tomorrow

Experiencing technology with Schaeffler

Less is more

To embark on a successful journey toward a sustainable future, we have to leave unnecessary ballast behind

Issue 1/2022 · Reduction

SCHAEFFLER

Re|duc|tion; [rɪˈdʌkʃ(ə)n]

1. The act, process, or result of reducing.
2. The amount or rate by which something is reduced, e.g. in price. A 5% reduction in robberies.

Source: reduction. (2022, April 3). Wiktionary, The Free Dictionary.
Retrieved 11:17, May 31, 2022 from https://en.wiktionary.org/w/index.php?title=reduction&oldid=66340011.

tomorrow has won recognition

Special Mention
"Communications Design Editorial"

Silver
Special Award "International Communication"

Special Mention
for "Outstanding Branding"

Award of Excellence
for Cover (2/2017) and cover story "Electric Leader"

Gold Winner
"Websites: Customer Magazine"

Award of Distinction
"Cover Design, Overall Design, Corporate Communications, Copy/Writing"

Gold Winner
"Websites, Feature Categories, Best Copy/Writing"

Gold Winner
"General Website, Categories-Magazine"

Silver
"Writing: Magazines Overall"

Grand Winner
"Magazine"

Dear readers,

95 years ago, in May of 1927, aviation pioneer Charles Lindbergh made history with his non-stop solo transatlantic flight. That he relied on bearings of today's Schaeffler product brand FAG should just be mentioned as an aside. The factor enabling his daring feat in the first place is far more important: reduction. To enable him to take the fuel required for his mammoth flight on board, the heroic pilot had everything removed from his single-engine "Spirit of St. Louis" that wasn't absolutely necessary – up to and including a parachute – which goes to show that less is often more. Sometimes less is even a must, as Lindbergh's example demonstrated that you can read about starting on page 22. With that excursion into aviation history, I'd like to welcome you to our first issue of "tomorrow" in 2022. As you may have guessed by now, our focus topic is reduction.

People who tend to see a glass as half empty rather than half full may initially flinch at the word "reduction" and tacitly translate it to mean "regression." On the following pages, we'd like to prove to you that the opposite is true: that reduction means progress. We need to turn onto this pathway of progress if we want coming generations to continue enjoying a satisfying life on a planet Earth whose vital signs are intact. The unreflected pursuit of more, more, more is a thing of the past. More with less has to become our new credo. More sustainability due to less emissions, less resource consumption and less waste. More quality of life due to less noise, less congestion, less stress.

Discover how technologies help transform less into more. For instance, how robots not only enhance efficiency on the factory floor but also relieve us humans of monotonous or even hazardous tasks (starting on page 8). Or how autonomous ships can take over the hauling of goods that used to be transported on the road (starting on page 28). Starting on page 68, our Chief Operating Officer for Production, Supply Chain Management and Purchasing Andreas Schick explains how supply chains and production processes have to recalibrate themselves to become more flexible, resilient and sustainable. A key element in Schaeffler's view is the process of switching to green – in other words carbon-neutral – steel that we've initiated. Our extensive Sustainability Report starting on page 38 describes what else is necessary to switch supply chains to "green" – from raw material production through to the consumer. In the process of decoupling global growth from fossil resources, hydrogen plays a key role. That's precisely what motivates Schaeffler to drive hydrogen technologies as a pioneer (starting on page 48).

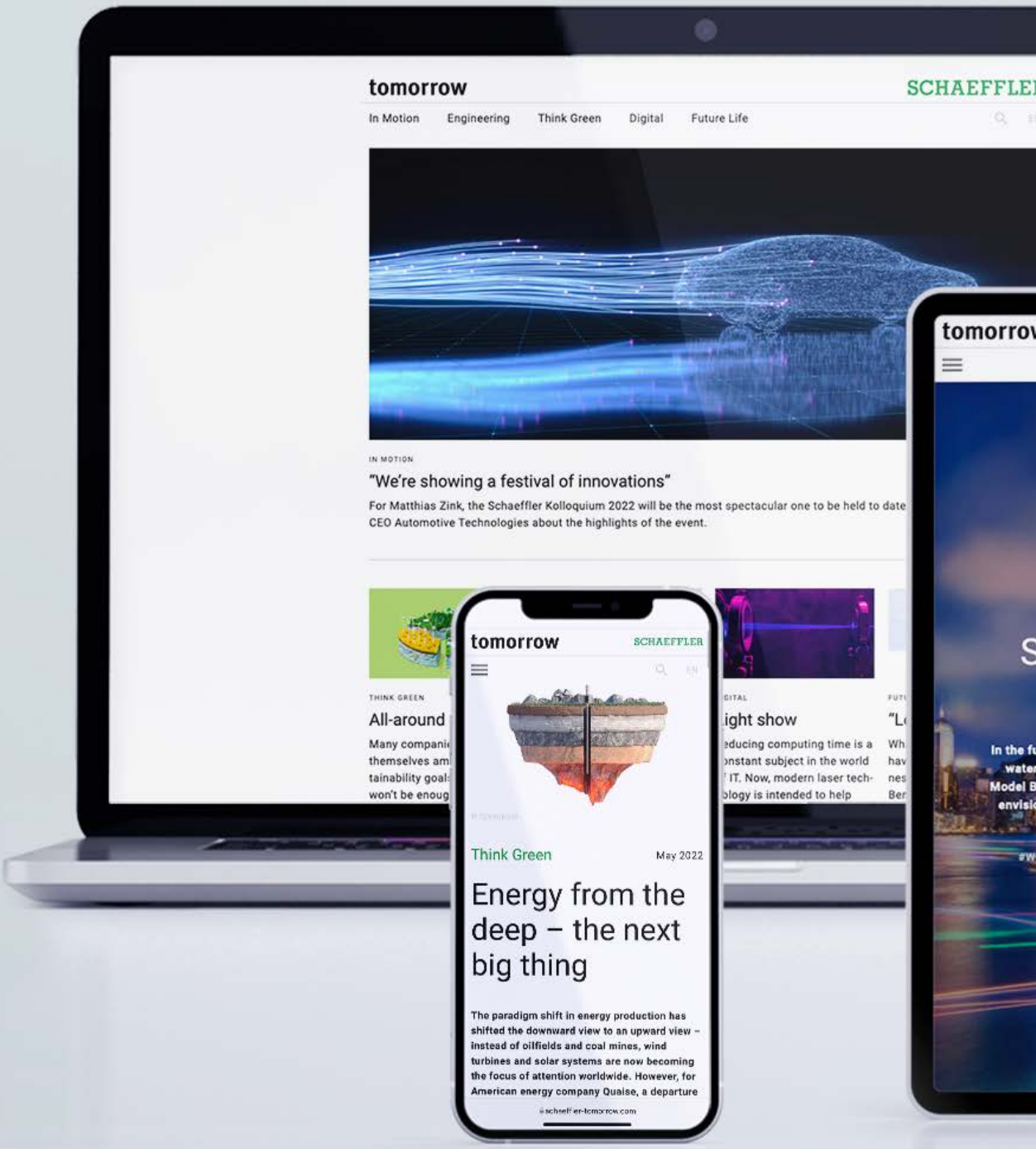
I don't know if you've already noticed that this issue of "tomorrow" has two parts. On the back cover, a special section published on the occasion of our Schaeffler Kolloquium welcomes you. The host of our mobility product show is our Automotive Technologies CEO Matthias Zink, who promises nothing less than a "festival of innovations." Our Kolloquium is focused on "reduction" as well, or more precisely: the reduction of CO_2, or put another way: the decarbonization of mobility. In our special section, our Chief Technology Officer Uwe Wagner and the President of our E-Mobility Division Dr. Jochen Schröder explain what sustainable concepts and innovative mobility solutions Schaeffler offers in that area.

