



Corporate Communications

Anne Lenartz
Spokeswoman Production
Tel: +49 (0)841 89 40034
E-mail: anne.lenartz@audi.de
www.audi-mediaservices.com



Technische Universität München



Responsibility for the environment: “Oak Forest” research project

Summary

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Summary

Responsibility for the environment: “Oak Forest” research project

36,000 oak trees have been planted. Together they constitute a scientific experiment unlike any other in Germany: Together with the Bavarian State Forestry and the Chair of Forest Yield Science at the Technical University of Munich, Audi has launched the “Oak Forest CO₂ Reservoir” research project in the Kösching Forest near Ingolstadt. Trial sites near Győr, Hungary, and other locations worldwide are to follow. By funding this project, Audi underscores its commitment to sustainability and environmental protection. This commitment is also evident in the Company’s systematic measures to conserve resources both in the products themselves and in their production.

Oaks are special trees, and not only in mythology. In nature they provide a diverse biosphere for a wide variety of animal and plant species. They can also store large amounts of carbon. The aim of the research project in the Kösching Forest is to identify the relationships between stand density on the one hand and CO₂ sequestration potential and biodiversity on the other. The Kösching Forest is the starting point for the international expansion of the project to sites with different climatic conditions. Another trial site with an area of four hectares at the Audi production site in Győr, Hungary, will be planted with more than 13,000 Pedunculate Oaks. The trial site will also be managed by the Technical University (TU) of Munich as a cooperative project with the University of Sopron. Plans are already underway for additional sites at international locations.

The roughly six hectare wooded area in Kösching Forest was almost completely destroyed in 2007 by bark beetles, drought and the storm "Kyrill," and replanted with approximately 36,000 young Pedunculate Oaks in 2008 as part of the research project. A portion of the acreage was planted in a special pattern so that a large number of different growth conditions and growth patterns can be studied within a small area.



Environmental protection at Audi – the strategy

The continuous improvement of the environmental compatibility of the products and production sites and the ecological use of natural resources are firmly anchored in the Audi Environmental Policy. Audi follows a systematic strategy to reduce consumption and emissions. Audi will further reduce the CO₂ value of its models by around 20 percent by the year 2012. The strategy also calls for the continuous reduction of site-specific and company-specific CO₂ emissions. This means efficiency, low fuel consumption, long service life and the use of environment-friendly materials in the products as well as the sustainable and ecological use of resources in production.

Environmental protection at Audi – energy efficiency and CO₂ reduction

Energy-efficient products and resource-friendly production have top priority at Audi in accordance with the company's holistic strategy for environmental protection. A series of innovative technologies and the systematic use of the modular efficiency platform has propelled Audi to a leading position in its premium field of competitors. The new Audi A3 1.6 TDI, for example, is expected to set a new best mark in terms of CO₂ emissions next year: It will undercut the 100 gram per kilometer mark (*160.93 g/mile*), with CO₂ emissions of only 99 g/km (*159.33 g/mile*), corresponding to a fuel consumption of just 3.8 liters of diesel fuel per 100 km (*61.9 US mpg*).

Audi employs a full range of advanced technologies to achieve the necessary efficiency and reduction of CO₂ emissions in production, including trigeneration (power, heat, and cooling) with excellent efficiency, the use of waste heat, and heat recovery. Audi also makes space available at the Ingolstadt and Neckarsulm sites for the installation of innovative photovoltaic arrays. Efficient production processes and optimal logistics in all areas of production conserve additional resources.



Full version

“Oak Forest” research project – funded by Audi

In cooperation with the Bavarian State Forestry and the Chair of Forest Yield Science at the Technical University of Munich, AUDI AG launched the “Oak Forest CO₂ Reservoir” research project outside the Ingolstadt site in 2008. The project includes the reforestation of an area in the Kösching Forest east of Ingolstadt that suffered massive damage from bark beetles, drought and, in early 2007, Hurricane Kyrill. The aim of the Audi-funded project is to replace the existing population of fir trees with a stable, ecologically valuable deciduous forest that can withstand the changing conditions of the future climate. 36,000 young Pedunculate Oaks were planted.

