White paper

Reduce energy costs in compressed air systems by up to 60%

In order to survive in a tough competitive environment, many companies are searching for ways to make savings in their production. Such savings can often be found in their existing compressed air systems, which have generally been in place for years. Up to 60% of energy costs can be saved through optimisation at both the production facility and system level. However, companies can only achieve this target by considering the compressed air system as a whole.

All areas, from generation through preparation and distribution to application, must be taken into account and factored into the choice of subsequent measures. The necessary equipment must also be available for performing reliable analysis and implementation. In many cases, the measures have a positive effect in that they reduce the need for maintenance in future. Since potential sources of failure are being eliminated, general process reliability and productivity will increase.

This white paper includes information on:

- How much does compressed air generation cost and how much do leakages cost?
- Where can potential energy savings be made in compressed air systems?
- How can these potential energy savings be identified?
- Who should take what measures, and who can implement them?
- How quickly will these measures be amortised (ROI)?
- A practical example

What are the costs of compressed air generation?

Compressed air costs are normally expressed in Nm³ (at 1.0 bar and 20 °C to ISO 6358 or, for many compressor manufacturers, in m³ to ISO 1217:2009, Annex C). These can be determined using the sum of fixed and variable costs and using the annual delivery output of the compressor station:

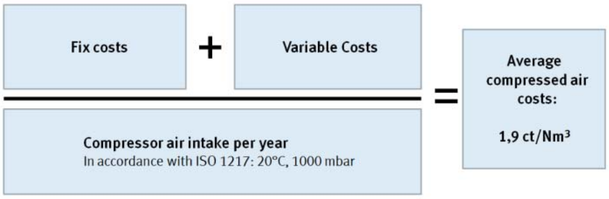

Figure 1: Calculating average compressed air costs

Annual (p.a.) fixed costs include

- Depreciation of the investment made
- Interest rate
- Space utilisation costs

Variable costs are made up of

- Energy costs over the full-load periods and no-load times of the compressors
- Costs of consumables such as oil, coolant etc. p.a.
- Maintenance and costs

The largest part of the costs, at approx. 75%, is taken up by the energy costs[1]. In order to generate 1 Nm³ of compressed air, modern compressor stations require between 100 and 120 Wh/Nm³ (compressed air index [kWh/Nm³]).

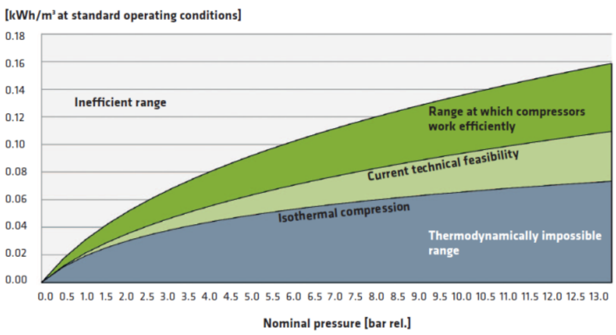

Figure 2: Compressed air indices for compressor stations[2]

Compressed air costs can be reduced by up to 30% through using a central waste heat recovery system (WHR) – the savings are based on the heating costs saved. So, for example, in the case of WHR with warm water, up to 72% of the compressor output can be utilised as heat or, in the case of air cooling only, the figure can be as much as 90%.

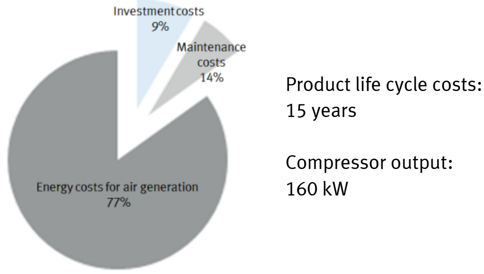

Figure 3: Costs of compressed air generation[3]

Calculating the average costs of compressed air generation

In practice, the range of values for compressed air costs is between 1.5 ct/Nm³ and 2.7 ct/Nm³. The high fluctuations depend on many factors. The most important are:

- Electricity costs per kWh
- Specific output of each compressor, i.e. the type of compressors used
- Use of an intelligent global control system
- Size of the company / of the compressors
- Atmospheric conditions of the air drawn in (density)

The average price of compressed air for a system pressure of 6 bar rel. can be expressed in figures as 1.9 ct/Nm³. This is based on the following assumptions:

- Generation costs at 120 Wh/Nm³ (for 8 bar rel. at the compressor)
- Electricity costs of 12 ct/kWh
- Ratio of energy costs to additional costs of 75% to 25%

Calculating the individual, plant-specific costs of compressed air generation

Determining the individual compressed air costs per Nm³ for each compressor station is essential for an accurate analysis of the potential savings.

The costs of compressed air per Nm³ can be determined very accurately by measuring the electricity requirement and the actual delivery rate. The delivery rates specified in the data sheet are often used for this purpose. However, the actual delivery rate measured fluctuates depending on the intake conditions and should therefore be measured at the same time as the energy consumption.

If it is not possible to carry out a precise measurement, the compressed air costs can be roughly estimated. To do this, it is necessary to know the technical data for the compressors, i.e.

[1] EnEffAH project " Energy efficiency in production in the drive and handling technology field", (2008-2012); Study "Compressed air systems in the European Union", Fraunhofer Institut ISI (2000)

[2] EnEffAH project (2008-2012)

[3] Study "Compressed air systems in the European Union", Fraunhofer Institut ISI 2000

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- Nominal power [kW] and nominal delivery rate [Nm³/h] at the required pressure level [bar rel.]
- Average utilisation rate of the individual machines
- Working time in the plant

These values can be used, together with the local electricity prices [€/kWh], to estimate the compressed air costs [€/Nm³] and the annual costs [€] for the amount of compressed air used [Nm³].

In order to determine costs during productive operation, the following steps must be performed:

1. Power consumed [kW] the a sum of full-load and no-load power
   Full-load power = nominal power [kW] * utilisation [%]
   No-load power - 30%*nominal power [kW] * (100% - utilisation [%]),
   Note: The actual power is generally up to 30% higher than the nominal power; this can be taken into account when making the estimate.
2. Delivery rate [Nm³/h] during productive operation
   Delivery rate = utilisation [%] * nominal delivery rate [Nm³/h]
3. Compressed air index [kWh/Nm³]
   Compressed air index = (full-load power + no-load power) [kW]/delivery rate [Nm³/h]
4. Compressed air costs [€/Nm³]
   Compressed air costs = (1/75%) * compressed air index [kWh/Nm³] * electricity costs [€/kWh]
   Note: On average, compressed air costs are made up of 75% energy costs and 25% additional costs
5. Annual consumption costs [€/a]
   Costs = productive working hours [h/a] * delivery rate [Nm³/h] * compressed air index [kWh/Nm³] * electricity costs [€/kWh]

To get a complete picture of consumption, possible leakage costs that may occur in non-productive operation should be calculated using the same method.

How do leakages occur and what additional costs do they incur?

How do leakages occur?

Just like standby consumption in electric drive systems, it is not (yet) technically possible to avoid leakages in compressed air systems. However, with today's technology, it is feasible to ensure the leakage rate is at an economically acceptable level – by managing the compressed air medium properly and by continuously monitoring leakages.

The causes of avoidable leakages are many and varied:

- **Installation and systematic errors** such as insufficient or excessive tightening of screws and seals, or mechanical damage, e.g. as a result of rubbing tubes.
- General **incorrect handling** of compressed air components, e.g. as a result of cutting the tubes incorrectly
- Leakages caused by of **wear** on the compressed air components
- Chemical stresses due to **operating conditions** of the components caused by incorrectly selected materials

How much do leakages cost?