In spite of how much we like reduction, I hope this issue shows that there's one thing we're not going to reduce: the variety of topics that makes our magazine "tomorrow" a powerful and exciting read. Again, welcome to our new issue focused on "reduction" in the spirit of "less is more."

Klaus Rosenfeld
Chief Executive Officer

Interest in more tec

Discover the online world of *sc*



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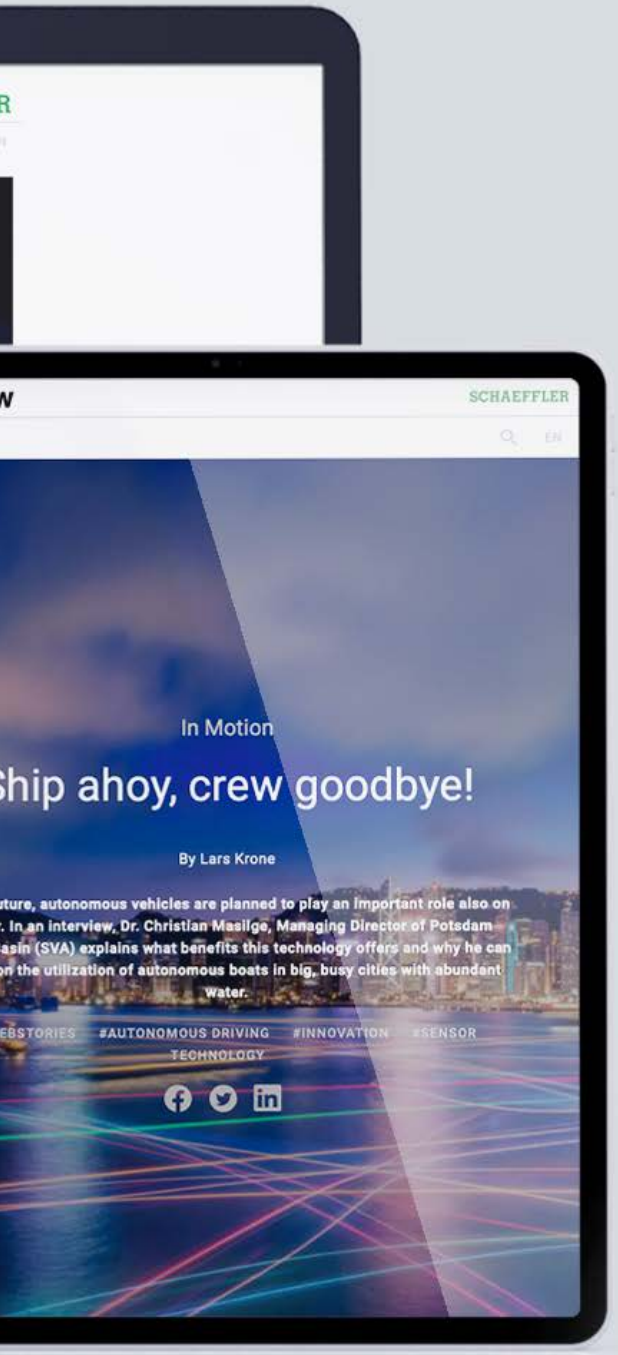


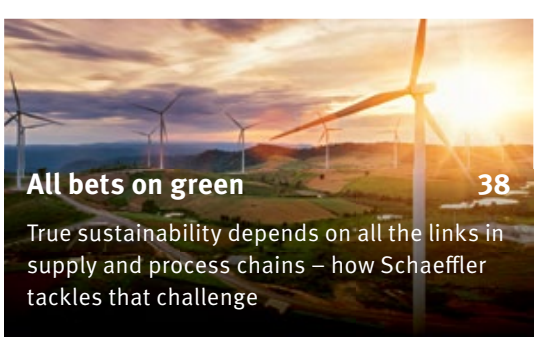
Click here and begin surfing through the technological world of *tomorrow*

tomorrow

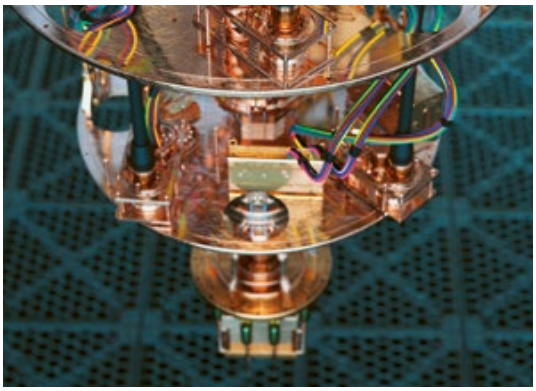
Engineering

In Motion

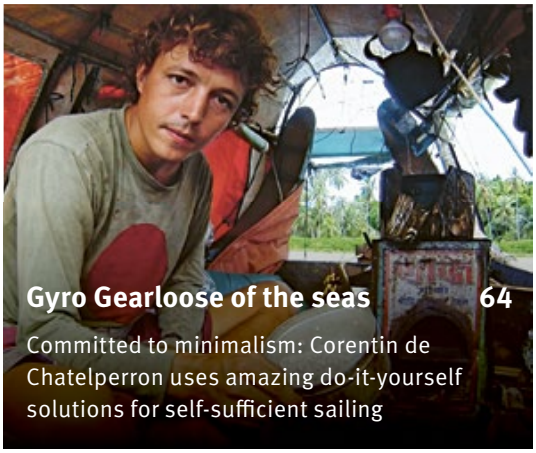
Think Green



Digital



Future Life



Schaeffler Kolloquium 2022
Coverage of the key topics

Energizing the next generation

Engineering

In research and development centers all over the world, specialists are working on innovative ideas to minimize the footprint of civilization.

Giga(watts) project

The storage of electricity is a key component in the climate reduction effort and the transition process toward sustainable energy production. Using surplus electricity to move a mass upward and to lower it again when electricity is needed is an extremely efficient means of storing electric power that experts refer to as elevation potential energy. Pumped storage power-stations are a classic example but require hilly areas and can therefore not be used everywhere. By contrast, gravity storage systems would also work in flatlands. They use surplus electricity to hydraulically pump a mass of rock or concrete of several hundred meters upward. When electricity is needed, this piston is lowered pushing water through turbines driving generators just like in a hydro powerplant. The system has a minimum efficiency of 80 percent. Its storage capacity is huge and would amount to several gigawatt hours. Equally huge, though, are the pressures acting on turbines, lines and seals – resulting in a correspondingly long to-do list before such a system is ready to operate.

Additional storage ideas can be found at schaeffler-tomorrow.com

8,000 m²

or 86,111 square feet: That's the size of Schaeffler's new tool technology center at its German location in Höchstadt an der Aisch, where precision tools are created for Schaeffler's global network of plants, especially for the strategic forward-thinking fields of e-mobility and robotics as well as for mechatronic chassis applications. **By concentrating its know-how in the areas of manufacturing excellence and innovative tool technologies** Schaeffler combines development, production and tooling at one site for optimally addressing future customer requirements.

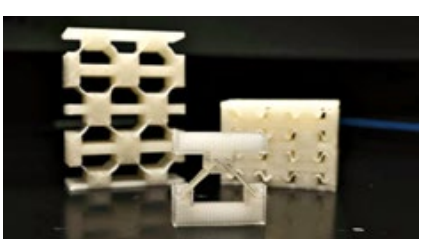
Several automated robotics lines are among the technological highlights at the new tool technology center

"Those who seek new answers have to ask new questions"

Johann Wolfgang von Goethe (1749–1832), German poet

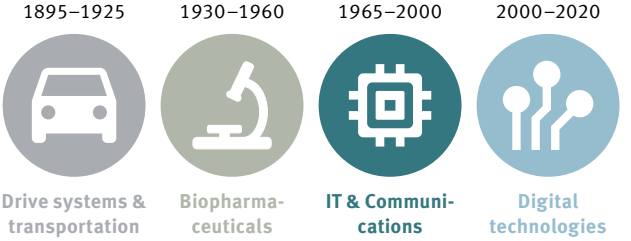
Soft, hard and lightweight

Moving a mass requires energy. That's why lightweight design is an efficient way to save it. That's exactly the direction pursued by researchers at Johns-Hopkins University in Baltimore (USA), who developed a **honeycomb structure with the resistance of metal and the light weight of a sponge.** Liquid crystal elastomers that are also used for creating artificial muscles have enabled this balancing act. Flex-walls formed from this material combine several rows into a high-strength supporting structure. In the event of an impact, these walls reversibly deform and absorb the impact energy while the firm structures provide the requisite protection. **The more layers the greater the protective effect.** Helmets and protective clothing or car bumpers might be examples of future uses.



