The "Efficient Compressed Air" Campaign in Germany: Market Transformation to Activate Cost Reductions and Emissions Savings

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ABSTRACT

Compressed air systems are widely used throughout industry and craft for diverse purposes. Although this special energy form has many technical advantages, it has to be taken into account that compressed air systems consume considerable amounts of energy. In Germany, these systems consume as much electricity as the German railway for traction or the amount produced by 1.3 nuclear power plants. According to an EU study published in 2001 (Radgen 2001), approx. one third of this energy could be saved profitably.

The "efficient compressed air" campaign addresses these huge saving potentials by providing information about energy and cost efficient compressed air systems for all industrial users, mostly via the Internet, specialist press articles, seminars, conferences and networks. The results show that the information and the instruments offered by the campaign are appreciated by the target groups.

In addition, companies are invited to have their compressed air systems (the entire system from the compressor to the end-use device) analyzed by compressed air experts in order to detect weak points and subsequently to show ways to improve both the compressed air quality and the energy efficiency. Due to public and private funding, this analysis was able to be provided free of charge to about 100 companies until the end of 2002. The results will be worked out as branch-specific case studies which will be distributed among the industrial users.

Other instruments of the campaign include benchmarking which compares the compressed air systems of different companies, a competition for the best compressed air systems supply and a demonstration plant.

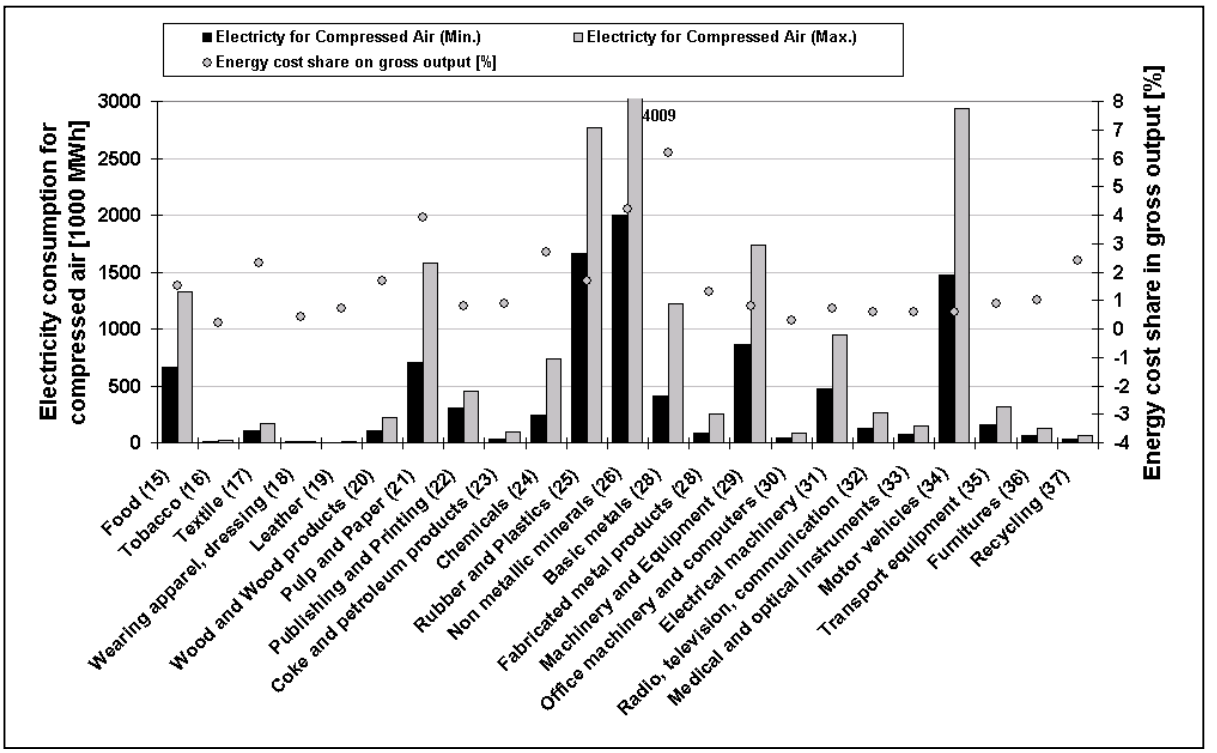
Introduction

Compressed air is widely used for industrial purposes due to its various technological advantages, such as high operating speed, force, accuracy and safe handling. But despite these advantages, it has to be taken into account that compressed air systems are high energy consumers. In Germany, compressed air systems account for 7 % of industrial electricity consumption. According to an EU study published in 2001, approx. one third of this energy could be saved profitably. In order to exploit these enormous saving potentials, the campaign "efficient compressed air" was launched in Spring 2001. The campaign informs system operators in industry and commerce about energy and cost efficient compressed air systems and offers instruments for analysing saving potentials and improving energy efficiency. This paper provides a short review of the campaign and its elements and focuses on the analyses' results.

