Energy Efficiency – Made in Germany

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Translation
BMWi

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Introduction

Fossil energy resources are becoming scarce and energy prices are on the rise. New technologies conserve fossil resources.

With energy prices on the rise and energy resources becoming scarce, both prosperity and competitiveness increasingly depend on our ability to use energy as efficiently as possible. This is true of industry as well as private households and the transport sector.

Germany has to import most of its energy resources. This is why, for several decades now, Germany has had a tradition of treating resources with respect and conserving energy, while still ensuring a high standard of living. Germany’s total primary energy consumption is less than 7 gigajoules per € 1,000 gross domestic product (GDP). In terms of energy consumption, Germany is one of the most productive industrial nations in the world. In 2007, the total primary energy consumption achieved its lowest value in more than 25 years, even though the gross domestic product had more than doubled during this same period.
World leader in energy efficiency

For a long time now, “Made in Germany” has been synonymous with high-quality products. Increasingly, however, German technology is also proving to be exceptionally energy-efficient. When it comes to energy-efficient technology, Germany is the international market leader and chief innovator. This is also reflected in the exceptionally high number of patent applications submitted in the areas of efficient building services technology, energy-efficient industrial procedures and processes as well as energy-efficient industrial cross-application technologies. In the years 2002 to 2004, German researchers and companies submitted between 30 and 40% of global patent applications in these areas.

For example, the world’s market for condensing boiler technology, which is deployed in gas and oil central-heating boilers and achieves efficiencies of almost 100%, is served almost exclusively by the German heating industry. This is also true of the system technology market for using renewable energies.

Stable domestic market with international benefits

International customers of German companies benefit from a stable domestic market for energy-efficient products. Market continuity provides planning reliability for companies. In this way, the industry can continuously optimise systems and components as well as test innovations in live operation. With approximately € 8 billion invested in environmental protection (most of which has been invested in energy efficiency) and export volumes in the region of € 3 billion for capital goods which help to protect the environment, Germany is once again one of the world’s leading suppliers in this area.
I. Industry

Introduction

Energy is and remains an essential basis for the economies of the industrialised world. Trade and industry can considerably reduce its energy consumption in the coming years without endangering productivity. Or, to put it another way: In other words, energy efficiency equates to cost efficiency – a clear competitive advantage.

Globally, in all fields of industry, the potential for improved energy efficiency through improved procedures is significant. The following industrial technologies are widely used: compressed air and pump systems as well as air, refrigeration and conveyor technology. Today, most companies could potentially reduce their consumption of electricity and associated costs for these cross-application technologies by 5% to 50%. In most cases, the payback period is less than two years and the return on investment is more than 25%. Therefore, measures that improve energy efficiency are extremely appealing to companies for economic reasons.

Breakdown of final energy consumption in 2006 by sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>28.5%</td>
</tr>
<tr>
<td>Transport</td>
<td>28.9%</td>
</tr>
<tr>
<td>Industry, Trade, Services</td>
<td>14.4%</td>
</tr>
<tr>
<td>Households</td>
<td>28.2%</td>
</tr>
</tbody>
</table>

Example: Research laboratory in Jülich

Measures:
Daylight planning, optimised lighting, ventilation and heat recovery, active cooling, renewable and passive cooling

Energy Savings:
Following the refurbishment of the research laboratory, 85% of the exhaust air is now used in heat recovery, which at full load can recycle half of the contained heat. When the refurbishment was complete, the primary energy requirement fell by more than half to 600 kWh/m²a.
In refrigeration, there is great potential for reducing energy costs.

**Refrigeration**

Refrigeration technology is an inherent part of many production and logistics processes and is widely used in trade and industry. Therefore, various technologies are deployed and the size of refrigeration systems differs greatly. However, all of these systems have one thing in common, i.e. they generate cooling energy that must be incorporated into the product or process.

Even though refrigeration technology is used extensively, it was rarely considered as a possibility for improving energy efficiency until now. However, in refrigeration technology, there is often great potential for reducing energy costs. In particular, this concerns the continuous operating costs of such systems, which may account for up to 80% of the total costs associated with a refrigeration system.

**General approaches for improving efficiency:**

- improved heat insulation
- reduced heat radiation
- adjusted “busy” times and operating times
- basic process design
- optimised power, pressure and temperature levels
- efficient control technology
- detailed design and selection of individual components
- use of thermal cooling machines, for example, with solar heat, district heating, industrial waste heat as well as waste heat from combined heat and power systems (CHPs)

---

**Potential savings: Use of efficient appliances and systems**

<table>
<thead>
<tr>
<th>Use of efficient appliances and systems</th>
<th>Potential Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drives with speed control for compressor, ventilators and pumps</td>
<td>up to 6%</td>
</tr>
<tr>
<td>High efficiency motors for ventilator on vaporiser</td>
<td>up to 5%</td>
</tr>
<tr>
<td>High efficiency cooling compressor</td>
<td>up to 5%</td>
</tr>
<tr>
<td>High efficiency motors for ventilator on condenser</td>
<td>up to 5%</td>
</tr>
</tbody>
</table>

Source: Federal Ministry for Economic Affairs and Energy
Thorough planning and system optimisation can significantly lower the costs associated with the production of cooling energy. Therefore, it is important that the purchase price is not the primary determining factor when purchasing a refrigeration system. Rather, the total cost, including the very high lifetime operating costs associated with refrigeration systems, should be considered.

German refrigeration technicians have expert knowledge of high-quality, energy-efficient systems. This is reflected, for example, in thermal cooling machines, which are an energy-saving alternative to electrical refrigeration systems – absorption, not compression. Thermal cooling machines use heat energy directly for cooling purposes. Accumulated industrial waste heat, which would otherwise go unused, provides a good source of heat in this case. If heat is generated from free solar energy through the use of solar-thermal technology, an almost CO₂-neutral operation is achievable.

It is also possible to combine refrigeration systems with combined heat and power systems (CHPs). The economic efficiency of CHPs is heavily dependent on a continuous heat requirement. By combining it with the refrigeration system, the CHP is utilised more during warmer times of the year and is therefore more economically efficient.

German manufacturers provide highly efficient thermal cooling machines with cooling capacities for almost all areas of application. In Germany, approximately 2,200 companies employ 15,000 people in the area of refrigeration and air-conditioning. Their annual combined turnover is in the region of € 3 billion and exports account for 40% of their total sales.

<table>
<thead>
<tr>
<th>Potential savings:</th>
<th>Reduction in cooling requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cleaning of heat exchanger surfaces</td>
<td>up to 3%</td>
</tr>
<tr>
<td>Control of final discharge pressure of cooling compressor</td>
<td>up to 15%</td>
</tr>
<tr>
<td>Defrost control</td>
<td>up to 5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential savings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing unnecessary temperatures</td>
</tr>
<tr>
<td>Cleaning of heat exchanger surfaces</td>
</tr>
<tr>
<td>Control of final discharge pressure of cooling compressor</td>
</tr>
<tr>
<td>Defrost control</td>
</tr>
</tbody>
</table>

Example: Modernisation of a refrigeration circuit deployed by a soya milk producer

Measures:
Energy-efficient drives, pumps, control technology, refrigeration

Energy Savings:
By replacing the damper control for compressors with speed control, the quantity of energy consumed when providing cooling water has been reduced considerably. The annual savings are in the region of € 70,000 to € 90,000. Approximately € 120,000 was invested and recouped within approximately 16 months.
Compressed Air

Trade and industry frequently require exceptionally large volumes of compressed air, which is one of the most widely used cross-application technologies and is mainly used in industrial processes.

Compressed air is used in the following areas:

- pneumatics
- active air (compressed air as a means of transport)
- process air (for example, drying processes)
- vacuum technology

Air, as a commodity, is an infinite resource and does not cost anything. However, compressed air/vacuums are usually supplied by electrical compressors. This generates costs of approximately 1.5 to 3 cents per cubic metre. The electricity required to generate compressed air can account for 20% to 80% of the overall energy costs in a company. Significant energy savings could be made here. If a company were to invest in efficient compressed air technology, it could yield energy savings of between 5% and 50% with a payback period of less than two years.
In order to determine the potential savings, it is always appropriate to consider the system as a whole. In order to improve the efficiency of the system as a whole, it is necessary to optimise the individual components:

- replacement of the electrical drives with more efficient motors
- use of motors with variable speed control
- use of improved compressors
- use of modern control technology
- improvement in tubing, filters and dryers
- prevention of friction pressure losses
- improvement of airtightness
- regular filter replacement

Unfortunately, the overall efficiencies achieved with compressed air supply are extremely low. The electrical energy consumed by an air compressor does not compare favourably with the compressed air that is output at the end of the system chain. Even if air compressor efficiency is 50%, an efficiency of just 5% is achieved if we consider the overall system from its creation through to its use. However, the remaining 95% does not have to remain unused. Frequently, the waste heat accumulated when operating a compressor can be deployed. Another option is to improve the efficiency of the entire process by optimising the system components.

German companies manufacture the entire range of compressed air technologies; from small compressors for skilled craft enterprises through to complex compressed air systems with several megawatts of power. In the case of vacuum technology, which has become a key compressed air technology in industry and research, German suppliers are the market leaders with approximately 80% of the world’s annual turnover. The prominent role occupied by German suppliers of compressed air is also reflected in the ever-increasing number of patent applications. This is particularly the case in the important application area of pneumatics.

German companies not only supply components and complete systems, they also provide compressed air contracting. In particular, customers who have easily calculable requirements really get their money’s worth with this all-inclusive package.

Example:
Company based in Minden

Measures:
Installation of three new 10 kW piston compressors

Energy Savings:
By installing three new 10 kW piston compressors and reducing the mains pressure, the company’s compressed air costs have fallen by over 60%. This corresponds to approximately 60,000 kWh of electrical energy per year and a total annual savings of €20,000. Since €40,000 was invested in the compressors, the payback period is just two years.
Electrical Drives

Trade and industry requires electrical drives worldwide. They consume 64% of all electricity used in industry. Here, there is also great potential for improved efficiencies in trade and industry.

Electrical drive systems consist of the following units:

- the electric motor, which converts electric power into mechanical power,
- a frequency converter, which converts the electrical power of the mains in a controlled form (electronic speed control),
- and the gearbox, which adjusts the mechanical power of the motor to the working point of the driven machine (reducing speed and increasing torque).

The individual components have been highly optimised already. However, there remains an enormous savings potential in the use of optimum system concepts if such concepts are evaluated by their costs across the entire life cycle.

When you consider the lifetime of an electric motor, the costs associated with the consumption of electricity account for up to 96% of the total cost. Therefore, when purchasing a motor, it is important to bear in mind its expected electricity consumption as this is a considerably greater factor than the initial purchase cost.

Great savings potential in electrical drive systems lies in the use of energy-saving motors. These energy-optimised motors convert electrical into mechanical energy with the fewest possible losses whilst maintaining the required technical properties.
In industry, three-phase asynchronous motors are widely used as standard drives. The vast majority of three-phase motors used today are asynchronous machines because they are good value for money and require very little maintenance. In terms of energy efficiency, however, they cannot compete with other types of motor. However, strong efforts have been made in the past years to reduce the energy losses of such asynchronous machines substantially. In the highest class of the European motor efficiency scale, EFF 1, losses are on average reduced by 40%.

Higher efficiency levels may be obtained when using special motor types such as synchronous motors or EC motors:

- Synchronous motors have a very high electrical efficiency, even during partial load operation. Precise regulation of frequency converters is possible.

- Electronically commutated (EC) motors, also known as brushless DC motors (BLDCs), supplement the positive attributes of synchronous machines by being able to adjust to their load. They are highly efficient, even when working with partial loads, have a high power spectrum and are easily regulated.

In 1998, the European motor manufacturers made a voluntary commitment to the European Commission to promote the selling of energy-saving motors. The proportion of energy-saving motors of efficiency class EFF 1 has been rising constantly ever since.

At first glance, simply replacing an old motor with an EFF 1 motor is the simplest way to improve energy efficiency. However, when assessing the economic efficiency of an electrical drive, it is not primarily the motor that determines the optimal efficiency but rather the way in which the motor or machine speed is controlled. The savings potential of electronic speed control is four to five times greater than that of efficiency class EFF1 motors. Electronic speed control can save between 20% and 70% of the energy costs of conventional mechanical methods such as throttle valves.

### Example:

**Modernisation of the bottle transportation system in the Lammsbräu brewery**

**Measures:**

Energy-efficient drives, control technology, material transport

**Energy Savings:**

Following its modernisation, the quantity of electricity consumed by the bottle transportation system has fallen by approximately 40% to just 79.5 kWh/day, thanks to energy-saving drives. When compared with traditional solutions, this results in savings of between €2,500 and €5,000.
Taking life cycle costs into consideration, investments in energy saving can often be amortised within just a few months. Only about 12% of the motor capacity installed in Germany today is operated with energy-saving electronic speed controls. It is estimated, however, that it would be beneficial in energy terms for over half of this motor capacity to be equipped with electronic speed control.