Innovation through the ages

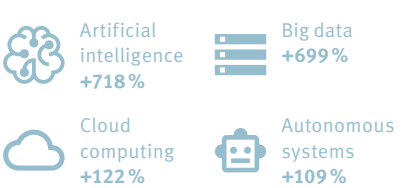
The industries with the largest number of patent applications during the past 120 years



Source: World Intellectual Property Report 2022

The key innovation drivers in relation to patents in the field of digital technologies

Growth 2016–2020



Little and larger helpers

The evolution of robots is rapidly picking up momentum. The automated helpers are learning faster and faster: to move around, to enhance their vision and tactile sensitivity and to smell. When it comes to learning per se, they're becoming increasingly independent as well. The worker-bees among them are becoming more powerful and ruggedized, liberating their human colleagues from hard and hazardous work. A status report from the world of machines.

By Lars Krone and Volker Paulun

The venerable university in Cambridge has produced more Nobel Prize winners than any other institution of higher education in the world. Whether a robot made in Cambridge will achieve such honors anytime soon remains to be seen. However, even at this juncture, robots are being taught a lot there. Most recently, scientists from Cambridge made headlines with a robot chef that had been taught to taste food. As well as in the research and development departments in industry, the evolution of robotics is driven at many universities around the globe. Scientists at ETH Zurich are working on the development of artificial skin that's supposed to provide robots with a human-like sense of touch. The examples from Cambridge and Zurich alone illustrate the pace at which robotics has advanced into areas that just a few years ago were epitomes of utopian science fiction. Merely six decades passed between the development of the first hydraulic industrial robot and the current state.

Nimbly and precisely this industrial robot with a height of 2.5 meters (8 feet) and a weight of 3 metric tons (3.3 short tons) juggles body side panels at a Seat plant

Robots have been used for 60 years

George Devol had the first teachable robot patented in 1954, which laid the foundation for modern robotics. Two years later, Devol, together with Joseph Engelberger (subsequently dubbed the "father of the industrial robot"), founded the first robotics company. This innovation hotbed named Unimation was also the company that in 1961 sold the first hydraulic industrial robot to its customer General Motors, once again making the automotive industry a trendsetter just like it had previously been with the moving assembly line. The first robot processed injection-molded parts – so fast and with such precision that as early as in 1964 General Motors ordered 66 additional machines of this kind from Unimation. Other companies followed suit in robotics, both as manufacturers and users.

In 1973, KUKA Famulus, the world's first six-axis robot, marked the next milestone achievement, ringing in a new era in automotive body manufacturing. In the following years, the evolution of industrial robots kept progressing, with electric motors replacing hydraulic control units, sensors enabling the performance of more sensitive work or robots autonomously moving around on the factory floor.

Today, manufacturing operations are inconceivable without robots. In 2021, more than three million industrial robots were in use worldwide, joined each year by some 400,000 new ones, according to the International Federation of Robotics (IFR), whereas statistics for 2010 only reflected 120,000. The market is booming.

"The use of robots is rapidly gaining momentum in both traditional and new industries," says IFR President Milton Guerry. "More and more companies are recognizing the benefits that robotics and automation can bring to their business models." Along the same lines, Ralf Moseberg, Senior Vice President Industrial Automation at Schaeffler, emphasizes that "there's an enormous worldwide need to catch up in the areas of robotics and automation. The huge demand meets with an offering that's becoming better and better. For us as a supplier, the technological development makes solutions possible today that just a few years ago were not feasible at all or could be realized only at clearly higher costs. Robots are becoming increasingly flexible, fast, precise, efficient and therefore affordable also for smaller to medium-sized companies."

1 in 10

households in Europe already uses a robot. Robotic lawn mowers were the first robots for domestic use. In 1998, manufacturer Husqvarna presented the first model that not only mowed autonomously but also traveled back to its charging station independently. Robotic vacuum cleaners achieved their breakthrough in 2001 thanks to iRobot Roomba. Floor mopping and window cleaning robots followed. **In 2021, 6.7 billion U.S. dollars were spent on 31.2 million domestic robots.** In 2023, that amount is expected to increase to 10 billion. The calculated time savings for household chores amount to 14 hours per week.

Source: International Federation of Robotics

IFR statistics underpin the Schaeffler expert's view that there's a huge global need to catch up. In the pre-pandemic year of 2019, there were 2,743 industrial robots per 10,000 employees in South Korea's car industry. That was a top ratio worldwide because the global automotive industry average was just 722. Across industries, the ratio was merely 113. For the compact collaborative robots called cobots for short, the ratio was even as low as 4 per 10,000 human colleagues.

Simplified teaching

There's an important aspect assisting in the race to catch up, says Moseberg: "Both industrial robots and the more compact cobots are increasingly easier to program and implement." Especially in the case of large industrial robots working in shielded settings that are separated from human workers to ensure safety, the implementation costs proved to be a major impediment to their widespread use. Unsurprisingly, especially small and medium-size companies don't embrace the prospect of incurring implementation costs amounting to two or three times the robot's price.

A forward-thinking trend: Cobots that are installed on autonomously traveling platforms and can therefore independently change the locations at which they work

Schaeffler is among the companies pursuing an intriguing approach to lowering that hurdle. “We emphasize simplified installation and startup operation,” explains automation expert Moseberg. “Using the so-called teach-in function, cobots learn movements by rehearsing processes that are guided by hand. The sensors implemented in our gearboxes assist in the required data acquisition. That clearly simplifies programming.”

Intuitive user surfaces operating with symbols are in line with the trend toward simplified implementation just like the development of complete hardware and software eco-systems that we’re familiar with from smartphones. From an app store, customers can download preconfigured applications for simple and frequently desired uses enabling easy incorporation of grippers, sensors and control units.

New fields of work for robots

There are other factors besides simplified implementation and operation that are conducive to accelerating the wide-spread use of the nimble machines. Labor shortage, for instance, is a major aspect motivating the deployment of robots. Even sectors in which robots have so far failed to get an “arm” in the door are now investigating automation out of sheer necessity. They primarily include companies that, due to small volumes or complex processes, have so far had to rely on manual work. Likewise, the restaurant business, the retail trade as well as logistics and farming are now investigating the use of robotics for the first time.

In its current trend report, the IFR additionally found that shifts in consumer behavior toward customized products and deliveries as well as online retail in the consumer goods sector that has received an additional boost by the pandemic have led to a downright boom in demand for robots. Worldwide, the paper says, thousands of robots are being used in this segment, which was inconceivable just five years ago. “At Schaeffler, we’re also seeing a massive increase in demand for robots as well as for cobots in non-industrial sectors such as healthcare, food and logistics,” confirms Ralf Moseberg.

Classic suppliers of large industrial robots like Fanuc, ABB, KUKA, Yaskawa or Siasun want to benefit from the recent yet unmissable trend as well and are pushing into this growth market. KUKA’s CEO Peter Mohnen, tongue-in-cheek, put it this way: “We’re not the first to join the party – but the party hasn’t really started yet.”

