ZVEI: Die Elektroindustrie

More energy efficiency through process automation

- Checking economic viability
- Implementing improvements

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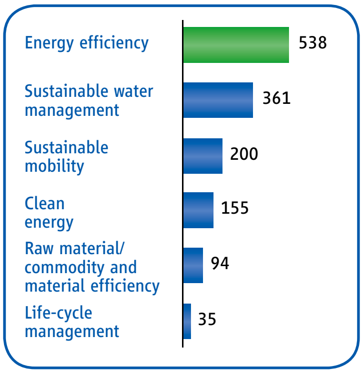
Global market value for environmental technologies in 2007 [in billion euro]



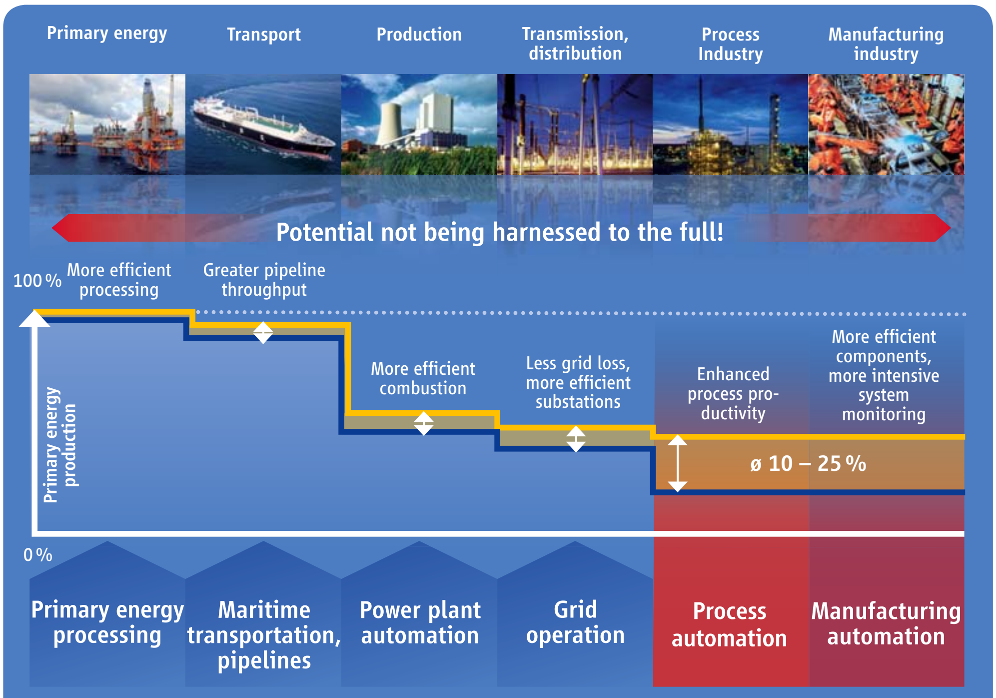
Source: Roland Berger; Federal Ministry for the Environment, Nature Conservation and Nuclear Safety: GreenTech Made in Germany

What is process automation?
Measuring technology and process automation constitute an important area of automation. Process automation and measuring technology (including instrumentation and control (I&C)), refers to the measurement, control and regulation of production-specific and process-engineering processes (such as heating, cooling, vaporization, condensation etc. of substances) using measuring and analytical devices, control systems, computer technology and software engineering. Values such as O_2 content, pH value, temperature and pressure are measured.

They help sectors such as the chemical, pharmaceutical, primary industries and power industry to operate efficiently, cleanly and safely. The industry employs over 100,000 people in Germany. In 2011, it generated a turnover of € 17.8 billion, or more than 10 % of the overall turnover of the electronics industry in Germany.

Energy efficiency is of central importance from both a social and economic perspective. As early as 2007 Roland Berger valued the global market at € 538 billion (see Figure on left). Rising energy prices will pose an enormous challenge, particularly for energy-intensive industries, such as the basic chemical industry [1], metal-producing industries, the cement industry and the oil & gas industry. Roland Berger Strategy Consultants, for example, forecast that the price of electricity will increase by roughly 70 % in the coming 20 years. According to Roland Berger, the German basic chemical industry alone required € 2.6 billion of electricity in 2010. [2] Considering that electricity only accounts for approx. 30 % of the energy needs of the basic chemical industry, and 70 % of energy costs are attributable to energy sources such as gas, coal, oil, steam and compressed air [3], the total energy costs in the basic chemical industry in Germany were probably in the region of € 9 billion in 2010.

ZVEI estimates that demand-driven automation technology alone could already deliver additional energy savings of between 10 % and 25 % in machines and plants deployed in Germany, including those in municipal production and disposal firms. This means that within one year the entire industry in Germany could save an additional € 7 billion in energy, or 43 million tonnes of CO_2 equivalent. [4] Instrumentation and control (process automation) can make a key contribution to boosting potential for energy efficiency (see Figure below).



Potential efficiency gains in industrial processes are especially high.

Source: ABB Group, ZVEI

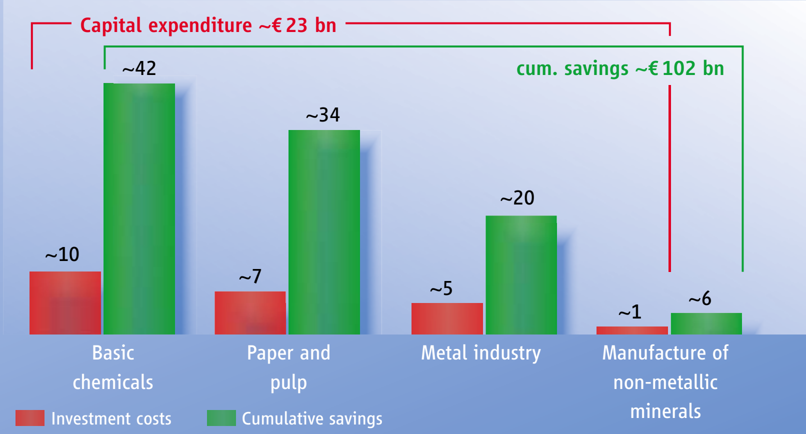
Greater focus on the economic viable of measures to boost energy efficiency

To ensure the continued success of energy-efficiency measures, organizations need to ask themselves the following questions: How cost-effective are my measures? Does investing in energy-efficient and efficiency-enhancing technologies make business sense for my company?

