

FACT SHEET XXL

IAA 2017

Mobility for tomorrow

SCHAEFFLER

Future now

Schaeffler presents itself at the 67th IAA as an innovative supplier with forward-thinking expertise



Electric future

How Schaeffler develops holistic solutions

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Sustainable mobility

The entire energy chain is crucial

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Editorial



Matthias Zink
CEO Automotive
Schaeffler AG

Welcome to the 67th IAA. We all know that electrified drive systems are going to decisively shape the future. For decades, Schaeffler has been one of the preferred technology partners of the automotive industry and embracing the challenges of the future with great

passion and many innovations.

As the world's leading mobility show, the IAA is an ideal stage for us to present our developments and ideas for "Mobility for tomorrow." Our commitment is not focused on isolated solutions but on a holistic concept that makes low-emission and zero-emission driving viable for the future. On the following pages, we have compiled the aspects which in our view are the most important ones in this context. We hope you'll enjoy browsing through our Fact Sheet and would of course be delighted to welcome you personally at our booth in Hall 5.1.

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Propulsion solution Schaeffler's
E-Axle for electrified powertrains

The International Motor Show (IAA) is the world's leading mobility show. Held for the first time in 1897, it most recently assembled more than 1,100 exhibitors in an area of 230,000 square meters. Over 930,000 visitors in 2015 were fascinated by the latest products and services. More than 11,000 journalists from 106 countries reported about the event that is held every two years.

**"Our focus is placed on
the forward-thinking field
of electric mobility"**

Klaus Rosenfeld
CEO Schaeffler AG

Future now

At the IAA 2017, Schaeffler (Hall 5.1, Stand A04) is showcasing technologies for low-emission and zero-emission driving of the future billed as "Mobility for tomorrow"

In 2017, the 67th International Motor Show is billed as "Future now." For Schaeffler, the leading German automotive trade show is one of the most important ones around the globe to present itself as an innovative supplier demonstrating forward-thinking expertise in central fields of technology. This year, Schaeffler's appearance in Frankfurt is focused on three major topics: environmentally friendly drive systems, electric mobility and the entire energy chain as the standard for evaluating propulsion concepts. The ideas from Herzogenaurach are a central element enabling mass production of environmentally friendly powertrains.

Electric drive systems as a focal topic

Schaeffler's holistic concept addressing the challenges of the future reflects the divers-

ity of applications. Technologies for low-emission and zero-emission driving encompass a wide variety of components because, just like in the past and present, there will not just be a single propulsion solution in the future either. Schaeffler has the appropriate concepts for all-electric and hybrid powertrains as well as those strictly using IC engines.

Electric propulsion will be an area of particular emphasis. In the future, Schaeffler will be pooling a products and system solutions for hybrid and battery-electric vehicles in a dedicated electric mobility business unit. This Fact Sheet IAA provides a detailed account of the innovations from Herzogenaurach that are going to help save energy in our everyday lives in the future. ■

Targeting **zero** emissions

Schaeffler makes a direct contribution to measurably reducing emissions of harmful substances and greenhouse gases

Schaeffler is showcasing the technologies for environmentally friendly drive systems at the 2017 IAA in Frankfurt. Innovative electric propulsion systems mean that electric mobility will be increasingly accepted in the future. At the same time, Schaeffler uses production-ready technologies to improve the overall environmental performance of IC engines.

Technologies already exist today

Putting environmentally friendly drive systems into production requires both creativity and high flexibility as regulations around the world vary. In the European Union, so called Real Driving Emissions (RDE) tests have been required since September 1, 2017. They no longer measure emissions on the test bench but in real-world road tests. In China on the other hand, regulations establishing quotas for zero-emission electric vehicles will soon be in effect.

From Schaeffler's perspective, the technologies to meet these requirements already exist today. The company anticipates a continual increase of electrified powertrains. A scenario forecasts a 30-percent share of fully electric vehicles for 2030. Another 30 percent would still only be using an IC engine and the other 40 percent a hybrid powertrain. "Even in this extreme scenario, more than two in three new vehicles would still have an IC engine on board," analyzes Prof. Peter Gutzmer, Schaeffler's Chief Technology Officer. "That's why we

have to do everything within our means to continue to reduce the emissions of IC engines."