The oak is one of the best suited tree species, in part because it offers a significant degree of carbon storage and biodiversity (diversity of species). It provides a diverse biosphere for a wide variety of animal and plant species. Audi has partnered with the Technical University of Munich for scientific support of the project and to address pressing issues. Issues include the productivity of forest trees and CO₂ absorption under the prevailing climatic and site-specific conditions.

The project in Kösching Forest is particularly well suited for the analysis of the climate-relevant carbon sequestration by forests and the consequences of different growth forms on biodiversity. Planting the trial site in the form of Nelder circles enables the ideal collection of data for a wide range of factors in an oak forest with a variety of growth densities. Another trial site is currently being prepared near the Audi plant in Győr, Hungary. Plans are currently underway for the international expansion of the project under the title “Diversity and Productivity of Forests. Comparison of Monocultures and Mixed Forest in Different Climate Zones.” Forest zones of different temperatures – from Atlantic to continental to tropical climates – will be analyzed to determine how different forest structures can contribute to climate protection through carbon sequestration, and how productivity and diversity of species can be brought into optimal balance with sustainable forest management.



The research – CO₂ sequestration and biodiversity

The forest ecosystem plays a major role in the CO₂ balance of our atmosphere. Like all green plants, trees absorb carbon dioxide (CO₂) from the atmosphere during photosynthesis for the production of energy. They store a portion of the carbon contained therein for an extended period in the biomass of their woody structures. Although CO₂ absorption of an oak, for example, is slight during the initial years of growth, the capacity for binding carbon increases rapidly after only 20 years. One hectare of oak forest already has 21.4 tons of CO₂ stored in its biomass after 20 years. After 30 years, the hectare of oak forest has already removed 121 tons of CO₂ from the atmosphere, and 321 tons after 60 years. After 110 years, one hectare of oak forest has permanently bound nearly 490 tons of CO₂.

The forest as a CO₂ sink functions only under ideal parameters for the ecosystem and corresponding, sustainable management of the forest. The Chair of Forest Yield Science at the Technical University of Munich is investigating the growth pattern with various plant densities at the Audi-funded trial site and the effects on the flora and fauna associated with the oak. A portion of the young oaks were therefore planted in two large circles, each having 14 concentric rings of different radii so that the individual trees have growth spaces ranging from 0.1 to 200 square meters. Continuous evaluation in the years and decades ahead will provide valuable data for forest yield research. This will allow more precise conclusions in the future on the relationship between productivity and capacities for carbon sequestration, and the protection of biological diversity, which can be used for the sustainable management of forest ecosystems.



The researchers – in the name of sustainability

The Chair of Forest Yield Science at the Technical University of Munich has partnered with Audi to support the science project in Kösching Forest. Under the direction of Professor Dr. Dr. h.c. Hans Pretzsch and based in Freising-Weihenstephan, the chair conducts research into the ecosystemic relationships of forest growth, which is the foundation for modern, resource-friendly and sustainable management of forests.

Sustainability, a much-discussed term whose original meaning has since been distorted, is old hat and deeply familiar to Professor Pretzsch. After all, the term “sustainability” was coined by one of his scientific ancestors in the early 18th century: In 1713, Hans Carl Carlowitz published his work *Sylvicultura oeconomica – Anweisung zur wilden Baumzucht*, in which he called for the protection and planting of forests in such a way as to ...”achieve continuous, lasting and sustainable use...”. Carlowitz was a mine administrator in the court of Kursachsen in Freiberg, Saxony, and was responsible for supplying the mining industry with wood. Due to the destruction of forests during the 30 Years War and disregard of the forestry regulations established in the Middle Ages, there was a shortage of wood during this time. He presented corrective actions and concepts for the sustainable management wood as a resource in his book.