“Cobots have clearly greater freedom of motion than classic industrial robots, which opens up all-new fields of application”

Ralf Moseberg,
Senior Vice President Industrial Automation at Schaeffler

Not least due to staffing shortages, robots are increasingly used in healthcare. Developments are focused specifically on hygiene, sensor systems and fail-safe design

Schaeffler's expert Moseberg is a cobot fan, too. "Cobots interact directly with humans and safety cages are no longer needed," he explains. "As a result, their freedom of motion is clearly higher than that of classic industrial robots, which opens up all-new fields of application. Obviously, these new fields present completely different challenges than mass production."

That calls for innovative technical solutions. "For example, in settings where medical robots are used, healthcare staff, patients and robots come into very close contact with each other and measuring even the smallest forces, for instance due to touch, is essential," Moseberg continues. "For this purpose, we have incorporated torque sensors into strain wave gears that are able to measure such forces with very high precision while maintaining high control accuracy."

Moseberg expects yet another development: "Various technical areas are going to continue growing together. The combination of AGVs (automated guided vehicles) and cobots, in other words robots for versatile uses that are installed on autonomously traveling platforms and independently proceed to where they're needed, is a case in point." Digital connectivity is another area in which value is added due to interdisciplinarity. While in use, cobots collect data for forwarding to IT systems in real time. These systems process the information immediately and feed it back to the factory floor, which enables continuous optimization of the production process. For Moseberg, this

“sustainable engineering” is a powerful lever for saving energy and raw materials.

The steadily increasing requirement profiles for robots also include resistance against harsh conditions. “After all, cobots and robots are intended to replace humans especially in activities that are particularly strenuous for human workers,” Moseberg explains, “for instance, in settings involving very high or low temperatures or handling of heavy loads. The question is, where do such working conditions exist and in which places can relief be achieved? We’re going to take a closer look at such areas. One of the products we offer to address those needs are XZU bearings enabling lightweight robots to be loaded with even higher weights without suffering higher wear of the gearboxes.”

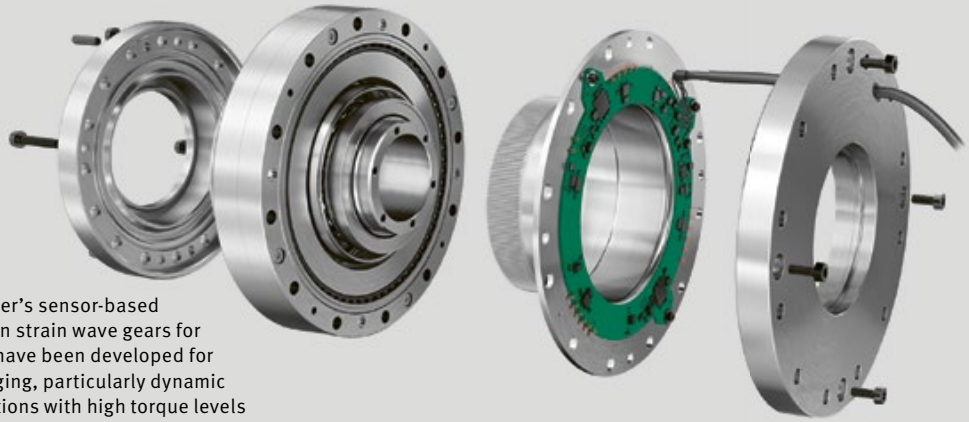
Fitness program for classic industrial robots

In parallel with the advance of cobots, the evolution of the classic industrial robot, which already has a payload of several tons and range of up to five meters (16 feet) today, continues. “Higher precision, a smaller footprint, higher efficiency and longer maintenance intervals are the areas here that we’re obviously working on as well,” says Schaeffler’s expert Moseberg.

A departure from limiting robots to performing predefined tasks toward greater flexibility as a prerequisite for companies to accelerate their response to market changes is another field on which developers of classic industrial robots are focused. In addition to simplified programming, a modular robot design is a key enabler of diverse use cases.

In robotics expert Moseberg’s view, there’s no doubt about it: “For me, a ‘factory for tomorrow’ is unthinkable without robotics deployment proceeding in both directions, that is cobots as well as the larger industrial robots, because there are use cases for both types of robots in modern manufacturing operations.”

Easy to operate and powerful: Robots have become firmly established in production processes that are fit for the future



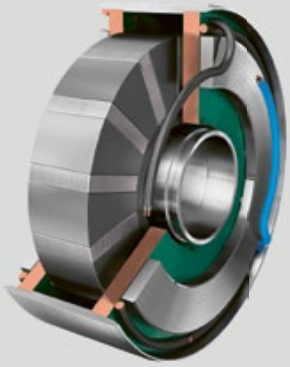
Schaeffler's sensor-based precision strain wave gears for cobots have been developed for challenging, particularly dynamic applications with high torque levels

Robotic innovations by Schaeffler

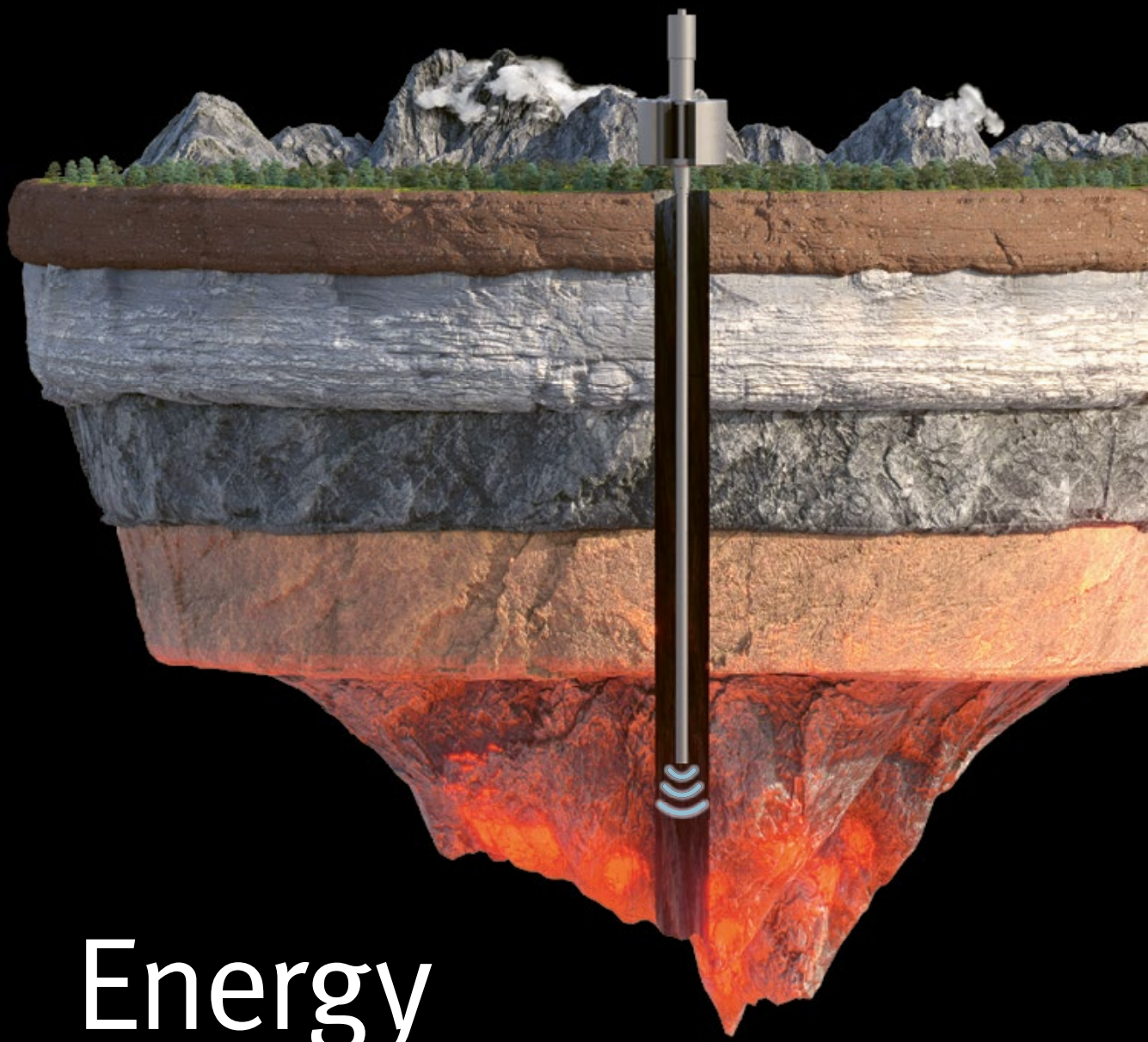
At the 2022 Hanover Fair, Schaeffler's Industrial division unveiled several new developments in the field of automation. For lightweight robots and cobots, the company presented new main bearings, gearboxes and fully integrated sensor systems. "For instance, with our solutions package, cobots can be up to 50 percent faster or haul respectively heavier loads. For sensitivity, we offer an innovative concept: our sensor-based precision strain wave gears. As a result, it will be possible to develop other fields of application," explains Ralf Moseberg, Senior Vice President Industrial Automation at Schaeffler. The technology group has the requisite production capacities and quality management for medium and larger volume production and everything else that's needed to cover the future demand for system components for lightweight robots.