Schaeffler presents premieres

Fellow Board member Prof. Peter Pleus, CEO Automotive, points out an approach to solve



Hot and cold The latest-generation thermal management module reduces emissions thanks to an optimized thermal management strategy



Environmentally friendly drive systems

Schaeffler is putting energy-efficient technologies for low-emission and zero-emission driving into production. The wide-ranging development expertise of Schaeffler's engineers makes important contributions to an efficient and clean mobility world of tomorrow, from electric to hybrid and through to IC engine powertrains.

1 Electric mobility

Schaeffler expects about 30% of all automobiles to be powered by electricity in 2030 and Schaeffler's products will help decisively shape electric mobility. For instance, the thermal management module (TMM) of the future will not only control the cooling circuits of the engine and the transmission but also those of electric traction systems. The electric axle for them is supplied by Schaeffler as well.

- a Thermal management module
- b Electric axle

2 Powertrains using IC engines

To further enhance the efficiency of IC engines, Schaeffler offers a range of production-ready products. From sophisticated thermal management significantly reducing the cold running phase to dynamic engine valve control through to cylinder deactivation – Schaeffler has the holistic know-how to make the design of the conventional powertrain as environmentally friendly as possible.

- a Electric camshaft adjuster
- b UniAir
- c Dual mass flywheel with pendulum absorber
- d Thermal management module

3 Hybridization

The electrification of the conventional powertrain offers significant savings potential. 48-volt systems with components from Schaeffler represent a particularly cost-efficient solution for driving with zero local emissions. In addition to hybrid modules and electric axles, electric clutch systems enabling new efficient and convenient functions can be integrated into existing vehicle architectures as well.

- a e-Clutch
- b PP2 hybrid module for 48-volt and high-voltage applications
- c Electric axle

**“Even in an extreme scenario,
more than two in three new vehicles will still have
an IC engine on board in the future”**

Prof. Peter Gutzmer
Chief Technology Officer

that problem: “Emissions can be reduced especially after a cold start. Cold oil in the engine and transmission increases friction, fuel consumption and thus harmful emissions. At the IAA, Schaeffler is presenting the second-generation thermal management module. It controls the cooling circuits of the engine, transmission and, if necessary, additional electric drive systems including the traction battery. The circuits can be shut off so that the units can warm up faster. Savings of up to three percent can even be demonstrated in the NEDC (New European Drive Cycle) measurement method.” On a short trip following a cold start in winter weather, this value increases once more.

“The valve train of an engine harbors further potential to limit consumption,” explains Prof. Pleus. Schaeffler is one of the world’s first

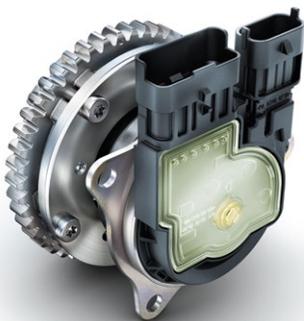
suppliers to have developed an electric camshaft adjuster. It is able to adjust the camshaft at a crankshaft angular velocity of 600 to 800 degrees per second. This exceeds the level achieved by the hydraulic systems conventionally used so far by a factor of two to ten. The advantage is that opening and closing times of the intake valves can be varied quickly this way and, as a result, the air flow into the cylinders be adjusted more effectively.

Systems that shut off the cylinders in low-load conditions reduce fuel consumption as well. Schaeffler has developed a hydraulic-switchable valve tappet to deactivate individual cylinders. In 2018, production of the first three-cylinder engine with such a system from Herzogenaurach will be launched. Innovative damper technologies by Schaeffler, i.e. a dual-mass flywheel

Comfortable economy Assisted by converter systems, including new integrated damper technology, automatic transmissions are role models in terms of efficiency. Schaeffler’s portfolio includes the innovative iTC converter