There are basically two different types of industrial drive systems:

- drive systems which need electronic speed control if they are to function,
- and electrical drives that could be operated without speed control. It is in this group that the use of electronic speed controls opens up great energy savings potential.

If the great potential for energy savings that lies in mechanical system optimisation is to be used, it is important for mechanical engineers and designers of machinery and plant to work together. This holistic approach can achieve almost 60% of the total energy savings potential in electric motor-driven systems.

In drive engineering, there are numerous ways to save energy and increase efficiency:

- use motors that have the best possible efficiency class, for example, the “CEMEP seal of approval” (CEMEP: European Committee of Manufacturers of Electrical Machines and Power Electronics);
- use motors with variable speed control;
- use frequency converters (recuperation of brake energy into the system).

In Germany, several projects are currently underway in a bid to unlock more potential energy savings in trade and industry. One such project, in particular, is the "Motor Challenge Programme". Its goal is to motivate companies to optimise the efficiency of their electric motor systems.

For decades, electrical drive engineering has been one of the German economy’s main export items. Thanks to the combination of a keenness to innovate and comparatively high energy costs in Germany, Germany’s high-tech products are receiving increasing levels of global attention because of their impressive energy efficiency.
Pumps presently account for a good 25% of the industrial electricity consumed worldwide. It is believed that approximately 40% of this energy could be saved. Centrifugal and displacement pumps occupy a large market share, with centrifugal pumps accounting for 73%. Centrifugal pumps, in particular, represent great potential for energy savings because approximately 75% of these pumps are oversized, frequently by more than 20%.

The German Energy Agency (dena) has an ongoing campaign entitled “Energy-Efficient Systems in Trade and Industry”, which advises companies active in the following industries on measures that they can introduce to increase their energy efficiency: chemicals, paper, electrical, food manufacturing, plastics, metal processing, water supply and waste water disposal. In particular, this campaign demonstrates that all companies, irrespective of their industry classification, will benefit financially from any energy-saving efforts that they undertake. Depending on its size, a company could potentially save between € 2,000 and € 50,000 per year. The payback period for the corresponding investment is generally two to three years. This campaign also shows that, on average, companies can reduce the electricity consumed by their pumps by approximately 30%.

Savings are made through the use of highly-developed pumps.
Modern pumps can reduce electricity consumption by up to 40%.

In addition to comprehensive system optimisation, the use of efficient high-tech products and highly developed controls are the two main ways to increase energy efficiency:

- replace oversized pumps with smaller pumps that have highly efficient motors,
- use highly efficient pumps,
- use frequency converters for variable-speed operations,
- equip pumps with proportional control,
- optimise downstream heat exchangers.

Germany is the second-largest global supplier of pumps and compressors. German companies are frequently the market leaders in highly efficient high-end pumps and compressors for specific purposes.

**Example:** Renovation of the Sportiom leisure pool in Den Bosch, the Netherlands

**Measures:**
Energy-efficient drives, pumps, control technology

**Energy Savings:**
By modernising flow regulation through the use of pool valves with speed control, energy costs have fallen by 85% per year, which corresponds to annual savings of up to € 96,000. Therefore, the modernisation costs were recouped after five months.
Process heat is the heat required for numerous technical processes and procedures in trade and industry. Unlike room heat, process heat is available at a considerably higher temperature level, which is optimised for each application. Process heat is necessary for cooking, baking, sterilising, drying, smelting, forging, welding and producing steam. Due to the high temperature level of process heat, it is generally not possible to use waste heat from other processes, which means that process heat is generated by combustion processes or electricity.

40% of the energy used in Germany is consumed in trade and industry and in the services sector. Approximately 66% of industrial energy consumption is required to generate process heat. Therefore, this is a large area of activity in which measures can be taken to save energy. Approximately half of all process heat required is below 300°C; the remaining half is below 180°C.

Generally, the greatest energy savings potential for reducing costs is to change the energy resource from electricity to gas. This generally cuts down on CO₂. However, it does not necessarily reduce the quantity of energy required, i.e. simply changing from one energy resource to another does not automatically increase the efficiency of a process.

Increased energy efficiency is mostly achieved by optimising the system technology. Potential energy savings can be attained, for example, by using energy-saving motors. This improves energy efficiency and reduces losses. The use of combined heat and power (CHP) or combined cooling and power (CCP) should also be considered. Poor insulation is frequently associated with energy loss. Heat recovery is an important consideration for potential energy savings. When smelting metals, it makes sense to constantly monitor the smelting temperature and adjust the smelting cycle to the throughput of the casting machine. First and foremost, a policy of efficient load management should be adopted. The total energy savings potential is at least 15%.

Process heat can also be generated using solar energy. This is of particular interest, given the rising energy prices and the reduction of greenhouse emissions. Germany is working intensively on the further development of solar process heat. Possible areas of application include agricultural drying plants and industrial operations such as washing, cooking, drying and pasteurisation.

Solar energy can also be used for processes at high temperatures.

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**Example:**

**Organic bakery deploying waste heat**

**Measures:**
Heat recovery, heat exchangers

**Energy Savings:**
The bakery has installed a heat recovery system that captures waste heat for the purpose of providing hot water and heating. The total system cost € 33,000 and 47,500 kWh is saved annually as a result of overhauling the system.
Heat Recovery

Heat recovery is a collective term for the practice of reusing the thermal energy generated during a manufacturing process and frequently emitted into the environment as unused waste heat. This waste heat can be deployed effectively in heat recovery. Therefore, the potential energy savings are huge. Return air streams or flue gas streams that deploy heat recovery technologies can be used to pre-heat room air or combustion air. By linking procedures in an intelligent manner, it is possible to considerably reduce the amount of primary energy that needs to be consumed.

Heat recovery measures result both in lower energy costs by reducing the use of primary energy and in lower investment costs for heat production plants. Furthermore, the volume of greenhouse gases emitted is reduced considerably. Heat recovery is responsible for achieving sustained conservation or renewal of energy streams ultimately released by manufacturing processes into the environment. Therefore, heat recovery can be regarded as a renewable energy.

The advantages associated with heat recovery can be summarised as follows:

- Heat recovery can reduce the connection power for heat energy and cooling energy, the level of energy consumption for heating and cooling, investment costs and operating costs as well as pollutant emissions. System technology can be scaled down; heating boilers, refrigerators, re-cooling plants, piping, stacks etc. are no longer required.

- Numerous technical possibilities are associated with heat recovery. Process heat can be transferred directly to solids. Furthermore, it can also be transferred to gases and liquids, for example, when pre-heating water or combustion air for furnaces or dryers.

Possible heat sources include:

- Use of condenser heat from steam systems and boiler systems
- Heat recovery from ventilation and air-conditioning systems
- Extraction of residual heat from waste heat in order to pre-heat heating water or domestic water

Germany’s expertise in this area ranges from heat recovery in large plants to possible applications of heat recovery technologies in small and medium-sized companies.

German companies are especially committed to energy efficiency because Germany has state sponsorship programmes (for example, the ERP energy-saving programme) as well as financing concepts backed by financial institutions and leasing companies for energy-saving measures.

The government also finances energy consultations for companies. All of the above has given rise to a domestic business market for innovations in industrial heat recovery. The resulting expert knowledge can also be applied globally.

Example:
Heat recovery deployed in injection moulding production

Measures:
Heat recovery, process heat

Energy Savings:
While taking measures to use energy more efficiently, the company installed a heat pump that deploys the waste heat from mould cooling to supply hot water and to heat the workshops. € 40,000 was invested, resulting in savings of € 2.50 per operating hour. This investment can be recouped in just 4 years as there are 4,000 operating hours in each year.
Process Automation

Process automation can contribute in many ways to higher energy efficiency in industrial production facilities. Its equipment and systems which ensure intelligent measurement and control of production processes can make a big contribution towards greater energy efficiency. This can result in average energy savings of 10 – 15% – up to 70% in some cases – in industries using the technology. German process automation firms play a leading role here.

Modern process automation solutions from Germany can help companies to substantially reduce energy consumption. This can easily save an energy-intensive company in the metal-working, chemical or cement industry several million euros a year on electricity, gas, steam and compressed air. In the medium to long term, this cuts the production costs for companies using the technology and makes them more competitive.

Sectors like metal production, the cement industry, basic chemicals and paper and cellulose are extremely energy-intensive. An intelligent use of energy becomes the key criterion for corporate success. For example, the chemical industry heats, cools, gasifies or comminutes great quantities of material. Energy costs account for approx. 20% of the production costs of complex chemical facilities. In the metal-producing sectors (steel, copper, aluminium), energy costs can be up to 50% of the production costs.

### Energy intensity of various sectors of industry, taking power intensity as an example

*Power intensity in kWh/€m (quotient of power consumption and gross value added by sector)*

<table>
<thead>
<tr>
<th>Sector</th>
<th>Power Intensity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automotive manufacturing</td>
<td>3.9</td>
</tr>
<tr>
<td>Mechanical engineering</td>
<td>1.6</td>
</tr>
<tr>
<td>Metal-working</td>
<td>3.7</td>
</tr>
<tr>
<td>Non-ferrous metals, non-ferrous foundries</td>
<td></td>
</tr>
<tr>
<td>Metal production</td>
<td></td>
</tr>
<tr>
<td>Processing of construction materials</td>
<td>10.8</td>
</tr>
<tr>
<td>Glass and ceramics</td>
<td>10.7</td>
</tr>
<tr>
<td>Rubber and plastic goods</td>
<td>6.9</td>
</tr>
<tr>
<td>Other chemical industry</td>
<td>3.5</td>
</tr>
<tr>
<td>Basic chemicals</td>
<td></td>
</tr>
<tr>
<td>Paper-making</td>
<td></td>
</tr>
<tr>
<td>Food and tobacco</td>
<td>3.9</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Oil processing</td>
<td>11%</td>
</tr>
<tr>
<td>Paper and cellulose</td>
<td>3%</td>
</tr>
<tr>
<td>Mechanical engineering</td>
<td>9%</td>
</tr>
<tr>
<td>Iron and steel</td>
<td>5%</td>
</tr>
<tr>
<td>Food, beverages and tobacco</td>
<td>9%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>6%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>19%</td>
</tr>
<tr>
<td>Other</td>
<td>2%</td>
</tr>
<tr>
<td>Construction materials</td>
<td>6%</td>
</tr>
<tr>
<td>Oil and gas production</td>
<td>15%</td>
</tr>
<tr>
<td>Energy industry</td>
<td>15%</td>
</tr>
</tbody>
</table>

*Source: Hamburgisches Weltwirtschaftsinstitut, Gesellschaft für Wirtschaftliche Strukturforschung mbH, 2007*
There is enormous potential for energy saving in the use of new products, systems and solutions offered by process automation technology. In order to develop it, it is necessary to optimise all the production-related processes and operations in energy terms. Here, a distinction is basically made between two key measures:

- measures to optimise the technical infrastructure of a production process
- measures to optimise the actual production process itself

When optimising the technical infrastructure, there are three main areas which help to prevent additional energy being consumed by equipment failure and resulting start-up and closing-down processes or faulty output. The assessment of the present situation serves to recognise causes of faults and weak points in good time before equipment failure and damage occurs. The relevant maintenance and repair work is optimally planned and is carried out with minimal impact on the production process. The experience gained from the main areas mentioned above can be used to pinpoint the weak points of plant and to remove them by optimising the infrastructure, thereby substantially reducing the failure rate.

Three main areas can also be identified when it comes to optimising the production process. The first area is process information. Here, it is necessary to ensure that the parameters best suited to the assessment of the process are being measured and monitored with the necessary degree of precision. Here, the selection of the “correct” yardstick for the evaluation of the process can have a key influence on the amount of energy used. If the process is to be designed well, the best suited aggregates and processes need to be used for the relevant task. An optimally designed facility can be further improved by suitable process management. Here, all available process information is subjected to a holistic evaluation in context, and the optimal strategy to attain the economic objective is drawn up. This process is frequently supported by the use of computer simulations.

### Contribution by process automation to better energy efficiency

<table>
<thead>
<tr>
<th>Optimisation of energy use in production facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimisation of technical infrastructure</td>
</tr>
<tr>
<td>1 Assessment of current situation</td>
</tr>
<tr>
<td>2 Maintenance of current situation</td>
</tr>
<tr>
<td>3 Optimisation of infrastructure</td>
</tr>
</tbody>
</table>

Source: ZVEI, department for metrology and process automation, 2009
The technical possibilities for this exist, but even greater use needs to be made of them. Here, German firms offer intelligent applications and solutions for process automation which can be used to provide the vital information for successful energy management by the companies. The measurement and analytical equipment and the computer programmes show not only how a facility works: they also simulate different operating conditions. This makes it possible to find the appropriate strategy for an optimal operation of the facility in terms of energy consumption. The software used for this can learn, it can shorten response times, predict trends and optimise maintenance intervals.

The optimisation of the facility has to be undertaken jointly by the manufacturer and the user. Positive return-on-investment calculations show that investment and process automation solutions can be amortised very quickly.