Today sustainability in forestry no longer applies just to the supply of wood as a raw material. The principle has been expanded to include a whole series of ecological, economic and social effects and services, including biological diversity, the recovery function, and the climate protection function of the forest. Professor Pretzsch and his employees collect data on forest growth and the condition of the forest from numerous trial sites. Many of these sites were planted over 130 years ago and have been cared for ever since by generations of forest researchers. The wealth of data in a wide variety of areas related to the forest serves to improve computer models and simulations used for the almost time-lapse visualization of different handling variants and the computation of scenarios – such as how mixing two species of trees can diffuse the risk of damage and increase yield, or how an extension



of the vegetation period as a consequence of climate change increases the growth rate in some regions and reduces it in others.

Professor Pretzsch considers the Audi-funded research project and the trial sites in Kösching Forest to be a valuable contribution to sustainability research. “The support that Audi is providing here is unleashing a significant compounding effect, and not just for forestry management.”

The oak – the tree of trees and its mystique

Homo sapiens set out to conquer the entire world roughly 160,000 years ago, and everywhere they went, the oak was already there. The oldest fossil finds of the tree date back 12 million years. The oak genus now includes roughly 600 different species. The oak is found all over the world, has adapted to a wide range of conditions, and for people from a wide variety of cultures is the tree of trees, about which numerous myths have arisen.

“Someone who spends his life surrounded by tall, stately oaks would become a different person than someone who spends each day under airy birches,” Goethe once mused about the endearing nature of the oaks. Since antiquity the oak has maintained its firm place in the mythology and symbolism of mankind like no other plant.

The ancient Greeks and Romans revered their oaks, but it was not our German oaks that the ancient poets had in mind when they spoke of oaks. The oak that the Greeks dedicated to Zeus and the Romans to Jupiter bears the name *Quercus esculus*, also known as the Italian Oak. The decisive difference between it and the German Pedunculate Oak is that unlike our acorns, the fruit of the Italian Oak is edible for humans and a high-yield, carbohydrate-rich source of nutrients. The oak was therefore Antiquity’s ultimate symbol for vitality and nourishing fertility.

This is also why Zeus, also known as Phegonaeus, the nourishing father, was honored at the famous oak grove of Dodona, which in its day was also very well known for its oracle. If you asked the Father of the Gods for advice under a holy oak and he heard the person’s plea, there would be a powerful rustling in the divine crown of the tree – even if the winds were still.



The ancient Greeks believed that Zeus in physical form lived in the mighty crowns of the oaks.

They had more proof, too: They noticed that the oak tree was frequently struck by lightning bolts. It was unclear, however, whether Zeus, the Master of Lightning, threw them down from heaven to the oak, or from the oak up to heaven. This also explains the origin of the questionable proverb that says to avoid oaks and seek out beech trees in case of a thunderstorm. To avoid being struck down by lightning at the hands of Zeus, the Greeks regularly brought offerings of incense to him and decorated his images and altars with wreaths of oak leaves. This same honor was bestowed upon Hercules, and the oak has been the symbol of strength and bravery ever since. To this day, medals and medallions awarded for exceptional bravery to this day are entwined in oak leaves in recognition of this.

St. Boniface also needed a certain amount of bravery when, in the year 723, he took an axe to a sacred Germanic symbol – an oak dedicated to Donar, the god of thunder, in the Hessian town of Fritzlar. The Germanic people believed this mighty oak tree to be the central support for the firmament. Contrary to expectations, the heavens did not fall on their heads and they then willingly agreed to convert to Christianity. This marked the end of the oak as the most important Germanic sacred object. Legends about Charlemagne and the Christianization of the recalcitrant Saxons include similar elements, and Saint Patrick was also supposed to have driven the religious adoration of the oak out of the Celts, much to the displeasure of the Druids.

This was not one hundred percent successful with the Germanic tribes: The oak remained the Germans' most popular tree up into the modern era. Its symbolism has even been immortalized on our coins. And with its deeply rooted down-to-earthness, the mighty oak remains a symbol of fertile Mother Nature. The oak is synonymous with solidity, trustworthiness, and reliability. And nobody who was allowed himself to linger beneath the crown of a mighty oak can ever completely escape its special magic.