According to Roland Berger Strategy Consultants, capital expenditure of € 10 billion through to 2050 in the basic chemicals industry would bring about cumulative energy savings of € 42 billion. Here, capital expenditure primarily comprises additional costs for using more efficient machines and measures to increase the efficiency of industrial processes, such as modern instrumentation and control technology. Similar levers can be expected in other energy-intensive sectors, such as the paper industry, the metal production industry and in industries involved in the processing of non-metallic mineral products. [5]

[1] Basic chemicals = inorganic petrochemicals, polymers
[2] See Roland Berger Strategy Consultants: Study: Boosting efficiency in electricity-intensive industries, outlook and strategies for action through to 2050, Munich, August 2011, P. 4
[3] See ZVEI: Measuring Technology and Process Automation Division: own estimates
[4] See ZVEI: High-tech environmental and climate protection: Automation: Putting energy efficiency first, Frankfurt am Main, 2010
[5] See Roland Berger Strategy Consultants: Study: Boosting efficiency in electricity-intensive industries, outlook and strategies for action through to 2050, Munich, August 2011, P. 14

Investment costs * and savings through to 2050 – industry-specific [billion EUR]



Capital expenditure primarily comprises additional costs for using more efficient machines and measures to increase process efficiency

Overall, some € 23 bn must be invested through to 2050 in the industries examined to reach the energy efficiency goals

* Calculation based on market size for efficiency measures and a payback period of around 10 years

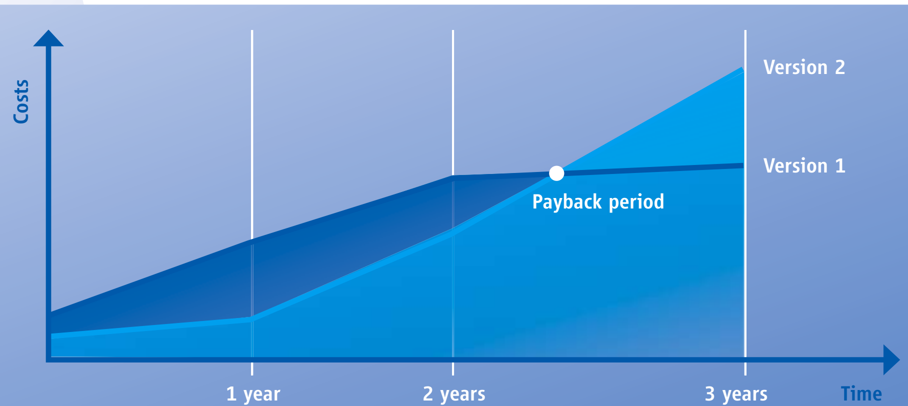
Source: Roland Berger Strategy Consultants

Businesses need to be somewhat far-sighted to be able to identify these effects, as situations must be viewed over the medium to long term. It is often the more expensive technology that actually delivers ecological and economic advantages for a business, particularly in light of imminent hikes in energy prices. While the Public Tender Ordinance does specify that total lifecycle costs should be considered when making investment decisions, in reality this is often not the case: ZVEI studies have found that around 80 % of stakeholders only consider the purchase price or pay-off period when evaluating a purchase, but do not measure economic viability, such as the cash equivalent of the total cost of ownership. [6] This is because buyers are often not responsible for operating costs and consequential costs. However it is also due to the lack of reliable, vendor-neutral tools for life cycle costing/whole-life costing.

ZVEI tool calculates and compares lifecycle costs

In collaboration with Deloitte and with the support of nine businesses, [7] ZVEI has developed a vendor-neutral Lifecycle Cost Evaluation Tool (LCE). It can be downloaded free of charge from www.zvei.org/Lebenszykluskosten. The focus here is on providing a quick and easy format to compare efficiency measures and make the associated economic implications for the business transparent: Once basic information such as purchase, energy and operating costs have been entered, the Excel-based tool compares the project options on the basis of the cash equivalent/ cash value and the annuity. It assesses which option is more energy efficient, which solution results in the lowest cost of ownership and quantifies the differences. For example, it is possible to compare individual components, component lines and plant units. Rather than being restricted to certain applications and technologies, this tool is a purely economic instrument offering versatile use in industry and infrastructure.

The payback period is often reached after a relatively short time



Version 1 constitutes the initially more expensive investment which is recouped over the life cycle due to the lower energy costs.

[6] See ZVEI: Energy efficiency pays off: presenting an instrument to calculate lifecycle costs when deciding to invest/making investment decisions, Frankfurt am Main, 2011

[7] ABB, Auma, Endress+Hauser, Festo, Krohne, Pepperl + Fuchs, Phoenix Contact, Siemens, Vega

Practical example of a WWTP

Steinen wastewater treatment plant
Source: Endress+Hauser

In the specific example of the Bachwis wastewater treatment plant in Switzerland, the operator had two options to choose from: standard modernization (investment project I), which entailed feeding oxygen into the aeration basin on the basis of time control, and energy-efficient modernization (investment project II), which involved feeding oxygen on the basis of continuous oxygen and ammonium readings obtained using sensors. The latter version can be specifically controlled and requires less energy. While at first glance it appears to be the more expensive option – with a procurement price 100 % higher (double that) of option I and higher annual operating costs – it allows for substantial energy savings: Viewed over the system life cycle of 15 years, this results in a 42 % reduction in energy costs and a 27 % cut in the total cost of ownership. Overall total costs of close to 400,000 CHF can be saved. What appeared to be the more expensive version actually proves to be the most economical solution. This is just one of several practical examples that proves that energy efficiency and cost effectiveness are not contradictory in terms. Measures to increase energy efficiency are also often the commercially viable option.

An overview of energy efficiency measures in WWTPs is also provided in Chapter II, Section 7.

Example: Wastewater treatment plant at Bachwis, Fällanden, Switzerland (comparison between standard and optimization)

	Investment Project I	Investment Project II
Measure	Time-controlled aeration basin (standard modernization)	Aeration basin with oxygen and ISE sensors, i.e. additional ammonium and nitrate measurement (optimization)
Investment amount	Initial investment of CHF 90,000, then CHF 2,000 per year	Initial investment of CHF 208,000, then CHF 6,000 per year
Energy costs	CHF 110,000 per year	CHF 63,000 per year
Period under consid.	15 years	15 years

WWTP analysis (standard vs. optimization)

Energy efficiency	Investment Project I	Investment Project II
Cash equivalent of energy costs for one-off project implementation	1,313.2	752.1
Cash equivalent of energy costs over harmonized project life span	**1,313.2**	**752.1**
Nominal energy savings, absolute		561.1
Annual annuity (energy costs)	**110.0**	**63.0**
Nominal energy savings (per year)		47.0
Percentage energy savings (cash value observation)		-42.7 %
Economical comparison/study/profitability comparison	**Investment Project I**	**Investment Project II**
Useful life (years)	15	15
Installation phase (years)	0	0
Operating phase (years)	15	15
Deinstallation phase (years)	0	0
Useful life with harmonized project life span (years)	**15**	**15**
Discount rate	**3.0 %**	**3.0 %**
Cash equivalent of lifecycle costs for one-off project implementation	1,427.0	1,031.7
Cash equivalent of life cycle costs over harmonized project life span	**1,427,0**	**1,031.7**
Annual annuity	**119.5**	**86.4**
Percentage savings (cash value observation)		-27.7 %
Select →	**Investment Project II**	

Investment project II enables savings of roughly CHF 400,000

Source: ZVEI, Endress+Hauser

Data input for Project II WWTP (standard vs. optimization)