German manufacturers are international leaders in the field of measurement technology and process automation. Employing 90,000 people in Germany, German firms have a 12% share of world production in terms of value.

Example: Resin production for paper processing (chemical industry)

Measures:
Process radar level metering systems (radar metering systems) for resin production to ensure safe and maintenance-free level and volume measurement. Pinpoints foam contamination at an early stage, prevents blocking of bypass tubes and filters. Status and diagnosis information from the radar measurement system avoids production losses and cumbersome and expensive cleaning, cooling and heating processes. Improved sensor measurement security optimises production quality and energy input.

Energy Savings:
Reduction in energy costs when initiating the production process, Increase in energy efficiency in terms of savings on heating and cleaning processes, since incrustation and contamination can be immediately discovered and treated. The plant operator put the potential energy savings at € 100,000 a month per reactor. Given these savings, the amortisation period is less than a month. The savings in energy costs are estimated to be 15% of the running costs for this production process.
Decentralised Supply

Today’s still largely centralised energy supply uses a power plant to supply energy to a large number of consumers in different geographical locations. However, a great deal of energy is lost while it is being transferred along very long routes to the consumer.

Frequently, a decentralised energy supply would be more efficient. This concerns the supply of energy by small plants located in close proximity to the consumer. The plants are located directly where the energy is used.

The following advantages are associated with a decentralised energy supply:

- efficient use of electricity and heat production
- significantly lower transmission losses
- independence
- energy security
- generator directly influences the energy source
- diversification of different energy sources
- job creation
- regional accumulation of value

Therefore, centralised and decentralised energy supplies are not mutually exclusive. Both systems can co-exist and complement each other (integral energy supply).
Germany has recognised this fact and has been promoting the use of decentralised energy supply for years now. As a result of the support and promotion of renewable energies and the incentive to use combined heat and power, which was provided by the German Renewable Energy Act (Erneuerbare-Energien-Gesetz) and the combined Heat-Power Cogeneration Act (Kraft-Wärme-Kopplungsgesetz), Germany has had the foundation necessary to promote technologies in these areas since 2000.

**Possibilities associated with a decentralised energy supply:**

- greater efficiency through the use of combined heat and power
- use of renewable energies

First and foremost is the use of combined heat and power (CHP) systems, which is characterised by the simultaneous generation and use of heat and power. In Germany, there are CHP systems in power classes from 0.8 kWel upwards for every application. Furthermore, expertise in this area continues to grow.

Different renewable energies can also work together. This is evident in the example of the German renewable "combined power plant”.

The renewable combined power plant uses 36 wind, solar, biomass and hydraulic plants that are spread throughout Germany. Through joint control of small and decentralised plants, it is possible to provide a reliable source of electricity to meet requirements. The objective is to combine and benefit from the advantages associated with various renewable energies. Since the volume of electricity generated by wind turbines and solar heating systems depends on how much wind and sun is available, biogas power plants and hydraulic turbines are used to supply energy at times of peak demand. With a sophisticated control strategy, it is possible to achieve a fully decentralised energy supply through renewable energy alone.

**Example:**

**Combined renewable energy power plant**

**Measures:**
Combination of 36 wind, solar, biomass and hydraulic power systems in Germany

**Energy Savings:**
A full energy supply through renewable energy alone is achievable. The combined renewable energy power plant connects and controls 36 wind, solar, biomass and hydraulic power plants spread throughout Germany. The biomass and hydraulic systems balance out any fluctuations in wind and solar power. One central control unit connects the individual plants to each other. The combined power plant makes “up-to-the-minute” adjustments to the current requirement.
II. Buildings

Introduction

Energy consumption in buildings currently accounts for over 40% of all energy consumed in Europe. This is by far the greatest share of total energy consumption, ahead of transport and industrial production. Approximately 85% of the energy consumed in buildings is attributed to heating and hot water generation, which means that the potential for energy savings is huge: according to the EU Commission, the energy efficiency of European building stock can be increased by 50%. Improvements can be made not only to heating systems and other technologies, but also in the area of insulation. Higher targets for energy savings and reduced CO₂ emissions can be achieved by combining perfectly co-ordinated components to create efficient, fully integrated systems.

Of particular note is the potential for making heating systems (for room and water heating), air conditioning and lighting more energy efficient using the following technologies, in order to attain the energy standards of low-energy houses and passive houses:

- oil and gas heating (for example, condensing boiler technology)
- heat distribution (for example, pumps), heat emission (for example, radiators and underfloor heating systems) and controls (for example, valves)
- ventilation technology (for example, ventilation devices with heat recovery)
- air-conditioning technology
- combined heat and power generation
- heat insulation (energy-efficient products and components)
- lighting technology (for example, daylight redirection systems)

Another option is to replace conventional fossil fuels, such as oil or gas, or combine them with renewable energy sources. Finally, renewable energy resources are available in almost unlimited quantities and provide options for long-term, sustainable energy as they reduce our dependence on fuels that have a limited supply. Renewable energy sources also make a valuable contribution to environmental protection and climate control because they significantly reduce CO₂ emissions.

The key application areas for renewable energies in buildings are as follows:

- solar thermal technology for domestic hot water and/or to support heating systems
- photovoltaic technology to generate electricity for domestic use or for grid supply
- innovative wood-burning solutions, for example, using split logs, wood pellets or wood chips
- solutions that leverage environmental heat or near-surface geothermal heat, for example, using heat pumps for heating
Germany has an established tradition of energy saving that stretches back at least as far as the oil crises of the 1970s. Since then, German regulations have been placing increasingly stringent demands on heating insulation and heating systems. The German Energy Saving Ordinance (EnEV) has been in force since 2002 and was amended in 2007. The EnEV envisages a holistic view of the building envelope, systems engineering and the preparation and conversion losses of the fuels used. A further planned amendment of the EnEV aims to tighten the rules on energy consumption in buildings by 30% before 2009.

For several years, the Federal government’s energy saving regulations for buildings have been accompanied by its concerted promotion of the research and development of innovative technologies for the “buildings of the future”, which allow standards to be raised.

State sponsorship (for example, through financing with KfW Förderbank) is directed in particular at energy-efficient and environmentally friendly applications that are not yet economically viable. For many years, German industry has been adapting to these challenging conditions and availing of the opportunities for sponsorship, and now offers particularly efficient technologies. For example, the German heating industry achieved fresh export success last year thanks to a growth of over 100% in the market in some European countries. It currently enjoys a market share of 60% in the EU and 33% worldwide. Germany holds a 90% share of the global renewable energy market. Even in the highly competitive photovoltaics market, Germany is the clear front-runner with a share of 50%, surpassing even Japan.

### Example: Renovation of a listed “Art Nouveau” building in Nuremberg

**Measures:**
- Gas condensing boiler, ventilation and heat recovery, insulation with ecological insulating materials

**Energy Savings:**
After the renovation, the building’s heating requirement fell by almost 60% and is now around 109 kWh/m²a.

### Market shares in Germany’s heating industry

<table>
<thead>
<tr>
<th>Share in %</th>
<th>Total</th>
<th>Market share of German firms in gas and oil condensing boiler technology</th>
<th>Renewable energies in the heat market*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>90 %</td>
<td>95 %</td>
<td>95 %</td>
</tr>
<tr>
<td>EU 25</td>
<td>60 %</td>
<td>85 %</td>
<td>85 %</td>
</tr>
<tr>
<td>Global market</td>
<td>33 %</td>
<td>90 %</td>
<td>90 %</td>
</tr>
</tbody>
</table>

* Solar-thermal systems, heat pumps, wood-burning systems as central heating systems

Source: Federal Industrial Association of Germany for House, Energy and Environmental Technology (BDH)
II. BUILDINGS

Condensing Boiler Technology

In Europe, the main technologies used for room heating and the heating of drinking water are hydraulic heating systems with oil and gas central-heating boilers. Since the largest portion of energy is consumed by the generation of heat in buildings, the renovation of heating systems is one of the areas offering the greatest potential for savings. The German heating industry is at the forefront of efficient high-tech boiler development.

Low-temperature boilers, where the temperature of the water in the boiler is adjusted in line with the external temperature, set the standard for many years. Even with these boilers, the flue gas loss and standby loss were only between 10% and 12% of the effective heat energy.

The latest-generation boilers are called condensing boilers. These represent an enhancement of the low-temperature boiler and reduce heat loss considerably. As a result, the amount of heat now released from the fuel is almost at the limit of what is physically possible. Condensing technology also utilises the condensation heat contained in the flue gas, which would otherwise remain unused. An additional increase in efficiency is achieved through lower flue gas temperatures, which mean that less flue gas is lost. As a result, condensing boilers can achieve efficiency values in excess of 98%.

Condensing boilers are cost-effective because the cost of purchase is recovered in terms of energy saved within just a few years. Replacing an outdated heating system, for example, with an oil condensing system in a single-family or two-family house in Germany costs, on average, €8,000. At a heating oil price of 60 cents per litre, a current annual heating oil consumption of, say, 4,500 litres (for heating and hot water) and a reduction in consumption of 30%, approximately €1,350 can be shaved off the annual oil bill. This means that the cost of the condensing boiler system would be redeemed over approximately 6 years.
II. BUILDINGS

How a condensing boiler works

| A | Air |
| B | Blower |
| C | Gas valve |
| D | Natural gas |
| E | Heating outflow |
| F | Heating return flow |
| G | Waste gas |
| H | Condensation drain |

Source: BDH

Comparison of carbon emissions of various heating systems

- A Standard boiler (pre-1978)
- B Low-temperature boiler
- C Natural gas condensing boiler with solar power for hot water
- D Natural gas condensing boiler with solar power for hot water and auxiliary heating

Source: BDH

Example: Office buildings of the Civil Engineering Office in Nuremberg

Measures:
Insulation, thermal insulation composite system, replacement of boiler installation, control technology, installation of a mini bio fuel heating system

Energy Savings:
The building’s systems technology was renovated at a cost of € 127,000. The outdated boiler unit was replaced by a gas condensing boiler and low-temperature technology. Overall, the renovation resulted in annual energy savings of approximately 270 MWh and reduced the energy costs for heating by around one third.
Professional insulation can achieve savings of up to 80% of the heating requirement.

**Insulation**

Since renovation projects often take a long time to complete, older builds often do not meet the latest insulation standards and use disproportionately large amounts of heat energy for room heating. However, with a professional energy-saving renovation, any building can be as well insulated as a new build.

Inappropriate insulating measures, on the other hand, may cause structural damage. Expert consultation and planning is therefore just as important as successful project execution by an experienced company and the use of suitable building materials.

Thanks to Germany’s long tradition of energy saving in residential, commercial and industrial construction, German engineers and building contractors can be counted on as reliable partners for projects both at home and abroad. German partners are involved in many such projects all over the globe at all levels, from consulting to planning and execution.

**Potential savings**

German building stock currently consumes approximately three to (in the worse cases) ten times as much energy for heating as new builds. Up to 80% of the heat energy consumed for room heating can be saved by having insulation installed by a professional contractor and through energy-efficient renovation. Energy-efficient renovation of older builds has the added benefit of increasing thermal comfort at lower room temperatures.

**Schematic representation of a wall with transparent heat insulation**

- Solar radiation
- HEAT LOSSES
- HEAT GAINS
- Transparent coating
- Transparent heat insulation material
- Absorption layer
- Air cavity (optional)

Most insulating materials are available in varying qualities.

**Source:** Solarpraxis
German engineers and construction companies are reliable partners in energy-saving construction.

## Insulating techniques

Conventional building materials tend to be very good heat conductors. In other words, they do little to stop heat loss through the transfer of heat from inside the building to the exterior. Technology cannot eliminate this natural flow of heat but insulation can reduce it significantly.

To increase the insulating effect of a wall construction, additional insulating layers with low heat conductivity are added to older buildings. These insulating layers are usually positioned on the “cold” side of the existing structure. In the case of external walls, this is the exterior of the building.

In this case, the insulating materials must either be naturally weatherproof or fitted with weatherproof protection.

The following are all commonly used insulating materials and some also serve as thermal insulation composite systems:

- foamed plastic (polystyrene, polyurethane etc.)
- mineral wool, glass wool, cellular glass
- mineral materials, such as porous concrete, pumice stone, perlite
- injected cavity fill made of cellulose flakes, hemp-clay mixes
- wood fibre, wood shavings, cork
- plant or animal fibres, such as hemp, flax, coconut, wool
- reed plates
- calcium silicate plates (for example, for internal insulation)

### Different thicknesses required to achieve the same insulating effect

![Diagram showing different thicknesses for insulation](Image)

Source: Solarpraxis
Innovative insulation systems are also possible, for example:

- vacuum insulation
- transparent heat insulation

It is generally recommended that the following parts of a building be insulated:

- roof or top floor ceiling
- exterior walls
- basement ceiling, basement exterior (where relevant)
- glazed surfaces
- heating system and heat storage unit

**Special regulations in Germany**

The energy performance certificate introduced in Germany assesses the energy efficiency of buildings (for example, new builds and old builds that are to be rented, let or sold). Based on this rating, specific renovation measures are proposed to improve the energy efficiency of existing buildings.