Facts on the topic:

CO₂

CO₂ stands for carbon dioxide. The colorless and odorless gas is a natural component of air. We humans and other life forms produce the lion's share of CO₂ by our cellular respiration. Another significant portion comes for the complete combustion of raw materials containing carbon.

CO₂ emissions

According to the German Institute for Economic Research, roughly 68 percent of all CO₂ emissions in Germany can be attributed to industry and power plants. Automobile traffic accounts for roughly 12 percent. Between 1990 and 2005, the German automobile industry was already able to reduce the CO₂ emissions of its vehicle range by 25 percent. The EU has now targeted a limit of 130 g/km (*209.21 g/mile*) by the year 2012 to further reduce CO₂ emissions.

CO₂ and the greenhouse effect

The reduction of CO₂ emissions is part of the current discussion on climate protection. The reason: CO₂, like all greenhouse gases, reflects the longwave terrestrial radiation and returns this to the Earth. On the one hand, this effect is essential to survival as it is only thanks to the greenhouse gases that the Earth's average temperature is tolerably warm and human life is even possible. However, the burning of fossil, carbon-based raw materials burdens the natural carbon dioxide cycle of the atmosphere with additional CO₂. The greenhouse effect is amplified, and this contributes to the warming of the Earth's atmosphere with in part still unforeseen consequences.

The forest as a CO₂ sink

The forest ecosystem removes CO₂ from the atmosphere and sequesters the carbon it contains, primarily in the biomass of the trees. However, large quantities are also bound to humus and sequestered in the soil. During the growth phase of the forest, the biomass and the amount of humus increases, resulting in increased sequestration of carbon. This process removes more CO₂ from the atmosphere than the entire ecosystem adds to it. The forest becomes a CO₂ sink during this growth phase. The natural CO₂ cycle of the forest closes with the termination of the growth phase, when trees die off



and the carbon bound in the biomass is released as it rots and decomposes. This process and the metabolism of all the organisms involved in decomposition returns a portion of the carbon, bound with oxygen, to the atmosphere in the form of CO₂. Dying trees thus become a source of CO₂. The sequestration and release of CO₂ are in equilibrium in the undisturbed, balanced life cycles of the tropical virgin forests. In contrast, the CO₂ sink function predominates for many decades in the relatively slow-growing European deciduous and conifer cultures, with the oak and its large carbon storage capacity playing a major role.

The Pedunculate Oak

36,000 Pedunculate Oaks were planted as part of the research project in Kösching Forest. The botanical name for the Pedunculate Oak is *Quercus robur*. It belongs to the genus of oaks in the beech family (*Fagaceae*). The tree, which is also known as the German Oak, is found almost throughout Europe, ranging from southern Scandinavia to the British Isles to northern Spain and from the Baltic countries, the Eastern European states and southern Russia to Greece. The Pedunculate Oak prefers deep, nutrient-rich loamy soils and clays, but also does well in other soils. Depending on the location, it can grow to be 40 meters tall with a trunk diameter of three meters. Life expectancy ranges between 500 and 1,000 years, with a maximum age of up to 1,400 years in exceptional cases. The acorns, the fruit of the Pedunculate Oak, hang in their husks on stems up to 4 cm long from which the Pedunculate Oak gets its name.

Oak as a biotope

From the roots to the crown, the oak is a habitat for thousands of animals, plants and organisms. The large number of species – biodiversity – is indicative of the long evolutionary history and age of the genus. 400 species of butterfly alone are either directly or indirectly dependent on the oak. Added to this are 28 species of birds such as the Eurasian Jay, numerous mammals such as the squirrel, and hundreds of beetles and other winged and wingless insects. Countless mosses and lichen are associated with the oak, as are a number of fungi that share a symbiotic coexistence with the oak.



Environmental protection at Audi – the strategy

The Environmental Policy of AUDI AG follows a holistic strategy. The aim is for cars and their production to pollute the environment as little as possible. Realizing this strategy requires systematic action according to the provisions defined in the environmental principles of AUDI AG.