Energy Consumption and Saving Potentials in Compressed Air Systems

The approx. 62,000 compressed air systems installed in Germany in different areas of production consume approx. 14,000,000,000 kWh electricity annually or 7 % of industrial electricity consumption. This is as much electricity as the German railways consumes for traction or as the annual production of 1.3 nuclear power plants. Figure 1 shows the significance of energy consumption for compressed air production in different sectors in Germany. By far the largest compressed air users are plastics and the non-metallic minerals (mainly glass industry). Other sectors such as the food industry, the paper industry or motor vehicle construction should also not be neglected.

Figure 1. Electricity Consumption for Compressed Air Production and Share of Energy Costs in Gross Output



Source: StaBu, 2002 and Radgen, 2001, own calculations

An EU study published in 2001 revealed that existing compressed air systems often have enormous potentials for optimisation. The economically and technically feasible energy savings lie between 25 % and 40 %, usually with a payback time of less than two years.

A typical example is exchanging a time controlled condensate trap for an electronic condensate trap. The cost for replacing the trap is about 150 Euro (165 Dollar), whereas the resulting annual energy savings typically amount to around 100 Euro. Therefore the payback time for this measure is 1.5 years.

An efficient use of compressed air does not only improve the profitability of companies, but also contributes substantially to climate protection. Up to two per cent of the CO_2 emissions caused by industry as a whole could be avoided by using efficient compressed air systems.

The best way to exploit the energy savings potential is to optimise the complete system, ranging from planning, generating, processing and distribution to financing possibilities. Lots of systems are not being operated optimally due to insufficient maintenance and service, but also due to faults in plant layout and design and mistakes made during procurement. The most common faults are leaks in the system which may result in additional electricity costs of several thousand Euro per year which often go unnoticed. Despite the profitability of technical measures needed for increased energy efficiency, these measures are often not carried out by private enterprises. One main reason for this is a lack of information regarding the savings potential and the measures to exploit them. This is where the campaign "efficient compressed air" comes in.

Addressing the Potentials: the German "Efficient Compressed Air" Campaign

The campaign "efficient compressed air" aims to inform system operators in industry and commerce about cost and energy efficient compressed air systems and to motivate them to exploit the savings potentials. To this end a variety of instruments was developed: the Internet platform www.druckluft-effizient.de, free of charge measurements of compressed air systems, a benchmarking which compares systems of different companies, a competition for the best compressed air systems supply and many other activities.

The campaign was launched in Spring 2001 at the Hanover Trade Fair and runs for four years. "Efficient compressed air" is implemented by the German Energy Agency (dena), the Fraunhofer Institute Systems and Innovation Research (Fraunhofer ISI) and the German Engineering Federation (VDMA). The project is sponsored by the German Ministry of Economics and Labour (BMWA) and supported by several industrial partners of the compressed air industry.

In the following, the various instruments of the campaign are described in more detail:

Information Brokering and Qualification

Internet platform. One central instrument of the campaign is the **Internet platform** www.druckluft-effizient.de. On this web site industrial users can find competent and multi supplier information on all questions of compressed air technology. Downloadable fact sheets on various topics regarding compressed air systems are available here as well as national and international studies. The fact sheets deal with all aspects of compressed air systems, from the production, treatment, distribution and uses as well as questions related to control or the thermodynamic principles of compressed air. Since they were published in German, we have received many enquiries about copies in other languages. Translations into different languages are now in preparation. The Internet platform also provides a discussion forum where questions can be posted and will be answered by compressed air experts. The efficient compressed air campaign is conducted together with industry specialists and independent consultants. The independent research organization, Fraunhofer ISI, supervises all the activities in order to guarantee independent results. It has become appararent that there is growing interest in outsourcing the compressed air system. However, although contracting is well known for its ability to support the uptake of measures to improve energy efficiency,

this improvement can sometimes be limited if the contracts are not well designed. The "Guideline to financing methods of energy-efficient compressed air systems" (Dudda, Radgen, Schmid 2002) describes different financing methods (own funding, operating agencies, contracting etc.) together with their pros and cons for the contracting parties. All documents can be downloaded from the web site free of charge. The web site also provides useful links to relevant contact persons and covers the most recent news on its home page. Furthermore a free regular electronic newsletter gives information about new activities and publications. Email subscription is free of charge. The newsletter can also be downloaded from the web site.

