$10 spent to offer a CAC training session.

This paper will summarize the findings of two recent independent evaluations were conducted by USDOE to assess the impact of CAC training and the market for compressed air efficiency services. One significant finding is that while approximately 76% of participants in the CAC training took specific actions within the 12-month period following training to improve the efficiency of their compressed air system, less than half of those randomly selected from the untrained population had taken any action at all in the past two years, including fixing leaks. Energy savings from improvements as a direct result of CAC training are conservatively estimated at \$12.1 million per year. The market assessment also offers the first documented evidence that the CAC is beginning to have an impact on the compressed air market in promoting and supporting a shift from a component-based to a system-based approach.

In 2002, the CAC sponsors have renewed their focus on training. Other projects recently undertaken by the CAC include: industry-driven enhancements to AIRMaster+ software; coordination with USDOE to offer training for industry professionals to become Qualified AIRMaster+ Specialists; coordination with Iowa State University on the first graduate engineering course on compressed air systems; publication of a Best Practices manual; and an Operators Certification program.

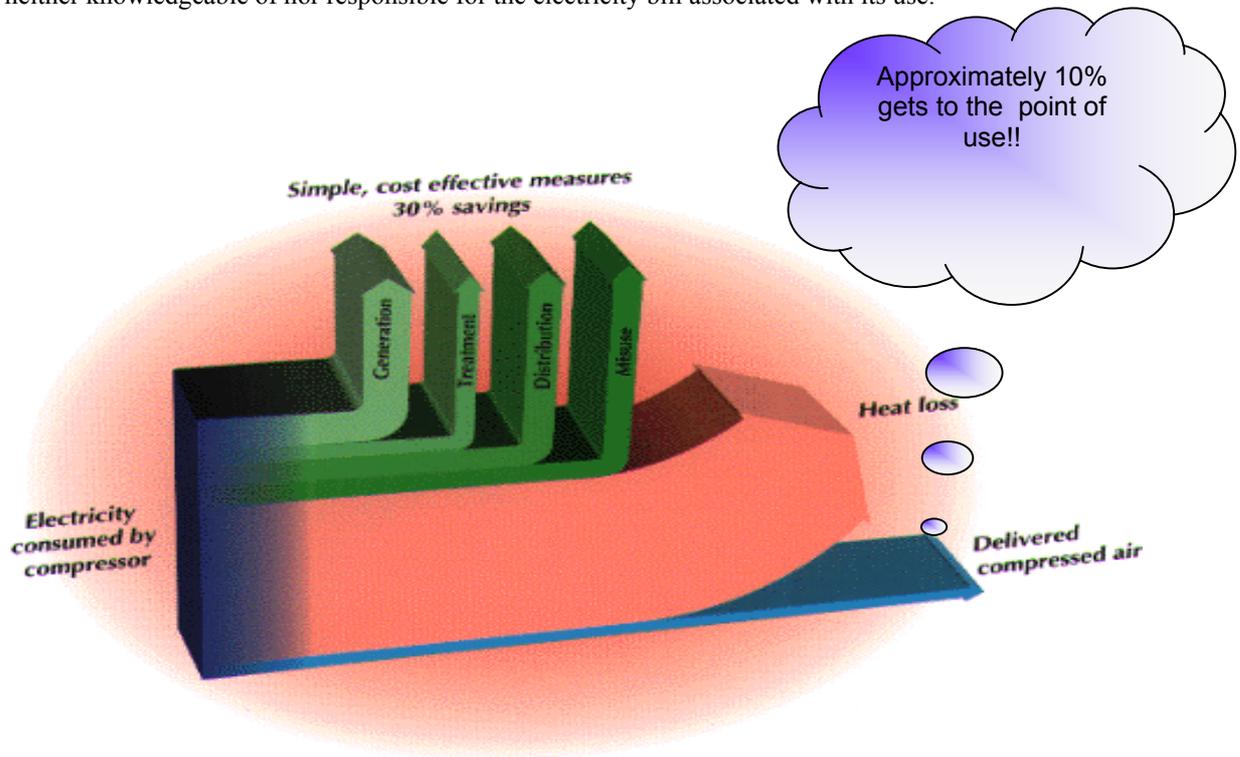
## **COMPRESSED AIR SYSTEM OPPORTUNITIES**

Optimization of compressed air systems represents one of the largest non-process, industrial energy efficiency opportunities, with improvements of 20-50% readily achievable through the introduction of a best-practices approach. Lack of information has been a primary barrier to realizing substantial improvements in the efficiency, reliability, and productivity of industrial compressed air systems. Compressed air systems in US manufacturing account for \$4.5 billion US (\$4.2 billion Euros) per year of energy costs and 21 MMTCE of total US carbon emissions (1-2 percent of total US emissions).