The energy performance certificate is an inexpensive way for owners to obtain initial information about how to renovate their buildings. It records the most important details of the building, provides information about its current level of energy efficiency and indicates whether renovation would make sense in each case. Specific recommendations for renovation in the energy performance certificate provide a starting point for renovation planning or for further, detailed energy consultation. In Germany, expert initial consultations are provided by, among others, energy consultants, planning offices and skilled craft companies. For many years, the Federal Ministry for Economic Affairs and Energy (BMWi) has also been promoting qualified, unaffiliated energy consulting, and has therefore played a role in the establishment of Germany’s nationwide network of independent energy consultants.

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### A rough comparison of the insulating effect of various building materials

The same insulating effect is achieved with:

<table>
<thead>
<tr>
<th>Insulating Material</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeze block or vertical coring lightweight brick</td>
<td>2 cm</td>
</tr>
<tr>
<td>Softwood</td>
<td>6 cm</td>
</tr>
<tr>
<td>Straw clay</td>
<td>6.5 cm</td>
</tr>
<tr>
<td>Solid clinker brick</td>
<td>23.5 cm</td>
</tr>
<tr>
<td>Concrete</td>
<td>40.5 cm</td>
</tr>
<tr>
<td></td>
<td>105 cm</td>
</tr>
</tbody>
</table>

Source: dena
II. BUILDINGS

For potential buyers and tenants, the energy performance certificate provides a welcome point of comparison and a decision-making tool for selecting a building or apartment based on projected energy costs. Minimum energy-efficient standards must be met when performing extensive building renovations in Germany. These standards and those for new builds are regulated by the Energy Saving Ordinance (EnEV). Over the years, German regulations governing standards for energy efficiency have become increasingly rigorous and this trend will continue for the foreseeable future. The EnEV ensures that the insulation and technologies used in new builds meet high standards and specifies prerequisites for renovation based on the latest technological developments, while simultaneously taking account of economic viability.

As a result of the provisions enshrined in the legislation and the high demand for renovations, which can only be met by degrees, a large percentage of the labour force employed in skilled crafts or in the planning/consulting sector is currently involved in energy-efficient renovations.

German specialists are also employed as consultants or skilled craft providers on a global scale. The Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and its partners foster a well-structured, high-quality transfer of knowledge as part of these projects. The BMVBS and the German Energy Agency (dena) support energy-efficient construction and renovation through well directed international projects, for example, in China. Specific measures include the publication of reference books, the hosting of regional seminars and conferences, representation at trade fairs ad exhibitions, and the promotion of products and services from German companies.

The close collaboration between Germany and its international partners under the auspices of the International Energy Agency (IEA), for example, in the context of the "Implementing Agreement on Energy Conservation in Buildings and Community Systems" (ECBCS), affords German science and industry greater opportunity for teamwork on a global scale.

The energy performance certificate records the most important details of a building, provides information about its current level of energy efficiency and is ultimately an incentive to improve a building’s energy efficiency.

**Example:**

**Renovation and reconstruction of a childcare facility in Wismar**

**Measures:**
- Insulation, gas condensing boiler and buffer storage unit, solar panels, ventilation and heat recovery, windows

**Energy Savings:**
- After the energy-efficient renovation and reconstruction of the childcare facility was completed, energy consumption dropped by about 65%. The renovation also resulted in a significant reduction (21%) in the ventilation heat loss.
II. BUILDINGS

Combined Heat and Power Generation

In conventional power plants, only one third of the energy consumed is fully utilised. Combined heat and power (CHP) generators provide a viable, environmentally friendly alternative. CHP plants work on the principle of combined heat and power generation, whereby the energy consumed is simultaneously transformed into both electricity and useful heat. As a result, up to 40% of the primary energy can be saved compared with centralised power generation and decentralised heat generation.

In addition to medium-sized and large CHP units, German companies also offer “mini CHP systems” with a capacity of up to 30 kW. Mini CHP units essentially comprise a combustion engine, a power generator and a system of heat exchangers. The electricity generated in the generator can either be used in the building directly or fed into the public grid. The waste heat generated by the combustion engine is recovered by heat exchangers and can be used for heating purposes. The heat is usually stored in a buffer storage unit until needed.

The size of a small CHP depends on its capacity but is not generally larger than a standard boiler. The engines also make very little noise and therefore can easily be installed in basements. The capacity of a mini CHP unit can provide enough thermal heat for a large single-family house or multiple family dwelling. The greater the heating load required, the greater the amount of electricity generated and the sooner the cost of the CHP system will be recovered.
Small CHP units can be used in residential buildings, in recreational buildings (including hotels, guesthouses and restaurants), public buildings or healthcare facilities (including hospitals, care homes and health centres), in other words, wherever heating is required on an ongoing basis. In addition, standalone mini CHP systems without a connection to the grid provide an attractive alternative to traditional power generators in isolated areas.

German legislators recognized the environmental benefits of CHP systems many years ago and implemented appropriate measures such as the Heat-Power Cogeneration Act (KWK) and the Energy Saving Ordinance (EnEV) to promote and extend the use of combined heat and power generation. Electricity tax is not applied to the consumption of electricity generated by CHP, while the fuel used to generate the electricity is exempt from energy tax.

Germany currently has some 2,500 CHP units with capacities of between 50 kWel and 2 mWel. Since 1990, the electrical power of CHP engines has increased in Germany from 500 mW to more than 4,100 mW, which represents 3.5% of the national energy supply. Experts predict a further increase to 10%. In other words, a large number of manufacturers and a wealth of expertise have been present in Germany for several years. German manufacturers are continually pushing the boundaries of their technological innovations to make them even more effective and to identify new applications. These include, for example, the use of micro gas turbines to drive mini CHP systems.

Example: Radical refurbishment of the office towers of the KfW Bankengruppe (KfW banking group)

**Measures:**
Curtain wall and day-light systems, optimised lighting, ventilation and heat recovery, combined heat and power generation, combined heat and cooling, control technology, control and optimisation of operations, building automation, curtain wall systems, daylight planning and systems

**Energy Savings:**
A CHP system has been providing the building’s heating since the mid-1990s. Since the renovation, the waste heat from this system is now used by absorption cooling machines to generate cooled air. This innovation has played a major role in reducing the building’s primary energy consumption, which was almost halved. It is now down from 331.1 kWh/m²a to 174.6 kWh/m²a.
Low-Energy Houses and Passive Houses

Particularly energy-efficient buildings offer economic benefits in the face of rising energy prices, help combat climate change and provide a very pleasant room temperature.

In Germany, buildings that meet the low-energy house standard have an annual energy requirement of between 30 and 70 kWh/m². The term “passive house”, meanwhile, refers to particularly efficient buildings that do not require an active heating system to achieve a comfortable room temperature. To meet this standard, the annual energy requirement per square metre for room heating must be reduced to less than 15 kWh, while the building must also be equipped with ultra-efficient ventilation and heat recovery systems.

To achieve these values, renovation of the building envelope and the heating and ventilation systems must be planned and executed by professional experts. Energy-efficient optimisation of the building envelope includes doors and windows, as well as insulation of the exterior walls and basement, roof, roofspace and floor slab. Thermal bridges, in particular around windows and in entrance areas, are to be avoided as far as possible. Savings can be made in the building’s HVACR (heating, ventilation, air conditioning and refrigeration) through efficient heat generation and distribution, a large proportion of passive solar energy utilisation and sophisticated ventilation technology.

Due to the multitude of energy-efficient buildings that have already been constructed in Germany (including passive houses), German companies have had the opportunity to acquire extensive expertise in meeting specific challenges in relation to building construction and technology. Changes in consumer behaviour play a key role in this context because the active ventilation systems required (in passive houses in particular) render many old and particularly inefficient practices superfluous, for example, tilting windows to ventilate a room.

Knowledge gained from and technologies used in the construction of energy-efficient buildings (for example, passive new builds) can also be applied to the renovation of building stock, including the optimisation of heating technology to ensure low wastage, ventilation measures and the avoidance of thermal bridges. German companies can achieve savings of more than 80% in a typical old build.

The “Energy-Optimised Construction” (EnOB) programme of the Federal Ministry for Economic Affairs and Energy and the “Low Energy Standards for Existing Buildings” project of the German Energy Agency (dena) provide impressive demonstrations of how, through best practices in energy-efficient renovation, existing buildings can meet the same standards as a low-energy houses (see www.enob.de).
Ventilation system with heat recovery

Active ventilation systems minimise heat losses and improve the room climate.

Example: “Neue Burse” student hall of residence, Wuppertal

Measures:
The hall of residence was thoroughly modernised and given an energy make-over in two phases. The first construction phase adhered to low-energy standards, and the second was in line with passive house standards. Priorities: Insulation, curtain wall systems, windows and glazing, ventilation and heat recovery

Energy Savings:
Renovation cut the primary energy consumption by more than 60% to 80 kWh/m²a. After the first phase alone, the heating requirement fell by approximately 58% to around 68 kWh/m²a. The renovation to bring the building in line with passive house standards should reduce it further to 26 kWh/m²a. The renovation reduced total energy costs to just 15 €/m²a and the total cost of electricity to 6 €/m²a.
Correctly proportioned and regulated radiators can reduce heating costs by up to 12%.

**Heat Distribution and Emission**

Reliable and efficient heating of a building requires heat generation and distribution and a tailored heat supply to heat consumers.

A building’s heat distribution system, which comprises pipework, pumps and line fittings, transports heat from the heat generator to the heat transfer point.

The heat transfer system, meanwhile, comprises radiators or heating panels and room temperature controls. A comfortable room temperature is easily achieved using the heat radiated by the system.

Components of a heating system: boiler, pipework, pump, thermostatic valves and radiators

If the individual components work together efficiently, energy and costs are saved while comfort levels are increased.
Some key considerations in relation to efficient heat distribution and transfer are outlined below:

- The latest energy-saving heat circulation pumps require less than half of the electrical energy required by conventional, unregulated pumps. Electronically commutated (EC) motor pumps are much more effective than the asynchronous motors used in the past, even when working with partial loads. Since EC motors use permanent magnets and therefore require little or no magnetising current, energy losses are very small.

- Regulated pumps also eliminate bothersome noises in the heating system.

- Configurable thermostatic valves enable precise room temperature regulation.

- Time-controlled and temperature-controlled valves automatically ensure a comfortable level of room heating.

- Perfectly proportioned and hydraulically balanced heating surfaces increase comfort levels and save energy.

Individual renovation steps in the area of heat distribution and transfer, such as hydraulic balancing, the installation of configurable thermostatic values or the replacement of obsolete thermostatic heads, produce the greatest energy savings per investment cost.

With modern, large-area radiators, comfort levels are increased, while the temperature of the working medium in the heating system may be dramatically reduced (low-temperature heating). Lowering the room temperature also produces significant energy savings. For example, lowering the temperature by 2°C using correctly proportioned and regulated radiators reduces heating costs by up to 12%.

The German government promotes efficient heat distribution and transfer through its programme of incentives, including direct subsidies for particularly efficient circulatory pumps.

**Example:**

**Käthe Kollwitz School, Aachen**

**Measures:**
Insulation, optimised lighting, ventilation and heat recovery, combined heat and power generation, combined heat and cooling, control technology, operating control systems, building automation

**Energy Savings:**
As part of the renovation, the heating circuit distributor and pump technology were replaced, and a new ventilation system with integrated heat recovery technology was installed. The pipework was also upgraded from a single-pipe to a double-pipe system. The final energy requirement for room heating, hot water and ventilation dropped by 65% as a result. The primary energy requirement, meanwhile, fell by more than 75% to 47.0 kWh/m²a. Total costs of this work amounted to € 2.8 million.
**Lighting**

A large proportion of electricity consumption in buildings is accounted for by artificial lighting. This is directly reflected in the running costs of many buildings. In the housing sector, at least 10% of electricity is consumed by lighting. In the office and commercial sector, lighting can even account for up to 50%. The bulk of this consumption is still based on economically and environmentally inefficient technologies like the traditional light bulb.

Light is still generated primarily by electricity passing through a light bulb, the oldest and least efficient technology. At most, just 5% of the electricity flowing through is converted into light. The unused remainder is transmitted into the environment as heat. Energy saving lamps are an alternative. Although they have been on the market since the 1980s, they are only gradually becoming widely used. At the same time, the previous concerns about light quality and warm-up periods are no longer valid. Such lamps are now on sale in the various designs of traditional bulbs and some are even dimmable.

The commercial sector still tends to use obsolete lighting systems. They generally consist of traditional fluorescent tubes, many of which have poor reflectors (or none at all) and inefficient ballasts. The light generated is absorbed within the tube itself and emitted into the room without direction. Simple retrofitting of reflectors can minimise the energy loss. Furthermore, modern ballasts can cut power consumption even further.