The Internet platform was set up in July 2001 and since then has been regularly updated and supplemented with further information. To further improve the compressed air user needs, the web site was relaunched at the beginning of 2003.

Seminars. The campaign offers a supplier neutral **seminar** for the further qualification of companies in the field of energy efficiency. The seminar is offered at a very reasonable cost, the price only covers the printing of the seminar materials and the lunch and coffee breaks. The seminar was developed by the "Compressed air systems group of VDMA" and further optimised by the project group of "efficient compressed air". In the seminar, the companies learn how to optimise the compressed air systems supply from planning and generating to processing and distribution. Starting from the principles of thermodynamics and the typical uses of compressed air, the seminar covers the efficient production of compressed air (types of compressors, cooling, layout of compressor house, heat recovery, etc.). This is followed by chapters on air treatment, condensate treatment, and distribution networks (materials, dimensioning, pressure losses, leakages). The influence on receivers is discussed together with the possible saving potentials by optimal compressor control. The seminar concludes by road mapping the opportunities to improve compressed air systems, taking into account the compressed air system as a whole (Seminar 2002).

In order to ensure a high educational standard, the trainers had to take part in a three days "train-the-trainer"-seminar which was also offered in the context of the campaign. The seminar was held for the first time in 2002. Due to the positive feedback from the participants, the seminar will be repeated throughout Germany in 2003. In total about 24 seminars are planned. Information on the seminar together with the participation form is available on the efficient compressed air web site at www.druckluft-effizient.de/seminare/seminare.php (so far only in German).

Public relations. The success and widespread impact of the project is to a large extent determined by effective **public relations**. To this end, ongoing publicity via the press, presentations at fairs and conferences and other advertising media constitutes an important element of the campaign. At the beginning of the project, the objective of the PR-campaign was to show the significance of energy-efficient compressed air production for the economic efficiency of the company. Subsequent press releases focussed on important events and results of the campaign.

At the beginning of the project, all relevant multipliers were given information about the campaign by e-mail. This approach made it possible to address specialist branches which are usually difficult to reach by press. Press releases and specialist articles are distributed to a broad mailing list during the whole running time of the project.

In addition the campaign is presented at various conferences, industry fairs (e.g. Hanover Trade Fair) and seminars. For example, in Spring 2002, a two-day conference was organized in cooperation with VDI (association of German engineers) and the Bavarian Energy Forum. The presentations covered the whole spectrum of the compressed air system, ranging from planning, generating, processing and distribution to financing possibilities and specialized applications.

A poster in both German and English has been created as an advertising medium for presentations as well as a project flyer which provides brief information about the project and refers to the web site for further information.

Measuring campaign. In Autumn 2001, companies were invited to have their compressed air systems (the whole system from the compressor to the end-use device) analyzed by experts in order to detect weak points and subsequently to show ways to improve both the compressed air quality and the energy efficiency. The experts comprised both manufacturers and consultants, but were supervised by an independent research organization to assure the neutrality of the results. Due to public and private funding, this analysis was able to be provided free of charge for about 100 companies. Most of the free compressed air audits were conducted during 2002. The audits are used to determine the possible saving potential in terms of energy, CO_2 emissions and costs. The energy savings identified in the audits conducted so far have typically been in the range from 10 to 35 %. To identify the savings, the compressed air systems were inspected by compressed air experts. Some savings could already be identified during this initial inspection. In the following some examples are given for incorrect or inefficient installations.

Case 1: the company uses compressed air to transport material from outside silos to the production plant. During the winter, freezing causes clogging of the material, therefore a cold regeneration adsorption dryer was installed . However, during the summer there is no need for a dew point as low as –50 °C, Figure 2. Operating the additional adsorption dryer only in winter time saved the company a lot of energy, compressed air and costs, without having to make any additional investments.