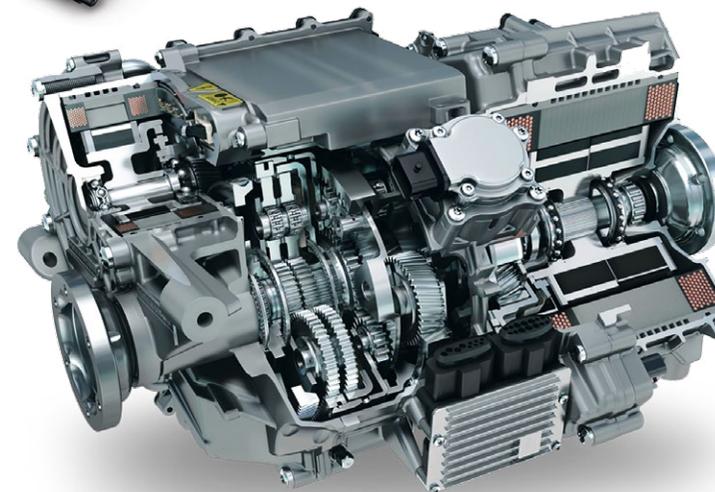
Quick adjuster Electric camshaft adjustment is far superior to hydraulic systems



Fully variable From phase adjusters to switchable tappets through to the fully variable valve control system UniAir (pictured) – Schaeffler offers a comprehensive modular kit for valve train variability



Modular e-mobility Schaeffler offers engineering design solutions for the various systems and arrangements. Pictured here is an electric drive unit with a disengagement clutch and transmission



Clever axle Schaeffler’s E-Axle marks a major milestone on the way toward electrified IC engine powertrains. It can be used in fully electric automobiles as well

with an integrated centrifugal pendulum-type absorber, are used to control NVH (noise, vibration, harshness) performance.

Solutions for various layouts

If a conventional powertrain is electrified by means of a 48-volt system, consumption can be reduced even further. Schaeffler offers solutions for different architectures – from belt-crankshaft driven versions to the integration into the engine-transmission unit and through to a separate axle drive. If the electric motor and the battery are designed to enable active coasting, the IC engine can even be shut off in these coasting phases.

A high-voltage hybrid module in a plug-in hybrid drive system even paves the way to locally emission-free driving across longer distances. Since 2010, Schaeffler has been supplying major components for such a system, now being followed by the next generation. The future hybrid module will be able to transfer torques of

up to 800 Nm. The power flow within the unit has been patented. In addition, the hybrid module can be combined with the converter of automatic transmissions allowing even car-trailer combinations with high mass to comfortably pull off from rest using electric power.

Schaeffler completes its portfolio with electric traction systems for axles or wheel-integrated units. Whereas the wheel hub motor is still in a pre-development stage, volume production of the electric axle is about to be launched in four different projects. ■

E-mobility

as a new business unit

Electrified powertrain architectures challenge automotive engineering. As early as at the end of the nineties, Schaeffler set the course for this age with hybrid products in the transmission environment

Schaeffler's new E-Mobility business unit pools engineering, products and system solutions for hybrid as well as fully battery-electric vehicles. "Proceeding from individual solutions, Schaeffler from an overall perspective on electrified powertrain topologies evolves into a company providing total system solu-

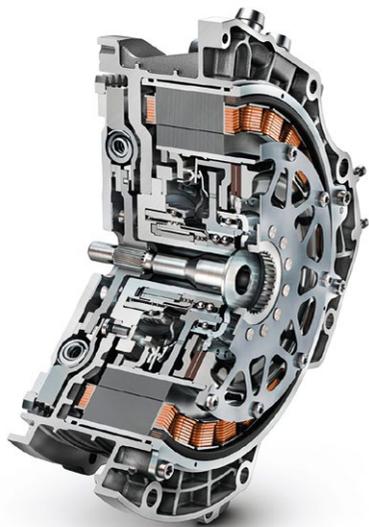
tions," says Matthias Zink, CEO Automotive at Schaeffler.

Schaeffler is already one of the preferred technology partners of the automotive industry today. Emission-reducing vehicle and powertrain concepts of the future depend on holistic system solutions of the kind already found in the company's portfolio today. The electric control side, the mechanical and the mechatronic elements are already available as components at Schaeffler but may be fully integrated as well.

Reducing consumption with an eye on cost

Around the globe, Schaeffler is working on various production orders for powerful high-voltage hybrid modules. 48-volt hybrid modules bridge the gap on the IC engine's road to an electric future. With their help automobiles can pull off and maneuver on electric power, maintain speed in urban traffic in fully electric mode and efficiently recuperate energy while braking. At affordable cost, this technology helps tap into significant savings potential and reduce consumption.

