VDI Zentrum Ressourceneffizienz

Competitive Advantage: Resource Efficiency

Definitions, Basics, Facts and Examples

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

NATIONAL CLIMATE INITIATIVE

Facts on Resource Efficiency

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The guiding principles of the German Resource Efficiency Programme

Resource Efficiency

Climate Protection and Competitive Advantage

Dr. Martin Vogt
Managing Director VDI ZRE GmbH

"Achieving more with less" is the basic principle of efficiency

The industrial landscape of Germany is mainly characterized by medium-sized businesses, many companies produce for global consumers. Those who produce efficiently lower their costs and thus safeguard jobs in their businesses. The leading position of the German industry both in technology and innovation is the basis for its success on the world market. There are numerous excellent examples of innovative companies that were able to further boost their competitive position in the market through intelligent resource management. Lower resource input in production is of key importance for the protection of our environment. It lowers CO_2 emissions and reduces sewage and waste. The guiding principle of decoupling the use of finite natural resources from economic growth and consumption produces many winners: competitive companies, a motivated workforce, Germany as an attractive business location and the conservation of our planet's natural resources.

Introduction

The meaning of resource efficiency

Resource efficiency increases with increasing benefit at constant resource consumption or with decreasing resource input at constant benefit.

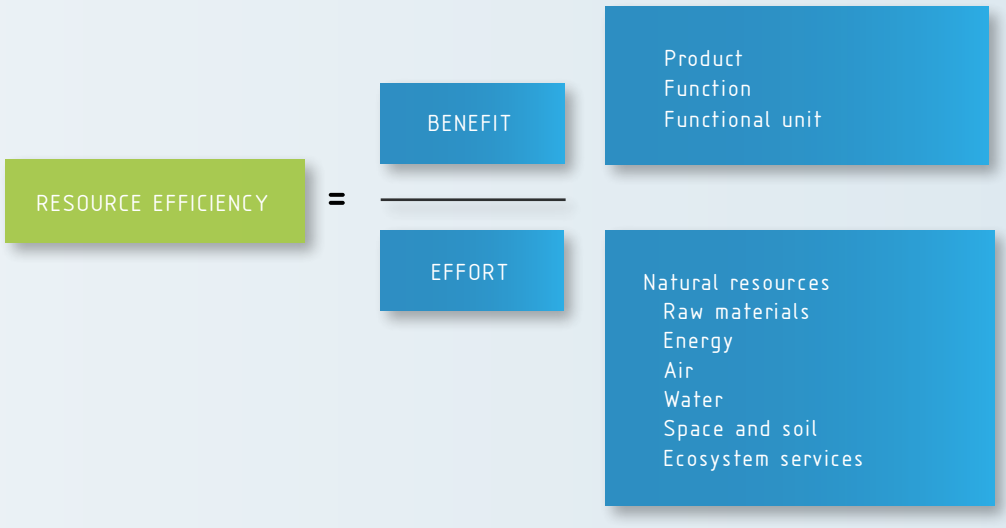
NATURAL RESOURCES

Resources are things occurring in nature that humans use to survive and to create wealth. Natural resources include biotic and abiotic raw materials, environmental media like water, soil and clean air as well as physical space available. Biotic raw materials are defined as biological products like wood, plants, animals etc., while abiotic raw materials comprise ores, minerals, energy feedstock such as oil and gas etc. Resources also include the ability to absorb emissions and waste and thus to fulfil the function of an environmental sink. In addition, so-called flow energy, e.g. geothermal energy, wind, tidal and solar energy may be included. Biological diversity as a resource refers to the diversity within species, between species and of biosystems. In the current discussion and assessment of the natural resources consumption we will focus on abiotic raw materials and environmental media, for which reliable cost items are quantifiable.

RESOURCE EFFICIENCY

Resource efficiency (RE) describes the ratio of a certain benefit to the resource consumption required for it. The utility is a concrete product (good, service or their combination). The benefit consists in the consumption of natural resources.

THE DEFINITION OF RESOURCE EFFICIENCY



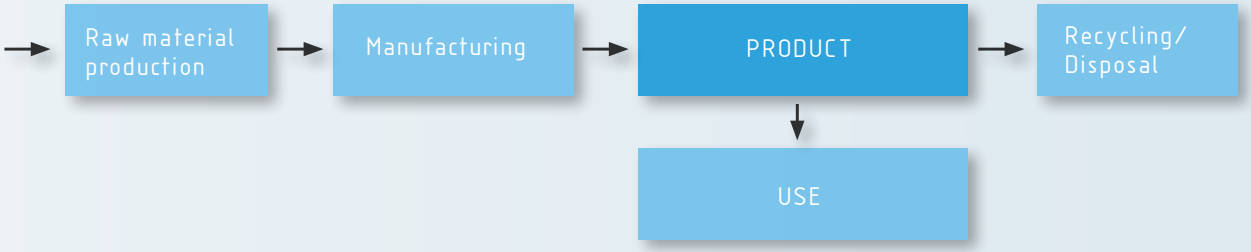
RESOURCE CONSUMPTION AND CLIMATE PROTECTION

Research results show the correlation between resource consumption and the emission of greenhouse gases, such as CO_2. In this context, the Federal Ministry of Education and Research was able to demonstrate this correlation in 22 projects of the funding measure r², Innovative Technologies for Resource Efficiency. A transfer of these results would lead to material savings of about 80 million tons each year and to an increase in raw material productivity of five to six percentage points. Furthermore, energy consumption could be reduced by about 75 terawatt hours and greenhouse gases by about 60 million tons of CO_2 equivalents per year.[1]
There are many other examples showing the correlation between resource efficiency and climate protection.