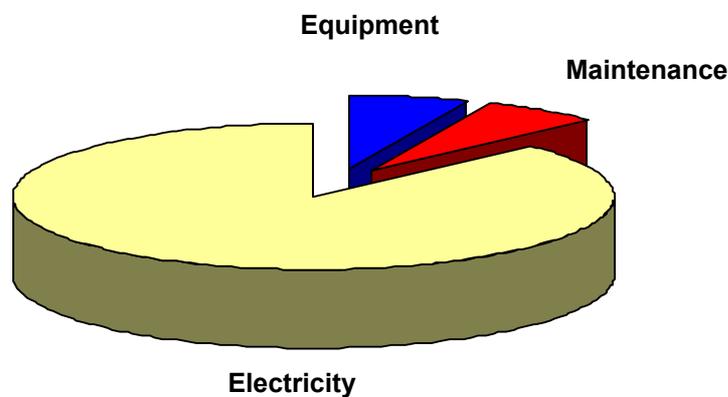
Compressed air is industry's "fourth utility"; it is central to production for many industries, including: chemicals, textiles, general manufacturing, plastics, mining, glass, pulp and paper, shipbuilding, furniture, automobile and aircraft manufacturing, iron and steel-making, and petroleum refining. Compressed air is used

extensively as a source of power for tools and equipment as well as in industrial processes for pressurizing, atomizing, agitating, and mixing applications.

Compressed air is the most expensive utility; a single compressor delivering 500 standard cubic feet per minute (scfm) 24-hrs per day can cost \$100,000 US (\$93,000 Euros) per year to operate. If the company using the compressor has a 5% net profit ratio, the cost of operating the compressor will be the equivalent of \$2 million US (\$1.85 million Euros) in production. In spite of its cost, this level of waste in a manufacturing facility is not uncommon, due to poor system operation coupled with a perception by production staff that compressed air is “free”. This is largely because compressed air is already present in distribution piping in the plant and the user is neither knowledgeable of nor responsible for the electricity bill associated with its use.



**Figure 1: 60-80% of the input energy to a compressed air system is converted to heat**



**Figure 2: The cost of operation far exceeds the purchase cost of a compressor**

An example of a market opportunity for improving compressed air systems is illustrated by the findings of the Assessment of the Market for Compressed Air Efficiency Services, completed for USDOE, in cooperation with

the Compressed Air Challenge in 2001. Phone interviews of 222 industrial compressed air users revealed the following:

- Only 9% identified controlling energy costs as a primary concern
- 71% identified **consistent, reliable compressed air supply** as a principle objective of system management
- 35% had experienced **unscheduled shutdowns** during the previous 12 months- 60% of these shutdowns were for 2 days or more
- 30% had service contracts- had no effect on incidence of shutdowns
- 75% of system operators had **no formal training** in compressed air system efficiency
- 57% had **taken no action** (include leak repair) to improve compressed air system efficiency in past 2 years

Overall, the Assessment findings indicated that compressed air users are not currently having their needs met by existing market delivery mechanisms, are unaware of the benefits of improving system efficiency, and are reluctant to purchase compressed air system efficiency services because they don't understand why they are beneficial. In short, there is still much work to be done to educate compressed air users.

## THE COMPRESSED AIR CHALLENGE

The Compressed Air Challenge® (CAC) was formed in 1997 and is an outgrowth of work on industrial partnerships begun under the US Department of Energy's (USDOE) Motor Challenge program. The themes which ultimately led to this project were first identified in the April 1995 Roundtable on Market Transformation Strategies for Industrial Motor Systems breakout session on compressed air systems. A general point of consensus at the Roundtable was that the major improvement opportunities are in the compressed air system, not the individual components.

The CAC is a voluntary collaboration that includes participation by USDOE, equipment manufacturers and distributors and their associations, facility operating personnel, consultants, energy research and development agencies, energy efficiency organizations, and utilities. In all, the CAC counts 15 separate organizations as sponsoring members, all of which contribute both funding and time to the collaborative efforts. Since 1997, the CAC has been successful in raising and managing a pooled resource of product development funds in excess of \$1 million. In 2000, the CAC was incorporated as a separate not-for-profit with an executive director.