Individual hybrid powertrain configurations, as well as battery-electric vehicles without an IC engine, in turn depend on electric axles. Schaeffler offers a wide range of designs



Highly integrated The P2 hybrid module combines the electric motor with an automated disconnect clutch

Electrified powertrain architecture

Electric mobility as a whole – including fully electric and hybrid vehicles – will be defining mobility of the future. From high-voltage hybrid modules to electric axles and through to visionary wheel hub motors – Schaeffler offers an extensive product portfolio for the age of electrified powertrain architectures.

1 Hybrid module
Plug-in hybrids can also be operated in all-electric mode and thus with zero local emissions. Schaeffler offers relevant technologies such as the powerful hybrid module for 48-volt and high-voltage applications: systems which, thanks to perfect interaction between the electric motor, power electronics, the battery and a complementary IC engine ensure efficient forward-thinking locomotion.

a Power electronics
b P2 hybrid module

2 Wheel hub motor
Schaeffler with its "eWheelDrive" electric wheel hub motor offers an innovative technology for mobility of tomorrow. The highly integrated drive system enables all-new vehicle concepts as well. Advantages in terms of space utilization, maneuverability, driving dynamics and active safety predestine it as a future technology for automated driving.

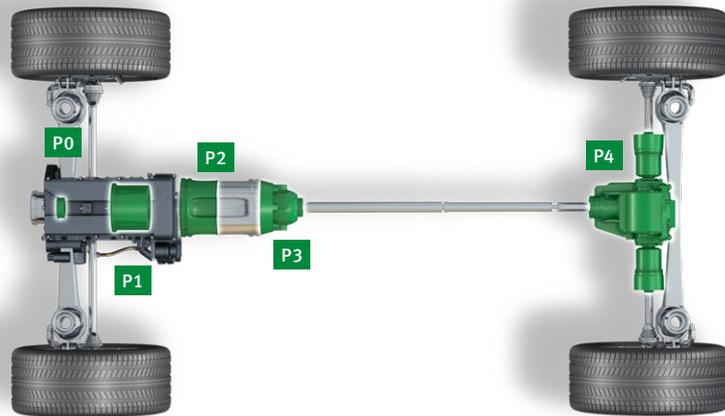
a eWheelDrive

3 E-Axle
With the electric axle Schaeffler has developed a modular kit solution for hybrid and all-electric vehicles. The fully electric drive system features a modular design for flexible use, either as coaxial or parallel-axis versions on the front and rear ends, and can be complemented by functions such as torque vectoring or a parking lock as needed.

a Battery
b Power electronics
c Electric axle
d Thermal management module



Installation options for hybrid systems



in this area. It starts with a single-speed ratio featuring either a coaxial – in other words around a common axis – or parallel-axis design. As the differential features a planetary design, the transmission is extremely compact and offers ample assembly space for the electric motor. The motor in turn can be supplied either as a permanently excited (PSM) or as an asynchronous motor (ASM) with or without power electronics. Other functional elements such as a parking lock complement the various design versions.

Some plug-in hybrid models require dynamic all-electric operation up to 120 km/h combined with high top speed. In the two-speed axle, Schaeffler offers its customers a system for torque vectoring as well. An additional transmission and an electric motor in the range of seven kilowatts allow torque to be systematically varied between the right and left driven wheel with a positive effect on lateral dynamics – in other words sporty cornering performance.

Perfectly coordinated interaction is a prerequisite for all the solutions to display their efficiency. In the case of hybrid automobiles, electric motors, power electronics, the traction battery and the IC engine have to be precisely attuned to each other. Schaeffler offers its customers decades of know-how relating to single