RESOURCE CONSUMPTION IN THE PRODUCT LIFE CYCLE

The product life cycle can be roughly subdivided into four phases, with the utilization phase often being the most important one. Consumption of resources occurs nearly across the entire product life cycle from raw material production to product manufacturing, use and recycling/disposal.[2] The improvement of the resource efficiency of one process or within a phase of life can lead to deteriorations in other phases of life or processes of the whole product lifecycle.
Therefore, resource efficiency should be aimed at throughout the entire product life cycle. In smartphones and other highly functional IT-products for example, numerous technology metals are processed whose manufacturing has a strong impact on the climate. Along with the short useful life of the devices of mostly less than three years, this negative balance can only be compensated by processing those metals via closed take-back systems and a technologically sophisticated recycling process and by returning them to the manufacturing process. With a proper recycling system, credits at the expense of the climate-wrecking effects of materials production are practically obtained. In comparison to the 1980s, modern washing machines as consumer durables consume less than half of the water and thus less detergent.[3]
This example shows that technical progress can provide an increase in resource efficiency without losses. In the end, long-lived assets and consumer durables with a lasting

PRODUCT LIFE CYCLE



use phase of 10 years and more are the most resource-efficient products, unless essential technical progresses are achieved during their useful life, which technically negate the advantages of long utilization.

Political support for resource efficiency

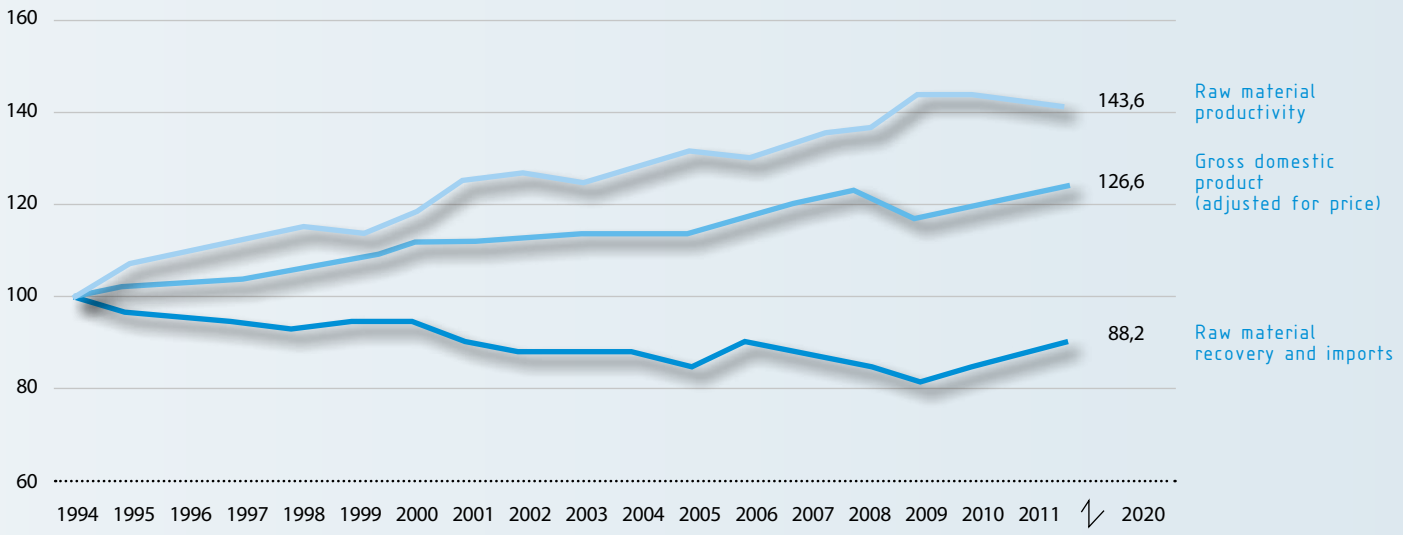
The Federal Government's strategy

ProgRess aims at the sustainable recovery and use of natural resources and at the reduction of the related ecological burden on the environment involved.

"ACHIEVING MORE WITH LESS"

In the National Sustainability Strategy 2002, the Federal Government set itself the goal to double the raw material productivity, measured in Euro value added per ton of abiotic raw material input, by 2020 compared to 1994. This goal was reinforced in the German Resource Efficiency Programme (ProgRess) adopted by the Federal cabinet in February 2012. The Federal Government aims at decoupling economic growth as far as possible from resource use, reducing the burden on the environment and at strengthening the sustainability, the competitiveness of the German economy thus promoting stable employment and social cohesion.