	Year of use	0	1	2	3	4	5	6
	Phase	Installation phase	Operating phase	Operating phase	Operating phase	Operating phase	Operating phase	Operating phase
Personnel	Enable cost driver							
Wages and salaries	No							
Social insurance fees	No							
Training expenses (internal)	No							
Others	No							
Personnel, total		-	-	-	-	-	-	-
Material								
Energy costs	Yes		63,000.0	63,000.0	63,000.0	63,000.0	63,000.0	63,000.0
Raw materials	No							
Auxiliary material	No							
Expendable supplies	No							
Waste	No							
Material, total		-	63,000.0	63,000.0	63,000.0	63,000.0	63,000.0	63,000.0
Outside services								
Expert opinion and advice	No							
Training expenses (external)	No							
SPV costs	No							
Insurance	No							
External substitute services in event of failure	No							
Other	No							
Total outside services		-	-	-	-	-	-	-
Facilities and equipment								
Site	No							
Infrastructure (PLC programming)	Yes	20,000.0						
Technical facilities and machines (fan (procurement + service))	Yes	90,000.0	2,000.0	2,000.0	2,000.0	2,000.0	2,000.0	2,000.0
Technical facilities and machines (oxygen measurement (investment + material))	Yes	40,000.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0	1,500.0
Technical facilities and machines (ISE-measuring systems (invest. + instal. + maint.))	Ja	58,000.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0	2,500.0
Other	No							
Facilities and equipment, total		**208,000.0**	**6,000.0**	**6,000.0**	**6,000.0**	**6,000.0**	**6,000.0**	**6,000.0**

Source: ZVEI, Endress+Hauser

II. Identifying priority areas to tweak energy efficiency and implementing improvements

Using the tool described in the previous chapter efficiently and effectively first requires some technical and business groundwork. First of all, data must be compiled on the implications and costs associated with possible energy efficiency measures. In many cases, this information is available from the manufacturer and, where necessary, can be compared/referenced against the individual experience of the users. The economic viability of the energy efficiency measures can then be gauged, preferably on the basis of the true costs, i.e. the life cycle costs. ZVEI has made a special LCE tool available on its website for this purpose: www.zvei.org/Lebenszykluskosten In the third step, appropriate improvements can be introduced and implemented for the priority areas where measures to increase energy efficiency are worthwhile.

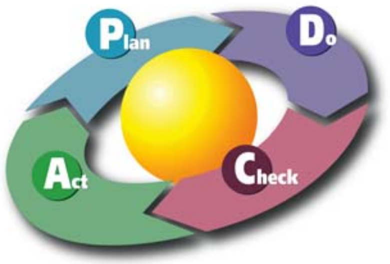
1. Obtain information on the particular costs and savings associated with the individual energy saving measures → e.g. manufacturer and user information on the technologies concerned
2. Determine the economic viability of energy efficiency measures and compare on the basis of life cycle costs → e.g. using ZVEI's LCE tool, see Chapter I
3. Identify key areas for tweaking energy efficiency and implement improvements (energy cost driver or useful energy efficiency measures) → see following sections in Chapter II

The following applications or industries will be analyzed in greater detail in the following section:

- Energy management
- Hydraulic systems (pumps)
- Compressed air systems
- Chemical industry
- cement industry
- Breweries
- water/wastewater industry (WWTPs)
- energy production (biogas plants)

1. General information on energy management

Energy management concerns the systematic adoption of the sustainable and efficient use of energy in business organizations. Furthermore, the procurement and use of energy in a business is continuously improved with an energy management system. The aim is to implement the continuous improvement process (CIP) in the business, as this is the only way to keep identifying new potential for efficiency and adopt appropriate measures to save energy.
The introduction of an energy management system that meets the requirements of DIN EN ISO 50001 can be an effective tool to implement energy management in the business, as the standard provides a framework for action.



Source: PDCA by Karn G. Bulsuk

The continuous improvement of energy management offers companies a wide range of benefits:

- Reduced energy input, and therefore lower energy and production costs
- Lower production costs improve the organization's competitive position
- The customer expects environmentally sound, energy-efficient production
- The business meets legislative and policy-specific conditions and therefore might be able to avail of certain tax benefits, for example

When introducing an energy management system, attention should be paid to certain areas, including:

- Define an energy goal for the business organization. This goal should be quantifiable and plausible/comprehensible as continuous improvement would otherwise not be possible.
- Define business energy KPIs. This is the only way to really compare the energy consumption of different lines, different products and different shifts.
- Decide whether the method currently used to capture energy data is adequate. How is the energy balance sheet created? Is everything read out manually or is an automatic data acquisition and processing system in place? Are enough energy measuring sensors installed or is the energy in some areas of production not recorded sufficiently?
- Create an overview of measures to save energy. This active document contains the necessary energy-saving measures to are to be implemented. The members of staff should be involved in this process as operators on site are sure to have very constructive ideas of how to improve the energy efficiency of their specific area of production.

Organizations with an energy management system appear future-forward and, if certified, these systems can be the basis to possible funding and tax savings within the framework of Germany's Renewable Energy Act (EEG) and the tax advantages for energy-intensive industries (Spitzensteuerausgleich).

2. Energy savings in hydraulic systems (pumps)

Source: Sondex BV/Samson AG, producers of hot water

Accounting for roughly 20 % of global electricity consumption [1], pumps offer considerable potential for saving energy in every business sector. To increase energy efficiency in a hydraulic system, it is necessary to view the system in its entirety, with the „"whole of system" approach comprising the pump, assemblies and consumers. If the individual components are viewed in isolation, it is not possible to fully tap the potential for saving energy.

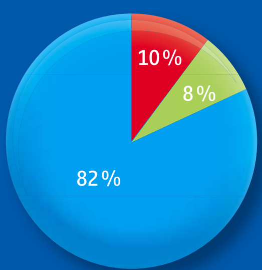
Engines have become more sophisticated, achieving very high levels of efficiency, which in turn increases the energy-saving potential of the overall system. Roughly 15 – 20 % of pumps are currently operated via variable-speed frequency converters where energy is saved if the speed is reduced. For example, reducing the speed by 20 % cuts energy consumption by 50 %.

Centrifugal pumps, for example, have a clearly defined maximum efficiency at around half the maximum rate of material flow. As pumps today are generally oversized, this limits the impact of speed regulation. If a pump is only operated at half the maximum pumping capacity, the degree of efficiency drops due to the internal reverse flow. If several consumers are connected to a pump, the control fitting has a considerable impact on the pump's energy consumption due to the pressure loss experienced. The pressure loss in the control fittings significantly determines the control/regulation quality. By combining speed regulation and throttle control, it is possible to move to any of the points in the pump's map so that the entire hydraulic system can be operated in a way that optimizes energy.

Apart from industrial applications, private households also play a central role as they account for a third of total energy consumption. The numerous pumps to be found in heating, ventilation and air conditioning applications offer considerable potential for energy savings. With regard to the generation of drinking water in residential buildings, for example, the heating of drinking water can sometimes account for over 25 % of a building's total heating needs, with a large percentage lost through circulation. Modern motor valves with integrated regulators and a combination of the continuous flow principle to heat drinking water can significantly reduce such energy loss without compromising on comfort or convenience. For example, the costs of operating a circulation pump with an operating time of 16 hours and a power consumption of 30 W amounts to approx. 40 euro per year. Given the 40 million private households in Germany alone, this results in substantial potential savings.

Businesses frequently tend to ignore the fact that the acquisition costs of a system often only account for a fraction of the overall cost of ownership. In a pump system, 82 % percent of costs can be attributed to energy consumption. Therefore when planning a system the focus should not only be on the acquisition costs. The various costs that are incurred over the entire life cycle of a system must be taken into consideration.