Figure 2. Unnecessary Use of an Adsorption Dryer in the Summer

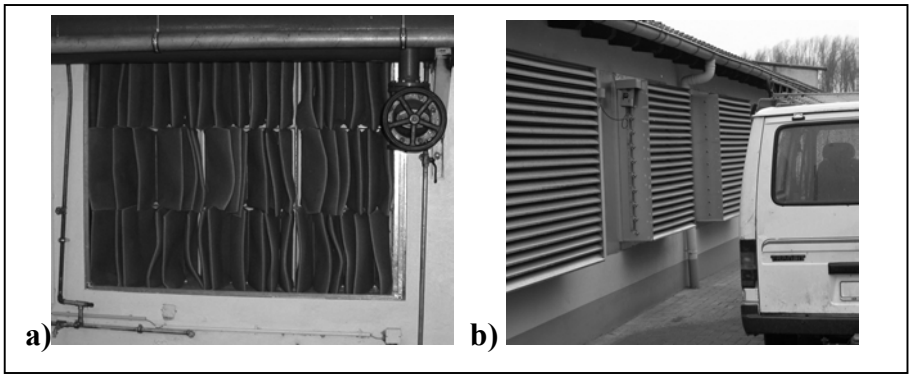
Source: Druckluft effizient 2002

Case 2: the inlet air opening for cooling the compressor house was designed based on the manufacturer's specifications. However, due to a large particle load around the plant, a pocket filter was added later, Figure 3a. This has reduced the free cross section of the air intake and caused increased temperatures in the compressor house. Due to this increase, plant failures have been reported when outside temperatures are high in the summer.

Case 3: the inlet and outlet air openings from the compressor house are located next to each other. Therefore a short circuit has been produced, where the warm air from the outlet

flows back into the room via the cold air intake, Figure 3b. In addition it can be remarked that trucks and light trucks are often parked in front of the openings, worsening the described situation, Figure 3b.

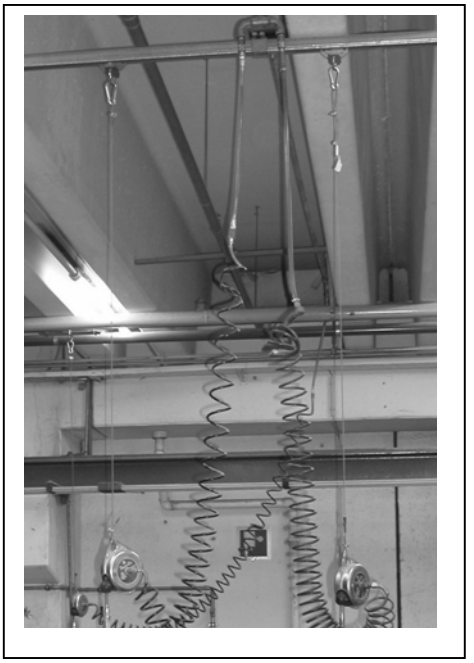
Figure 3. Pocket Filters Reduce the Free Cross Section of Air Intake Openings (a) and Cold Air Intake and Warm Air Outlet Are Located Next to Each Other (b)



Source: Druckluft effizient 2002

Case 4: the compressed air tools used to be connected to the distribution network via spiral hoses. Later the connections were changed to hose dispensers. However the spiral hoses are still in use, now serving to connect the hose dispensers to the network, even though this is unnecessary , Figure 4. They only add additional pressure losses which could be avoided. An additional pressure loss of one bar adds about 6 to 10 % in additional energy costs.

Figure 4. Spiral Hoses Connecting the Hose Dispenser to the Compressed Air Network, Adding Avoidable Pressure Losses