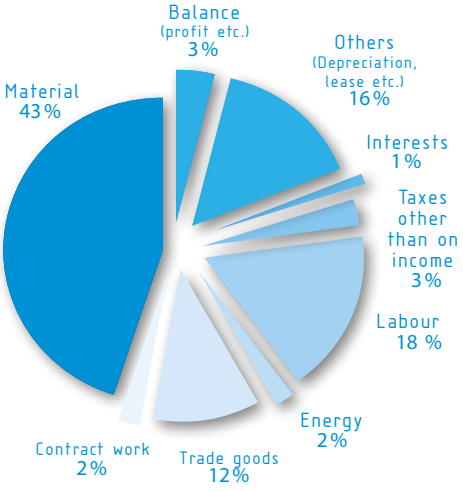
DEVELOPMENT OF RAW MATERIAL PRODUCTIVITY IN GERMANY SINCE 1994



The relevance of resource efficiency for companies

Savings in resources boost sales

COST STRUCTURE IN THE MANUFACTURING INDUSTRY 2014



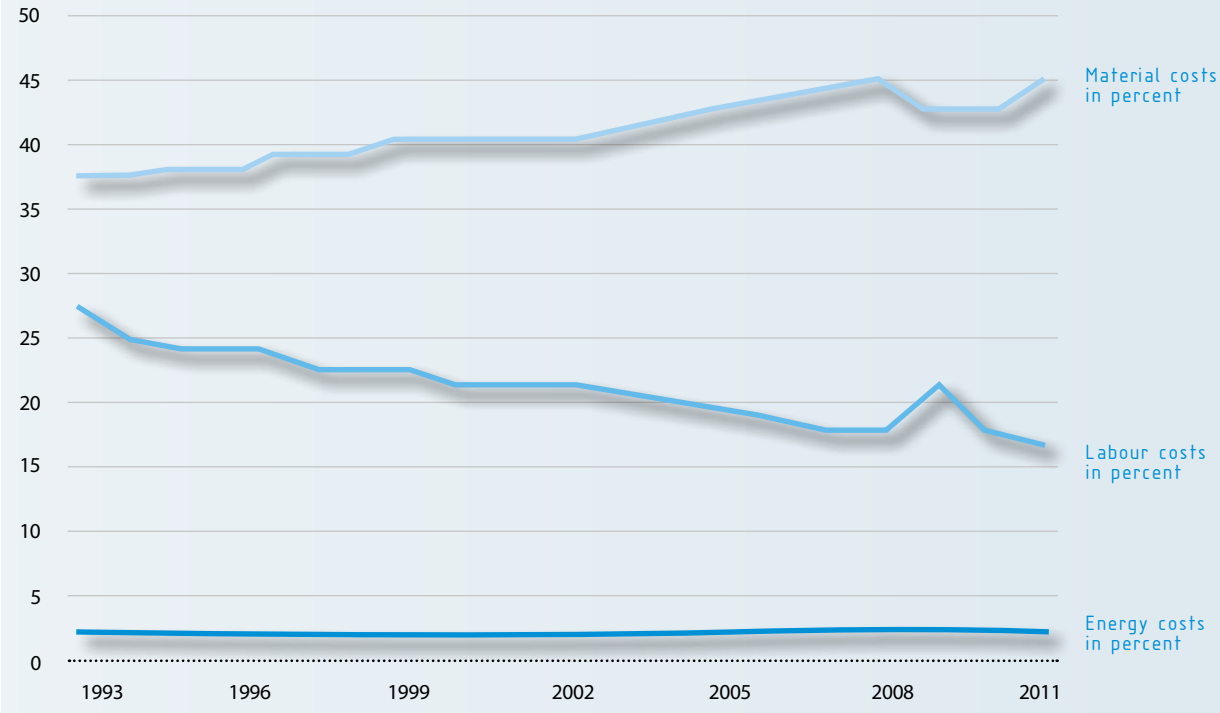
The large proportion of material costs in the manufacturing industry is reflected by its internal cost structure. The expenses for materials increased from 36 percent in 1993 to 45 percent in the year 2013, while in the same period, labour costs decreased from 27 to 18 percent. The proportion of energy cost remained almost constant at 2 percent.

The efficient use of materials significantly improves the competitive situation of a manufacturing company. The German Agency for Material Efficiency (demea) expects the operational saving potential for material costs to be at 20 percent.[4]

In 2011, the proportion of material costs in the gross production value of the manufacturing sector amounted to 831.61 billion Euros. 20 percent of it means about 166 billion Euros. Thus, conservatively estimated, the saving potential in the manufacturing sector could amount to at least 100 billion Euros.

In addition, the results deriving from 736 projects carried out by demea in small and medium-sized manufacturing enterprises show that the average annual saving potential per enterprise amounted to well 200,000 Euros. According to demea, this corresponds to an average saving potential of slightly below 2 percent of the turnover of the companies under consideration. Many efficiency potentials can be realized with limited investment funds.[5]

SHARE OF COSTS IN THE MANUFACTURING SECTOR IN TIME SERIES

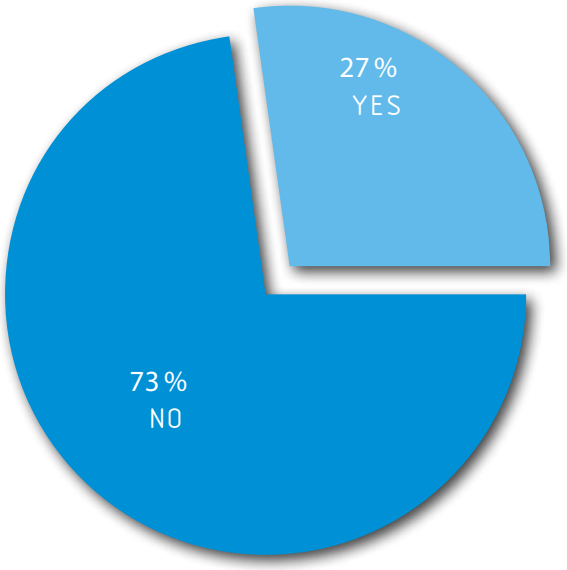


Potentials for resource efficiency

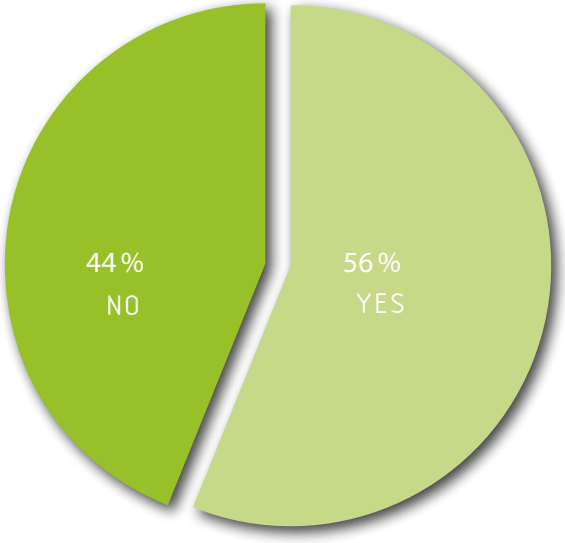
Economic benefit

According to a survey commissioned by the VDI Center for Resource Efficiency in 2015, only 27 percent of the small and medium-sized enterprises think that the saving potentials in their own sector are already fully utilized. The smallest proportions are found in the areas of Chemistry (21 percent), Electrical Engineering (21 percent) and Plastics (22 percent). The highest proportions are recorded in Metall Processing (36 percent), Metal Production (32 percent) and Mechanical Engineering (27 Percent).
Every second company knows examples of resource efficiency projects that led to competitive advantages - even through innovations.[6]

> In our sector, all the resource efficiency potentials are already utilized.