Life cycle costs of pump systems



- Energy
- Maintenance
- Acquisition

Total costs for a sample pump system (investment and operating costs)

Source: Bavarian State Office for the Environment, Guidelines for the Efficient Use of Energy in Commerce and Industry, 2009, P. 12

Overview – points to consider when identifying potential savings

Design

Pumping capacity
- Determine required suction height
- Determine required flow rate

Operation range
- Normal operation
- Startup
- Overload/emergency operation
- Partial load (partial load recirculation) Emergency stop

NPSH value (net positive suction head)
- Cavitation
- Stall
- Number of impellers
  - single-stage
  - multi-stage
- Impeller size
  - Adapted to pumping capacity
- Impeller condition
  - Damaged
  - Soiled

Upstream and downstream straight lengths/type of flow
- Cavitation
- Stall

Motor

Motor design
- Particularly energy-efficient motors (such as IE3 for example)

Lifecycle costs
- Energy consumption

Maintenance costs

Pump

Choice of pump
- Displacement pump
- Flow machines
  - radial
  - mixed flow ???????
  - axial

Control

Two-point control
- On or off

Speed regulation
- Nominal flow – minimal Flow
- Natural frequency of pump
- Interference (EMC)

Throttle control
- Valve size
- Startup
- Cavitation

Bypass control

Operating performance

Service performance

Operating point
- Position of the operating point

Source: Samson AG

[1] See Andreas Schreitmüller, Danfoss, in: Chemie-Technik, May 2008, P. 62

3. Compressed air systems and applications

Energy consumption in process automation, and especially in pneumatic applications (compressed air), is not only determined by the efficiency of the compressor used but particularly by the interaction and efficiency of all the components in the pneumatic chain. The use of smart sizing and design tools in engineering can save up to 40 % of the compressed air consumed and 10 % of the application costs.

Attention should be paid to the following points when sizing maintenance units:
- Determine the quality of the compressed air from the compressor
- Determine the maximum total compressed air required by the system
- Determine the compressed air quality required for the components used

Maintenance unit for decentralized preparation and switch-off options
Source: Festo

A maintenance unit should perform the following functions:
- Manual switch-on valve
- Electrical switch-on valve
- Filter control valve
- Pressure build-up valve
- Pressure sensor
- Other sensors (e.g. flow sensors) can be integrated

Valves and/or valve terminals

Valves should be installed as closed as possible to the drives. This achieves the following:
- Reduction of the dead volume in the hose
- Shorter drive response times

Hose length	3.0 m	0.3 m
Hose compressed air consumption	0.919 Nl/cycle	0.092 Nl/cycle
Energy costs/year (2.5ct/Nm³)	~€ 145/year	~€ 15/year
Compressed air consumption of working cylinder 2.4 Nl/cycle	~€ 350/year	~€ 350/year
Savings from hose length reduction		26 %

With system pressure of 6 bar.

Cylinder/valve combination to reduce hose length
Source: Festo

Pneumatic drives

- The application determines the choice of drive system
- When it comes to drives, selecting the right size can result in significant savings

Questions to ask when choosing the drive system
- Is smooth movement required?
- Must long distances be covered and high speeds therefore needed?

If you can answer "NO" to these questions, it can be worthwhile using a pneumatic drive here.
If you can answer "YES" to any of these questions, it can be worthwhile using an electric drive here.

Low-pressure return stroke

Drives often only make one productive stroke and one unproductive stroke where no work is performed. Here it is possible to use less pressure to perform this unproductive stroke and thereby save compressed air.

Savings from pressure reduction

	Control with same pressure for forward and return stroke	Control with different pressures
Cylinder used	Ø 32 mm/250 mm stroke	Ø 32 mm/250 mm stroke
Pressure	6 bar	6 bar move out; 2.5 bar move in
Travel time	0.5 s move out; 0.5 s move in	0.5 s move out; 0.5 s move in
Energy costs/year (2.5 ct/Nm³)	€ 365	€ 280

Application: Moving a cheese wheel weighing 12 kg, path: 250 mm; 60 cycles/min; 8 h/day; 200 days/year

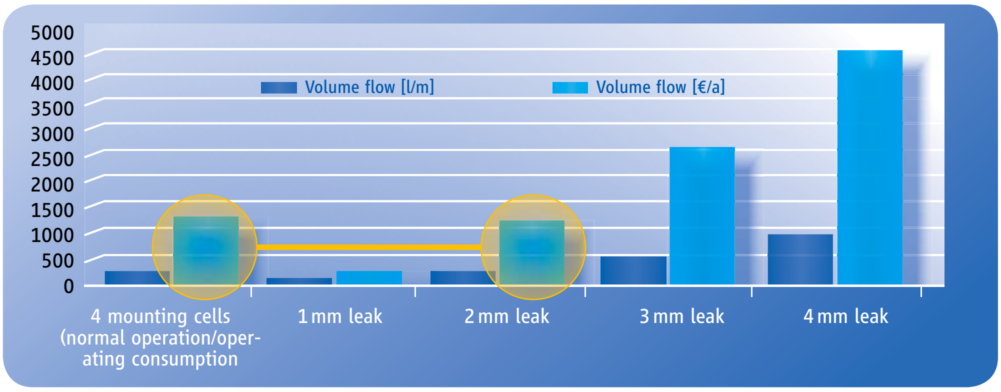
Over the entire life cycle of the production plant, energy-efficient production also requires the continuous monitoring of the compressed air system. An analysis of a real production plant reveals that leaks can cause compressed air loss equivalent to the volume of compressed air consumed by the plant.

Typical production plant with 80 pneumatic drives in 4 mounting cells

- 6 bar process pressure
- Two-shift operation on 250 days/year
- 2 ct/m^3 compressed air costs
- Consumption of von 270 m^2/d
- Energy costs 5.40 EUR/d, 1350 EUR/year

Source: Festo

Comparison of leaks of different sizes with compressed air consumption



A leak with a diameter of 2 mm causes compressed air loss equivalent to the volume of compressed air consumed by the production plant.

In addition to leak detection, condition monitoring systems also facilitate the early detection of changes in the production process by continuously comparing production parameters with values from reference routines. In the scheduled maintenance intervals technicians can then specifically search for these changes and replace any faulty components.

Source: NAMUR AK 4.17

4. Energy efficiency in the chemical industry

The German chemical industry has set itself ambitious energy and climate protection targets which it has been able to meet up to now. In 2009, absolute energy consumption was 33 % below 1990 levels, while specific energy consumption was down by more than 50 %.[1] Over the same period greenhouse gas emissions had dropped by roughly 45 %.[1] Furthermore, innovative chemical products, such as high-tech materials for using renewable energy sources for electricity generation, high-efficiency insulating materials or light-weightt components for the automotive industry make a key contribution to overcoming the challenges posed by the Germany's new energy policy (Energiewende). Investment in modern power stations and more energy-efficient processes have significantly improved efficiency in the chemical industry. Nevertheless there is still plenty of room for optimization. At large production centers, the integration of processes from both a material and energy perspective is a key area. Automation engineering provides the framework to enable closely linked processes despite increasing complexity. Furthermore it is an important lever to operate integrated plants and machines in a way that optimizes energy consumption and drives the development of individual optimizations to create an overall optimum. NAMUR, the International User Association for Automation in Process Industries, identified energy efficiency as a cross-cutting issue as early as 2009 and set up Working Group 4.17 which deals with the contribution automation engineering makes to energy efficiency. This Working Group drew on the experience from its member companies and, in NAMUR Worksheet 140, described a systematic approach to executing energy-efficiency projects with automation engineering. Regardless of whether the voluntary energy conservation targets are met in 2012, the chemical industry still faces the challenge of reducing energy consumption even further.