More than 2 billion light bulbs are sold every year in Europe. One can calculate that a shift to energy saving lamps would save 7.5 billion kWh and 4.5 million tonnes of CO₂ in Germany alone. Assuming an electricity price of 20 cents per kWh, this would imply savings of €1.5 billion for the residential sector as a whole.

The potential amount of energy to be saved in terms of lighting is enormous. Various measures can dramatically reduce the energy consumption both when planning and when modernising a building:

- optimised use of daylight when planning a building (shade, electronic light intensity control, etc.)
- use of highly efficient illumination
- modernisation using energy-efficient lighting systems
- use of intelligent lighting control

---

**Potential savings from modern lighting equipment**

<table>
<thead>
<tr>
<th>Lighting System</th>
<th>Electricity Consumption in %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old lighting</td>
<td>100</td>
</tr>
<tr>
<td>Up-to-date mirror louvre luminaires</td>
<td>70</td>
</tr>
<tr>
<td>Electronic ballast</td>
<td>50</td>
</tr>
<tr>
<td>Daylight-responsive dimming</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: dena
Over the last 15 years, the German lighting industry has developed new technologies which are three times as efficient as older systems. And the important energy savings go hand in hand with other benefits:

- lower maintenance costs
- lower waste-disposal costs
- better ergonomics
- better light

Example:
Lighting in an average 1970s office building for 200 employees with gross floor space of 4,250 m².

Measures:
Variation A: complete replacement of the existing lighting – without control technology

Energy Savings:
Variation B: complete replacement of the existing lighting – with additional on-site and daylight control

Energy consumption was cut by up to 75%. This can cut costs by € 13,500 a year. The amortisation period is just under four years.

Optimising lighting – cutting costs

Source: German Energy Agency (dena), Berlin
When planning to construct a building, the air-conditioning system should be tailored to the actual requirements of the building.

**Air-Conditioning Technology**

Air-conditioning technology is technology that creates and maintains comfortable ambient conditions in a room in terms of temperature, humidity and air quality. This includes air-conditioning systems that convey heat into (heating systems) or out of (cooling systems) a room (for example, using airflow or ventilation technology) or systems that increase or reduce humidity by conducting air or water as heat carriers.

When planning to construct a new building, it makes sense to install an air-conditioning system tailored to suit the requirements of the specific building. The operating costs should also be as low as possible and the energy used as efficiently as possible. Most importantly of all, regulation and control of the various technologies used should be co-ordinated as efficiently as possible.
Air conditioning based on efficient systems and renewable energies can be very energy-efficient. German companies have expertise in the two key areas, which are outlined below:

**Heat recovery ventilation (HRV)**

With heat recovery ventilation, the energy content of the air extracted by the ventilation system is used to heat the air entering the building. The fresh air supply is usually pre-warmed during cold weather. During warm weather, particularly efficient ventilation systems use the evaporative heat loss to cool the air supply. Another option is heat recovery from waste water. For example, warm waste water (from showering etc.) can be used by heat exchangers to heat cold water, thereby saving energy, costs and CO₂ emissions.

**Solar cooling**

In addition to the solar energy that can be used to heat water and support room heating, any excess energy generated during the summer months can be used to cool a building. This approach works well because a building’s cooling requirement increases in tandem with the amount of solar energy that can be generated, which means that the greatest cooling effects can be achieved when they are most needed. For this purpose, a thermal cooling machine can be used in conjunction with a solar heating system. Unlike conventional cooling machines (i.e. compression cooling machines), this uses a thermal compressor. The advantages of these machines over conventional cooling machines are that cooling agents, which are harmful to the environment, are not required and that environmental heat instead of valuable energy (usually electricity) is used to operate the compressor.

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Example: Bremen State and University Library

**Measures:**
Optimised lighting, ventilation with heat recovery, active cooling, renewable and passive cooling, control technology, operating control systems, building automation, optimisation of operations

**Energy Savings:**
Energy costs for ventilation, refrigeration and cooling were reduced by 73 %, from 11 €/m²a to 3 €/m²a. The primary energy consumption for heating, cooling, ventilation and lighting dropped by 70 %, from 831 kWh/m²a to 230 kWh/m²a.
Combining Building Technologies to Best Effect

The greatest energy efficiency is achieved by combining various energy-efficient technologies. Of course, competent planning and selection of measures, and their careful execution, are absolutely essential. The special provisions in German legislation encourage full utilisation of the scope and potential of these technologies and promote diversity in the approaches used. As a result, German engineers are driving the energy-efficient merging of insulation and heating technology and the development of the necessary control systems. German companies are global leaders in energy-efficient boiler technology, renewable energies and control systems, offering the greatest number of solutions and the most advanced.

Examples include:

Buildings with optimised insulation, such as passive houses, are virtually air-tight. In these buildings, ventilation systems provide the hygienically required air renewal and maintain a constantly optimised quality of air, while minimizing the supplementary heat requirement. A central ventilation system is an ideal solution for utilising the heat in the extracted air to pre-warm the incoming fresh air. Air-to-air heat pumps can reduce the ventilation heat requirement by up to 95%, for example.
Where solar radiation (which is free of charge and of CO₂) is used as an energy source, an intelligent combination of technologies involving heat stores and heat generators provides the solution for periods of low sunlight:

- Well-insulated heat storage tanks with a tall and narrow design and minimised heat stratification, used in conjunction with intelligent control technology, enable the use of various levels of heat and the storage of heat from various sources, while keeping heat loss to a minimum. These are used both by the solar heating system and by the secondary heat generator, for example a pellet or condensing boiler or a heat pump in order to reduce partial-load conditions or cycling.

- Other storage solutions are also available. The structure of the building itself can balance day/night differences if the thermal mass of its components is activated (for example, with water pipes in the ceiling). In addition, latent heat storage (with PCM, or phase change materials), such as encapsulated paraffin in the surface of interior walls (for example, plaster, gypsum plasterboard or chipboard) can maintain the desired temperature over longer periods.

In terms of systems engineering, geothermal probes significantly enhance the potential of solar heating systems and heat pumps. During the summer months, the soil around the probes can be regenerated using the surplus heat from the solar heating system. This type of coupling also protects the solar unit against stagnation, which would damage its components.

During the summer, solar units can normally provide a building’s entire hot water requirement, which saves heating costs and, of course, reduces CO₂ emissions.

Pellet boilers and condensing boilers can similarly be used in combination with solar heating systems. By having these boilers provide almost all of the hot drinking water required during the summer months, inefficient partial-load conditions are avoided. This protects the environment, reduces costs and enhances the durability of the boilers themselves.

Example:
Printing company in Karlsruhe

Measures:
Curtain wall systems, windows and glazing, optimised lighting, ventilation and heat recovery, regenerative and passive cooling, thermo-active building component systems, daylight planning

Energy Savings:
Energy consumption was significantly reduced, thanks to an innovative cooling system and a sophisticated building design. The building measures and integrated cooling system with heat recovery reduced heating requirements by almost 90% to 21 kWh/m²a. The primary energy consumption fell from 344 kWh/m²a to 86 kWh/m²a. Construction costs amounted to 860 €/m², while the cost of implementing the technical systems was 370 €/m².
II. BUILDINGS

Gas condensing boiler
Oil condensing boiler
Wood boiler
(Pellets, split logs, wood chips)
Mini-CHP
Heat pump
(Air/water, brine/water, water/water)
Solar thermal system
Photovoltaic system
Ventilation system
Under-floor heating
Radiator

Source: BDH
III. Transport

Introduction

Energy efficiency in the transport sector – possibilities

The consumers of energy in the transport sector are to some extent the same as those in the industrial and building sectors, e.g. in the case of drives and motors, insulation and lighting. There are also substantial technological overlappings between the various modes of transport: for example, the development of motors is resulting in more efficient use of conventional fossil fuels, e.g. by recovering energy from exhaust gases. Also, progress is being made on the use of alternative forms of energy like hydrogen or electricity generated from renewables for battery, fuel cell and hybrid drives. Furthermore, all of the sectors are placing their hopes in innovative construction methods, lightweight construction, aerodynamics, capacity enhancement, and energy-saving vehicle components. Other possibilities to increase energy efficiency in the transport and mobility segment include state-of-the-art infrastructure components, lighting concepts and traffic management systems. They optimise the traffic flow and increase the efficiency of the individual transport routes.

Germany: a high-tech country

German firms can supply these solutions. Germany’s automotive manufacturers and their suppliers employ a total of more than 750,000 people; they had a turnover of € 288 billion in 2008, and roughly € 181.5 billion of this was exported. These firms invested € 18.9 billion in research and development.

In recent years, the volume of traffic worldwide – and thus also of energy consumption – has risen continuously. The transport sector currently accounts for more than 30% of Europe’s energy demand (cf. diagram). The density of traffic is higher in Germany than in any other European country. As a result, the development of the country’s traffic management systems is especially far advanced. German technology leads the world here, e.g. in terms of traffic guidance systems, fleet management and logistical concepts like strategies for traffic relocation, terminal management and improved handling in storage facilities.

Overview of energy-efficient technologies by mode of transport

<table>
<thead>
<tr>
<th>Technology</th>
<th>Mode of transport</th>
<th>Maritime shipping</th>
<th>Inland shipping</th>
<th>Rail</th>
<th>Road</th>
<th>Aviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alternative fuels (H₂, gas, bio)</td>
<td>▲</td>
<td>●</td>
<td>▲</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
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<td>Lightweight construction</td>
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<td>●</td>
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<td>●</td>
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<td>Hydrodynamics</td>
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<td>●</td>
<td>●</td>
<td></td>
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<tr>
<td>Aerodynamics</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Braking/heat energy recovery</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Alternative drive technologies</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Diesel direct injection</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<td>Hybrid technology</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
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<tr>
<td>Fuel cell</td>
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<tr>
<td>Efficient capacity increase</td>
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<td>●</td>
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<td>●</td>
<td></td>
</tr>
<tr>
<td>Speed optimisation</td>
<td>●</td>
<td>●</td>
<td>●</td>
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<td>Load optimisation</td>
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<td>●</td>
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<td></td>
</tr>
<tr>
<td>Driver training</td>
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<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Optimised logistical processes</td>
<td>●</td>
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<td>●</td>
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<td>●</td>
<td></td>
</tr>
<tr>
<td>Optimised infrastructure</td>
<td>●</td>
<td>●</td>
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<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Intelligent telematics</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>

▲ Commercial realisation ● Under development

This overview was researched as fully as possible but makes no claim to be exhaustive.
German firms particularly offer innovative solutions for the manufacture of vehicles and components. They are making a major contribution towards cutting global energy consumption thanks to products like novel drive systems, brakes, energy recovery and storage systems, improvements in aero- and aquadynamics, and innovative weight-saving materials. Modern technologies, e.g. in electrical engineering, offer a very great potential for further improvements in efficiency. Furthermore, Germany can offer outstanding expertise in the field of power and control electronics.

**Outlook**

Networked national and international traffic solutions will become a decisive factor for economic and social development in the coming years. In future, mobility will no longer be dominated by one specific mode of transport or technology. Rather, there will be a need for an efficient networking of modes of transport and infrastructure. German transport system technology is characterised by the way it combines all sub-sectors and fields of technology, thereby integrating the entire field on an interdisciplinary basis. This means that German products already offer (and will continue to offer) the potential to safeguard mobility and transport both in economic and ecological terms.

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**Energy consumption by sector in the EU 27**

<table>
<thead>
<tr>
<th>Sector</th>
<th>EU 27</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sectors</td>
<td>100 %</td>
</tr>
<tr>
<td>Industry</td>
<td>27.5%</td>
</tr>
<tr>
<td>Transport</td>
<td>31.4%</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>81.9%</td>
</tr>
<tr>
<td>Rail</td>
<td>2.4%</td>
</tr>
<tr>
<td>Air</td>
<td>14.0%</td>
</tr>
<tr>
<td>Inland waterways</td>
<td>1.6%</td>
</tr>
<tr>
<td>Private households, services, agriculture, etc.</td>
<td>41.1%</td>
</tr>
</tbody>
</table>

Source: Eurostat 2008

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**Passenger and freight transport – Transport categories**

Source: German Federal Statistics Office
Modes of Transport – Road

The car has become the main means of passenger transport in most countries around the world. Road transport also dominates the freight market. The proportion of energy consumed in road transport is correspondingly high compared with the other modes of transport. Road transport is also expected to account for the greatest rates of increase in freight and passenger traffic – but this need not necessarily go hand in hand with a further increase in energy consumption. Improvements in conventional engine and vehicle technology and new propulsion systems can help to reduce the consumption of fossil fuels in particular and to save costs.

Conventional engine technology

Engine technology offers a major path towards improving energy efficiency in road transport and reducing fuel consumption. The direct-injection dual-charged internal combustion engine with high specific capacity and low consumption improves the energy efficiency of petroleum-fuelled engines by approx. 20%. Here, German firms can provide innovative world-beating solutions.

The principle of the diesel engine offers consumption-related advantages over the internal combustion engine. In the case of gas-fuelled engines, natural gas combustion processes offer consumption levels equivalent to those of diesel, coupled with minimal emissions.