Preamble

AUDI AG develops, produces, and sells cars worldwide. It is responsible for continuously improving the environmental compatibility of the products and production sites and for the ecological use of natural resources. It therefore considers the development stages of advanced technologies under aspects of both ecology and economy. AUDI AG makes these technologies available worldwide and enables their use along the entire process chain. AUDI AG is a partner with society and politics at all of its sites, thus making a sustainable contribution to social and ecologically favorable development.

Principles of the Environmental Policy

1. AUDI AG offers high-quality cars that meet in equal measure the demands of its customers with respect to environmental compatibility, economy, safety, quality, and comfort.
2. Research and development are an integral component of the Audi Environmental Policy. AUDI AG develops ecologically efficient processes and concepts for its products, thus enhancing its international competitiveness.
3. It is the stated aim of AUDI AG to take anticipatory measures in all its activities to prevent harmful effects on the environment. Compliance with environmental regulations is a matter of course.
4. Environmental management at AUDI AG ensures that, in collaboration with vendors, service providers, trade partners, and recycling companies, the environmental compatibility of the automobiles and production sites is continuously improved.



5. The Board of Management of AUDI AG is responsible for compliance with the Environmental Policy and the viability of the environmental management system. The Environmental Policy is reviewed regularly with respect to its suitability and appropriateness for the intended purpose, and is updated as necessary.
6. The open and clear dialogue with customers, dealers, and the public is a matter of course for AUDI AG. There is a trusting relationship with the government and the authorities. This includes emergency planning and response at the individual production sites.
7. All AUDI AG employees are briefed, trained, and motivated with regard to environmental protection as appropriate for their function so as to foster their sense of responsibility for the environment. They are bound to these principles.
8. This Environmental Policy is binding for all AUDI AG sites, and is supplemented and/or more precisely specified through the formulation of site-specific primary action areas.

Product environmental principles

The continuous improvement of our products with respect to environmental compatibility and the conservation of resources is an integral component of our corporate policy so that we may live up to our responsibility to our customers, society and the environment. The prudent handling of the ecological challenges determines our actions and all processes.

From this the following objective areas are derived:

Climate protection

- Reduce greenhouse gas emissions
- Reduce fuel consumption in the test cycle and in real-world driving
- Support fuel-efficient driving styles



Resource conservation

- Improve resource efficiency
- Achieve the best possible recyclability, taking into consideration innovative recycling technologies
- Use renewable raw materials and recycled materials
- Develop and provide alternative drive technologies
- Enable the use of alternative fuels and other energy storage systems, taking into consideration regional conditions

Health protection

- Reduce limited and non-limited emissions
- Avoid the use of dangerous and hazardous substances – pursuant to the world’s most stringent materials legislation whenever possible
- Minimize cabin emissions, including odor
- Reduce exterior and interior noise values

AUDI AG develops each vehicle model to have better overall environmental properties than its predecessor. We ensure that improvements are achieved over the entire life cycle. The company accepts the challenges posed by the changes to mobility and the environment as a result of increasing urbanization. The environmental objective areas serve as characteristics differentiating us from our competitors to the benefit of our customers. Audi strives to be “best in class” on environmental matters.

Audi follows a systematic strategy to further reduce consumption and emissions. By 2012, Audi will reduce the CO₂ value of its models by roughly an additional 20 percent relative to the value for 2007. Taking into consideration current planning with respect to the number of vehicle units through 2015, site-specific and company-specific CO₂ emissions at Audi will be reduced by 30 percent relative to the 1990 value by the year 2020. AUDI AG is doing this as a contribution to sustainable growth and environmental protection.



Environmental management and production

Sustainable business practices are an integral component of the Audi corporate strategy, in which environmental protection and innovation are linked. With its pioneering technical innovations, Audi is helping to drive advancements in environmental protection and bears the European Union's seal for outstanding environmental protection. The Audi Group is considered both in Germany and abroad to be one of the pioneers of site-specific environmental protection.