- P0** Belt-driven starter-generator for start-stop systems. Schaeffler offers belt tensioning systems and belt decouplers
- P1** Electric motor on the crankshaft. Schaeffler delivers integrated dampers and centrifugal pendulum absorbers
- P2** Installed position between the engine and transmission. Schaeffler produces complete modules, disconnect clutch systems, automated clutch systems, integrated dampers and centrifugal pendulum absorbers
- P3** Electric motor in the transmission or on the transmission output shaft. Schaeffler produces electric motors with a mechanical reducing gear
- P4** Electric axle. Schaeffler offers e-axes for 48-volt and high-voltage drive systems as well as subsystems such as mechanical transmissions and single components

components and total systems. The company based in Herzogenaurach is equally capable of executing the composition of the mechanical systems and the power electronics. The latter provide electrical energy precisely fitting the respective situation and application. Schaeffler cooperates with Semikron and thus expands its electronics expertise. Power electronics are optimized for every assembly space, efficiently convert electric energy, control its utilization and coordinate the total system.

Tailor-made for the customer

Sophisticated software is a key to success for all alternative forms of propulsion.

In the field of engineering, Schaeffler has the expert knowledge that is characteristic of a total system supplier of electric axles and electrified propulsion systems. Thanks to specifically adapted software, torque can be transferred nearly loss-free and the codes control the harmonious interaction of the drive units on the level of the total system. Schaeffler is able to develop fast control algorithms and desired customer-specific functions and to perfect them on in-house test benches. In this context, customers benefit from the knowledge that Schaeffler has acquired on the way to winning the 2016/17 FIA Formula E Championship.

“We are able to either produce the electric control unit, the mechanical and the mechatronic part as components or fully integrate them”

Matthias Zink,
CEO Automotive at Schaeffler

Technology transfer Schaeffler in Formula E



The commitment in the FIA Formula E electric racing series serves as a development laboratory for future production electric powertrains, among other things. Schaeffler is the exclusive technology partner of Team Abt Schaeffler Audi Sport and responsible for the powertrain of the “Abt Schaeffler FE02.” In the 2016/2017 season, Lucas di Grassi clinched the title for the team. Be it system understanding, cooling of the motor, the development of new materials or recuperation, the know-how gained on the race track migrates directly into the development departments.



Success story Schaeffler and the team celebrate Lucas di Grassi's title win in Montreal

From *well* to *wheel*

When is mobility sustainable? Only when the entire energy chain is used as the evaluation standard can the various mobility concepts be realistically assessed as well

Cars with zero local emissions are not necessarily equipped with an environmentally friendly propulsion system because the question is: How is energy provided in the first place? How is it stored? Only a look at the entire energy chain allows making a valid statement about the environmental impact on humans and nature.

Experts refer to this measurement method for CO₂ emissions as “well to wheel.” Energy is produced, stored and ultimately converted into kinetic energy – i.e. locomotion – in the automobile. Schaeffler has calculated what this may mean in the case of an electric vehicle. Based on the current electric energy mix in the European Union, an electric vehicle still generates up to 65 percent of the amount of carbon dioxide which a comparable model with a conventional gasoline engine produces. The reason is that fossil fuels still dominate the production of electricity. However, if an electric vehicle is charged with 100 percent electric power generated from renewable sources, the CO₂ emissions compared with an IC engine drop to a mere three percent.

“Not only the propulsion concept is of crucial importance. Equally important is the way in which energy is produced and stored”

Prof. Peter Gutzmer, Chief Technology Officer at Schaeffler

“Electric vehicles are essentially able to meet the personal mobility needs of people in conurbations,” says Prof. Peter Gutzmer, Schaeffler’s Chief Technology Officer. However, not only a vehicle’s propulsion concept is of crucial importance. Equally important is the way in which the energy for the car’s powertrain is produced and stored. Otherwise, there’s a risk that CO₂ emissions are merely shifted to another place.” The field of topics and challenges addressed also include the parameters of energy availability – in other words grid infrastructure – and the required battery charging times.

Sustainable and available energy

Wind and solar energy, hydropower, geothermal energy or biomass help produce tomorrow’s electricity. Schaeffler supplies state-of-the-art components providing low-friction bearing support of the drivetrains of wind turbines. In addition to the commonly known bio energy sources, Schaeffler in concert with its partners is pursuing new research projects, for instance relating to the use of wave and tidal power stations to produce electricity. This energy must be sustainable, highly predictable and economically available.