NAMUR

Energy and process optimization

Generally, the same procedure applies for energy-optimization projects as for any other improvement project. From an automation perspective, there are 4 stages to boosting energy efficiency in a process-engineering process.

Stage 1: improving operations

The existing plant should be operated in a way that optimizes energy consumption. For example, this can be accomplished by improving coordination between power sources and drains or by introducing a plant-wide control concept that uses models to determine the optimum operating point from online data and then intervenes in the operation of the plant. This is a typical project scenario for automation engineering and the focus of improvement efforts.

Stage 2: improvement through plant modification

To move closer towards a theoretical optimum, there is a need to reduce any loss caused by suboptimal machine design. To this end outdated equipment is exchanged or plant units are remodeled with modern replacement parts. The focus here is often on objectives such increasing capacity, improving heat integration or more efficient machines. The planned changes frequently give the process manager a window to make additional improvements. The innovations are often only possible by improving process management. Here it is very important that system planning engineers and process managers work together from an early stage of the project to choose the right technologies and tools and create the necessary interfaces. The use of frequency converters for pump motors is a classic example of energy optimization where a comparatively minor change delivers substantial savings. The flow volume required is regulated by varying the pump speed.

Stage 3 and 4: improvement through building new plants or replacing products

The biggest potential for saving energy, but also the biggest cost factor, is when new plants are being planned or completely new plant types are being developed, for example when introducing new processes or new products. The machines would then deploy cutting-edge technology which would aid energy efficiency. Such situations are relatively rare for process management engineers. As explained in Step 2, the challenge is to work together with the planning team at an early stage to identify solutions that work in harmony with one another. Other opportunities then also arise, such as using training simulators to test process control offline and train plant operators at an early stage. Examples of Steps 3 and 4 are the process for direct oxidation for propylene oxide production (-35 % energy consumption [2]), replacing chlorine production with mercury electrodes or the ban on CFC gases and the development of substitute substances.

NAMUR Work Sheet 140 [3]

Automation engineering is the basis for ensuring that processes remain safe and stable despite changes to the operating points and interference in the process, while pushing the process boundaries. Its aim must be to make operation easier for the operator and keep the distance between the operating point and the optimum to a minimum over time. NAMUR Works Sheet 140 serves as a guideline for increasing energy efficiency and explains the contribution automation engineering makes in the chemical industry. [3] The document is aimed at individuals working in the industry who plan and implement measures in their organization to increase energy efficiency. The guidelines can be regarded as an introduction to this area but will never replace experts with their specialized knowledge and expertise.

Sources

[1] Verband der Chemischen Industrie (Chemical Industry Association): Energy consumption, energy efficiency, slideshow presentation on energy and climate policy, personal e-mail communication with Volker Baumann on 17/10/2011

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[4] K. Schächtele, S. Krämer: Energy optimization in the chemical industry: political wish or economic necessity?, atp edition 1–2, 2012, P. 888-897, 2012

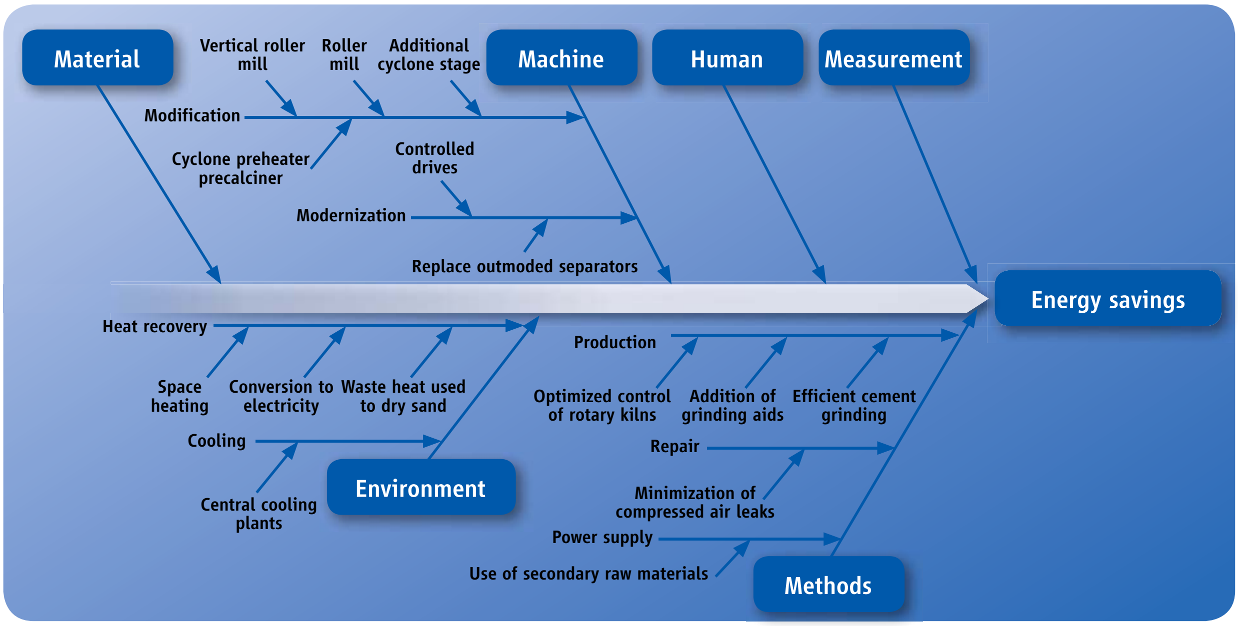
[5] Final report on „Energy efficiency: potential, economic impact and innovative action areas development areas for the National Climate Protection Initiative", ifeu Institute for Energy and Environmental Research Heidelberg, October 2011

5. Energy efficiency in the cement manufacturing

"Thermal energy requirements is the most important parameter for appraising energy efficiency in the cement industry." ([1], P. 29) "In cement production, electrical energy is primarily used to treat raw materials (roughly 35 %); to burn and cool the clinker (approx. 22 %) and for cement grinding including packing and loading (approx. 38 %)." ([1], P. 44)

"Cement rotary kiln plants have a service life of between 30 and 50 years. During this time, the plants are usually subject to a major overhaul every year in which the operation is optimized and some plant components are replaced. Furthermore in general it can be said that the reduction in energy costs alone can never economically justify the replacement of individual plant units (such as the clinker cooler for example) ." ([1], P. 30). For this reason it is important to take a "whole-of-system" approach. Instead of modifying the plant due to energy costs, this approach involves making smart choices in selecting new technology when modifying a plant to make additional cost savings.

Possible ways to save energy in the cement industry



Source: ABB

Machine

Cement factory
Source: ABB

Modification:

- As an alternative, a **roller press for shredding** can reduce the energy requirements of the pebble mill in the main step. Increases throughput by up to 100 %, energy savings of up to 50 %. ([1], P. 49)
- Possible installation of an additional **cyclone stage** exceeding the number theoretically required (due to the water content of the raw material). Possible energy savings with regard to fuel energy requirements of 80 to 100 kJ/kg plug. [2]
- **Cyclone preheater and precalciner:** Cyclone preheater and precalciner technology were introduced to improve energy efficiency. Energy savings of up to 50 % can be achieved. [5]
- Does the clinker cooler used have an efficiency rating of 75 % or more? Modern coolers have an efficiency level of up to 80 %. [1]

Modernization:

- **Controlled drives:** In one case study, drive optimization at 3 sites was able to reduce annual electricity needs by 672 MWh. ([1], P. 51), (ABB expert opinion: potential savings of up to 70 %).
- **Replacing outmoded separators** with efficient, high-precision, powerful separators enables energy savings of roughly 15 %.