Even small leakages offer the potential for significant savings. The table below shows how much air is lost as a result of leakages with a specific hole diameter and what additional costs are incurred:

p1 (rel.)	**Leakage rate in Nl/min**					
	0.5 mm	**1.0 mm**	**1.5mm**	**2.0 mm**	**2.5mm**	**3.0mm**
3 bar	9	36	81	145	226	325
4 bar	11	45	102	181	282	407
5 bar	14	54	122	217	339	488
6 bar	16	63	142	253	395	569
7 bar	18	72	163	289	452	651
8 bar	20	81	183	325	508	732

p1 (rel.)	**Costs/year**					
	0.5 mm	**1.0 mm**	**1.5mm**	**2.0 mm**	**2.5mm**	**3.0mm**
3 bar	€ 90	€ 361	€ 812	€ 1,444	€ 2,256	€ 3,248
4 bar	€ 113	€ 451	€ 1,015	€ 1,805	€ 2,820	€ 4,061
5 bar	€ 135	€ 541	€ 1,218	€ 2,166	€ 3,384	€ 4,873
6 bar	€ 158	€ 632	€ 1,421	€ 2,527	€ 3,948	€ 5,685
7 bar	€ 180	€ 722	€ 1,624	€ 2,888	€ 4,512	€ 6,497
8 bar	€ 203	€ 812	€ 1,827	€ 3,248	€ 5,076	€ 7,309

Table 1/2: Leakage costs within one year for operation 24 h/365 days, calculated using compressed air costs of 1.9 ct/Nm³.

The point at which a leakage is identified as a loss depends on the ratio of leakage to overall consumption. Major leakages – where the air leak is clearly audible – are costly and must be rectified immediately. Medium and small leakages (leakages with a hole diameter of less than 0.5 mm) are simple to detect using professional leakage detection equipment and should be rectified promptly.

As a rule of thumb:
20% of the detectable leakages in existing systems account for up to 80% of the avoidable costs.

It is worth rectifying leakages quickly as every leakage fixed saves energy, and hence costs, straight away.

Where can potential energy savings be made in compressed air systems?

Leakage detection is a fundamental factor in locating potential energy savings. As part of an integrated analysis, all the 4 areas of a compressed air system must be considered:

- Compressed air generation
- Air preparation
- Compressed air distribution
- Compressed air application

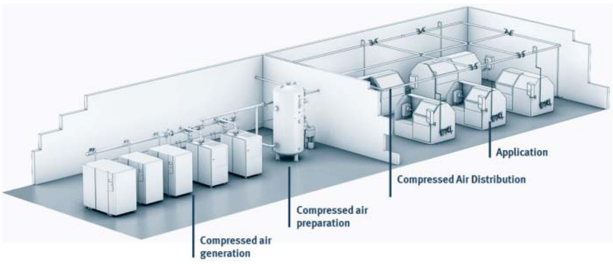

Figure 4: Savings are possible throughout the entire compressed air system

Depending on the applicability of the energy-saving measure, how cost-effective it is and the savings produced, the average potential savings in the individual areas of the system vary:

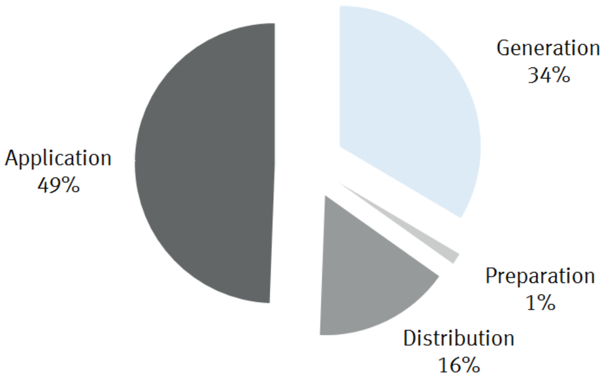

Figure 5: Cost-effectiveness of measures in the individual areas of the compressed air system[4]

The measures proposed below relate to an existing compressed air system which has not been updated in the last 5 years.

How can potential energy savings be identified?

There are various measures for realising potential savings in compressed air systems; these have different effects depending on the particular part of the compressed air system.

First of all, performing a **compressed air audit**, i.e. a precise analysis of the existing system with a focus on energy efficiency (effective and efficient use of energy), is recommended. In order to develop recommendations for actions that are well thought out, economically speaking, and are designed to exploit potential savings to their fullest, a good audit will examine four different areas: the complete system, compressed air generation, air preparation and actual usage of the air.