> I know companies in our sector which have gained competitive advantages through measures to increase resource efficiency.



Concrete practical examples

Economic benefit of resource efficiency

Resource efficiency is an attractive and appropriate tool to sustainably strengthen the economic situation of a company. Comprehensive experiences gained in successful projects on material and energy efficiency show multiple possibilities to improve the economic situation through efficient use of material and energy. Basically four successful measures can be identified among the multitude of successfully implemented projects in industry and trade.

IMPROVEMENT OF INTERNAL PROCESSES

Efficiency can be increased in various subprocesses, such as logistics, production planning, purchasing, and thereby provides exact knowledge of Total Costs of Ownership (TCO). Mostly, this requires low investments, and with less than 2 months, the amortization period is very short.

RESOURCE EFFICIENCY THROUGH CHANGES IN PRODUCTION

The potential analysis of the German Agency for Material Efficiency has shown that improvements in the production process can result in considerable advantages in the economic success of a company. A medium-sized foundry company, for example, changed its production process in a way that product quality could be enhanced significantly, typical rework could be minimized and energy costs could be reduced by 65 percent. This enormous increase in efficiency also convinced the Federal Environment Agency which supported this innovation with funds from the Environmental Innovation Programme (UIP). In other cases, entrepreneurs reduced off-specification batches to almost zero by using software for continuous monitoring of production flows.

TECHNOLOGY CHANGE PROVIDES CONSIDERABLE IMPROVEMENTS

Successful companies of the manufacturing sector also realize that previous production processes do no longer provide increases in efficiency. This means the whole production process must be re-designed using new manufacturing technologies. This change requires entrepreneurial courage and a perfectly adjusted internal process that involves all staff. The examples provided below illustrate the enormous efficiency potential, which, in one case, may amount to the reduction in the consumption of upscale material of 80 percent. Given the extensive investments, the amortization periods are significantly longer; on the other hand, however they considerably strengthen the economic position of the company. For this purpose, even the offerings of the Environmental Innovation

Programme (see UIP) and the German Federal Foundation for the Environment (DBU) can be used.

RESOURCE EFFICIENCY AS A HOLISTIC PROCESS

In this approach, resource efficiency is synonymous for a completely new plant concept, comprising new highly-efficient and resource-saving manufacturing processes, including modern logistics. In addition, it encompasses energy supply based on renewables or even compact building structures with compact cladding and high thermal insulation. The industrial processes are designed in a way that all consumables and utilities are returned to production where they are reprocessed. The aim is the development of successful production models that operate without waste and emissions or in part, produce even more energy than needed in production. This efficient, state-of-the-art production process with the respective infrastructure is sustainably ensured by the active continuous quality process supported by all employees.

Resource efficiency in the company ranges from small projects to the reorganization of the whole production process.

Blechwarenfabrik Limburg GmbH

Improvement of internal processes

The Blechwarenfabrik Limburg GmbH has an annual output of about 70 million tinplate packaging products.

STARTING SITUATION

The company consistently implements the guiding principle of resource efficiency in all fields of work. Apart from the economical consumption of materials and energy, this also comprises efficient business processes. Even small changes may lead to considerable results.

APPLIED RESOURCE EFFICIENCY

A small and obvious project, initiated by trainees, was convincing: the company saves money by washing work gloves instead of throwing them away. In a pilot project, trainees found out that work gloves can be washed and reused up to six times before they lose their safety function. With this, the company saves about 80 percent of its glove demand. At the Blechwarenfabrik Limburg however, resource efficiency is also a joint task. In order to make the projects public to all employees, the company initiated the "Year of Sustainability". Exhibition walls with constantly changing contents were positioned at a central point in the production hall in order for employees to keep themselves informed about current projects.

ABOUT THE COMPANY

In recent years, the Blechwarenfabrik Limburg has turned into a leading company of the packaging industry and has received important awards for its sustainable resource-saving and future-oriented company policy. Since 1997, the quality management system of the Blechwarenfabrik Limburg has been certified according to ISO 9001 and since 2010, its environmental management according to ISO 14001. Since 2012, they have been certified according to ISO 50001 (energy management), according to OHSAS 18001 (health and safety-at-work management) and according to DIN EN 16001 (energy management certification).

www.blechwaren-limburg.de

Work gloves can be washed up to six times without any loss in quality

ECONOMIES
80 percent of
work gloves

Moll Marzipan GmbH

Improvement of internal processes

In the long-established Moll Marzipan GmbH over 7,000 tons of almonds and apricot kernels are processed to marzipan and other delicacies each year. With this, the company belongs to the top five of the leading producers in Europe.

STARTING SITUATION

In 2010, the Moll Marzipan GmbH started a comprehensive investment programme, which primarily aimed at the quality improvement of the products and at the improvement of the company's efficiency. The first two key investments were a new blanching machine and a new fryer for the candy department.

APPLIED RESOURCE EFFICIENCY

Production could be increased by more than 30 percent per hour, in particular through improved production batch management and corresponding work flows. Energy consumption increased disproportionally by only 19 percent. Cleaning processes were optimized as well and provide savings of about 15 percent of the cleaning costs. Significant success was achieved through organizational restructurings, above all in the production of preparations, as this process is not automated as is the production of marzipan paste. Here, savings in the energy sector can be quantified at about 7.8 percent per kilogram of production, which is mainly attributable to better plant utilization. In addition, there is the effect of employees thinking about possible improvements. Since they are involved in the process optimizations their jobs become more interesting and more demanding. Thus the improvement of efficiency provides the company with savings and motivates employees.