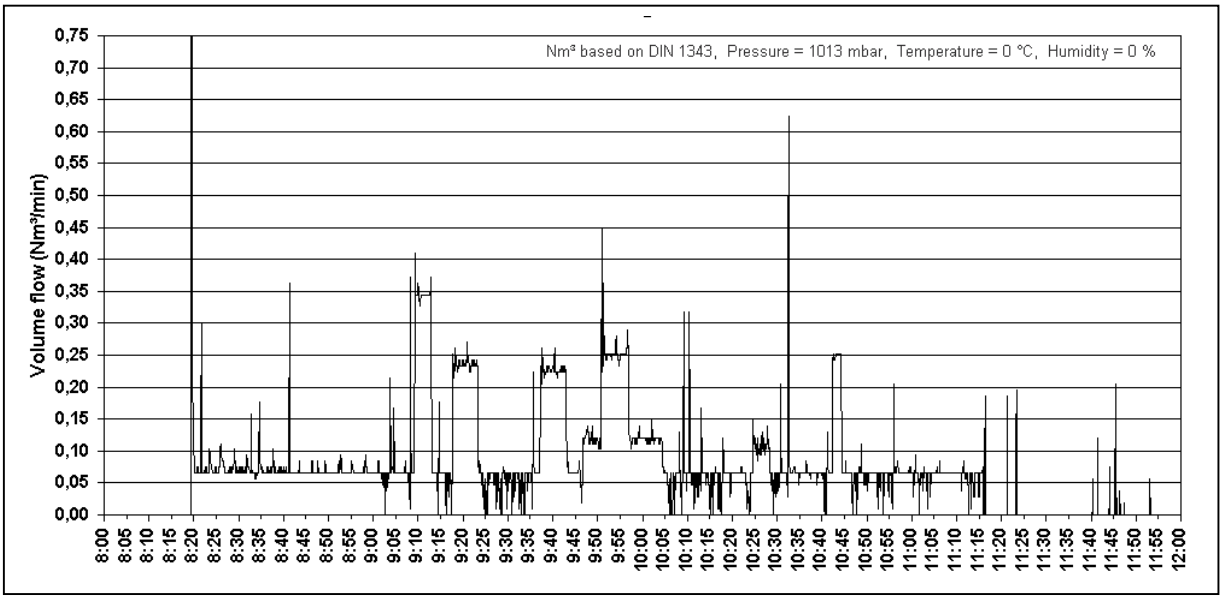
Source: Druckluft effizient 2002

The list of such non optimal solutions could be extended further. The reasons for such unfavourable solutions in practice are often due to a lack of clear responsibility for compressed air or even a misunderstanding of compressed air systems.

In addition to the work through on-site inspections, the compressed air systems were also analysed using measuring equipment, looking at the consumption figures and pressures over a period of at least 10 days. Special attention was given to compressed air leakages, as they are responsible for the largest part of the overall losses. The scope of the audit was defined based on the situation at the customer's site. In most cases the volume flow of compressed air was measured indirectly with a data logger via the operating time of the compressors. Pressure probes were used and pressures at the worst point of the system were collected during the same periods. The power capacity of the equipment at full load and in idle were taken from manufacturers data or were measured for short periods. In some cases the volume flow was also measured directly with flow sensors. The actual situation in the compressor house and the distribution network on site was documented by photographs. All the data were ultimately compiled into a report which was presented to and discussed with the customer. Special attention was paid to the leakage rate, as the reduction of compressed air leaks is typically the most cost effective measure.

Figure 2 shows the leakage measurement in a company with no production on Saturday. However a leakage location program was performed on this day, opening the pipe connections to different shops and production machines one by one for about half an hour each. As can be seen, the leakage rate varies between 0.05 and 0.35 m^3/min. In combination with the valve opening protocol, leak reduction work can then start where it will be most efficient.

Figure 5. Result of Measuring a Leakage at a Weekend with Different Parts of the Distribution Network Disconnected from the Supply