Important: an audit should be adapted to the compressed air system in question, as each system is different and the objectives of the individual companies also vary. Below is a description of what should be taken into account during the audit, and how a good audit is structured.

1. Cost-saving measures in compressed air generation using energy analysis

An accurate energy analysis of the compressor station is essential so that a reliable statement can be made about the compressed air costs of the plant or the company and the specific potential savings in this area.

The following objectives can be achieved with an energy analysis:

- Creating consumption profiles of the compressor station(s): profiles document the compressed air requirement including fluctuations in consumption at different operating times
- Gathering information about the complete system with its power reserves and identifying opportunities for savings
- Calculating the individual, plant-specific compressed air costs

Implementation

For the consumption profiles, various parameters of compressed air generation are recorded, some simultaneously, over a relatively long timeframe (at least 7 days), in particular

[4] Study "Compressed air systems in the European Union", ISI 2000

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- Electricity consumption of the individual compressors
- Actual delivery rates/compressed air consumption
- Air pressure in the central air reservoir and in the compressed air network shortly before application.

It is important that recording also takes place during downtimes and at the weekend.

A special measuring device is used to determine the consumption profiles. The test probes can usually be installed during operation so that it is no longer necessary to interrupt the compressed air supply for the installation.

Using the measured values, the observed data can now be evaluated and interpreted in a qualitative manner in order to qualify the leaks and create a cost analysis. To do this, the utilisation of the compressors (load/no-load cycles per hour), the total leakage volume during downtimes as well as other variables are calculated.

Figure 6: Energy analysis of compressed air generation

Popular measures for improvement include

- Reducing the pressure drops and hence the compressor pressure
  Note: A pressure reduction from 7 bar rel. to 6 bar rel. at the compressor results in an average saving in energy consumption of 6%.
- Using a higher-order global control system to minimise no-load losses, and using peak load compressors for significantly fluctuating air consumption profiles
- Rectifying leakages at the production hall level
- Switching off the compressed air supply
- Waste heat recovery

2. Cost-saving measures in air preparation using compressed air quality analysis

Supplying compressed air applications with optimal compressed air quality is important when it comes to ensuring process reliability. During the air preparation stage, particles (oil, water and contaminants) that are present in the ambient air are removed and the air is compressed into the smallest space possible using a compression process. The compressed air quality is defined in DIN ISO 8573-1 (2010).

Compressed air quality to DIN ISO 8573-1

Class	Dust/particles		Water		Oil
	µm	mg/m³	DTP [°C]	g/m³	mg/m³
1	0.01	0.1	-70	0.003	0.01
2	1	1	-40	0.12	0.1
3	5	5	-20	0.88	1
4	15	8	3	6	5
5	40	10	7	7.8	25
6	-	-	10	9.4	-
7	-	-	Not specified		-

Figure 7: Overview of dust, water content and oil content in compressed air to DIN ISO 8573-1 (2010)

Components of compressed air applications used in production areas that do not have to comply with high standards require a minimum level of compressed air quality. Well-known manufacturers of pneumatic products, such as cylinders, therefore recommend an average compressed air quality of 7.4.4 for most of their products (dirt particles max. 40 µm, pressure dew point at +3 °C and residual oil content at 5 mg/m³). The same air quality is generally also sufficient for operating quarter turn actuators and linear actuators for process valves. Coarser particles will wash out the life-time lubrication, or cause increased wear and damage to seals. Damage to the seals, corrosion, or blocked cable cross sections lead to higher energy costs and operating costs. This often results in unplanned production downtime.

To operate position and process regulators as well as valve control units on process valves, the compressed air is generally subject to higher requirements. Depending on the type of regulator, compressed air qualities of up to 3:4:3 are required (particle size max. 5 µm, oil max. 1mg/m³). If the equipment is used in outdoor applications or in unheated storage and production areas, the air must be dried further depending on the climatic conditions. A pressure dew point of -20°C (class 3) or -40°C (class 2) is standard. This results in a compressed air class of 3:3:3 or 3:2:3.