ABOUT THE COMPANY

Established in 1860, the Berlin-based company employs a staff of 85 who produce a total annual output of approx. 12 million kilograms. The Moll Marzipan GmbH holds the relevant food certifications, such as IFS, BRC, DIN ISO 22000 etc. all with the addition of "highest standard".

www.mollmarzipan.de

Managing Director Dr. Armin Seitz in front of the new blanching machine of the Moll Marzipan GmbH

ECONOMIES
10 percent of energy
15 percent of cleaning costs

Edelstahlwerke Schmees GmbH

Resource efficiency through changes in production

The family company Edelstahlwerke Schmees produces castings of stainless steel for companies around the globe.

STARTING SITUATION

The production of castings is an extraordinarily energy-intensive and thus CO_2-intensive process. Following the smelting of the metal raw material in the melting furnaces, it is in particular the pre-heating of the ladles that requires a lot of energy. At the same time, this sector provides high energy savings potentials, since obsolete techniques are often applied and gas burners with open flame are used for heating. This results in high energy losses and thus in high operating costs.

APPLIED RESOURCE EFFICIENCY

In the ladle pre-heating station, the company uses new burner technology called porous burner, developed by the company Promeos. In these natural gas-air-volume burners, the natural gas flamelessly combusts in a sponge-like ceramic matrix and warms it up. The developing heat is then transferred to so-called steel bodies, whose form is adapted to the internal contour of the ladles. Afterwards, heat transfer from the glowing steel shot to the refractory of the ladles occurs by means of convection and radiation, which renders the ladles particularly efficient and homogeneous and significantly accelerates the heating-up process. Thanks to the new ladle heating station, 61,400 cubic meters per year and thus more than 50 percent of natural gas are saved in the works of the Edelstahlwerke Schmees compared to the old system with natural gas flame burners. This saving corresponds to the avoidance of 114 tons of CO_2 per year.

ABOUT THE COMPANY

156 of the 400 employees work in Langenfeld, 244 in Pirma. The energy management certification according to ISO 50001 has already occurred. The company received funds in the amount of 54,273 Euros from the environmental innovation programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety for the realization of the resource-saving ladle heating station.

www.edelstahlwerke-schmees.de

Deslagging of a stainless steel melt at a temperature of 1,600 degrees celsius

ECONOMIES
50 percent of
natural gas

MSR Technologies GmbH

Resource efficiency through changes in production

The MSR Technologies GmbH is specialized in the mechanical machining and assembly of metal precision parts. The company manufactures, inter alia, turbo charger components for gasoline and Diesel engines, hydraulic control blocks, airbag parts and magnetic valves.

STARTING SITUATION

With exact time-related registration of all production flows and their continuous evaluation, companies can save large amounts of material and energy and can reduce their costs considerably.

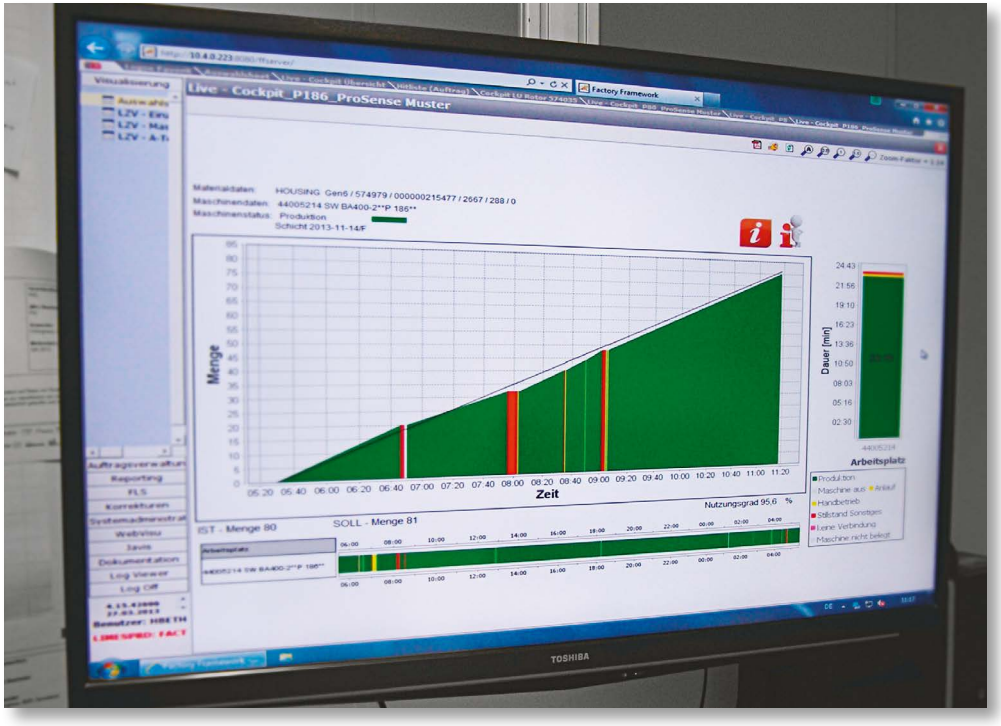
APPLIED RESOURCE EFFICIENCY

The company carried out comprehensive data monitoring and since then, all data of all machines and plants at MSR Technologies converge in one control station. The detailed overview of the manufacturing process provides a clear picture of material, machine and energy utilization and possible parameters for cost savings. Machine malfunctions, which are recorded almost in real-time and reported to the production management via WLAN, can be remedied more quickly. The rejection rates of the parts to be produced will decrease. Production planning profits from it: it makes production faster, more precise and more efficient. And this makes companies save material, energy and manufacturing costs and has a positive effect on the business operating times.