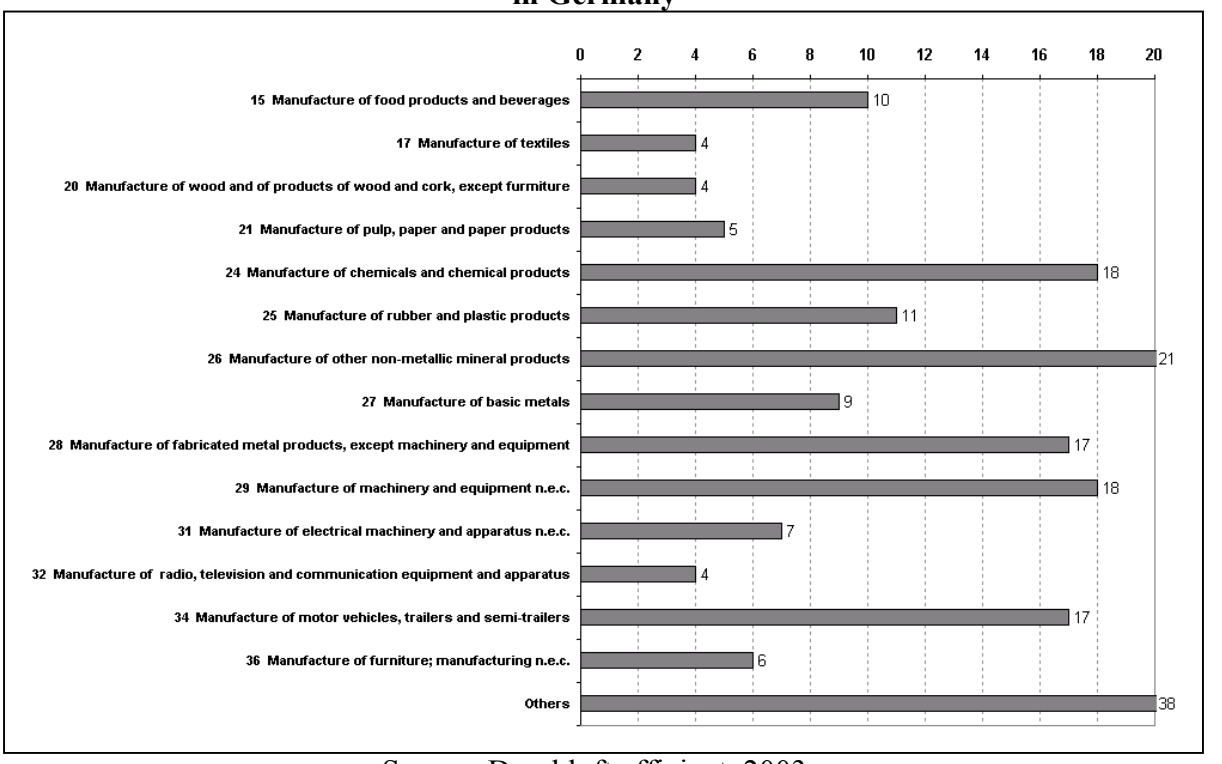
Source: Druckluft effizient 2002

In addition to the individual reports for each company, an overall analysis of all the compressed air audits performed under the efficient compressed air campaign will be made to identify general patterns and saving potentials by type of plant and industry sector . A short- and long-term evaluation of the measuring campaign will also be made to gain insights into the uptake of the proposed measures.

Preliminary results from the overall analysis show that about 15 % of the applicants had an installed capacity of less than 50 kW, 37 % between 50 and 300 kW and 48 % more than 300 kW. All relevant types of compressors have been covered. Companies with larger compressed air systems tend to be more sensitive to the cost of compressed air, even if the overall share of compressed air costs in turnover is similar to companies with smaller systems.

Figure 3 shows the distribution of applicants for the measurement campaign in Germany. 14 sectors have more than 4 applicants, the other applications have been grouped together. The industrial sectors which were strongly represented include metal production, the chemical industry, the food industry and car manufacturers. One reason for this might be the high importance of compressed air costs in these sectors, a second might be the high cost competition in these markets, this will be analysed in more detail in the future.

Figure 6. Applicants by Sector for the Free Compressed Air Measurement Campaign in Germany



Source: Druckluft effizient, 2003

Based on the audits already conducted, it can be stated that the saving potential given in the study for the European Commission can be substantiated. Table 1 shows some of the results from the measurement campaign. Identified savings range from 17 to 77 % of electricity consumption for compressed air systems. The emission reductions calculated are

based on the average German electricity generation in 2000 with an emission factor of 580 g CO_2/kWh. Payback times for the measures are not given in this table because the investment costs for the measures have not been accounted for in detail as they could only be based on list prices. However for the purchase of, e. g. compressors, the difference in price for the same compressor can be in the range of 70 % and will depend strongly on the actual market conditions.

