

High-speed hybrid. This Mercedes sports coupé test car offers fuel savings of more than 25 percent without sacrificing driving performance. The vehicle goes from zero to 100 km/h in under seven seconds.



Lowering Emissions

Automakers and governments want to get pollutants off the road. Solutions from Siemens are helping by making combustion engines cleaner and improving hybrid cars — the forerunners of fully electric vehicles. Siemens engineers are also developing technologies to make trains and ships run cleaner.

Air quality is extremely important — but it's being endangered by gases like carbon monoxide and nitrogen oxides, which can cause respiratory problems such as asthma and bronchitis. Some 60 percent of these harmful gases are produced by motor vehicles — reason enough for European legislators to take action by further toughening the Euro 4 emission standard. In September 2009 the Euro 5 standard will go into effect for new cars, requiring automakers to lower emissions of hydrocarbons and nitrogen oxides from the current level of 300 milligrams per kilometer driven to 230 mg/km. This will be followed in 2014 by Euro 6, which will require a further 27 percent reduction in emissions, to 170 mg/km.

Motor vehicles also play a key role in emissions of the greenhouse gas carbon dioxide. One-fifth of all CO₂ emissions come from motor vehicles, whose number worldwide could increase to more than two billion by 2030. The EU Commission has therefore decided to limit the CO₂ emissions of new vehicles sold in Europe to 120 grams per kilometer by 2012 (about 25 percent lower than current levels). By improving automobile technology, automakers are supposed to achieve 130 grams of CO₂ per kilometer. Other measures such as the

admixture of biofuels should bring a further 10 g / km reduction. A similar reduction around 20 percent is being targeted by countries such as the U.S. The final result of the process could be zero-emission vehicles, a goal companies like Siemens are already working on.

From Hybrids to Electrics. Siemens VDO (SV) recently presented a forward-looking project in the form of a demonstration vehicle with a hybrid drive system. Experts from VDO in Regensburg combined the combustion engine in a Mercedes C 230 K sports coupé with an electric drive unit (see *Pictures of the Future*, Spring 2006, p. 41). The engine and the electric motor, which have roughly the same output, are operated via an integrated powertrain management system that either links them or runs them separately, depending on the driving situation. Switchovers between the two are hardly noticeable.

Equipped with a lithium-ion battery, the electric motor has an output of some 75 kilowatts, which accelerates the vehicle from zero to 100 km/h in just under seven seconds. Developers had to make extensive adjustments to the engine and transmission management systems to combine the two drives via an electronically controlled clutch. The electric motor's

high output is made possible by adding a traction network that operates with 380 volts of electricity to the 14-volt onboard network.

The developers were quite successful. Measurements show that this full hybrid concept reduces fuel consumption by more than 25 percent as compared to a conventional drive system, and also produces correspondingly lower emissions. The high demand for hybrids in the U.S. and Japan demonstrates that such vehicles have a bright future. Around 90 percent of all full hybrid vehicles are sold in those markets, which is one of the reasons why SV acquired the Electric Drives division of Ballard Power Systems in Dearborn, Michigan, at the end of 2006. Siemens plans to transform the division into a development center for power electronics, motor design and electric drive systems for hybrid and fuel cell vehicles.

However, hybrids are viewed as only an interim solution on the road to the drive system of the future, as Dr. Klaus Egger, member of the SV Managing Board, explains: "We believe the electric motor is the long-term drive-system solution that will meet the most stringent emission limits." The Siemens hub motor concept would actually have four electric motors powering the cars of the future — one inside each

wheel. This system converts up to 96 percent of generated electrical energy into power to propel the vehicle, which makes it very efficient. By comparison, full hybrids will use around 85 percent of available energy under optimal conditions, while combustion engines like gasoline and diesel engines convert at most only around 50 percent of the energy in their fuels.

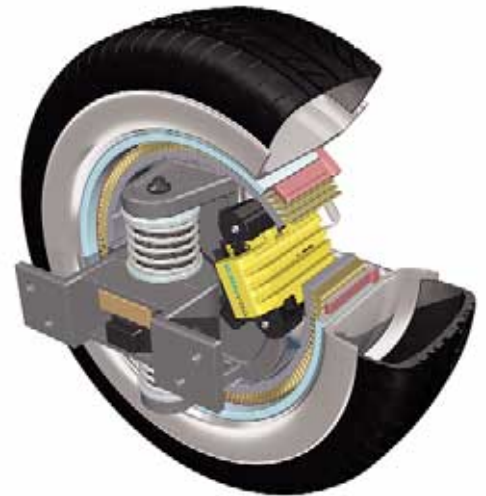
In summer 2006, SV engineers launched a development they named the eCorner Module. This new drive system concept, which uses electrical and electronic systems exclusively, integrates not only the electric motor directly inside the wheels but also the steering, damping and braking systems. This frees up space beneath

the hood and eliminates the need for many attached parts in the steering column, brakes and transmission. It thus opens up nearly limitless possibilities for automotive design. The first step on the path to the hub motor will be the electronic wedge brake that is expected to go into mass production at the end of 2010 (see *Pictures of the Future*, Fall 2005, p. 41). Pure drive-by-wire vehicles, in which mechanical parts are replaced by electronic systems, won't be ready for mass production until 2022 at the earliest.

Achieving Optimal Fuel Combustion. In the near future, automotive experts will also further optimize conventional combustion engines in



Thanks to several fuel injections per power stroke, Piezo technology lowers fuel consumption by up to 20%.