ABOUT THE COMPANY

The automotive supplier has 265 employees.

www.msr-tec.com



Fast, precise and efficient with data monitoring

ECONOMIES
25 percent increase in business operating times

Martin Pfaffmann Wein-Gelee

Resource efficiency through changes in production

Based on an old traditional recipe, the company Martin Pfaffmann Wein-Gelee produces approx. 800,000 jars of wine jelly from 100,000 litres of wine.

STARTING SITUATION

The production of wine jelly is a very heat and water-intensive process: the company uses a lot of gas to heat the source material. For hygienic reasons, the jars must be cooled down quickly after filling-in the wine jelly. Previously, this was carried out in a water bath.

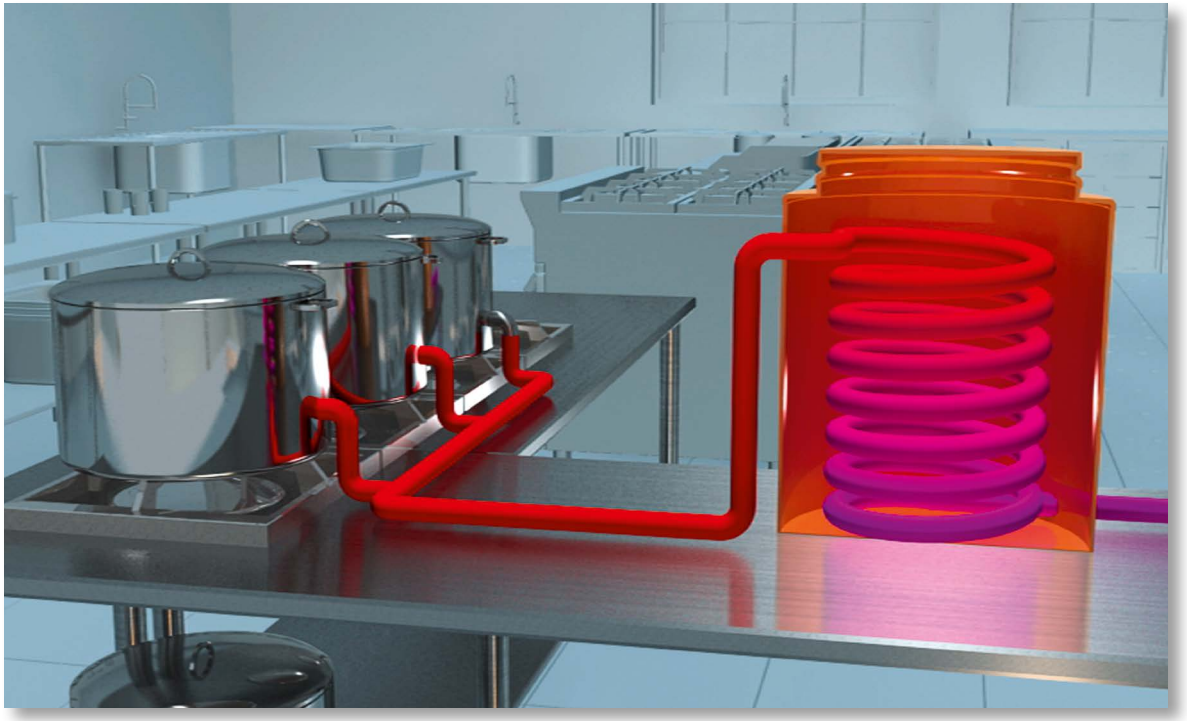
APPLIED RESOURCE EFFICIENCY

A good portion of the energy and water consumption could be reduced by means of an optimized heating and cooling system. A heat exchanger helped optimize the wine heating process: the heat exchanger is used to pre-heat the wine before it will be processed in the cooking pots. This low-loss pre-heating reduces gas consumption by 33 percent. The one-shot investment will have paid off in two years. The cooling of the finished jelly occurs through a new spray cooling system instead of a water bath: the jars are only sprayed while the evaporative heat loss provides the desired temperature. This saves 200,000 litres per year, which corresponds to water savings of 90 percent.

ABOUT THE COMPANY

The family business in Landau-Wollmesheim has 15 employees. In 2008, the company took part in the Rhineland-Palatinate consulting project Eff-Check and with the help of a consultant it was able to reduce its gas consumption by about 50 percent and water consumption by even 90 percent.

www.weingelee.de



Gas savings through heat exchanger

ECONOMIES
33 percent of gas
90 percent of water

TITAL GmbH

Technology change with considerable improvement in resource efficiency

Since 1974, the TITAL GmbH has been a leading manufacturer of sophisticated investment castings of titanium and aluminium alloys.

STARTING SITUATION

The company is development and production partner for global leaders in the field of aerospace, electronics and optics, industrial and medical systems. Until 2008, the TITAL GmbH manufactured titanium investment castings up to a size of about 600 millimetres with the existing casting furnace.