Hybrid drive

Hybrid drive – whereby a vehicle is initially accelerated by an electrical motor before the diesel engine takes over – offers great promise for cars, urban buses, lift-trucks and local freight distribution. Also, in many cases the energy produced by braking is recovered and returned to a newly developed, high-performance, long-life and light lithium-ion battery or to the “ultra caps” for the electrical drive. And there is usually an automatic start/stop mechanism which switches off the engine during longer stand-still periods and starts it up again when the accelerator is lightly pressed or a gear is engaged. In the case of urban buses, hybrid drives can cut fuel consumption by 20–25% compared with diesel-only vehicles. A German manufacturer recently launched the world’s most efficient luxury hybrid limousine. Its petrol consumption is a mere 7.9 l per 100 km, resulting in the world’s lowest CO₂ emissions for this vehicle and power class, of only 186 g per kilometre. The power output is 220 kW/299 bhp, and the combined maximum torque 385 Nm. The hybrid luxury limousine undercuts vehicles of this class with conventional engines by up to 2.1 l per 100 km.
**Electrical drive**

Vehicles which power their propulsion from an electrical energy storage facility are also an energy-efficient alternative for road transport. Electrical motors are less complex than combustion-based engines, need a less complex gear system and produce zero local exhaust emissions when in operation. There are two types of electrical motor in use in road transport – battery-powered and fuel-cell.

The key to the success of battery-powered vehicles lies in the battery technology. The Li-ion-based batteries currently used for IT offer great potential for use in vehicles. They can store substantial quantities of energy in a reasonable size and weight, thereby fulfilling an important precondition. Ranges of 200 km and more are possible from Li-ion batteries in a compact class car. It is thus already worthwhile using battery-powered electrical vehicles, particularly in urban areas.

Another approach is to use fuel cells in vehicles. The chief advantages of the fuel cell are the level of efficiency, which is roughly twice that of the combustion engine, and the zero-emission operation. In a fuel cell, “cold combustion” of hydrogen and oxygen transforms chemical energy into electrical energy highly efficiently. This can be used both to power the vehicle via an electrical motor and to operate the numerous other appliances.

The focus of the development of both of these types of engine is currently on increasing the range and on reducing the price of the vehicles. One priority here is to optimise the performance of the on-board storage system.

**Aerodynamics**

In addition to new engine technologies, there are a number of further ways to improve energy efficiency in road transport. In the case of the HGV, for example, aerodynamics offer particular potential. Taking all the aerodynamic possibilities for the tractor unit and the trailer together, the drag co-efficient (cw figure) can be cut by around 20% and consumption by approx. 3 l per 100 km, despite the fact that full cladding including complete covering of the wheel arches adds at least 220 kg to the weight. German superstructure manufacturers recently presented a vehicle with a payload of 1,100 kg and a maximum permissible gross weight of 3.5 t which – thanks to aerodynamic improvements – consumes 4 l diesel less per 100 km than conventional transporters. The higher purchase price should be recouped after roughly two years.

**Lightweight construction**

High-strength steel, aluminium, or carbon composites – lightweight construction is a well-tried means used by German car and truck designers to cut consumption or increase the payload by reducing the unladen weight, thus reducing the consumption per tonne of payload. The lightest superstructure developed so far by a German manufacturer weights 5400 kg. Conventional superstructures weigh roughly 1000 kg more. The weight reduction means that an extra 1000 kg of freight can be transported, thus saving journeys and, in terms of the weight transported, fuel costs.
**Increasing capacity**

EuroCombis – extremely long trucks – are extremely efficient. Field tests using vehicle combinations up to 25.25 m in length and up to the currently permissible weight have shown that 15 – 30% less fuel is consumed per transported tonne. Two EuroCombis can carry the load of three current trucks, which means that the volume of traffic can be substantially reduced. German-manufactured trailers lead the world and are therefore exported around the world.

**Training the driver**

Training the driver can cut truck fuel consumption by around 5% in the long term. If a training course is assumed to cost around € 370 per driver, plus the loss of the services of the driver during the course and staff costs, the expense of the training course will have been recouped within two to three months. Sensitive driving also produces substantial savings in terms of wear-and-tear on tyres, brakes and clutch, as well as a much lower damage rate. Further to this, German firms manufacture intelligent driver assistance systems which keep the driver constantly informed about his driving and provide tips on improvements. If proper use is made of these systems, fuel savings of between 2.5% and 5% can be achieved, depending on the load and the distance.

**Downsizing**

Downsizing is an effective way to cut fuel consumption and emissions of pollutants for both internal combustion and diesel engines. Small cylinder capacities are used to generate high performance and torque. Downsizing therefore necessitates particularly efficient fuel injection and supercharging systems and makes great demands of motor engineering.

Downsizing can make a higher utilisation of the existing engine capacity possible. The selection and combination of appropriate technologies in terms of cylinder capacity, power and torque can produce substantial fuel consumption reductions of 10 – 30% compared with traditional engine concepts. Basically, there are two ways to downsize: increasing the output of an existing engine by supercharging or by increasing rpm, or replacing a large engine with a small engine with the same nominal power. The scale of the downsizing frequently depends on the relationship between the required transport performance and the desired reduction in fuel consumption.

**Example:**

**Aerodynamic add-on kit for semitrailers**

**Measures:**

Installation of an aerodynamic add-on kit consisting of side trim and underride protection, additional side curtain with pneumatic central locking

**Energy Savings:**

This measure cuts fuel consumption by between 5% and 7%. At the same time, the time needed for opening and closing drops by 70%. Given an annual distance travelled of 120,000 km and a diesel price of € 1.32, the cost of an add-on kit is recouped after a year.
Modes of Transport – Rail

The railway is regarded as an extremely environmentally friendly and energy-efficient mode of transport. Nevertheless, constantly rising energy prices mean that more energy-efficient drive technologies and all opportunities to save energy should be utilised. Germany’s railway industry regards the challenges of the market as an opportunity to develop state-of-the-art rail transport technology. Employing around 580,000 people, the railway companies, rolling stock manufacturers, component suppliers and railway constructors achieved a turnover of around € 50 billion in 2008. Their innovative technologies provide outstanding, economic systems and components for rolling stock and railway infrastructure, thus ensuring higher energy efficiency on the railways.

Energy consumption in railway transport compared with other modes of transport

<table>
<thead>
<tr>
<th>Mode</th>
<th>Diesel equivalent in l/Pkm</th>
<th>Diesel equivalent in l/tkm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Railway transport</td>
<td>0.034</td>
<td>0.012</td>
</tr>
<tr>
<td>Domestic air traffic</td>
<td>0.073</td>
<td>0.039</td>
</tr>
<tr>
<td>Road transport</td>
<td>0.056</td>
<td>0.013</td>
</tr>
<tr>
<td>Maritime transport</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Storing energy

The recovery of braking energy, in which the drive motor is used as a generator when braking in order to feed the energy back into the system, is already in use in trains. In local transport, where there are many stops, this can cut electricity consumption by over 20%.

The newly developed stationary flywheel energy storage system is a further possibility. It makes it possible to store recovered electrical energy and to feed it in a targeted manner to electricity-consuming appliances. This separates the supply of and demand for (braking) energy, so that it can be used even more efficiently.

Latent heat accumulators utilise the waste heat from the cooling water for the diesel engine in order to bring the engine to its start-up temperature without any additional energy consumption.

Vehicle components

As is always the case with vehicle manufacturing, improvements in aerodynamics and weight offer potential to improve energy efficiency. Trains can be made lighter, for example by means of modular sandwich construction as in the Stockholm metro, or by the use of aluminium or fibre-glass composite materials, as in the front mask used by the new Oslo metro trains. This cuts the weight by 15%. In combination with the high energy recovery capacity of the new vehicles, energy consumption has been cut by 30% compared with the previous model used in Oslo.

If freight cars are equipped with the Compact Freight Car Brake (CFCB), which was developed in Germany, the weight drops by up to 1000 kg per car compared with the conventional K-type brake blocks. This means that more freight can be loaded per car, and energy consumption falls per t/km. The CFCB is more efficient than conventional brakes because the power is transmitted from the brake cylinder via a single transmission lever to the brake block so that almost all of the pressure from the brake cylinder is transformed into braking power. There is no longer any need to transfer the force via brake linkages, whereby the power from the cylinder is diverted several times via open bearings, causing the loss of a substantial proportion of the power generated without any braking effect being produced. Also, the CFCB is lower-maintenance and quieter. The purchase costs for CFCB-equipped cars are roughly the same as those for a conventional brake, including all the attachments in the car body.

Assistance for train drivers

The effects of railway driver training sessions are backed up by driver assistance systems exported all round the world by German firms. The train driver receives information about the track ahead and information about the status of the train and current energy consumption, so that he may be able to drive the train in a manner which is more energy-efficient and produces less wear-and-tear than before. The systems process information like inclines and curve radii, speed limits, signal positions, and the braking pressure status.

Example:
Use of braking energy to start moving or accelerate. Also, the energy can be used to bridge passages without trolley lines.

Measures:
Use of a braking energy storage system on the trams in Mannheim. Double-layer capacitors ("UltraCaps") are used to store the energy.

Energy Savings:
Depending on the vehicle type, the energy costs for trams amount to an average of € 30,000 per year and vehicle. The system to utilise braking energy can cut energy consumption by up to 30%. Only 60% of the energy otherwise needed to start the tram moving is required. The other 40% come from the on-board energy storage facility – a saving of 25%. On top of this there is another 5% saved due to the reduced energy take-up from the grid, which also reduces the losses in the trolley lines.
III. TRANSPORT

Modes of Transport – Inland Waterways

Inland waterways can relieve the burden on port infrastructure – especially in the maritime ports – and on the surrounding rail and road infrastructure, thereby reducing congestion, energy and fuel costs. In terms of energy consumption per tonne of freight, inland shipping is already regarded as one of the most efficient means of transport. Nevertheless, work is constantly being done in Germany on the development of modern, energy-efficient and environmentally friendly vessels for inland waterways in order to achieve energy and cost savings as the volume of freight transported by inland waterways increases.

Modernising the fleet

German firms have not merely developed entirely new types of vessel for use on inland waterways. They also offer various structural alterations, modernisation and refitting for existing fleets:

- Replacement of the main power system in order to improve performance and reduce fuel consumption.
- Replacement of or addition to the propulsion system, e.g. propeller nozzles to make the system more efficient and thus save fuel.
- Redesign of the stern and of thruster tunnels to enhance the efficiency of the system.
- Alteration of the ends of the vessels in push-tow combinations to reduce turbulence between the units and thus resistance.

These actions can result in a drop in specific freight transport costs of between 1% and 8%. A combination of these measures boosts energy efficiency even further – e.g. a combination of the first three measures cuts specific transport costs by up to 14%. If these measures are implemented in parallel to regular or exceptionally required (general) overhauls, the potential fuel savings mean that the investment can pay off within a few years. The services described above are marketed by German shipyards. And similar outcomes can be achieved by using appropriate German products.

| Comparison of distances transported for one tonne of freight given the same energy input |
|---------------------------------|---------------------------------|---------------------------------|
| Road transport                  | Railway transport               | Maritime transport              |
| 100 km                          | 300 km                         | 370 km                         |

Source: Federal Waterways and Shipping Administration
III. TRANSPORT

Large inland cargo vessels

In addition to the design of the vessel and the propulsion/rudder system, the cross-section of the waterway in relation to the immersed vessel is of crucial importance for the speed-related resistance and thus the power needed by vessels on internal waterways. Trials have shown that, given a sufficient water depth, large inland cargo vessels (more than 1,500 t payload, 95–110 m length) use significantly less energy per laden tonne than smaller units. The deliberate alteration of the fleet structure towards substantially more energy-efficient large cargo vessels can cut fuel consumption by around 9%.

Fuel cell technology

Fuel cell technology is already being used for passenger vessels on inland waterways. For example, the Zemship (Zero Emission Ship), which runs on the Alster in Hamburg, has a hybrid system consisting of two 48 kW fuel cell systems plus a lead gel battery. A smart energy management system co-ordinates the division of the work between the fuel cells and the battery. The fuel cell hybrid drive is the main power source. The vessel is fuelled with gaseous hydrogen by the world’s very first hydrogen boat fuelling station at Hamburg’s Stadtpark. Up to 50 kg of the gaseous hydrogen is stored on board in 350-bar pressure tanks, providing enough energy for three days of operations. The passenger vessel generates 100 kW of output and saves roughly 73 t of CO₂ emissions a year.