Schaeffler is now offering precision strain wave gears and precision planetary gears (pictured) for buckling arm robots for all axes and payloads – from just a few kilograms to more than 100 kg (220 lbs.)

For industrial robots, Schaeffler presented a portfolio of precision planetary gear units of the PSC series. Compared to the market standard, it's characterized by ten times lower torsional backlash and three times longer service life. In addition, the precision planetary gear units feature wear compensation that keeps the units' extremely low torsional backlash at constant levels. "Such major development leaps are very rare and an opportunity for industrial robotics to overcome previous barriers," says Moseberg. To strategically strengthen the company in this area, Schaeffler acquired Melior Motion GmbH (now Schaeffler Ultra Precision Drives GmbH) at the beginning of the year. The manufacturer of precision gearboxes for industrial robots is one of the innovation drivers in this field and with its products enables high-precision positioning and repeat accuracy of robots combined with particularly long lifecycles. For Schaeffler, robotics as a whole, including large industrial robots, is a field with major growth potential.



Schaeffler's motors of the UPRS series offer less installation space, lower weight, higher torque density and 80 percent higher revolutions per minute on average compared to drive systems commonly used in the marketplace

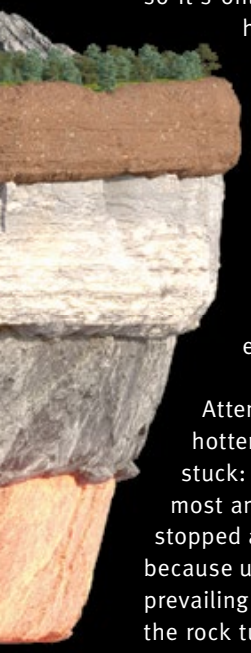


Energy from the deep

In pursuit of the goal to radically reduce greenhouse gas emissions, the downward view in relation to energy production is shifting to an upward view – instead of oilfields and coal mines, wind turbines and solar systems are now becoming the focus of attention worldwide. However, for American energy company Quaise, a departure from the deep is out of the question. Quaise intends to develop geothermal energy into all new dimensions.

By Kay Dohnke

In school, we all learned that Earth's liquid core has a temperature of around 5,000 °C (9,000 °F), so it's only logical that the deeper you drill the hotter it gets. But in many countries the utilization of this deep heat – primarily in volcanic regions – is still in its infancy. For instance, in Germany, a new-energies trailblazing country, there are just three such power stations in the Upper Rhine Plain using 97 °C (207 °F) hot water from a depth of 2,500 to 3,500 meters (8,200 to 11,500 feet) to generate heat and electricity.



Attempts to tap into deeper and therefore hotter water-bearing beds have literally gotten stuck: In 1995, after twelve years, Germany's most ambitious deep-drilling project had to be stopped at a depth of 9,101 meters (29,859 feet) because under the high ambient pressure and the prevailing temperatures of 260 °C (500 °F) there, the rock turns into a kind of viscous custard that puts up more and more resistance. Another project, on the Russian Kola Peninsula, was stopped as well, after nearly 20 years of work, at a depth of 12,289 meters (40,318 feet). All that's left of it is a rusty bolted cover on the world's – so far – deepest hole.

Energy for millions of years

Actually, using the incredible heat in Earth's interior would pay off because just 0.1 percent of the presumed geothermal energy could cover the worldwide energy demand for 20 million years, according to calculations of the Massachusetts Institute of Technology (MIT).

That's why "the next big thing" in terms of green energy is now being ushered in. Quaise appears on the stage: the people behind the MIT spin-off, all of them experts in plasma research and fusion energy, intend to unlock at least a tiny portion of this geothermal potential. In pursuit of this goal, they've completely reimagined geothermal energy and its application. Their plan is to access 500 °C (932 °F) hot water at a depth of 20 kilometers (12.4 miles) that's in a supercritical state due to the extreme pressure and to bring it to the top.

To tap into this humongous energy source, U.S. specialist Quaise is thinking along new lines, using previously known, extremely powerful microwave oscillator technology. By means of electromagnetic waves in the millimeter range and frequencies of up to 300 gigahertz these so-called gyrotons can generate temperatures of up to 150 million °C (302 million °F) – enough to pulverize even the hardest rock. Using argon gas, the particles are then blown upward while the rock around the "bore hole" fuses at these extreme temperatures and automatically seals off the shaft.

Down to 12 kilometers in 100 days

Since this technology, following short conventional drilling, basically just requires a pipe to be pushed down into the ground, there's no need for extremely time-consuming handling of drill pipes. While it took the Russians 20 years to penetrate the rock down to 12 kilometers (7.5 miles) in the Kola project, Quaise plans to achieve that in about 100 days using a 1-MW gyroton advancing at a rate of 70 meters (230 feet) per hour and then continuing to work its way forward. By comparison, the German geothermal power station projects operating with maximum drilling depths of 3,500 meters (11,500 feet) merely scratched the surface.

If the effort to tap the extremely hot deep water proves successful it will be followed by the application stage – in the form of an amazing re-powering plan. Quaise's concept involves a comprehensive advantage, a revolution of green energy generation, because the utilization of the super-hot deep water doesn't require the construction of new powerplants. The idea is to convert existing facilities and to continue using their technology for power generation.

Whether they're fossil, nuclear or solar, powerplants are actually nothing but hot-water boilers. They generate heat and use it to turn water into steam driving power-generating turbines. Quaise's plan – aside from technological challenges yet to be mastered in the field – is intriguingly simple: hot water pumped up from great depths would be fed directly into any available powerplant and drive the turbines there. That would make coal, gas, oil and uranium rods superfluous and the energy per se would be completely carbon-neutral. Theoretically, any power station previously heated

8 percent

of the European lithium requirement (for traction batteries in e-mobility etc.) could be filtered out just from the deep groundwater at the three operating German geothermal plants in Landau, Insheim and Bruchsal in the Rhine Valley – without causing any environmental burden like conventional lithium mining in South America, for example.

Source: Deutschlandfunk

25 percent

of the entire thermal demand (converted to 300 TWh) of Germany as an industrial country could be covered by currently available or upcoming hydrothermal technologies for deep geothermal direct use alone or in combination with large-scale heat pumps. Estimated investment volume: 140 to 175 billion euros. Hot rock formations (petro-thermal geothermal), seasonal underground heat accumulators and surface geothermal energy for heating and cooling buildings in the construction and housing sectors offer additional thermal potential.