EMAS II (Eco Management and Audit Scheme), the demanding environmental management system of the European Union that far exceeds standard requirements, was installed at the Ingolstadt (1997), Neckarsulm (1995), Győr (1999), and Brussels (2002) sites, and also at the Lamborghini site in Sant'Agata Bolognese (2009), and has been steadily optimized in the interest of continuous improvement. The Ingolstadt, Győr, and Sant'Agata Bolognese sites are also certified to the global standard DIN EN ISO 14001. This ensures the continuous improvement of environmental protection performance at the sites. The annual certification of the environmental management system documents this outstanding approach.

Employee involvement plays a major role at Audi. As the basis for a synchronous company oriented on the creation of value, the Audi Production System (APS) is a fundamental component of the Audi production strategy. This work organization concept creates transparency and interconnectedness in all areas of the company.

The methods module Environmental Protection is an important component of the Audi Production System. Active environmental protection is fostered by sensitizing each employee to those issues that he or she can influence directly on site. For example, employees are motivated to conserve water or given instructions on how they can reduce energy consumption, be it by minimizing compressed air leaks, an optimized plant operating mode, or simply by turning off unneeded lights. APS reminds the employees to ensure that internal environmental protection standards are adhered to during plant and process modifications, and to comply with the legal requirements.



Integrated Product Policy (IPP)

Efficient environmental protection must incorporate the entire life cycle of the product, as the use of raw materials, energy consumption and emissions are dependent on how a product is developed, produced, used, and disposed of. To further reduce environmental burdens, Audi follows an Integrated Product Policy (IPP). Under the IPP, the downstream effects of the product, i.e., the effects throughout the entire life cycle – from material procurement to disposal – are already studied as part of the development process. Audi has subscribed to this integrated product planning, which incorporates all environmental aspects from the very beginning, for many years now and has achieved significant environmental benefits as a result. As a party to the 3rd Bavarian Environment Pact, Audi participates in the IPP working forum. The forum placed an order for the development of an IPP training concept for Bavarian companies, which has already been tested in a workshop conducted by Audi. The training concept is aimed primarily at small and medium-sized businesses in the supplier industry. This is one way that Audi is helping to make the lessons learned in the area of IPP accessible to small and medium-sized businesses also.



Environmental protection at Audi – energy efficiency and CO₂ reduction for products and production

Efficiency technologies in products

Audi systematically uses the technologies of its modular efficiency platform to reduce the CO₂ emissions of its products. The engineers at Audi look at the car as a complete energy system and optimize the efficiency of all components and systems – with success. Worldwide, Audi offers 33 models whose CO₂ value is below 140 grams (*225.31 g/mile*), placing Audi in a leading position among the premium manufacturers. Fleet CO₂ emissions will be reduced by an additional 20 percent by 2012 to a combined average of less than 140 grams. Next year, the new Audi A3 1.6 TDI will set the record: It will crack the 100 gram per kilometer mark (*160.93 g/mile*), with CO₂ emissions of only 99 g/km (*159.33 g/mile*), corresponding to a fuel consumption of just 3.8 liters of diesel fuel per 100 km (*61.9 US mpg*).

Engines

Audi engineers are working on several subject areas on the engine sector, and are the global leaders with the TFSI and TDI engines. One of these subjects areas is mixture preparation, for example. In the TDI engines, the common rail systems work at an injection pressure of 2,000 bar, which allows combustion to be managed extremely precisely and efficiently. The Audi valvelift system is used in many gasoline engines to optimize gas exchange. In the normally aspirated V6 engines, it varies the stroke of the intake valves; in the turbocharged 2.0 TFSI, it affects the exhaust valves. Audi also had its eye on another objective during each step in the engine development process – lower emissions. In the TDI clean diesel, the ultra low emission system drastically reduces nitrogen oxides in the exhaust, making it the world's cleanest diesel.