Freight transport by inland waterway, million tonnes

<table>
<thead>
<tr>
<th>Transport link/freight category</th>
<th>2008</th>
<th>2007</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total of which:</td>
<td>245.0</td>
<td>249.0</td>
<td>-1.6 %</td>
</tr>
<tr>
<td>Transport within Germany</td>
<td>57.2</td>
<td>59.1</td>
<td>-3.3 %</td>
</tr>
<tr>
<td>Shipping abroad</td>
<td>57.1</td>
<td>59.5</td>
<td>-4.0 %</td>
</tr>
<tr>
<td>Shipping from abroad</td>
<td>107.6</td>
<td>107.4</td>
<td>+0.2 %</td>
</tr>
<tr>
<td>Through traffic</td>
<td>23.0</td>
<td>22.9</td>
<td>+0.6 %</td>
</tr>
<tr>
<td>Amount transported in million tonne-km</td>
<td>64,042</td>
<td>64,717</td>
<td>-1.0 %</td>
</tr>
<tr>
<td>Containers in 1,000 TEU</td>
<td>2,051</td>
<td>2,130</td>
<td>-3.7 %</td>
</tr>
</tbody>
</table>

Source: Destatis

Example:
The “Futura Carrier” is a new type of modular construction vessel for inland and coastal waters which adapts flexibly to existing waterways.

Measures:
This type of vessel is a modular system. It has a radically new hull design, four redundant steerable propeller drives – two forward and two at the stern – and what is easily the most efficient automatic control system for inland waterway vessels at present.

Energy Savings:
Compared with an inland waterway vessel with a traditional hull design and drive solely at the stern, this vessel offers extremely high manoeuvrability and operational reliability. Further developments on the basis of the first four vessels in operation indicate efficiency and cost advantages of at least 20%. Hydrodynamic tests with models in a towing tank have confirmed these figures.
III. TRANSPORT

Modes of Transport – Maritime Shipping

Maritime shipping is a particularly environmentally friendly and efficient mode of transport. In comparison to land and air traffic, it produces less emissions in terms of the load and distance transported, and is substantially more energy-efficient. Whereas 90% of intercontinental freight transport is handled by sea-going vessels, these only account for around 2.7% of global emissions. However, as with all modes of transport, substantial energy savings can also be attained in maritime shipping, thereby reducing costs. Numerous technologies have been and are being developed in Germany which help to make shipping more economic. The new rules of the International Maritime Organisation (IMO) on the transition from heavy fuel oil to much more expensive marine diesel are also resulting in ongoing efforts to conserve energy.

The Green Ship of the future

- SkySails 10–50%
- Flettner rotors 30–50%
- Hull design optimisation 1–5%
- Anti-fouling paint 3–6%
- ACS (Air Cavity System) 15%
- Propulsion technologies:
  - Diesel engine
    - Optimisation of pumps and auxiliary systems 1%
    - Automatic engine control 1%
    - MCR (Multi Maximum Continuous Rating) 3%
    - WHR (Waste Heat Recovery) 12%
  - Diesel-electric POD drive
  - Hybrid drive
  - Electric motor with fuel cell up to 100%
- Fuels:
  - Natural gas
  - Hydrogen
  - Bio fuels (biodiesel, biogas)
- In-port plug socket
- Slow Steaming
- DTA (Dynamic Trimming Assistant) up to 5%
- Load optimisation

Source: Green shipping trend study, HypoVereinsbank, © Ericos – Fotolia
Propulsion technologies

In recent years, a number of efficient propulsion technologies have been developed which have yet to be deployed in many types of vessels. The diesel engine has become accepted as the dominant propulsion technology for ships. Electronic direct injection (the common rail system) in particular has achieved clear efficiency gains. German technology is also used in efficient automatic engine control systems, which can save 1% of fuel. If this is optimised to provide a maximum steady output, the “Dual/Multi Maximum Continuous Rating (MCR)”, the savings can be as high as 3%.

Substantially higher fuel savings, of around 12%, can be produced by waste heat recovery (WHR). The pod drive, which has proved its worth as a propulsion system for certain types of vessel, such as ferries, is also particularly energy efficient. Unlike conventional ship drives, pod drives are not installed in the hull, but beneath it in a nacelle. Since the nacelle/propeller unit can be turned full circle, the combination of the two serves as a rudder. Conventional (shaft) drives, in contrast, also require a rudder for steering. The advantage derives from the diesel-electrical drive concept which can be adapted to suit the prevailing conditions for different loads and speeds and which can thus conserve up to 15% of fuel.

Electrically powered vessels using fuel cells are regarded as particularly forward-looking. These utilise a key technology for a sustainable energy supply, and are therefore at the focus of research and development, demonstration and marketing of efficient energy technologies. Their principle is as simple as it is ingenious: electricity and heat are generated in a single step when hydrogen and oxygen react. One innovation by Germany’s shipbuilding and component supply industry is the development of fuel cell technology for the onboard power supply of vessels, particularly at sea, but also for the energy supply in port.

Alternative propulsion systems and energy sources

In Germany, research is currently taking place not only into hydrogen, but also natural gas and biofuels as alternative fuels for use in maritime transport. Here, liquefied natural gas (LNG) offers great potential: it is already in use in dual-fuel engines on gas tankers. As the compressed raw material is transported from the gas fields, the LNG carriers use part of their load for fuel. On the empty return journey, in contrast, the engines use diesel fuel. If the necessary fuel-supply infrastructure were in place, purely gas-driven engines could be used in scheduled coastal and ferry services. This could cut CO₂ emissions by around 20%, and emissions of other pollutants would also drop significantly. During waiting times in ports, the provision of a gas connection to the on-board electricity generator could offer an efficient and low-emission alternative to powerlines from the land. Wind also appears to be a highly promising source of propulsion. Some German shipping firms have installed German-developed skysail systems on their vessels. These systems can cut fuel consumption by up to 35%, depending on the wind. A German firm is currently developing Flettner rotors for ships which save between 30% and 50% of fuel and thus make a decisive improvement to energy efficiency. The Flettner rotor is an aerodynamic drive in the form of a rotating cylinder exposed to a moving airstream, and thanks to the Magnus effect it generates a force perpendicular to the direction of the airstream. Germany has developed a high level of skills in this field and has correspondingly capable manufacturers.
**Technical innovations**

German shipping firms are increasingly banking on technical innovations to save energy or fuel. An optimised hull design slides more efficiently through the waves. Optimisation of the design and shape of the rudder and propeller can save additional energy. By reducing the water resistance of the ship, anti-fouling paint reduces fuel consumption by between 1% and 6%. The innovative “air cavity system” (ACS) produces fuel savings of up to 15%: it uses compressors to force compressed air into channels under the flat hull. The air cushion reduces the contact area between the hull and the water, thereby minimising friction which slows down the ship’s movement. Also, the use of a Dynamic Trimming Assistant (DTA), which calculates the optimal trimming of a vessel, can reduce resistance and save up to 5% fuel.

In addition to payload optimisation, many shipping companies are now also looking to “slow steaming” to cut fuel consumption. Even an 8% cut in speed can – calculated over the lifetime of the vessels – save around a quarter of the propulsion energy required. This more than covers the longer transport periods and additional operating costs.

**Example:**

Use of skysails on new vessels or retrofitted to existing vessels

**Measures:**

Installation of a skysail which utilises the strong and constant winds and the reduced friction at a height of 150 – 300 m above sea level, thereby helping to drive the ship forwards.

**Energy Savings:**

Assuming 210 days at sea per year, fuel costs of a 160 m tanker amount to approx. € 2.5 million. The use of a skysail system saves fuel worth roughly € 460,000. The investment is amortised in 3.9 years.

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**The skysails system**

[Diagram of skysails system with labels:

- A: Towing kite
- B: Control system
- C: Launch and recovery system
- D: Towing rope
- E: Winch
- F: Control pod
- G: Force transmission point]
Modes of Transport – Aviation

Global passenger forecasts suggest average annual growth of up to 5%. At the same time, the increasing international division of labour will boost air freight traffic by up to 7%. And airlines will be facing rising cost pressures and stiffer competition. This trend necessitates the development of new, energy-efficient and low-emission aircraft. Alongside the scientific community and large companies, in Germany the small and medium-sized component suppliers in particular are helping to promote more energy-efficient and lower-emission innovations in the aerospace field by developing subsystems, processes and services.

So far, kerosene is the only fuel used by civilian aircraft – with its unbeatable energy density and its stability in temperatures from -50°C to +50°C – in contrast to conventional petroleum it only ignites at very high temperatures and is thus relatively safe. Since the development of a reliable and sufficiently available equivalent to kerosene is still ongoing, it is important to start by utilising the technical possibilities to cut consumption. German manufacturers offer leading solutions for this.

Technical measures to save energy:

- More efficient aerodynamics due to winglets or adaptive wings which result in better uplift or resistance characteristics, or the use of elastic composites which make additional curvatures on the wing surfaces possible and thus create a non-turbulent airflow which lowers air resistance. Another approach is to use a foil imitating the structure of shark skin, which also lowers air resistance. For example, if the maximum possible 75% of the aircraft’s surface is covered by the foil, 3% of fuel can be conserved.

- Lighter construction techniques – for the aircraft themselves, e.g. by using carbon composites or metal/composite hybrids, or also for optimal-weight cargo containers. A conventional airfreight container made of aluminium weighs around 80 kg; new units developed by German firms made of composites weigh 15% less. The introduction of new lightweight containers can save the global aviation industry more than 10 million a year on fuels – the precise reduction in consumption is currently being trialled.

- Lower-consumption engines – either engines with an additional gear system to adapt the revolution speeds of the individual turbine stages or the open-rotor principle, in which turbine and propeller are crossed. Also, it is possible to use reduction gears and heat exchangers.

- Co-ordination and coupling of the energy supply for on-board systems in order to optimise consumption and weight. Conversion to the use of fuel-cell driven auxiliary power units (APUs) is also possible.
The aviation technology of the future

Researchers at the German Aerospace Center have developed the world’s first pilot-controlled aircraft which can take off, fly and land solely by fuel-cell drive. The technology is not yet ready for use in civilian aircraft. But engineers expect soon to be able to deploy the hydrogen technology as an onboard power supply for passenger aircraft.

Operational measures to improve energy efficiency in air transport:

- Optimisation of flight routes: using the latest routing technology to avoid indirect routes has enabled a German airline to save 26,500 l of kerosene (64,000 t of CO₂) a year on its Far East routes.

- Increase fleet capacity utilisation.

- Optimise aircraft loading.

- Variable cruising speeds so that aircraft on long-range flights can make better use of the wind: a newly installed flight management control system has enabled a German airline to save around 7,500 l of kerosene (18,000 t of CO₂) within a year.

- More precise definition of fuel requirements to avoid superfluous weight.

- Optimised approach procedures.

The latter two measures alone enabled a German airline to achieve substantial savings of up to 10,000 l of kerosene within a year. The Single European Sky and the expansion of airports are also efficient ways to lower fuel consumption in air traffic. These measures are covered in the “Infrastructure” section.

Example:
Weight reduction of the A350 by using carbon-fibre reinforced composites (CFRP)

Measures:
53% of the airframe of the new wide-bodied jet is made of composite materials, and is thus highly weight-efficient. The innovative CFRP-based fuselage concept reduces weight by means of optimal adaptation of the fibre layers and skin thickness. Furthermore, the A350 XWB has benefited from aerodynamic improvements and new consumption-optimised engines.

Energy Savings:
The innovative CFRP-based technologies help to ensure that the A350 XWB consumes 25% less fuel per seat.
Telematics and Traffic Management

As an exporting nation and a densely populated transit country, Germany works very hard to keep the traffic moving. One method is to expand the infrastructure. Another is to use telematics, i.e. intelligent technologies and systems. German companies are some of the world’s leading developers. Their products help worldwide to optimise traffic flows and avoid congestion.

Fuel consumption by trucks on German autobahns now averages:

<table>
<thead>
<tr>
<th>Consumption</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29.2 l</td>
<td>on the open road with no disruption</td>
</tr>
<tr>
<td>30.8 l</td>
<td>given moderate disruption</td>
</tr>
<tr>
<td>31.8 l</td>
<td>given a high level of disruption</td>
</tr>
<tr>
<td>61.9 l</td>
<td>in stop and go traffic</td>
</tr>
</tbody>
</table>

In other words, the figure in stop and go traffic is more than twice the level of consumption on the open road. For this reason, congestion avoidance is one of the key ways to lastingly improve energy efficiency in transport – and not only in Germany.

In the vehicle or on the road

The technologies now in use in Germany range from navigation systems with or without dynamic congestion warnings and route planning through to electronic road control systems. The first example enables the car or truck driver to reach his destination more quickly (cutting journey times by 5 % to 10 %) and uses correspondingly less energy. The other examples increase road capacity by between 5 % and 10 % by means of flexible, situation-responsive traffic control. The German electrical engineering and electronics industry can supply a range of solutions here. Exchange of information from vehicle to vehicle and between vehicle and infrastructure are the key technologies for the future, and successful progress is being made on them in Germany.
Flexible control

On the railways, measures include remote control by mobile radio of marshalling yards or traffic control technology on branch lines (radio signalling). Another approach has been developed by the German telecommunications industry: flexible gap management between trains. Computer Integrated Railroading (CIR) takes calculates both the varying length of trains and their respective speeds as it stipulates the distance between trains. This means that the trains can be operated more closely together. This ensures that the trains can travel at an optimal speed and in an energy-conserving manner. Also, more or longer trains can be operated. The volume transported per train and the capacity utilisation of the infrastructure rise correspondingly.