Methode

Heat recovery:

- Is the waste heat from the cooler exhaust air or the cyclone heat exchanger used to dry sand, preheat fuel, in heating systems, long-distance heating systems, or similar? The average untapped potential of waste heat is equivalent to approx. 10.5 % of the thermal energy used. ([1], P. 35)
- **Waste heat can also be used to generate electricity**. In a case study, waste heat was able to cover 1/3 of the electricity needs of a cement factory. [3]

Environment

Production:

- **Efficient cement grinding:** "The efficiency of the grinding processes, i.e. the grinding of the raw materials used into a fine powder and the grinding of the cement clinker [...], determine the power consumption of the entire cement factory." ([1], P. 44) "The best approach to reducing the amount of energy used in cement manufacture is to substitute the cement clinker with other cement ingredients, such as furnace slag, fly ash, limestone powder or puzzolan." ([1], P. 63)
- **Addition of grinding aids:** According to a cement manufacturer, the addition of grinding aids reduces energy consumption in the grinding process by roughly 10 % per tonne of cement powder. [4]
- Optimization of rotary kiln control: Thermal energy savings of 8 % possible (ABB expert opinion).

Repair:

- **Reduce compressed air leaks in operation to a minimum:** Regular leak-fixing can reduce these energy costs by up to 30 % (ABB expert opinion).

Power supply:

- Use of secondary raw materials: The use of secondary raw materials (e.g. certain kinds of waste) for firing purposes can indirectly reduce primary energy needs. In some cases, however, this might alter emission limitation requirements. This should be taken into consideration in the planning stage. ([6], P. 12; [7], P. 2)

Sources

[1] "Energy Efficiency of the Austrian Cement Industry", ZÖV, http://www.zementindustrie.at/file_upl/energieeffizienzanalyse.pdf
[2] WBCSD/ECRA: Development of State of the Art-Techniques in Cement Manufacturing: Trying to Look Ahead (CSI/ECRATechnology Papers). European Cement Research Academy, 2009 www.wbcsdcement.org/technology
[3] http://www.hitech.at/2011/10/13/wie-zementerzeuger-energie-sparen/
[4] http://www.sika.com/de/group/sustainability/megatrends/energy_and_raw_materials/grinding_aids.html
[5] http://www.analyticjournal.de/downloads_firmen/siemens_zement_de.pdf
[6] http://www.econsense.de/sites/all/files/HC_U_Bericht_04.pdf
[7] http://www.energietrialog.ch/cm_data/DeQuervain_Inputpapier_EM_07.pdf

6. Energy efficiency in breweries

In breweries, energy costs (electricity and heat) account for between 5 % and 10 % of revenues. 20 – 30 kWh of heat and 10 – 15 kWh of electricity are typically needed for every hl of beer produced for sale. From an energy perspective, breweries are often still a "blackbox." Generally, potential energy savings of 10 % and more can easily be achieved in this industry. Nevertheless, a trend is emerging towards the CO_2-neutral, self-powered brewery. This trend is primarily driven by the major breweries.

Below you will find a few examples of how breweries can be run with greater energy efficiency:

Brew-house

Integration of solar-based process heat
During the mashing process, large volumes of water at temperatures between 40 °C and 58 °C are required to produce the first wort. Solar power could be used to provide some of this heated water.


Brew kettle

Biogas production
After the mashing process, the spent grains remain in the lauter ton. The high water content of the spent grains depends on the production. However they contain many substances that are not soluble in water, such as glumes/grain husks, seedlings???? or protein coagulate. This leftover material from the brewing process can be used as a raw material for the production of biogas. With appropriate process design, it is possible to produce beer in a virtually carbon-neutral and energy-neutral manner.
By burning the biogas in the brewery's own co-generation power plant, the brewery can generate large amounts of heat and electricity from its only waste material.

Combined heat and power plant (CHP)
Biogas (ideally produced from spent grain) or natural gas can be used to run a combined heat and power plant (CHP). The CHP can be regarded as a big engine that runs on gas and drives a generator to produce electricity. Waste heat can be recovered from the cooling circuit of the CHP and from the exhaust gas. The waste heat recovered can be used to heat the wort, to heat rooms/spaces and to heat water. Any electricity generated can be used within the brewery instead of the electricity delivered by the external power provided.
Linking a CHP plant to an absorption refrigerator not only extends the service life of the CHP but also increases the energy savings that can be achieved. Cooling plays a central role in a brewery. It is usually the task of compressor refrigerators, which consume a lot of electricity and drive up electricity bills/costs. Absorption refrigerators, which use the waste heat from the CHP plant, are the more efficient alternative. Since absorption refrigerators are used to cover the basic cooling load, their operation increases the basic heat load range which is important for the CHPs. This increases the annual operating hours of the CHP plant and improves efficiency.

Process engineering

Heat-exchanger network optimization using process integration
The pinch-point method makes it possible to analyze and optimize the use of energy and water in processes and systems. First of all, the user takes stock of all the flows of heat energy and then aligns the warm and cold energy flows with the aim of optimizing thermal use. Any waste heat from the processes, such as wort cooling, can be integrated to preheat cleaning agents in the cleaning-in-place (CIP) system.

Filling

Integration of solar-based process heat
The heat required by the bottle washing machine could be reduced significantly by setting up a solar-heated and thermally insulated sedimentation tank. The installation of 100 to 200 m² evacuated tube collectors would be feasible to heat a tank of this kind.

General measures to save energy that could also have a significant impact in a brewery

Load management
A load management system measures the power acquired and forecasts energy consumption on the basis of the energy data gathered. If peak load overshoot is forecast within a quarter of an hour, an installed load management system can activate a warning or briefly switch off consumers in a predefined sequence by order of priority. The consumers are switched back on as soon as possible, but without exceeding the load peak. Smart load management can save up to 15 % of energy costs.

Energy-based process simulation
Energy-based process simulation makes it possible to predict load profiles and the energy needs of individual subsystems. Furthermore, simulation routines can also be used to identify and analyze possible optimizations.

References

[1] Conference Report of the 16th Symposium on Thermal Solar Energy, Staffelstein (DE), 17.-19.5.2006, pp. 308-313
[2] Guidelines for Reducing Costs with CHP in Breweries, B.KWK Bundesverband Kraft-Wärme-Kopplung e.V.
[3] Article on the energy-neutral production of beer; GTM 5/2009
[4] Franke, S. et al.: Production-based energy management in the food industry. In: Der Weihenstephaner, 78 (2010)
[5] Baumann, V., Salger, S.: Energy management as an opportunity. In: BRAUWELT, 1-2 (2012) (brewing industry journal)

7. Increasing the efficiency of wastewater treatment plants

Wastewater treatment plants are the biggest municipal consumers of energy The electricity consumption of WWTPs in Germany is estimated at more than 4.2 TWh/a and is therefore far higher than the electricity consumption of all the country's schools (3 TWh/a). [1] Given this enormous potential, implementing energy efficiency measures in WWTPs would definitely deliver results. These measures are presented in the following questionnaire. Please refer to the references listed below for more detailed information.