The mission of the CAC is to increase awareness of the benefits of the systems approach to compressed air systems through training and education. Training is delivered in cooperation with the sponsors, with many sponsors hosting training at a discounted cost for their constituent groups. Organizations that are interested in hosting training but are not currently sponsors may host a CAC training in cooperation with a CAC sponsor, several of whom have a national scope.

The CAC has already accomplished the following:

- Published & distributed more than 4000 copies of Compressed Air Sourcebook
- Developed 1-Day Training "Fundamentals of Compressed Air Systems" & 2-day "Advanced Management of Compressed Air Systems"
- Qualified pool of 22 qualified CAC Fundamentals instructors; 10 qualified Advanced Instructors
- Trained more than 4000 end users, consultants, suppliers
- Website, more than 20 case studies, new projects

To accomplish its educational mission, the CAC must work with both the supply and use side of the market to shift the focus from individual components to a systems services approach. The strength of the CAC training is its emphasis on balancing system supply and demand.

Compressed air systems are especially dynamic- changes in demand over time can have dramatic effect on the volume of air required and the ability to sustain a stable system pressure. Taking a "systems approach" means using controls, storage, and demand management to design a system that meets peak requirements but also operates efficiently at part loads. Failure to address both situations leads to less than optimal performance, which can not only affect energy efficiency and cost of operation, but also may reduce productivity and reliability.

## Recent CAC Activities

Not everyone that the CAC would like to reach with the systems message can participate in a one- or two-day training workshop. In today's economic climate, it is particularly difficult for plant personnel to take time away from their principal duties to go to an offsite training session. In recognition of this situation, the CAC has worked to develop a more complete portfolio of information to complement the two types of training.

The first effort involved developing an ongoing relationship with a magazine widely read by plant engineers and maintenance supervisors. Beginning in the last quarter of 2000, articles on different aspects of compressed air system efficiency, written by CAC Instructors, have been appearing every other month in *Plant Services* magazine. These articles are specifically designed to promote the CAC system message included in the training by providing a more in-depth view of one system-related topic per issue. A total of 12 articles have been published to date and have been read by hundreds of thousands of plant engineers and maintenance supervisors.

This year, the CAC will be publishing a Best Practices Manual, which is designed as a solutions-oriented desk reference for plant engineers responsible for managing compressed air systems. The purpose of the document is twofold, to provide systems-oriented guidance to plant engineers who are unable to participate in training and to serve as supplemental information for those who have already received the training.

The CAC has also cooperated with Iowa State University to offer the first US graduate-level course on compressed air systems for engineering students in Spring 2002. The initial course offering, which was oversubscribed in its first semester, has been evaluated and incorporated into the standard course offerings of the University starting in January 2003. The January course is also oversubscribed, with 75 students registering. USDOE has recently awarded a grant to the University to support development of a textbook by Professor Michael Pate.

In response to the results of the Assessment of the Market for Compressed Air Efficiency Services, the CAC developed a consensus document that provides guidance to purchasers of compressed air system services. The same document also provides a working market definition for system analysis services. The purpose is to give both the supply and demand side of the market a common vocabulary and set of working definitions when selling and purchasing compressed air energy efficiency system services. The objective of doing this is to create an educated customer base that understands the value of these services and is willing to purchase them. This document -*Guidelines for Selecting a Compressed Air System Service Provider*- includes criteria for obtaining quality energy efficiency services and also defines three levels of compressed air system analysis as follows:

- Walkthrough evaluation
- System Assessment
- System Audit

The CAC is working with its sponsors to publicize and encourage customers to use these *Guidelines* when obtaining energy efficiency services. These documents are available on the CAC website at [www.compressedairchallenge.org](http://www.compressedairchallenge.org).

## Allied Partner Qualified Specialist Training

To substantially increase the use of its software tools with and by industrial end users, USDOE worked with Allied Partner industrial trade associations and their member companies in developing a Qualified Specialist training and recognition program. This approach is designed to build use of the assessment software into existing interactions between industrial customers and their suppliers. The Allied Partners, who are already highly skilled in their respective area of specialty (in this case, pumping systems) also become skilled, qualified users of the assessment software. There are several advantages to this approach. First, it addresses the two major barriers to increasing effective use of the software- the time required to understand the tool and technical expertise in systems required to make full use of the software's capabilities. The goal is to increase the number of professionals qualified to use each software tool from <5 to >50 and greater in a relatively short period (two years).