The question of storage is being explored by Schaeffler engineers as well. Conventionally, a traction battery stores the electricity used for propulsion. But electricity is not only usable for charging a battery. It can also be used to produce hydrogen by means of electrolysis. Cars with fuel cell drive systems can use hydrogen to produce electricity in the fuel cell. Water

Know-how along the energy chain

Sustainable mobility for tomorrow can only be successful if the entire energy chain – from production to demand-based storage and conversion and through to utilization – is used as the standard for evaluating propulsion concepts. All this leads to a wide variety of drive systems for which Schaeffler develops innovative solutions.

1 Energy production

Sustainable mobility can only be successfully achieved if the primary energy for locomotion is produced from renewable sources such as wind power and hydropower, solar energy or geothermal energy. Schaeffler develops powerful components for wind power and hydropower systems and assists the operators with services such as remote diagnosis. In concert with its partners, Schaeffler is also exploring new ways of developing renewable sources such as electricity which can be predictably and economically generated by wave and tidal power stations.



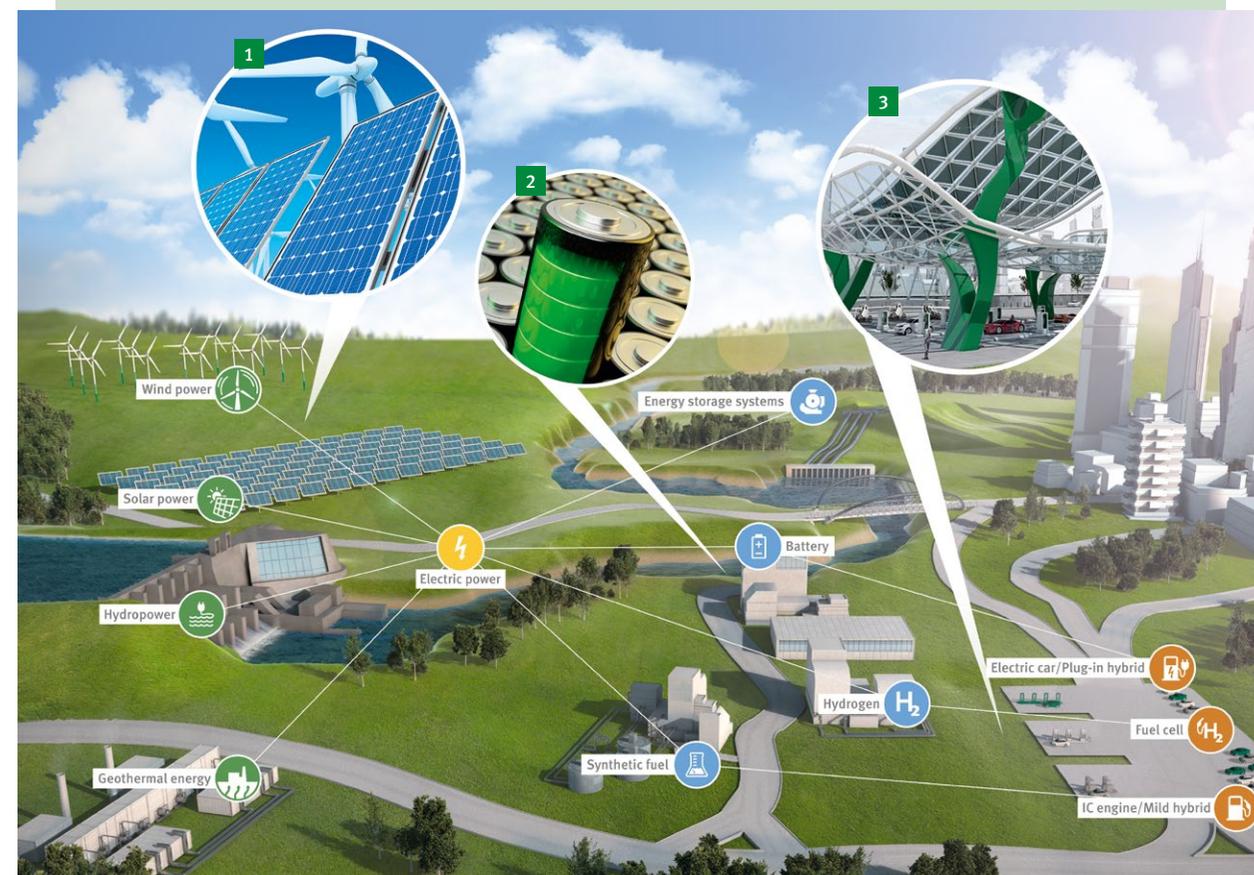
2 Energy storage and conversion

Before energy will drive a wheel it must be placed into intermediate storage. There are several possibilities for this, starting with the charging current for batteries. In the field of hydrogen/fuell cell technology, Schaeffler engineers are conducting research into surface coatings to enhance efficiency. Renewable electricity can also be used to produce synthetic fuels for IC engines which, under certain prerequisites, can be near-CO₂-neutral across the entire energy chain.



3 Energy utilization

For the utilization of propulsion energy there are various solutions as well for which Schaeffler offers a wide range of special technologies. In addition to optimizing the IC engine and the associated transmission, Schaeffler engineers are working on solutions to electrify the powertrain, optimally coordinated interaction of the IC engine and electric motor for hybrid vehicles and tailored electric drive systems for battery-electric and fuel cell vehicles.



is the only byproduct generated in this process. Schaeffler is exploring the coating of the “bipolar plates” which are the core element of the fuel cell.

Electricity from renewable sources can also be used to synthetically produce natural gas or liquid fuels, so-called syn fuels. Electrical energy can produce synthetic gases from liquids in various process steps. Across the entire energy chain, near-CO₂-neutral fuels can be produced and used this way. They are made available by the conventional filling station network.

Ideas for a complex mobility world