Table 1. Results of the Compressed Air Audits Conducted under the German Compressed Air Campaign

ID	Sector [Nace]	Compressed Air Savings	Cost Savings	Electricity Savings [total]	Electricity Savings [specific]	CO_2 Emission reduction
		[m^3/a]	[Euro/a]	[kWh/a]	[%]	[t CO_2 /a]
11	90 Sewage and refuse disposal, sanitation and similar activities	440000	5877	97944	28	57
13	24 Manufacture of chemicals and chemical products	780000	6514	130728	20	76
17	27 Manufacture of basic metals	4670000	140000	405000		235
32	28 Manufacture of fabricated metal products, except machinery and equipment	200000	8934	135833	77	79
36	25 Manufacture of rubber and plastic products	790000	6846	114083		66
47	85 Health and social work	135000	15500	190000		110
51	22 Publishing, printing and reproduction of recorded media	530000	14420	288399	55	167
54	28 Manufacture of fabricated metal products, except machinery and equipment	450000	5345	87855	39	51
61	24 Manufacture of chemicals and chemical products	130000	2901	19113	20	11
62	28 Manufacture of fabricated metal products, except machinery and equipment	1000000	4380	158466	17	92
89	31 Manufacture of electrical machinery and apparatus n.e.c.	1440000	20592	343206	66	199

So far the results cannot be interpreted in relation to the sector. One objective of the campaign is to generalise the saving opportunities by sector and publish them as case studies. This will enable the propagation of information in the different sectors.

Benchmarking. Many companies do not know how much energy they use for their compressed air production. Even if they know what they are looking for, they are not able to make judgements about the quality of the results they achieve. Benchmarking is a well known tool to help companies to further improve their systems. The project group is developing an Internet-based compressed air benchmarking tool. Companies can send their data and will receive information about their position in terms of costs, energy consumption,

plant configuration and compressed air costs. Benchmarking will be conducted on a sector-specific basis or for the industry as a whole. If a company falls behind the average values, the system will propose possible measures to improve the system step by step. The benchmarking can therefore trigger further activities and will help to convince high level management about the importance of compressed air systems. The benchmarking is scheduled to be online for the Hanover Trade fair 2003, which takes place in April and will have a focus on compressed air technology.

Competition. At the end of 2002 a press release announced a competition for a compressed air award for a company which has successfully and efficiently improved or maintained their compressed air supply. The bid was also sent to all companies interested in the project in combination with the newsletter. The main objective of this competition is to attract the attention of as many companies as possible. To this end a public awards show is planned for Spring 2003 at which the award will be presented to the winning company. It is planned that the presentation will be made by a Minister of the German Government or Secretary of State to attract as much publicity as possible. The measures undertaken by the award winning company together with the improvements achieved will be published in a flyer and distributed.

Demonstration plant. Information materials and information on a web site is helpful and necessary. But improvement potentials should also be made evident to ears and eyes. A simple demonstration plant was built to show the effects of different measures to reduce the energy consumption of compressed air supply. Effects shown include the pressure losses due to insufficient piping cross sections, the costs associated with compressed air leakages, the effect of faulty or outdated condensate traps or the effect of poor maintenance of filters and dryers. The demonstration plant will be used during the trade fair and will be dismantled and reassembled for the compressed air seminars. A main problem was therefore to construct a plant which can be easily transported in a small van and set up by a single person. Figure 4 shows the presentation of the demonstration plant at the international Hanover trade fair in April 2003. The plant attracted many visitors and provided an opening to discuss potentials to improve compressed air systems.

Results

Since the start of the compressed air campaign at the beginning of 2001, the project has gained broad recognition from industry. The campaign has produced a lot of helpful information materials and is bringing the figures regarding cost, energy and emission savings in compressed air systems to the attention of the industrial users.

The measurement campaign not only revealed huge saving potentials but also motivated the companies to exploit them. At the end of the project a survey will be conducted among the companies involved in order to show which optimisation measures have been implemented due to the results of the measurements. This will also allow a full quantification of the energy and CO_2 savings achieved.

Figure 7. Efficient Compressed Air Demonstration Plant at the Hanover Trade Fair, April 2003

Source: Fraunhofer ISI, 2003

The campaign is playing an important role to achieve the market transformation to an energy efficient economy in compressed air systems, this market transformation will not take place automatically as long as strong barriers to its development are still in place. The project so far has shown that many companies do not know their energy costs for compressed air production as these costs often form part of the overhead costs. Furthermore, in most companies, energy costs only constitute a small share of the overall costs and therefore do not attract the interest of the management. Together with a lack of information regarding the saving potentials and the technical ways to exploit them the situation arises that even highly profitable optimisation measures are not being exploited. In order to reduce these barriers, activities such as the campaign "efficient compressed air" are very important.

The multiple activities conducted so far will be continued and expanded in the future. Further actions include the expansion into other European countries and developing countries. The campaign will also be linked to the European Motor Challenge Program, which has been launched in 2003 by the European Commission (EC 2003).

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