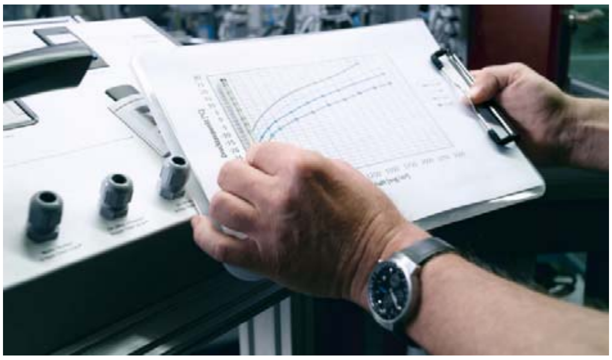

Figure 8: Measurement of compressed air quality

Compressed air in contact with sensitive products

The requirements of compressed air increase further if the compressed air comes into direct contact with raw materials, end products and packaging. This is particularly the case in the food and beverage industry, the pharmaceutical industry and in parts of the fine chemical industry. In the area of dry food and medicine, classes of 2:2:2 or even 1:2:1 can be required. Alternatively, many processes are seeing the application of sterile air, i.e. air that is free of micro-organisms. This is the case in the manufacture of ice cream and in pharmaceutical production. In bio-technological production (fermentation), one application of sterile air is for transferring material between two containers. For the filling of creamy products such as yoghurt, the storage tank of the filling machine is charged with a constant pressure to ensure uniform and reproducible filling.
To prevent the sterile filter from being overloaded, the compressed air should be prepared gradually until it reaches a minimum compressed air class of 3:4:1. During the final stage the sterile filter can then remove all the micro-organisms and other particles. If catalysts are used for the preparation of the sterile air, the incoming oil content can be higher. This is because the catalysts degrade all carbon compounds, regardless of whether the matter is living or dead.

Centralised or decentralised air preparation

If large volumes of sterile air are required in production, the ratio of sterile air to overall air consumption must be determined. In some pharmaceutical plants, entire sections, including process valve actuators and other pneumatic consumers, are supplied with sterile air to minimise risk and for the sake of convenience. This reduces the installation costs that would be incurred with two separate compressed air systems, but drives up the operating costs. Leakages also have a major impact on the costs per m³ of sterile air.

The following objectives can be achieved with a quality analysis:

- Checking the compressed air quality and adapting to the required conditions or quality classes if required
- Avoiding machine failures
- Reducing maintenance costs
- Increasing the service life of compressed air components

Implementation

- Measurement of water and residual oil content after centralised and decentralised air preparation
- Determination of the pressure dew point and water content with regard to the absolute air pressure
- Visual inspection of decentralised air preparation at the point of usage
- Documenting and evaluating of the results
- Identifying measures to improve the compressed air quality, e.g. by using filters or decentralised absorption dryers.

Figure 8: Festo AirBox, device for easy measurement of compressed air consumption and quality

Special measuring devices are required to carry out a compressed air quality analysis.

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3. Cost-saving measures for the complete system, at the production hall and system level using leakage detection and elimination

Systematically identifying leakages in the entire compressed air system and eliminating them makes a major contribution to reducing compressed air costs. Detecting and eliminating leakages is above all recommended for existing, relatively old systems. Both experience and a range of studies have shown that it is in particular in older systems that the greatest potential savings can be made – and are also easiest to find. The integration of sensor technology (pressure/flow rate) into air supply units enables an automatic leakage management system with remote maintenance to be installed.

The following objectives can be achieved with of leakage detection:

- Identifying leakages in the complete compressed air system and subsequently eliminating these.

Implementation

- Systematic check of the complete compressed air system at the production hall and system level
- Classification of leakages found according to leakage volume and marking them
- Documentation of the leakages with all relevant data for leakage elimination, e.g. necessary spare parts, estimated repair time, etc.
- Creation of a plant-specific action plan for leakage elimination
- Leakage elimination

Leakage detection is carried out using ultrasound detectors and can usually be performed during operation. This special equipment is needed so that even small leakages are audible during operation.