Dynamic train control

Dynamic train control is a similarly forward-looking approach, and German traffic planners are deeply involved in its development. This technology guides trains through the system with as few conflicts and delays as possible and with optimised energy consumption. Bottlenecks in the system can be passed without unscheduled stops and at the maximum possible speed. This also increases the capacity of the rail system. The driver of the respective train is automatically given recommendations via GSM-R which help him select the most forward-looking possible driving pattern.

The European Train Control System (ETCS) will initially be introduced on selected routes around Europe. This will harmonise the many different safety technologies and make cross-border train movements possible without stops to switch locomotive. It will enhance the productivity and attractiveness of rail freight transport, and the volume of environmentally friendly transport will increase.

Example: 
Installation of an electronic traffic guidance system in the Nuremberg metropolitan region which can process dynamic commuter flows, holiday dates, events and the use of local public transport.

Measures:
Equipping of 70 km of autobahns and 33 km of streets in the city with an electronic traffic guidance system. Measurement points and cameras provide data on each lane and register disruption. All the data are processed centrally by an overriding computer which monitors the entire system including traffic lights and which works from past experience. Route control systems, variable traffic signs, speed indicators and a dynamic car park guidance system are all used. Predefined “scenarios” are used to guide the traffic onto certain routes, and traffic lights are adapted to the respective situation.

Energy Savings:
Purchasing such a system is mainly worthwhile for larger conurbations like the Nuremberg metropolitan region, with around 560,000 vehicle movements a day and a catchment area of 2.2 million inhabitants, since the software alone costs € 1.6 million. The traffic flow has benefited greatly from the introduction of the electronic traffic guidance system. The number and length of tailbacks – and thus also the energy costs – have dropped correspondingly.
Logistics

Transport logistics embrace the entire organisation, control, provision and optimisation of processes governing both movements of freight and passengers within a system and the means of transport themselves. Energy efficiency in logistics can particularly be achieved via intelligent networking of different modes of transport and infrastructures. Further to this, there are various innovative developments by German firms and software designers which help to optimise transport processes.

Logistical and technical measures

On the one hand, there are purely logical questions to be answered by – generally computer-based – logistics. For example: how much freight fits into a standardised space? Which loading or unloading sequence is shortest? And which mode of transport is the best in terms of time and price? On the other hand, there are technical solutions like the use of fleet management systems or the use of energy-efficient equipment in transport.

Transport and tour optimisation

One traditional method is to optimise transport by improving the capacity management. Modern IT tools from German logistics software providers which take stowage rules into account support such systems. As well as improving the load factor, tour optimisation programmes reduce the proportion of unladen kilometres travelled and thus the fuel consumption per tonne of freight transported. Such systems also optimise the maintenance intervals for the means of transport, handle tyre management, and transmit various data to the shipping agent – e.g. on diesel consumption and driver performance in the case of road haulage (cf. diagram).

Efficient storage logistics

Energy-efficient technologies are available not only for transport but also for storage. Supported by increasing automation and state-of-the-art building technology, these optimise the operations. Various German firms – from storage equipment providers to conveyance system manufacturers, process optimisers and facility managers – offer not only energy-optimised new buildings, but also the modernisation of older storage facilities.

Managing the cold chain

Refrigerated goods make special demands of logistics. The cold chain must not be interrupted. Of course, energy-efficient packaging is available, from polystyrene boxes to refrigerated containers or trailers. The use of scroll compressors, which compress the coolant, offers particular benefits for refrigerated containers. They consume up to 40% less energy than conventional appliances. Special superstructures for trucks developed by German manufacturers make it possible to transport deep-frozen, refrigerated and ambient-temperature dry cargo side by side in multi-compartment vehicles. Another approach: the shipping on the return journey of products which do not require refrigeration. This clearly reduces the proportion of empty journeys and optimises the capacity utilisation of the means of transport. Energy efficiency improves, and costs are cut.
III. TRANSPORT

Transmitting information from truck to shipping agent

Energy efficiency in the transport sector depends largely on the fuel consumption performance of ships, vehicles and aircraft. But infrastructure also plays an important role. Firstly, it needs to be state-of-the-art, and secondly, sufficiently available to cope with the ever-growing volumes of traffic.

Example:
Modernisation of the automatic nine-aisle high bay warehouse of an automotive company with 22,000 storage spaces and nearly 4,000 movements in and out per day.

Measures:
Gradual conversion of the storage facility during operations to the latest mechanical, electrical and control solutions, e.g. via the introduction of a system to capture braking energy. Also, the stacker cranes only move as fast as is required by the current job situation. The most frequently required types of goods are now stored in the spaces which are closest to the point of need.

Energy Savings:
The throughput in the storage facility rose by 50% from 4,000 to 6,000 movements in and out. The energy conservation measures saved 118,500 kWh per year, equivalent to the electricity needs of roughly 30 4-person households. At current German electricity prices, this saving amounts to around € 25,000 per year.

Technical possibilities include the following measures which can be realised both by German construction companies and by German component suppliers abroad:

- acceleration of demand-led airport expansion to avoid congestion in the sky caused by insufficient capacity on the ground
- accelerated expansion of maritime ports in order to avoid long waiting times for ships
- intelligent road design to boost through-put speeds (roundabouts or use of hard shoulders)
- use of modern points systems to increase through-put speeds on the railways
- use of geothermal heating for points
- use of light-emitting diodes for signals
- emergency energy supply for signal boxes, railways etc. based on fuel cells
- use of energy-efficient street lighting

LED technology

The high technological standard of German developments in the field of infrastructure is also to be found in energy-saving LED street lights. Over the last 15 years, the German lighting industry has developed new technologies which are three times as efficient as older systems. The extremely low electricity consumption and the long maintenance intervals for LED street lights save municipalities money. Intelligent planning of lighting helps not only to avoid superfluous light pollution, but also makes it possible to minimise the number of points of light and in this way to further cut investment costs.
LED technology is also used in the new road signal providers developed by German industry, e.g. at level crossings or crossroads. Since the LED signal provider has a much higher light yield than conventional light bulbs, energy needs fall by 50 to 75%.

**Airport expansion and airspace management**

More than a million tonnes of kerosene is consumed in holding patterns over Germany alone each year. This is a clear indication that demand-led airport expansion is crucial to improving the energy efficiency of air transport. Germany’s construction companies have already worked successfully on various airport projects around the world, and German firms have also acquired a good reputation in airport management.

One operational possibility to reduce energy consumption in air transport is enhanced, international airspace management. In Europe alone, the Single European Sky could save airlines roughly 12% of their distance flown by smoothing out zig-zag routes cased by the various national flight corridors.

**Smooth rail transport**

As in various other segments of rail transport, German firms also lead the world on points technology. This is reflected both in the enhanced efficiency of conventional systems and in the development of point heating systems which use geothermal heat.
IV. E-Energy

A growing demand for energy and depleting fossil-based resources are spurring us on to develop new energy solutions. In particular, we must strive to increase energy efficiency, develop renewable energies and reduce greenhouse gas emissions. The complex nature of energy solutions demands, first and foremost, networks for the exchange of information and smart systems for analysing and processing data. Information and communication technologies (ICT), which furnish the main tools required in the area of energy supply, have not yet received due attention. This is a mistake because the latest studies and expert opinions make it clear that further development of the energy industry will be impossible without fully drawing on the potential of digital intelligence and networking.

The German Federal Government has acknowledged this shortcoming and launched the beacon project “E-Energy: ICT-based Energy System of the Future” while new activities have been initiated by the Federal Ministry for Economic Affairs and Energy (BMWi).

E-Energy harnesses the potential for optimizing of ICT in the energy industry.

E-Energy stands for:

- comprehensive digital interconnection,
- computer-based control and
- computer-based monitoring of the entire system.

In the E-Energy project, model regions will demonstrate how the tremendous potential for optimisation presented by information and communication technologies (ICT) can be best tapped to achieve greater efficiency, supply security and environmental compatibility (cornerstones of energy and climate policy) in power supply. Furthermore, the information and energy industry will be invigorated to develop new jobs and markets. In this regard, standards will be developed and the new E-Energy solutions from the model regions will be transferred to other energy supply systems. To enable the capacities to span various industries, numerous research institutes, power companies, and businesses are participating in the beacon project.
New solutions for the electricity sector

The electricity sector is the first area to be addressed by the project. The challenges in this area are particularly high. The generation and retail markets are opening up with the progressive liberalisation and decentralisation of power generation and distribution, thus resulting in greater competition and more complex market relations. Centralised large-scale power stations will gradually become less useful and will make way for distributed and weather-dependent electricity generators of various sizes and functions. The one-way system of transferring energy from a large-scale power station to the consumer will soon be a thing of the past. It will be replaced by a complex, dynamic network of electricity producers and consumers. The future lies in cross-border integrated networks with two-way power traffic and decentralised, weather-dependent power feed-in. The challenge is to develop an ICT-based system that constantly strikes a balance between power generation and consumption and which also ensures optimum utilisation of the power grid and dynamic use of the growing storage capacities. Furthermore, the provision of electronic services is becoming increasingly important for business partners and clients.

In an effort to accelerate innovation developments, the Federal Ministry for Economic Affairs and Energy (BMWi) announced an E-Energy technology competition for the development of integral ideas and system concepts for an “Internet of Energy” in April 2007.

Model projects are to show specifically:

- how the “Internet of Energy” can make electronic legal transactions and business dealings between all market participants secure and efficient,
- how the technical components and infrastructure of the overall electricity system can be intelligently monitored, controlled and regulated, and
- how direct linkages can be made to electronic market activities.

The aim is to achieve efficient, prompt and transparent co-ordination of the energy supply, energy demand and complementary services in and between all areas of the power supply system. This not only necessitates technological progress but also the adjustment of organisational structures and general frameworks.

To back up the model projects, the Federal Ministry has commissioned research which will directly link up the model regions.

No loss of comfort

Smart electricity meters play an important role in the E-Energy solutions. In combination with new digital gateway technologies, these will replace mechanical meters, including in private households, and will assume important control functions as energy centres for the distributed generators and consumers.
The new power meters boast a wide range of capabilities such as:

- individual rate storage,
- load profiling,
- easy remote reading and control or
- connection to in-house software.

The meters also act as an interface between the end customer and the grid network operators, suppliers and measuring point operators.

Furthermore, E-Energy solutions also make it possible to combine and co-ordinate different energy sources intelligently. This can, for example, offset weather-related fluctuations in renewables. This means that even in strong wind or sunshine, there is no need to dispense with comfort, energy security or quality.

**Overall, E-Energy means that:**

- the transaction costs are cut,
- business processes are made more transparent,
- the expansion of renewable energy resources is made possible,
- the existing grid capacities are well utilised,
- the load curves are smoothed out, and
- the need for control energy can be reduced.

Our competition to establish E-Energy model regions received a large number of entries. An independent jury selected the six winning projects, namely:

- E-DeMa, Ruhr area model region: Use of an “intelligent” gateway to control energy supply and consumption
- eTelligence, Cuxhaven model region: Use of an intelligent energy management system to integrated electricity that is generated locally
- MEREGIO, Baden model region: Integration of different power generators via smart metering
- Mannheim model city, Rhine-Neckar model region: adaptation to a variable electricity price via the “Energy Butler”
- RegModHarz, Harz model region: Provision of “clean” energy from the renewables-based combined power plant
- SmartW@TTS, Aachen model region: Use of a web-based “trading floor” to counterbalance fluctuations in renewable energy

For more information, please refer to the E-Energy brochure, which is available for download on the BMWi-website at:

[www.bmwi.de/English]
IV. E-ENERGY

The Energy Efficiency Export Initiative

When it comes to energy efficiency, Germany is a step ahead of most countries. In terms of energy consumption, Germany is one of the most productive industrialised countries, with primary energy consumption of less than 7 gigajoules per € 1,000 of GDP. One of the main reasons for this is that Germany is an international market leader and a driving innovator in the fields of energy efficiency technology and energy consulting.

We want to share our expertise with other countries and support their efforts to enhance energy efficiency. This is because greater energy efficiency means greater competitiveness.

Under the label "Energy efficiency made in Germany", the Energy Efficiency Export Initiative – a programme launched by the German Federal Government under the lead responsibility of the Federal Ministry for Economic Affairs and Energy – assists foreign partners in establishing productive contacts with German companies and energy efficiency experts.

The Initiative aims to:

- show you solutions in the field of energy efficiency,
- implement and expand energy efficiency measures as a key tool for boosting competitiveness,
- transfer know-how into the hands of political decision-makers, key opinion-leaders and market participants.
- make a tangible contribution to international climate protection.

On the website www.efficiency-from-germany.info/en you will find a database of German providers of the energy-efficient technologies presented in the foregoing sections of this brochure, together with the associated services they offer.

We urge you to take advantage of the in-depth experience and expertise of these companies. Enhance your energy efficiency, save on energy-related costs and boost your competitiveness. The Energy Efficiency Export Initiative will help you to make contact with the partners and experts who are right for you.

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