In addition, the process of developing the delivery program also encourages industry suppliers to provide detailed technical input to fine-tune the software, while building ownership in the final product. The long-term goal of USDOE is to develop a well-defined Qualified Specialist program element for each type of system

assessment software and to seek out transfer of long term stewardship of Qualified Specialist programs to key industry associations. By involving these associations in the early stages of developing the software and the corresponding Qualified Specialist delivery mechanism, it is hoped that this transition can gradually evolve over a period of approximately five years from each Qualified Specialist program launch.

In order to engage industrial suppliers and consultants in the Qualified Specialist effort and sustain their interest in participating, USDOE offers the following benefits:

- Recognition as a skilled user of the software (PSAT, AIRMaster+, PHAST, etc) each Specialist gets a signed, numbered certificate;
- Listing on the DOE BestPractices Website & access to quantities of software;
- DOE refers callers and trainees interested in software to the website list of Specialists;
- May also become qualified to offer DOE software training classes to customers;
- Invitation to provide referrals for possible DOE case studies on energy-efficiency projects identified by using software;
- Invitation to participate in review of proposed changes to software; and
- Ongoing technical support.

The Qualified AIRMaster+ Specialist training is being offered in cooperation with the CAC. The training includes 2 days of classroom training on AIRMaster+ and measurement techniques, a practical exam on measurement techniques, a take home exam using AIRMaster+, and a 4-1/2 hour written qualifying exam. As with the Qualified Pump System Specialist exam, the AIRMaster+ Specialist exam is open book and designed to test the individual's ability to apply systems knowledge as well as use the software. To date, five classes have yielded 41 Qualified AIRMaster+ Specialists. These Specialists are being used as the primary avenue for delivering AIRMaster+ training to industrial end users through an awareness training module.

## **PROGRAM RESULTS**

In late 2001, the effectiveness of the CAC training was evaluated. This evaluation assessment, conducted by Xenergy for USDOE in cooperation with Lawrence Berkeley National Laboratory and Oak Ridge National Laboratory and the Compressed Air Challenge, drew a representative sample from the population of individuals that were trained by the CAC as of May 2001, which included 3029 individuals attending Fundamentals of Compressed Air Systems and 925 individuals attending Advanced Management of Compressed Air Systems. Phone surveys were conducted of 200 participants (100 end users + 100 vendors) to assess what their reaction to the training and, more importantly, whether they had made any changes in the operation and maintenance of their compressed air systems as the result of the training or, in the case of vendors, any changes in the services offered to customers.

The draft edition of the *Compressed Air Challenge Training Program Evaluation* places the estimated annual savings from participants in the training is about US\$12 million. Participants generally found the sessions to be both useful and of high quality. An impressive 76% of customers participating in CAC systems training reported that they had made significant capital or operating improvements to their compressed air system since attending the training. Using conservative estimates, participants saved 8% of compressed air system energy on average as the direct result of the training. In addition, end users who implemented compressed air system efficiency measures experienced significant non-energy benefits, including: reduced downtime, reduced system moisture and contamination, and more consistent system pressure. Some quotes from participants included:

“As the result of the improvements, we saved time and money in all aspects of production”

“We gained sufficient air capacity to make quality products that we were previously incapable of producing”

The influence of the CAC on changing market interactions from a focus on components to a focus on system services was also assessed. The Evaluation found that 52% of vendors who participated in the training began to offer new energy efficiency services that included:

- Analysis of system efficiency
- Measurement of system performance (flow/power/pressure)
- Ultrasonic leak detection

Approximately 85% of vendors have used the training materials or information when evaluating customer's systems, with 58% using this information frequently. Although not addressed in the study, most major

compressor manufacturers in the US are now selling an integrated line of system equipment rather than just components.

## **NEXT STEPS**

The CAC has much work left to do to educate the end use industrial customer on the benefits of taking a systems approach. New initiatives under consideration include 1) the development of an Operator Certification Program that recognizes maintenance staff who are skilled in taking a systems approach and 2) a web-based version of the Fundamentals of Compressed Air Systems for individuals who are unable to participate in offsite training programs.

The CAC seeks to continue to host and promote CAC training, broaden awareness of the systems message through widespread adoption of the *Guidelines for Selecting a Services Provider and Levels of Analysis* by industrial end users, and promote greater use of the CAC website [www.compressedairchallenge.org](http://www.compressedairchallenge.org). In addition, the CAC is seeking additional strategic alliances to strengthen the organization as well as making the training available for licensing to use outside of the US.

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