In most companies, leakage detection is performed by an external service organisation. The professional service providers will collect detailed data during leakage detection so that the leakages can then be eliminated quickly and systematically.

Figure 9: Detection of leakages in the distribution of compressed air

Ideally, the observed data from everyone involved – including maintenance personnel, operations and plant managers – should be made available centrally via a database, where all measures are documented. These can also be used for evaluations and periodic comparisons.

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4. Savings measures for compressed air application: by means of" to "Cost-saving measures for compressed air application using

Compressed air consumption analysis

Knowing the compressed air consumption of the production hall – and hence of each machine – is a vital prerequisite for optimally designing and configuring the compressed air supply and distribution at the system level.

An optimal configuration of the piping and tubing in the system and providing components for decentralised air preparation help

- to avoid pressure drops caused by a shortfall and the associated reduction in productivity
- to put an end to unnecessary energy consumption due to oversupply.

The latter issue arises when the control pressure in the decentralised air supply unit is too high, for example if there are excessively high flow resistances in the system, or if too many filter stages are being used without producing the required compressed air quality.

A further advantage: if the consumption of each individual system is known, then sizeable deviations from standard consumption act as early warning signs, e.g. of an existing or developing fault.

Figure 10: Measurement of compressed air consumption

Objective

- To determine the actual compressed air consumption of individual machines as a basis for the optimal design of the compressed air supply to the machine
- To determine the leakage loss of individual machines
- To determine various characteristics in order to provide comparability over a relatively long period and lay the foundations for system monitoring.

Implementation

- Measurement of the exact consumption of compressed air by individual machines and applications during both downtime and operation
- Analysis of various characteristics:
  – Consumption per machine cycle
  – Average consumption per minute
  – Average pressure
  – Max./min. pressure
  – Max./min. air flow rate
- Evaluation and documentation of the measurement results

Here too, special measuring devices are used. The measured data must be stored for subsequent evaluation.

Machine energy efficiency analysis

In addition to data from the compressed air consumption analysis, the following information must be collected so that the energy efficiency measures can be precisely evaluated and determined:"

- Compressed air components (in particular air nozzles, sealing air) and pneumatic drives used
- Sizing of components and connecting components
- Technical requirements on the application (force, speed etc.)

A systematic review of the systems' energy efficiency (i.e. each application's usage of compressed air in line with demand) must be carried in order to identify economically worthwhile and technically feasible optimisation measures can be identified.

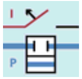
Objective:

- To analyse compressed air applications for possible energy optimisation potential
- To identify worthwhile and technically feasible optimisations

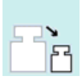
Implementation

- Identification and analysis of compressed air applications pertinent to energy use

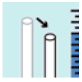
The following 12 energy efficiency measures are helpful. These can be implemented, and should at least be considered, for all compressed air systems and also for systems with electric drives:



Switching off power
- Switch off systems during breaks in production

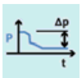


Reducing weight
- Optimal technology mix of electric and pneumatic drives (e.g. pneumatic Z-axes, grippers etc.)



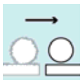
Reducing tube lengths (not diameters!)
- Use decentralised valve terminals
- Optimal tubing layout

Reducing pressure level
- Reduce system pressure in the event of oversizing
- Reduce pressure for the return stroke

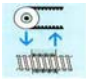


Reducing pressure drops
- Optimal cable diameter, fewer line resistances
- Reduce network pressure

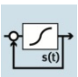
Reducing leakages
- Regular leakage detection, condition monitoring
- Use components suitable for operating conditions
- Professional assembly of compressed air components



Reducing friction
(Measure is generally only suitable for electric drives.)

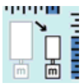


Choosing the right components
- Use single- instead of double-acting drive
- Air nozzles with appropriate nozzle geometry

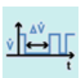


Efficient open- and closed-loop control
- Adapt operating profiles, optimise controllers
- Supply air in line with demand

Recovering energy
- Central waste heat recovery
- Use cascaded pressure levels



Correct dimensioning
- Optimal size
- For pneumatic drives, one size smaller
- Use of software engineering tools



Using air-saving circuits
- Vacuum generator with monitored switch-off
- Timed use of air nozzles, not permanently blowing

Who should take which energy efficiency measures?