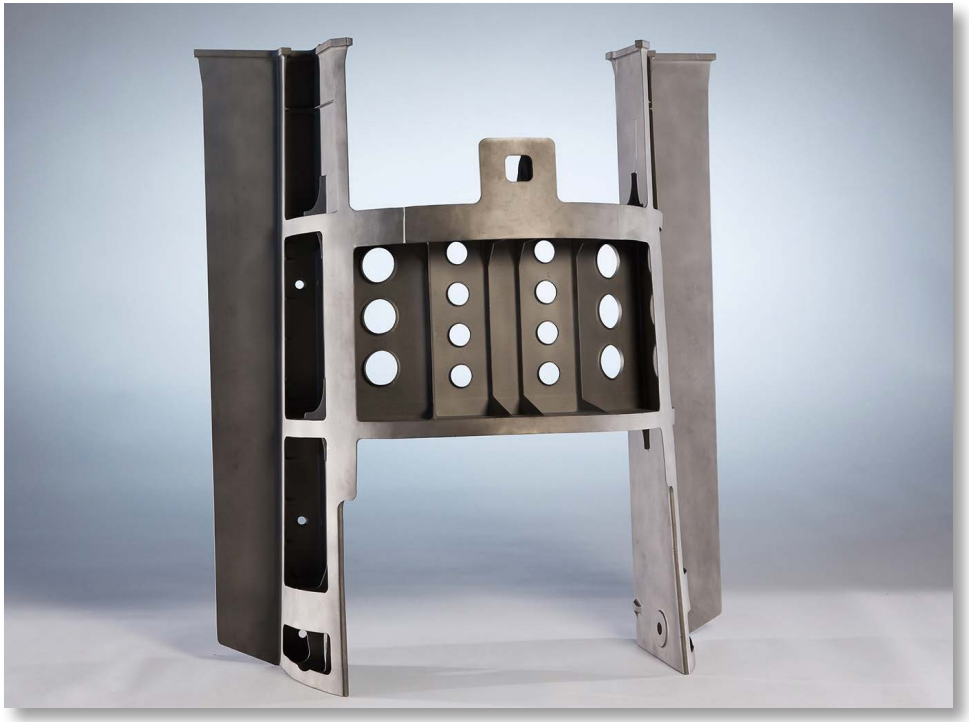
APPLIED RESOURCE EFFICIENCY

Casting instead of milling: Due to the investment in an innovative vacuum arc furnace from the ALD Vacuum Technologies GmbH, it is now possible to manufacture complex titanium castings with dimensions of up to 1.5 meters and components weighing up to 300 kilograms. Thus, compared to metal cutting technology, up to 75 percent of energy and material are saved in the field of titanium components while about 15,000 tons of CO_2 are avoided per year. At the same time, the new technology helped improve casting and product quality. For many years, the TITAL GmbH has also been leading in the resource-efficient manufacturing of aluminium components with complex designs. Since the mid-1990s, the company has been manufacturing aluminium cast parts of up to 1.5 meters and 90 kilograms with a casting factor of 1.0 applying the patented HERO-Premium-Casting® process, which resulted in considerable savings in weight and this, in turn, in material.

ABOUT THE COMPANY

TITAL was established in 1974. In 2006, the company was taken over by the management. Today, TITAL employs a staff of 550 and generates a revenue of approx. 64 million Euros. The project was funded with a subsidy of 854,760 Euros from the environmental innovation programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

www.tital.de



Titanium investment cast components, approx. 800 x 900 x 200 millimetres,
wall thickness partially smaller than 2 millimetres

ECONOMIES
75 percent of energy
75 percent of material

Schomäcker Federwerk GmbH

Technology change with considerable improvement in resource efficiency

At its headquarters in Melle, the Schomäcker Federwerk GmbH produces more than 3,000 types of suspensions on an area of 40,500 square meters. Each year, high-quality steel with a capacity of 20,000 tons is processed into quality suspensions which are exported into 50 countries worldwide.

STARTING SITUATION

Aim of the project was the development of an energy saving, innovative heating and transformation process for the manufacturing of parabolic beam links for truck semi-trailers and trailers. To this end, the process sequence should be designed in a way that the heating and transformation processes, which were separated so far, could be integrated to a shortened process chain. The aim was the development of a large-scale production of parabolic beam links with significantly increased energy and material efficiency as well as improved product quality.

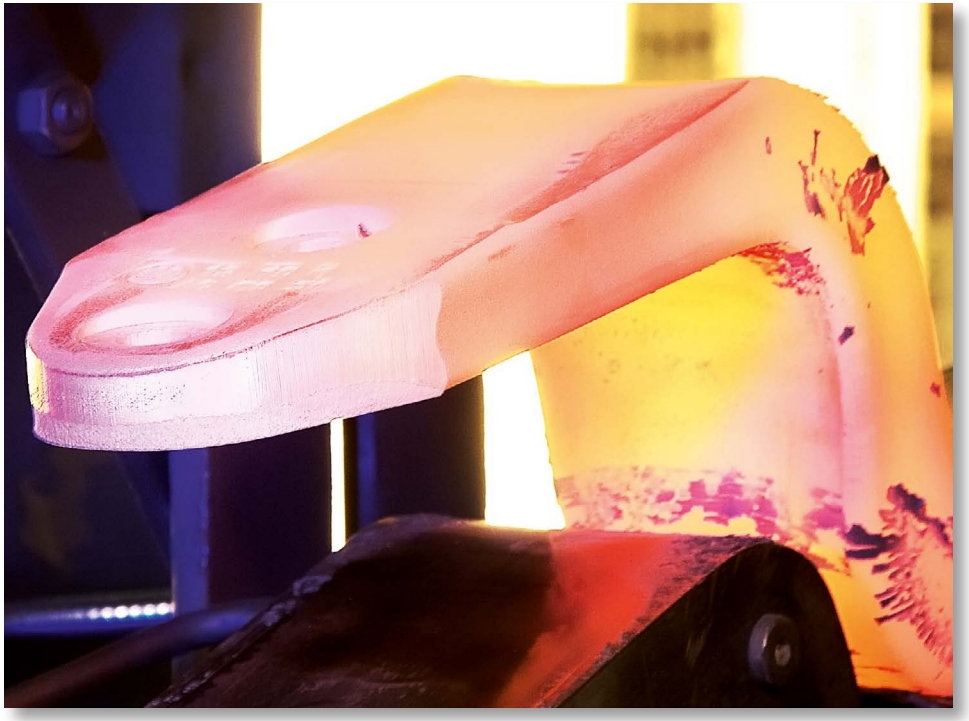
APPLIED RESOURCE EFFICIENCY

The company developed an innovative, resource-efficient process for the manufacture of suspensions for parabolic beam links by shortening the process chain. In this project, the process of heating and transforming the parabolic beam links was redesigned in order to significantly reduce the mentioned disadvantages in production. For this purpose, the three separated heating steps were streamlined to one and all subsequent hot forming processes were brought together in a shortened process chain.