“The internal combustion engine will continue to be an important element in transporting people and goods,” Gutzmer stresses. “This not only applies to passenger cars but, above all, to commercial vehicles, ships and aircraft for which there will be no serious battery-electric alternative in the foreseeable future.” A look at the entire energy chain in particular opens up



Low-friction power transmission Thanks to innovative bearings and power transmission, Schaeffler enhances the efficiency of wind power utilization

prospects for a future in which diverse forms of propulsion will continue to exist side by side. Consequently, the optimization of the IC engine and conventional power transmission will remain essential. In addition, Schaeffler is intensively working on the electrification of the powertrain and on assisting the IC engine by effective electric motors.

Fully electric drive systems have long been part of the Schaeffler engineers’ routine business. The holistic approach that takes the entire energy chain into account allows Schaeffler to develop tailor-made solutions for an increasingly complex mobility world. ■



12,700,000

charging stations for e-cars are expected to be built around the globe by 2020, according to a forecast by U.S. analysis specialists IHS Automotive – 12.7 times as many as in 2014

1,300,000

electric vehicles were registered worldwide in 2016 – accounting for less than 0.1 percent of all existing cars

450 km

is the expected range of an e-car by 2020. In 2016, the range of all e-cars sold in Germany was 270 kilometers

From well to wheel Many factors influence the assessment of environmental friendliness on energy’s way from its point of production into the car

Sales revenue of the Schaeffler Group by divisions

75.6 %

Automotive

24.4 %

Industrial

30

publicly funded research projects are supported by Schaeffler just in Germany

751,000,000 €

was invested by Schaeffler for research and development in 2016. This is 52% more than 2011

300

single mechanical and electronic components are contained in a P2 hybrid module from Schaeffler

Schaeffler facts and figures

15,000

needle bearing variants are produced by Schaeffler for automobiles, two-wheeled vehicles, construction or farming machines, etc.

17

Research and Development centers are operated worldwide by Schaeffler

65,000

products are offered by Schaeffler – from high-precision bearings all the way to heavy-weights for tunneling machines or wind turbines

2,400

new employees were hired across the Schaeffler Group in 2016

60

different industries are supplied by Schaeffler

2017

Lucas di Grassi wins the Formula E title with Team ABT Schaeffler Audi Sport



Schaeffler

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Learn more about mobility for tomorrow

Schaeffler compact

- ≈ 87,000 employees worldwide
- 13.3 billion euro sales in 2016
- > 2,300 patents filed in 2016
- 170 locations in 50 countries

Contact

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IAA hall plan

Hall 5.1, Booth A04

-  Schaeffler
-  Hall
-  Under construction
-  Outdoors