Drive system of the future. The eCorner Module (above) puts an electric motor inside every wheel.

terms of output, fuel economy and emissions. The goal is to achieve optimal fuel combustion through electronically controlled injection systems. High-speed piezo technology invented by Siemens enables injection valves to inject fuel into the engine cylinder in up to four differently sized portions within just one power stroke (see *Pictures of the Future*, Fall 2005, p. 102).

SV launched mass production of piezo direct injection systems for diesel engines in 2000, and for gasoline engines in 2006. Very fine fuel atomization and multiple injections now make the combustion of air-fuel mixtures more efficient than ever before. Gasoline engines with piezo systems consume up to 20 percent less fuel than those with intake manifold injection. To improve energy management, researchers at Siemens Corporate Technology are developing learning systems capable of further reducing fuel consumption.

These measures will also reduce nitrogen oxide and carbon particulate emissions from the engine, which in turn will reduce the bur-

Recycling energy. A new subway train in Oslo (left) reintroduces braking energy into the power grid. Exhaust gases from the Gudrun Maersk (right) generate up to seven megawatts of electricity.



den on downstream exhaust gas treatment systems. "We'll still need catalytic converters and filters in the future, though," says Wolfgang Maus, managing director of filter manufacturer Emitec, a joint venture of Siemens and British automotive supplier GKN. That's because of the nanometer-sized particulates in the exhaust, which are a health hazard. These diesel particulates can be removed with a filter from Emitec, which is installed behind a conventional oxidation catalytic converter and works as follows: The exhaust gas stream is sent through a metal fleece, where the nitrogen dioxide in the gas releases an oxygen atom that converts the carbon in the particulates into carbon monoxide. This

Cars today are already equipped with sensors (e.g. in ABS and ESP systems) that register when the vehicle skids or brakes abruptly. In the future, sensors could send this information to vehicles behind them, enabling drivers to react in time. Such a communication system could be implemented via a spontaneously generated radio network using broadband WLAN technology (see also page 38). "We want to make such ad hoc networks more stable and secure," says Dr. Christian Schwingenschlögl from Siemens Corporate Technology in Munich. Because these WLAN networks have a transmission range of only 200 to 300 meters, the cars within range must process the data they

cent of its material has to be disposed of, while the remainder can be recycled.

Black Sheep on the High Seas. Maritime shipping is a black sheep when it comes to air pollution. According to the World Health Organization, emissions of pollutants such as sulfur dioxide and nitrogen oxides generated by shipping will exceed those from all other sources in the transport sector by 2020 if no countermeasures are taken. Maritime shipping is already the largest single source of sulfur dioxide emissions in Europe, according to the European Commission. For this reason, the EU established limits in 2005 in order to reduce sulfur dioxide emissions in the North Sea, Baltic Sea and English Channel by over 500,000 tons per year. Emission levels remain high nevertheless. For example, the new sulfur limit for ship diesel is 15,000 ppm (parts per million), while the new limit for motor vehicle gasoline that went into effect in 2007 is only 10 ppm.

Whether in cars, trains or ships — new technologies will significantly reduce emissions in the future.

then burns together with additional oxygen to form carbon dioxide. In this manner the filter eliminates around 80 percent of the particulates measuring less than 100 nanometers in diameter.

WLAN on the highway. Emissions from motor vehicles can also be lowered by preventing situations like traffic jams, which needlessly release exhaust gases into the atmosphere. "We can't do much about traffic density, but we can prevent traffic from coming to a stop due to jams and accidents," says Dr. Abdelkarim Belhoula, a developer at SV in Wetzlar. For example, vehicles that warn each other in a timely manner about ice, rain and traffic congestion could help prevent rear-end collisions and jams. Automakers and suppliers therefore established a Car-to-Car Communication Consortium in 2004 to define standards for communication between vehicles.

receive within seconds. "That's why we're also optimizing the software so as to accelerate the establishment of the connection and the vehicle systems' reaction time," he adds. The WLAN standard is expected to be ready for use in 2008.

Siemens developers don't only want to make road traffic more environmentally friendly; they also believe there's potential to reduce energy consumption in rail systems. To this end, Walter Struckl from Siemens Transportation Systems in Vienna worked together with three colleagues to reduce energy consumption by approximately 30 percent on a new subway train in Oslo, Norway. For this achievement, they received the Siemens Environmental Award (see p. 102). The new train reintroduces back into the power grid the energy generated by braking when it enters subway stations. The rail car bodies are made of lightweight aluminum. Moreover, when the train is taken out of service, only some five per-

Kay Tigges, a marine specialist at Siemens Industrial Solutions and Services in Hamburg, believes that energy conservation is the best way to reuse ship emissions. To this end, I&S has developed a system in which the gas emissions from ships previously released through smokestacks are used to create steam that drives a turbine. The resulting electrical output of up to seven megawatts is used for onboard electronic systems. This waste heat recovery system was first installed in the Danish container ship *Gudrun Maersk* in 2005. It has proved to be effective. The conventional diesel-operated onboard generators are now used less often, thus reducing fuel consumption by up to 12 percent and lowering carbon and sulfur dioxide emissions as well. Last but not least, like all energy-saving systems, the waste heat recovery system ultimately also saves money, which encourages companies to invest in the new equipment and products. ■ Rolf Sterbak