There is no universal answer to this question. The measures must be defined individually for the respective plant or company.

Which measures are worthwhile depends on various factors, such as the state of the compressed air system, the extent of utilisation, etc. In the area of machine energy efficiency analysis, these are directly dependent on the application. Moreover, the individual measures should always be reviewed in relation to the total consumption in order to ascertain the economic efficiency of a particular optimisation measure.

A good provider will first of all ask the customer for their requirements and objectives, and then start by determining the top 3 measures together with the customer.

At Festo, this takes places as part of a "pre-audit". During this process, the basic data is determined to build up a picture of the status of the compressed air system, and the needs of the customer are identified. This data defines the further approach and planned measures.

How quickly will the cost-saving measures be amortised?

Based on experience, amortisation periods are usually between one and two years. In most energy saving projects the return on investment (ROI) was achieved within this timeframe. The deciding factor for a quick ROI is the prompt implementation of the measures identified.

How can the savings be guaranteed in the long term?

Once a compressed air system has been optimised and brought up to date, it is important to safeguard its energy efficiency and hence the cost-efficiency. There are two ways to do this.

On the one hand, this can be done by arranging service and maintenance contracts, e.g. regular leakage detection, compressed air quality analysis, maintenance of individual machines. A difference is generally made between

- preventive maintenance (tightening fittings, lubrication)
- inspection (checking for damage) and
- corrective maintenance (replacing components).

Alternatively, there is the option of transferring know-how from the service provider to the company in question by suitable trainings. This way, knowledge can be built up and secured within the company.

Who can implement the cost-saving measures?

To make the most of the potential savings that have been established, it is recommended that the identified measures are carried out promptly. This is because every day represents a cash saving.

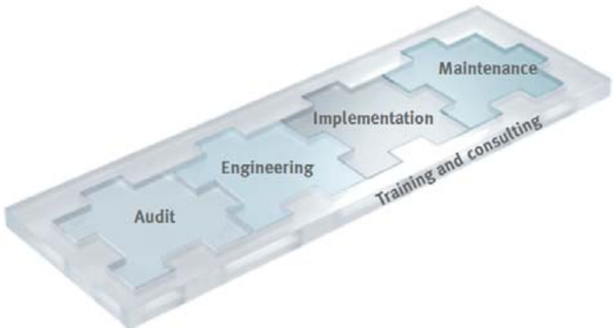


Figure 11: Holistic service package for energy saving in compressed air systems

However, there are often not enough resources available for a company to implement all the measures in-house. In many cases, staff do not have enough time, or the necessary measuring devices and corresponding know-how are not available. The measurement results must be interpreted correctly, spare parts sourced, and replacements identified for products that are no longer available. In brief, many different aspects have to be borne in mind to get close to the optimum in terms of energy conservation.

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certifies for

Festo AG & Co.KG,

that the "Festo Energy Saving Services" represent a suitable and expedient methodology for the assessment of companies with regard to the energy efficiency of compressed air plant.

"Festo Energy Saving Services" is a service program with a modular structure, composed of the following services:

- Compressed air energy efficiency audit in accordance with ISO/DIS 11011
- Engineering and implementation of measures for compressed air savings
- Measures for ensuring long term savings of compressed air

The aim of "Festo Energy Saving Services" is the best possible exploitation of compressed air savings potential.

The assessment of methods by the TÜV SÜD Industrie Service GmbH relates to the compressed air efficiency audit in accordance with ISO/DIS 11011. The compressed air efficiency audit in accordance with ISO/DIS 11011 includes the following modules:

- Analysis of compressed air generation
- Analysis of compressed air consumption
- Analysis of compressed air quality
- Leakage location/ elimination
- Analysis of machine energy efficiency in connection with compressed air usage

The methodology developed by Festo AG & Co.KG is assessed against the ISO/DIS 11011 "Compressed air energy efficiency audit". In addition the following are taken into account: VDI Guideline 3922 "Energy-Consulting for Industry and Business", DIN EN 15900 "Energy Efficiency Services" and DIN EN 16247-1 "Energy Audits".