Energy management

Energy management is another important efficiency area. The climate control system for the Audi A4, A5, and Q5 model series combines high performance with particularly low energy consumption. Another technology has found its



way into series production in a number of models – a recuperation system for the recovery of electrical energy during the braking and coasting phases. Intelligent thermal management ensures that the engine reaches its operating temperature more quickly. There are also many more attractive solutions for the near future in this area. Many Audi models are already equipped with optional daytime running lights comprising high-efficiency LEDs to reduce fuel consumption while simultaneously enhancing safety.

Transmission

The reduction of internal friction is an important topic when it comes to power transmission. Audi has devoted tremendous effort to optimizing the manual transmission. The six-speed tiptronic and stepless multitronic transmissions have also benefited from a number of detailed improvements for increased efficiency, and they are widely spaced to foster a low-rev driving style. The new seven-speed S tronic shares this same strength. This new dual-clutch transmission takes advantage of the strong pulling power of Audi's engines and a particularly long final gear ratio to lower both engine speed and fuel consumption. A number of models already come equipped with a start-stop system that switches off the engine when the car is stopped. We will soon be launching another efficiency technology – heating the transmission improves efficiency immediately after a cold start.

Driving resistances

The areas of body and tires harbor significant potential for reducing driving resistances. Tires with a low rolling resistance play a major role here. Sophisticated refinements to the aerodynamics, such as a fully enclosed underbody in the Audi A4, A5, and Q5 model lines, improves the flow of air around the vehicle. The car bodies have been put on a strict diet. The Audi TT, A8, and R8 have a body built largely or entirely of aluminum according to the principles of the Audi Space Frame. Reduced fuel consumption is a direct consequence of the savings in weight.



Auxiliary systems

The modular efficiency platform includes a separate area of action for the auxiliary systems for the steering and the engines. In the Audi A3 and TT, steering boost is provided electromechanically, and only when it is needed. On board the Audi A4, A5, and Q5 is an innovative hydraulic power steering pump that also is active only when needed. The same applies to the new oil pump that provides for lubrication in a number of engines. The Audi engineers used sophisticated methods to rework the cylinder barrels and dramatically reduce internal friction in a number of engines. This enabled a significant reduction in the tension forces of the cylinder rings and thus the friction with the cylinder barrels.

Assistance systems

The assistance systems from Audi address the most important factor for reducing fuel consumption: the driver. The latest version of the navigation system offers the driver a wide variety of assistance functions, such as dynamic routing and an economical route profile. The new onboard computer with efficiency program monitors energy flows in the car, gives practical tips for saving fuel, and integrates a redesigned gear-change indicator. In the large model series with the adaptive air suspension, the body is automatically lowered several millimeters at high speeds. This improves air resistance and thus saves fuel. Audi pays attention to every single detail: A clever function switches off the heating unit for the front passenger seat if it is unoccupied – yet another example of the systematic efforts that Audi makes to reduce fuel consumption.



Efficient, resource-friendly production

Reducing the energy consumption and thus lowering CO₂ emissions even during the assembly of the vehicle plays a central role in the environmental activities of AUDI AG. Climate protection and carbon dioxide emissions have long been among the leading environmental protection topics.

The search for new and improved processes in this area is a constant one, leading to new projects such as increasing the amount of district heat procured or the use of pioneering renewable energies such as photovoltaics. Taking the planned expansion of capacity into account, AUDI AG has stated the goal of reducing site-specific and company-specific CO₂ emissions by 30 percent relative to 1990 by the year 2020. It is therefore very important to continuously improve the energy efficiency of the production facilities. Overall energy consumption at the Audi Group has held steady for several years now, despite significantly increased vehicle production. An entire package of targeted projects has made this possible. Energy-savings measures are considered during the planning phase for assembly plants and buildings, for infrastructure and for logistics concerns.