Questionnaire on increasing the efficiency of wastewater treatment plants

a) Sewer system
- Reservoir management (peak load balancing)
- Reduction of infiltration water
- Check and, where necessary, calibrate wastewater volume measurement

b) Pump station
- Check degree of efficiency
- Filling options without buildup
- Control and gradation of pumping capacity

c) Exhaust air treatment (e.g. screening chamber)
- Control exhaust air extraction as required
- Aerate biofilter
- Clean scrubbers
- Ventilators controlled by Ex alarm unit
- Treatment stages depending on load

d) Aeration basin
- Calibrate oxygen probes
- Check oxygen contents
- Check degree of compressor efficiency
- Low-energy motors (IE3 instead of IE2) if motors need to be replaced
- Regulation of oxygenation based on NH4/NO3
- TS adjusted to effective load and time of year
- Upstream denitrification
- Appropriate control system to minimize agitation energy
- Check number of aerators
- Regulate recirculation in line with needs based on NO3
- Check efficiency of sludge stabilization

e) Filtration
- Take filter out of service following load
- Where possible, rinse filter at night when required

f) Heat pump

g) Return sludge pumping station
- Control based on influent volume
- Influent level as high as possible
- Minimum drain height
- Check efficiency of pumps
- Check pipe dimension for loss

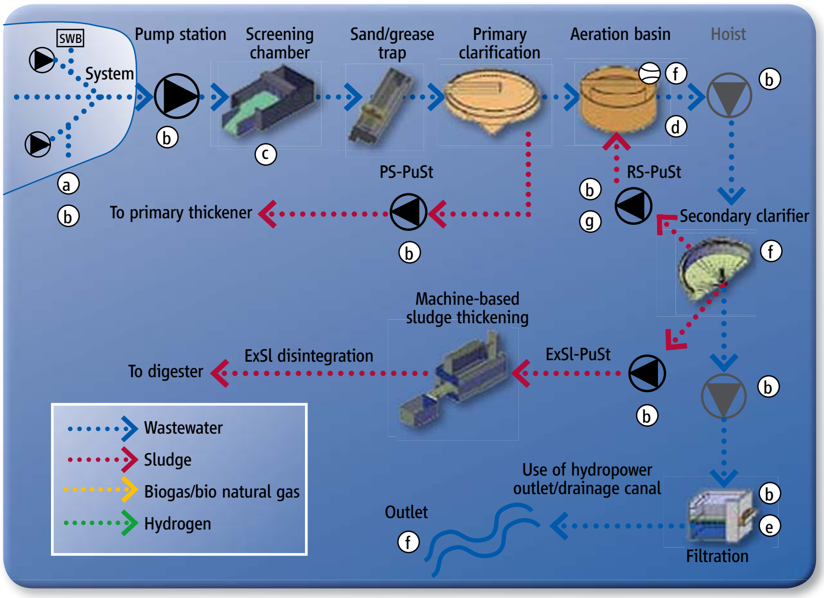
h) h+j) Primary thickener/secondary thickener
- Intermittent rabble rake
- Control sludge removal based on TS limit values
- Automated turbid water extract, TS-controlled

i) Digester
- Intermittent recirculation
- Machine thickening of excess sludge
- Internal digester recirculation
- Co fermentation
- Disintegration

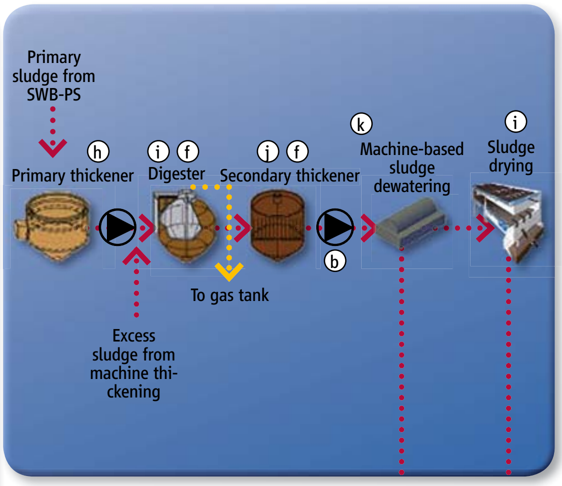
j) Machine-based sludge dewatering
- Dewatering at night, low rate
- Low-energy motors (IE3 instead of IE2) if motors need to be replaced

Source: German Association for Water, Wastewater and Waste (DWA), Hennef / Tuttahs & Meyer Ingenieurgesellschaft GmbH, Aachen

1. Water route



2. Sludge route



Source: German Association for Water, Wastewater and Waste (DWA), Hennef/Tuttahs & Meyer Ingenieurgesellschaft GmbH, Aachen

Sources

[1] DWA topics: Energy potential in German water management industry – focus on wastewater, April 2010, 146 pages, 32 graphics, 15 tables, 5 appendices with 8 fold-out pages, DIN A4, ISBN 978-3-940173-91-1, German Association for Water, Wastewater and Waste (DWA), Hennef

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[2] Research Report 205 26 307 UBA-FB 001075, 2008: „Increasing the Energy Efficiency of Municipal WWTPs" by Haberkern, Maier, Schneider, iat work group – engineering consulting for wastewater technology in collaboration with the University of Stuttgart, TU Kaiserslautern and Ryser Ingenieure Bern; http://www.umweltbundesamt.de

[3] "Energy efficiency of municipal wastewater treatment plants", Federal Environmental Agency 2009; http://www.umweltbundesamt.de

[4] Eco-efficiency in water management, "increasing the energy efficiency of wastewater treatment plants", Ministry for the Environment, Forestry and Consumer Protection, Rhineland-Palatinate; www.mufv.rlp.de