ABOUT THE COMPANY

The newly developed resource-efficient production process was funded by the Federal Foundation for the Environment (DBU).

www.schomaecker.de



Patented and energy-efficient production process for the manufacture of commercial vehicle suspensions (EnRed)

ECONOMIES
40 percent of energy
15 percent of material

J. Schmalz GmbH

Resource efficiency as a holistic process

The J. Schmalz GmbH belongs to the leading suppliers of vacuum technology worldwide.

STARTING SITUATION

The company develops, produces and sells individual vacuum components and ready to connect vacuum gripping systems for automation as well as vacuum handling systems for manual lifting tasks and vacuum clamping systems for the fixing of work pieces.

APPLIED RESOURCE EFFICIENCY

With the new production hall built in 2009, the company J. Schmalz GmbH redesigned its production from the scratch. The individual production steps were arranged according to the logic value-added process for the manufacturing of the products – unnecessary travel times and intermediate storage facilities could be saved. In the assembly area, one-piece flow was introduced with the aim of reducing scrap components to a minimum. Smart supply logistics supplements the lean production. The so-called Kanban system ensures that at the work place, there is exactly the amount of material that is actually needed. According to the milk-run principle, a special train provides the required supply and, at the same time, picks up finished goods and takes them to the shipping department or to the storage facility. With this measure, Schmalz could improve its material efficiency and also its product quality, cycle times could be shortened and manufacturing costs lowered. Moreover, Schmalz is a positive-energy company. With the utilization of solar, wind and water energy for power generation and the use of a wood-chip heating system, the family company is able to generate more energy from renewable sources than it needs for itself.

ABOUT THE COMPANY

Approx. 750 employees work for the J. Schmalz GmbH at the headquarters in Glatten (Black Forest) and in 15 subsidiaries abroad.

www.schmalz.com

Production hall of the J. Schmalz GmbH with two milk-run trains

Positive-energy company
CO_2-free production

Solvis GmbH & Co. KG

Resource efficiency as a holistic process

Founded in 1988, the specialist for solar heating systems is one of Europe's technological leaders today. The company is particularly proud of the development of the multi-award winning solar heating system SolvisMax.

STARTING SITUATION

As a company with products for the climate-friendly use of solar energy, it was self-evident for Solvis to set new standards in terms of climate protection with its own business activities, too. The result: a zero-emission factory, which, regarding its size and consistent energy concept, was the first of its kind in Europe.

APPLIED RESOURCE EFFICIENCY

The complex consisting of offices and production areas and storage facilities with approx. 14,000 square meters uses 75 percent less energy and water than conventional industrial plants and is completely supplied by renewable energies from in-house plants. About a quarter of all energy is supplied by the sun, the rest comes from a biogas combined heat and power unit (BHKW). The compact building is surrounded by a tight envelope with high thermal insulation: floor thickness 12 centimetres, outwall thickness 24 centimetres and ceiling thickness 36 centimetres. The continuous rows of windows in the production areas, the office windows as well as the light domes in the roof of the entire building are triple-glazed and reduce the power consumption due to the high use of daylight. A photovoltaic area of 2,000 square meters with 220 kilowatt peak supplies energy from the sun. The major part of the modules is erected on the company's premises.

ABOUT THE COMPANY

Solvis was awarded, inter alia, the European Solar Prize 2002, the Energy Globe 2003 (world award for sustainability) and the B.A.U.M. environmental award 2007 for its factory building and its commitment to climate protection.

www.solvis.de

Zero-emission factory Solvis GmbH & Co KG

Positive-energy company
CO_2-free production

Key players at Federal and State level

Resource efficiency on the spot

Here is where companies get support.

There are numerous players in Germany making efforts to increase resource efficiency. Below we provide you with some contacts on federal and state level.

VDI CENTRE FOR RESOURCE EFFICIENCY
www.resource-germany.com

BMUB – FEDERAL MINISTRY FOR THE ENVIRONMENT, NATURE CONSERVATION, BUILDING AND NUCLEAR SAFETY
www.bmub.bund.de/en/topics/economy-products-resources/resource-efficiency

DBU – FEDERAL FOUNDATION FOR THE ENVIRONMENT
www.dbu.de

DEMEA – GERMAN AGENCY FOR MATERIAL EFFICIENCY
COMMISSIONED BY THE BMWI
www.demea.de

FONA – BMBF PLATFORM FOR RESEARCH ON SUSTAINABILITY
www.fona.de/en/index.php

KFW ENVIRONMENT PROGRAMME
www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/Finanzierungsangebote/Umweltprogramm-(240-241)

RKW
www.rkw.de

FEDERAL ENVIRONMENT AGENCY
www.umweltbundesamt.de/en

ENVIRONMENTAL INNOVATION PROGRAMME
www.umweltinnovationsprogramm.de

HELMHOLTZ-INSTITUT FREIBERG FÜR RESSOURCENTECHNOLOGIE
http://www.hzdr.de/db/Cms?pNid=2423

RESSOURCENEFFIZIENZ-ZENTRUM BAYERN
www.lfu.bayern.de/abfall/ressourceneffizienz

EFFIZIENZ-AGENTUR NRW
www.efanrw.de

EFFIZIENZNETZ RHEINLAND-PFALZ
www.effnet.rlp.de

FREIE UND HANSESTADT HAMBURG BEHÖRDE FÜR STADTENTWICKLUNG UND UMWELT
www.hamburg.de/ressourcenschutz

HESSEN TRADE & INVEST
www.hessen-trade-and-invest.com

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Footnotes

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