Source: Roadmap Tiefe Geothermie für Deutschland

50 percent

of the entire energy consumption is fed into heat sources for houses, industry and other uses, according to the International Energy Agency (IEA). At the moment, only around 10 percent of the thermal energy is supplied by renewable sources – a percentage that will double by 2030, the IEA projects. Many scientists feel that such progress is too slow. They demand a ban on the installation of fossil-fuel heating systems to start as early as in 2024 if the German climate goals are to be achieved by 2045. Geothermal energy is a key to achieving these targets.

by conventional fuel could have its own source of deep water for emission-free generation of electricity and heat.

Obviously, in volcanically active regions very hot water could be accessed in much simpler ways and much closer to Earth's surface, like Iceland has been doing. But in most cases, such quasi-natural hot water sources are too far away from consumers, whereas driving an ultra-deep hole into the ground should be feasible anywhere with Quaise's technology. It's assumed that this would apply to 70 percent of Earth's surface.

The realization of Quaise's concept would result in several advantages. Electric power would be produced not only with zero emissions but conventional oil-, gas- or coal-fired powerplants that would have to be shut down for climate protection reasons could continue to operate. Because these plants are already integrated into power grids, there'd be no need for establishing corresponding infrastructure either, as required, for instance, for hydrogen as an energy source.

Energy from the deep is baseload-capable

In response to critics, the utilization of ultra-hot deep water can score in terms of a totally different aspect as well. Unlike with solar farms or wind farms, the space required for unlocking this potential is minimal. Nothing would impair the landscape, which should clearly simplify approval processes. Another crucial advantage of geothermal over solar and wind energy is its baseload capability – Earth's heat is not subject to any fluctuations. The risk potential that the utilization of geothermal power entails is minimal as well. What's critical is the actual drilling operations that may cause geological shifts in the ground. "If the drilling has been successful, geothermal energy should be assessed very positively not only from an economic but also from an environmental point of view," writes Lars Jaeger in his book "Wege aus der Klimakatastrophe" ("Ways out of the Climate Catastrophe"). Quaise even excludes this potential hazard for its microwave drilling operations.

In an extensive report, the World Bank points out another issue: Some geothermal power stations that are operating already have a worse climate

Piping hot water: There are few places on the planet where hot ground water can be accessed as easily as in Iceland. No wonder the world's first geothermal powerplant for electricity and heat, the Svartsengi Power Station (pictured), was established there

gas footprint than coal-fired powerplants because drilling into the Earth may cause carbon dioxide and methane that's bound there to escape. That's another challenge to be mastered by Quaise and other pioneers in this field.

Field tests to begin in 2024

To accomplish the move toward a new geothermal future from pure theory and research into the tough reality of field operations, Quaise raised funding in the amount of 63 million U.S. dollars at the beginning of 2022. The U.S. Department of Energy is on board as well. Any support is as welcome as it is necessary because gyroton drilling projects are "very difficult technological undertakings," says Quaise's co-founder Carlos Araque. To his surprise, he's also found support in the oil and gas industry. "These companies are starting to understand that they need to embrace the [green] energy transition," he told "MIT Technology Review."

A joint roadmap of the German Fraunhofer Societies and the Helmholtz Association also recommends a broad alliance of the political, business and academic communities for deep geothermal, like in the case of driving hydrogen technologies. That includes balancing the risks for private-sector companies and local governments tackling the exploration of deep geothermal energy. In addition, capital investment grants for key technologies are necessary, including drilling systems and pumps, high-temperature heat pumps and large-scale heat accumulators. Moreover, large-scale utilization of geothermal energy requires cross-sector integration and broadly designed combined heat networks.

In spite of all challenges Quaise continues driving its idea: initial demonstration drillings down to depths between 100 (328) and 1,000 meters (3,280 feet) are planned to start in 2024. Provided that they produce the expected success, the conversion of the first power station to deep geothermal energy is targeted for 2028. It remains to be seen whether that facility will be able to deliver energy at market-prices. Hence the road toward using deep geothermal energy is still as long as it's deep.

The author

Kay Dohnke looks back on many years as an editorial director, editor-in-chief and author of books. Today, he lives and works near Hamburg as a freelance journalist. His topics are focused on the sustainable transformation of energy, mobility, raw material usage and production technologies.

In Motion

Maximum progress with minimum use of resources – that's the key to sustainable mobility of the future.

Minimalism vs. giantism

Big wave surfers ride gigantic waves with just a tiny board under their feet. The most daring representative of these bold water sports athletes is **Schaeffler's brand ambassador Sebastian Steudtner.** The 37-year-old was recently recognized with an entry in the Guinness World Records for having surfed the highest wave ever (26.21 m / 86 ft.). A tour de force not against but with the help of nature's formidable forces, as Klaus Rosenfeld, Schaeffler's CEO, who was among the first people to extend congratulations, emphasized. What's more, Rosenfeld promised to use the industrial and automotive supplier's concentrated competence in the area of surface technologies to help Steudtner in continuing to push the envelope.

Old tires for new roads

Mobility without roads is (still) unthinkable. The problem is that asphalt surfaces not only suffer from the impact of vehicles traveling on them but also due to sunlight. Heat and UV radiation cause deformations, cracks and potholes. Australian researchers have developed a road surface material that reduces repair intervals: **rubber asphalt.** Like in the building industry, where shredded end-of-life tires have been mixed into concrete for a long time, used tires are now also intended to help make roads more durable. According to the scientists, future roads might **last twice as long as before by adding about 20 percent rubber to the top asphalt layer.** That would provide triple protection: against rutting and fatigue caused by the impact of traffic combined with resistance against UV aging.

"Tortoises can tell you more about the road than hares"

Khalil Gibran (1883–1931), Lebanese-American philosopher

50 micrometers

(or 0.001 inches): That's how small the riblets of the new sharkskin coating technology are that Lufthansa's subsidiary SWISS is going to apply to twelve Boeing 777 aircraft starting in mid-2022. According to Lufthansa Technik and its partner BASF, this type of sharklike high tech is supposed to reduce drag by 1.1 percent. That may not sound like much but, projected to the entire fleet of twelve Boeing 777 aircraft, will reduce **annual kerosene consumption by 4,800 metric tons (5,300 short tons) and CO_2 emissions by 15,200 metric tons (16,750 short tons).**

A tiny house on wheels

It's arguably the world's smallest camper van. **Japanese van converter Oka Motors has converted a Suzuki minivan with a mere length of 3.40 meters (11.15 feet) into a micro camper van that's got all the essentials on board by reducing equipment and furnishings to an absolute minimum.** Even so, the tiny house on wheels has a dining table, a microwave, a fridge that can be extended across the tailgate, space for up to three beds and an outdoor shower. Okay, the camper van's features don't exactly include headroom, but minimalism does have its limits somewhere …

“Autonomous boats can serve all-new fields”

In the future, autonomous vehicles are planned to play an important role also on water. In an interview, Dr. Christian Masilge, Managing Director of Potsdam Model Basin (SVA) explains what benefits this technology offers and why he can envision the utilization of autonomous boats in big, busy cities with abundant water.

Interview: Lars Krone

What are the advantages of autonomous boats and ships?
At the moment, the entire transportation sector is in a state of major transformation. Waterborne transportation systems can make an important contribution to solving our current transportation problems because waterways, particularly inland waterways, are the only modes of transportation that still have unused capacities these days. This offers plenty of potential for reducing the volume of traffic especially on roads. Waterways are currently used only to a small extent because barges as a mode of transportation are, at least in large part, unattractive for hauling goods.

How can technologies of autonomous operation add attractiveness?
There are several areas in this context. Inland navigation in Germany and Europe has a huge problem recruiting junior personnel and the average age of current personnel is very high. In addition, regulations require two people to be on board at all times. On larger ships even more. So, if you want to serve waterways on which only small units with a length of 40 meters (131 feet) or less are deployed, that's simply no longer possible today because the costs are prohibitive. Deployment of autonomous boats would be a viable solution. They would not require personnel and be suitable for 24/7 service. Another benefit of 24/7 service of the ships would be the opportunity to maximize the efficiency of their energy consumption in this way. For instance, a ship traveling at slow speed is more energy-efficient than a faster ship. By means of digital monitoring, the ships could be controlled in a way that they wouldn't have to wait in front of locks or ship lifts, for example.