8. Energy production (biogas plants)

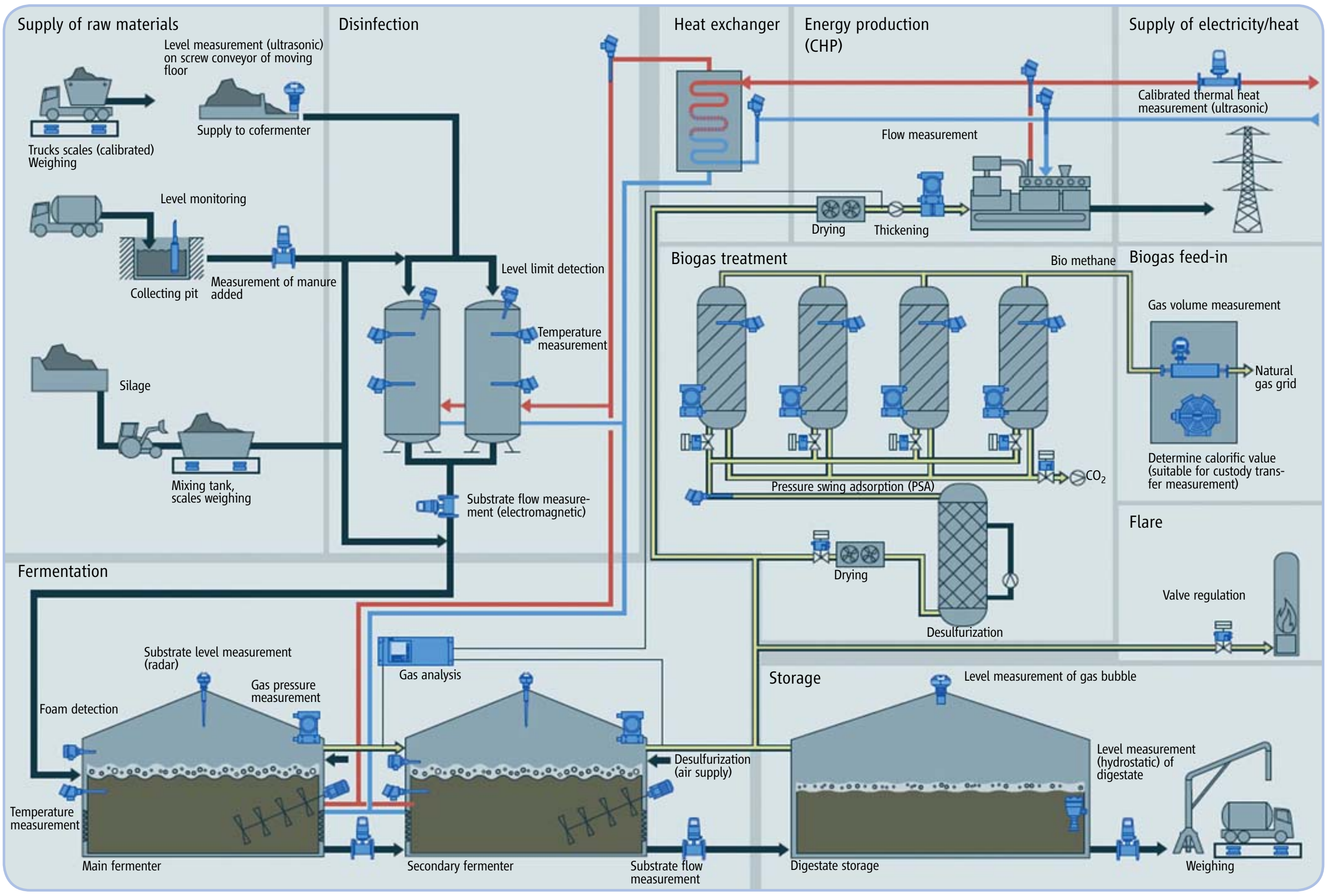
Biogas plant
Source: Siemens

Having the right environment for bacteria to convert organic substances to methane is a decisive factor in the efficiency of a biogas plant. Modern process instrumentation, analysis and automation ensure that all the parameters are always in the optimum range.

Biogas plants are based on a natural, biological process: Bacteria break down substrates such as liquid manure, cereal and other organic waste materials and produce methane gas in the process. This, however, requires an optimum environment for the anaerobic bacteria as changes to the pH value, temperature or the composition of the nutrient parts can seriously impact the fermentation process.

The right combination of process instrumentation and automation engineering makes a key contribution to stabilizing the biogas production process and increasing plant availability. Continuous level transmitters and flowmeters monitor the material fed into the biogas plant. Various analytical devices for measuring the pH value, ORP value and total solids ensure the optimum parameters for the fermentation process. The temperature is monitored on the fermenter by temperature sensors and transmitters, and the gas pressure is checked by pressure measuring devices. All the process data are monitored by process control systems and the process is controlled in such a way that optimum conditions are always present for the bacteria.

Currently, most biogas plants have an average capacity utilization rate of just 70 %. With continuous analysis and the automation of all processes with flexible and scalable process control systems, processes can be made stable over the long term and capacity utilization rates of over 95 % can be achieved. Both new plants and existing plants can be optimized with automation and process instrumentation systems.



Overall process of a biogas plant
Source: Siemens

The following offer HIGH potential for improvement:

- Selection of site of biogas plant
- Selection of planner
- Selection of plant type
- Agitator technology
- Pumps/pumping station (applies for project design / sizing!)
- Use of heat
- Electrical energy requirements
- Plant safety
- Substrate supply and storage
- Introduction of substrate into fermenter
- Filling, storage and extraction/removal of fermentation residue
- Concrete construction
- Plant visualization for plant sizes < 500 kW
- Collaboration between professionals involved
- Startup operation
- Ongoing process control
- Plant availability
- Regular plant operation
- Plant maintenance
- Organizational measures

The following offer MEDIUM potential for improvement:

- Plant sizing
- Piping
- Gas engine CHP
- Gas storage
- Factory building
- Access options
- Fermenter
- Additives/auxiliary material
- Fermenter heating and control of process temperature
- Measuring technology
- Electrical installation
- Operating costs and effort for ongoing operation

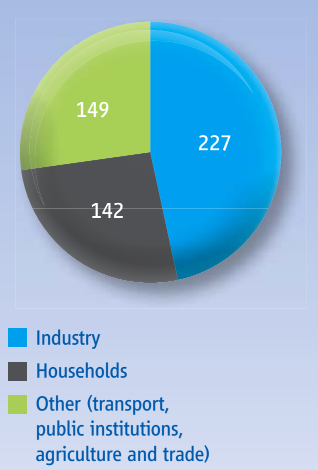
The following offer LOW potential for improvement:

- Shut-off units
- Gas flare
- Thermal energy requirements
- Desulfurization and dehumidification
- Level monitoring
- Disinfection
- Impurity and sediment discharge
- Weighing unit
- Plant visualization for plant sizes > 500 kW
- Fermenter insulation
- Air filter / bio filter
- Pumps/pumping station (applies for ongoing operation!)
- Homogenization

Overview of possible optimization measures in a biogas plant
Source: Siemens

III. Conclusion

Power consumption on 2010 by customer group (in bn. kWh)



Source: BDEW 2012

An increased focus on energy efficiency is needed to deliver on the climate goals Germany is pursuing. However, it must be borne in mind that energy efficiency measures can only be successful on the longer term if they are also commercially viable for an organization. This brochure has illustrated how the economic viability of measures to increase energy efficiency can be examined. In doing so, life cycle costs play an important role here. If more attention is paid to life cycle costs, there is a good chance that organizations will decide more often to invest in more energy-efficient measures when making investment decisions. Here, policymakers must also lead by example and make appropriate decisions in publicly owned businesses, for instance.

Furthermore, Chapter II demonstrated what an important lever energy efficiency is and how sensible/useful improvement measures can be implemented. The brochure focuses on selected applications and branches of the industrial sector, given the large potential these areas offer, accounting as they do for roughly 44 % of power consumption in Germany (households 27 %, transport/public institutions/agriculture/trade 29 %, see graphic). It is clear that the industrial sector in particular, and more notably the energy-intensive process industries, contain worthwhile areas that can build on smart technology to force the pace on energy efficiency. This not only benefits climate protection but also usually translates to cash savings for the end user.

The measures described in Chapter II are just a selection of wider ranger of options and are by not means exhaustive. We would also like to remind our readers that a many publications and tools focusing on the topic of energy efficiency and optimization are available on the websites of official authorities, research institutes, industry organizations and businesses in the industrial sector. For specific applications it is worthwhile spending some time running an Internet search, using the tools available and drawing on the expertise of ZVEI.

Die Elektroindustrie

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