Trigeneration (power-heat-cooling) and waste heat utilization

To optimize energy efficiency, Audi operates a power-heat-cooling trigeneration plant in Ingolstadt. The very efficient energy utilization of the natural gas fuel enables the plant to achieve an efficiency of up to 78 percent. This reduces CO₂ emissions by roughly 25 percent or 17,200 tons versus conventional power generation. In addition to its trigeneration plant, Audi procures most of the heat it needs from two, largely gas-fired heating plants owned by the company. And the consumption of natural gas will be reduced even further in the future. Ingolstadt's waste utilization plant began supplying waste heat to the Audi plant at the start of 2004. In 2008, Audi procured approximately 90,300 MWh of district heat from this source, saving the emission of 17,878 tons of CO₂ at the site. A new district heating contract between Audi, the City of Ingolstadt, and the Petroplus refinery establishing the Ingolstadt Energy Alliance for the Protection of the Climate was signed in September 2009.



The ecological benefits of using waste heat that would otherwise be lost are obvious. The contract calls for the amount of district heat provided by Stadtwerke Ingolstadt to increase to roughly 120,000 MWh per year in 2011. An additional increase to 200,000 MWh is planned, which would enable Audi to meet a large portion of its total demand of 410,000 MWh per year with waste heat. This would enable the Audi plant in Ingolstadt to significantly reduce the amount of heat generated in its gas boilers and thus save up to 45,000 tons of CO₂ each year.

Photovoltaics

The generation of electricity from solar energy using large-area photovoltaic systems on the roofs at the Ingolstadt and Neckarsulm sites is another pioneering project by AUDI AG.

Audi is making nearly 50,000 square meters of roof space available to a solar energy investor under the proviso that a variety of different, modern and innovative photovoltaic modules are used. A particular aim is to promote thin-film technology, whose production is much less energy-intensive than the production of conventional photovoltaic modules with monocrystalline and polycrystalline cells. This technology is also characterized by very high efficiency even under very diffuse lighting conditions. The electricity produced will be fed into the public power grid and the feed-in compensation paid to the investors who hold shares in the project. The wide-area use of the innovative, thin-film modules that require less energy to produce will drive the further development of this environment-friendly technology.

Heat recovery

Heat recovery is a central element of the HVAC systems. Several hundred heat recovery systems are in operation on the grounds of the Ingolstadt plant. One particularly effective type of heat recovery system is the thermal wheel. The use of 19 heat recovery systems at the Audi paint shop extracts approximately 35,000 MWh per year, or the annual heating requirement of roughly 3,270 single-family homes. Expressed as CO₂ this corresponds to an annual emissions savings of around 7,000 tons.



Efficient joining processes

Audi uses innovative and efficient joining processes to assemble bodies, including spot welding, laser welding and adhesive bonding. The respective welding technology is matched to the individual joining process so that the most efficient solution for the respective process can be selected. Electric motor-driven welding tongs have gradually replaced the pneumatic welding tongs in recent years. Energy consumption and thus CO₂ emissions are reduced by roughly 50 percent compared to pneumatic welding tongs used the exact same way. Based on the positive experience gleaned with the advanced technology, it will now be considered for all new projects at the Audi Group.

Efficient logistics

Roughly 60 percent of all automobiles leave Audi plants on freight trains. Audi and its suppliers work according to the principle of “short path logistics.” The Logistics Center (GVZ), which houses numerous suppliers, was established in Ingolstadt in 1995. Suppliers fabricate their assemblies in new fabrication centers and supply them to the plant “just in sequence.” The Logistics Center at the Ingolstadt site ensures just-in-time delivery via the shortest paths. More than 100 suppliers are based in the region, with 17 working at the Logistics Center. This close cooperation not only cuts logistics costs, it also reduces environmental pollution thanks to the short transport distances. To further improve the logistics, Audi collaborated with the renowned Fraunhofer Institute for Algorithms and Scientific Computing (SCAI) to develop the PACKAssistant. This computer system optimizes the utilization of load volume to reduce the number of truck trips required.

Shuttle bus service and bicycle sharing

Shuttle bus service was established at the Ingolstadt plant to reduce the number of parking spaces, improve traffic safety, cut costs and reduce pollution. The service saves an estimated 200,000 car trips on the plant grounds each year. In some areas, a bicycle sharing system was established, likewise in the interest of reducing motor traffic on the plant grounds. Employees needing a bicycle can reserve one on their PCs.