Your A-SWARM research project is heading precisely in that direction …
Exactly. Today, barges are used for bulk shipping on large rivers like the Rhine. However, ships have progressively disappeared from all the adjacent areas. That's why we – as well as other companies – are developing small autonomous boats particularly for serving cities and a wide variety of potential uses. At night, for instance, they could be hauling parcels to distribution hubs from where cargo bikes or electric vans would take over delivery on the last mile. This could avoid numerous on-road hauls. Autonomous boats could also be used for garbage disposal or for hauling food. Actually, there are no limits in this area and that opens up new fields to inland waterway transportation that cannot be served at the moment.

Mr. Boat: Dr. Christian Masilge is the managing director of Potsdam Model Basin (SVA) as well as an official expert, boat designer and adjunct professor at TU Berlin

What are the greatest challenges to the development of such autonomous boats?
Developing autonomous boats for inland navigation poses a greater challenge than it does for maritime navigation to begin with. Partially automated ships are already sailing the oceans today with autopilots or collision warning systems performing important roles. These vessels still have crews for monitoring the operation but, theoretically speaking, the ship could sail largely on its own after having left one port and up until arriving at the next one. By contrast, more complex things are still in development, in other words: what happens in case of an encounter with another vessel or in the event of an accident or damage? Inland navigation poses additional challenges. The navigable waterways are relatively narrow, there are bridges and locks and, above all, traffic density is much higher. All that makes very special demands on automated systems.

How do these systems work?
In the A-SWARM project, we divided navigation into two areas. First, there's so-called far-field navigation using GPS, which already enables very precise navigation. The second area is so-called near-field navigation using radar and lidar system sensors for monitoring the immediate environment of the boats. The objective of our development is to extend near-field navigation to a level that includes positioning capability. This would put an end to reliance on GPS because GPS is exposed to external effects such as spoofing and jamming, in other words to local distortions or interferences preventing the precise determination of a location. Consequently, autonomous systems will always require plausibility checks to verify the truth of data received. By the way, the AI computing operations performed in near-field navigation are highly suitable as a testbed for autonomous road traffic.

Aside from the technical challenges legal prerequisites have to be met for the utilization of autonomous boats. How is this area going to evolve?
Like in the case of self-driving cars, a lot of obstacles and hurdles have to be overcome on water as well, not just of a technical nature but also of an administrative and legal one. At the moment, for instance, it's not possible at all to use a watercraft that doesn't have a shipmaster. Authorities in Germany and the EU are working on that, but there's a wealth of issues affected by this. Basically, for instance: who is responsible and who is liable? Authorities are currently in the process of sifting through laws and regulations, which often contain hundreds of pages and countless sections, in search for areas that might be affected by autonomous shipping. Every shipmaster, for instance, is legally obligated to assist another ship in an emergency or when someone has gone overboard. The question is: what kind of future provisions can be made for this in the case of autonomous ships? However, the administrative side will resolve the required issues, while the technical side definitely poses the bigger challenge.

Projects like A-SWARM are intended to decongest road traffic

If you were to venture a look at the future, when might autonomous ships actually be used in regular service for hauling goods in big cities?
That's hard to say. Initial tests are already being run in ferry service or in maritime navigation around the world. But as I said before: inland navigation on variable and more challenging routes is clearly more complex. Things will probably take more time in this area. At the moment, the boats we're developing are on autonomy level 2. They're equipped with a path guidance assistance system, in other words they steer, accelerate and brake autonomously. In the next stage, they're supposed to recognize their surroundings, autonomously make decisions and perform evasion maneuvers, for example. This level 3 continues to require a possibility for manual intervention. The pursuit of full autonomy without any intervention options should also raise the question of whether or not such autonomy is really desired or if, for example, there should be a control center from which ships might be remote-controllable. Strictly from a technological perspective, a few more years will still pass before barges will be traveling autonomously from A to B or even determining their route themselves. I think that we're probably going to need at least ten more years before they can be deployed by covering all the bases, not just in terms of technological maturity but also regarding the evolution of regulations and infrastructure.

Captain Computer takes command

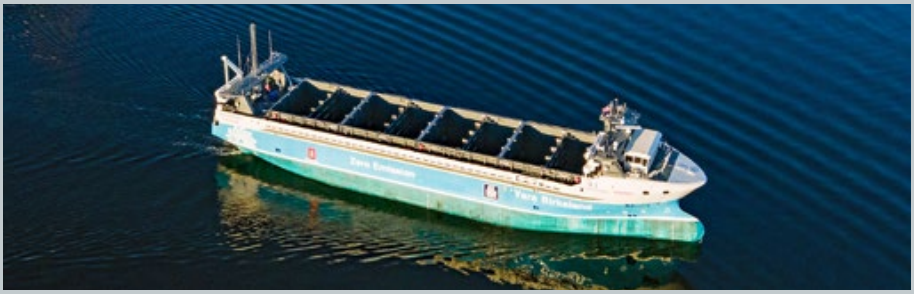
There are several examples of autonomous boat projects in progress worldwide. One of the most recent ones is the concept of a fully automatic laboratory vessel that accommodates a large number of autonomous vehicles on board and is planned to be deployed for marine research and other purposes. In addition, several cities are testing autonomous water taxi services. The changes planned for an automated future at the port of Singapore – which is the second-largest port in the world – are, no doubt, far more extensive. While other projects are still in experimental stages, the Norwegian container vessel "Yara Birkeland" has already entered service for further testing of autonomous operations, potentially replacing 40,000 truck shipments per year.

This robo-ship is planned to provide the basis for more than 50 other autonomous aircraft and vessels

The autonomous electric "Floating Platform" of the VAIARO project was designed for the port city of Kiel

Many ports (pictured here: Singapore) are planning to largely automate their operations – both onshore and offshore

The "Roboat" project in Amsterdam is being tested as a water taxi, garbage disposal vehicle and mobile bridge



Trial service: "Yara Birkeland" from Norway is the first autonomous and zero-emissions container ship worldwide

Obsessed by reduction

95 years ago, a young man from the United States made aviation history. In May 1927, Charles A. Lindbergh was the first pilot to cross the Atlantic in a solo non-stop flight. His success formula was to save weight. He even chose not to have a radio and parachute on board.

By Björn Carstens

At exactly 10.24 pm, on the night of May 21, 1927, the wheels of the "Spirit of St. Louis" touched down on the airfield of Le Bourget in Paris. Hundreds of thousands of French spectators had flocked to the airfield to cheer the new hero in aviation history. The crowd ran across the fences, flooded the landing strip, and soon the whole world would celebrate the success of pioneering aviator Charles Augustus Lindbergh, a 25-year-old Air Mail pilot and aerobatic aviator from the United States.

American President Calvin Coolidge even sent a battleship across the Atlantic to take the celebrated national hero home, where the biggest ticker-tape parade that New York City had ever seen awaited him. "Lucky Lindy," as Lindbergh was nicknamed, made it! Solo, non-stop across the Big Pond. From the Big Apple to the City of Love. But how did he make it? What was his success formula? To put it in a nutshell: It meant doing without any superfluous (in his view) bells and whistles! Even if that included a forward windshield.

Lindbergh's lesson was as valuable back then as it is today: maximum weight reduction to minimize energy consumption. Plus, he turned his approach into a win-win situation across the board: unlike his rivals (including aircraft manufacturer Anthony Fokker), who were able to invest more money in development projects, Lindbergh had to rely on the technical means of aircraft engineering that were available in the nineteen-twenties for his solo flight. And those means were rather limited. However, his simple-design single-engine "Spirit of St. Louis" fulfilled Lindbergh's maxim of "less is more" precisely: less aircraft weight for larger fuel tank volume, because he was clear about the fact that the leap across the Atlantic would require plenty of fuel.