The Festo AG & Co.KG has disclosed the internals of this methodology to TÜV SÜD Industrie Service GmbH. The potentialities are expertly and methodically correctly identified, evaluated, weighted and reported.

This Certificate is based on Audit Report No. 1918549 of 01.02.2013.

Dresden, 01.02.2013 — Auditor

Industrie Service · TÜV SÜD · Region Nordost

Dresden, 01.02.2013 — Auditor

TÜV SÜD Industrie Service GmbH · Drescherhäuser 5d · 01159 Dresden · Germany

TÜV®

Figure 12: Compressed air energy efficiency audit to ISO/DIS 11011, certified by TÜV SÜD

It is helpful to have a partner who is familiar with compressed air systems and the latest technologies and has the corresponding know-how. Ideally the service package includes all services – from audit, through engineering, right through to implementing the optimisation measures and providing staff training. The service package should be certified, e.g. in accordance with ISO/DIS 11011. This ensures that suitable and qualified measurements for energy saving are performed.

Summary

An integral approach to optimising energy usage in a compressed air system has a range of benefits for the operator of compressed air systems:

- Reduction in energy costs and, as a result, in operating costs
- Reduction in costs for maintenance and servicing
- Increase in process security
- Reduction in unplanned production downtime and associated costs

Which measures will be worthwhile depends on the circumstances and on the operator's objectives. However, numerous studies and research projects (Green Carbody Technologies 2013, EnEffAH 2012, Compressed Air Systems in the European Union, 2000) have shown that especially leakage detection and elimination are a low cost way of making a significant contribution to reducing compressed air costs. Like any other technology, compressed air systems are efficient if they are used and maintained professionally.

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A practical example

Customer
Global food manufacturer

Measures
Leakage detection and elimination at plant level

Initial situation

Plant:	approx. 50,000 m²
Installed compressor output:	410 kW
Compressed air consumption:	40 m³/min
Production hours:	8,000 hours/year
Compressor pressure:	6 bar rel.
Compressed air consumption:	16,475,000 m³/year
Average price for compressed air:	1.8 ct/m³
Compressed air costs:	€ 295,000/year

Result of a compressed air audit

Identified leakages:	296
Total compressed air loss:	1.63 million m³/year
Leakage loss:	€ 29,265/year
Reduction in annual CO_2 emissions:	approx. 160 t
Total project costs (including spare parts):	€ 31,000

Reduction in compressed air costs	**10%**
Saving in euro	**29,265/year**
Amortisation time	**13 months**

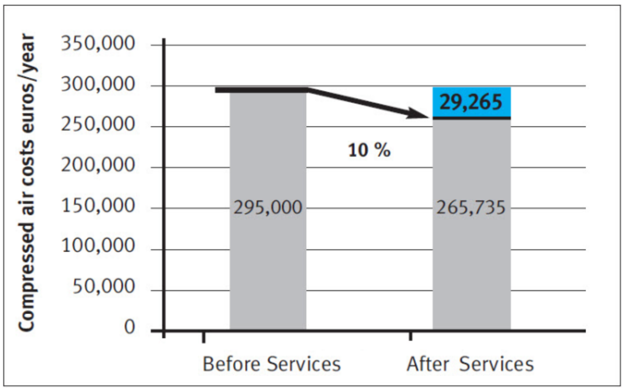

Figure 13: 10% of the compressed air could be saved as a result of leakage elimination.

Sources

- ISO/DIS 11011
- EnEffAH project " Energy efficiency in production in the drive and handling technology field", (2008-2012);
- Study "Compressed air systems in the European Union", Fraunhofer Institut ISI (2000)
- Research project „Green Carbody Technologies“, 2013
- Festo: brochure „Energy Saving Services“
- Festo: web page „Energy Saving Services” -> link
- Festo: movie „Energy Saving Services“ http:// www.festo.com/fess_movie
- Festo: web page „Energy efficiency@Festo“ http://festo.co.uk/energy

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