Competition sparks Lindbergh's ambition

Let's start by looking a few years back: Charles Lindbergh is interested in technology even as a young boy. That includes aviation although he personally "had never been close enough to a plane to touch it," as he later recalls in his book "We." Those are the early years of aviation in which historic pioneering feats practically take place on a monthly basis. Shortly before Lindbergh is born

in 1901, German-American aviation pioneer Gustave Whitehead purportedly achieves the first powered flight in human history, even before the commonly known Wright brothers, who take off for their epochal first motorized flight in 1903 – barely two years after Lindbergh's birth. In 1916, a man named William Boeing launches the production of airplanes, and as early as in 1919, the British pairing of John Alcock and Arthur Whitten Brown complete the first non-stop transatlantic crossing between Newfoundland and Ireland in an aircraft.

That same year a Paris hotel owner named Raymond Orteig offers a prize of 25,000 dollars for the first non-stop flight between New York City and Paris, sparking Lindbergh's ambition. He starts studying mechanical engineering but quits after barely two years in favor of taking up training as a pilot and mechanic. He buys a Curtiss JN-4 Jenny and travels through the United States as an aerobatic aviator. Now serving in the military, he graduates from pilot training as best-in-class in 1924 and subsequently starts working as an Air Mail pilot.

Euphoria abounds, onlookers are flooding the airfield

A cockpit reduced to the essentials: no radio, no fuel gauge and a seat like grandma's rocking chair

2,330

kilograms (5,137 lbs.) was the takeoff weight of the "Spirit of St. Louis;" around 1,360 liters (359 gallons) of fuel and the required oil accounted for more than half of the total weight.

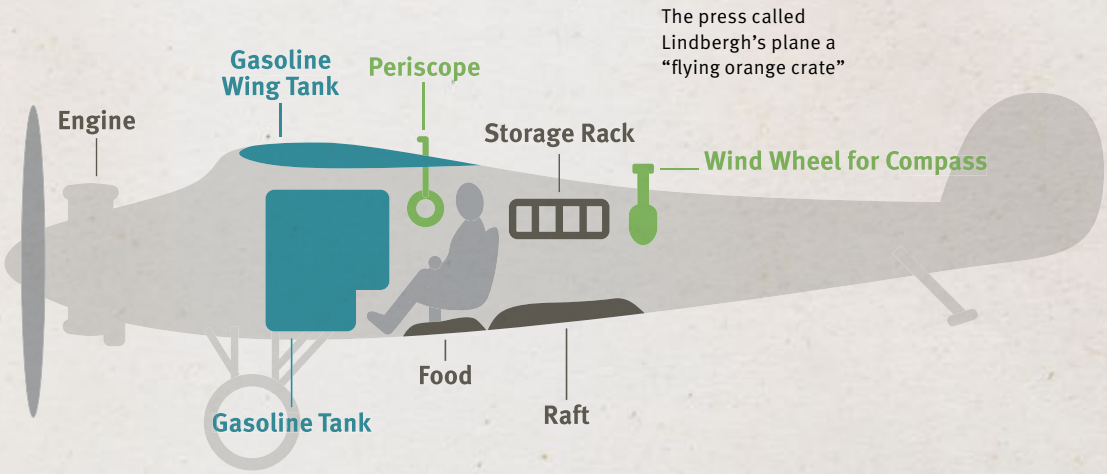
5,808.5

kilometers (3,609.2 miles) was the distance that Lindbergh covered from Roosevelt Field in New York to the Le Bourget airport in Paris.

33.5

hours was the duration of Lindbergh's solo flight that made him a national hero. A ticker-tape parade was held in his honor in New York City.

66 **people** crossed the Atlantic before Lindbergh, albeit none of them did so on solo flights.



The press called Lindbergh's plane a "flying orange crate"

By means of donations, a loan and all his savings he scrapes up enough money for commissioning Ryan Aeronautical, a smaller aircraft manufacturer based in San Diego, to build a single-engine airplane. Designing and building the "Spirit of St. Louis" takes only two months and by naming the aircraft after St. Louis Lindbergh expresses his gratitude to his investors who hail from the city on the Mississippi river. The aircraft consists of tubular steel and wood lined with fabric. Its technical equipment includes bearings from the subsequent Schaeffler brand FAG. There's only one engine on board because Lindbergh feels that the risk of engine failure increases with multiple engines.

Technical data of the "Spirit of St. Louis"

- **Length** 8.56 meters (28 feet)
- **Wing span** 14.03 meters (46 feet)
- **Height** 3.04 meters (10 feet)
- **Wing area** 29.64 m² (319 sq. ft.)
- **Empty weight** 974 kg (2,147 lbs.)
- **Takeoff weight** 2,330 kg (5,137 lbs.)
- **Top speed** 220 km/h (137 mph)
- **Engine** 9-cylinder Wright J-5C Whirlwind radial engine, 223 hp (166 kW)

No radio, no sextant

On May 20th, 1927, at 7.54 am, Lindbergh takes off for his record attempt, albeit not without having done a "thorough purging job" beforehand, in other words, relentlessly sorting out things. Lindbergh was obsessed with weight reduction, author Dan Hampton, a retired Air Force pilot, will subsequently explain in his report titled "The Flight: Charles Lindbergh's Daring and Immortal 1927 Transatlantic Crossing." To take the maximum amount of fuel on board, he not only enlarges the wings but even sacrifices presumably lightweight devices and potential life savers like a parachute, a fuel gauge, a radio and a sextant for navigation. Instead, he flies only with his wristwatch, maps and a compass. Even so, he reaches Ireland only a few miles off the planned course.

Neither does the "Spirit of St. Louis" have a forward windshield, because what for? An additional fuel tank installed in the cockpit obstructs his vision anyway. Only a small periscope he developed provides him with a forward view. Instead of in a plump, spring-mounted pilot's seat, he spends nearly 34 hours sitting in a lightweight willow basked. He even leaves an additional set of clothes for the potential victory celebration at home and just a single bottle of water is planned to quench his thirst. He forgets to eat the few sandwiches he's taken along due to the mental strain he's under during his daring adventure because that is not without complications.

According to Hampton's account, Lindbergh at times is flying only a few meters above the waves of the Atlantic in order to circumvent heavy snow

What else you should know about Charles Lindbergh:

- In 1930, Lindbergh's sister-in-law succumbed to heart disease. Lindbergh was surprised that it wasn't possible to save his relative by an artificial heart. He turned to Alexis Carrel, a laureate of the Nobel Prize in Medicine. Together, they performed research to build a device enabling a heart to be kept alive in a laboratory for several weeks. Lindbergh's pump was subsequently developed further by other scientists, which ultimately led to the development of the first heart-lung machine.
- Lindbergh wrote several books about his flight including "The Spirit of St. Louis" published in 1953 for which he was awarded the Pulitzer Prize in 1954.
- As a spokesman of the America First Committee (AFC) – a movement aiming to prevent the United States from entering the Second World War – Lindbergh held a spectacular speech in 1941, after which he was called an anti-Semite. In his book "The Double Life of Charles A. Lindbergh," Lindbergh's biographer Rudolf Schröck subsequently documented that the "Angel of the Skies" was neither a Nazi sympathizer nor an anti-Semite. Following the Japanese attack on Pearl Harbor, Lindbergh even flew 50 dangerous bomber missions. Schröck: "Does a friend of fascists act in this way?"
- Lindbergh and his wife, Anne Spencer Morrow, had six children. On March 1, 1932, their son Charles III was kidnapped and subsequently murdered. German immigrant Bruno Hauptmann was convicted of this crime and executed in 1936. Doubts about his guilt still exist. The killing of the Lindbergh baby in spite of the payment of ransom inspired Agatha Christie to write her novel "Murder on the Orient Express" that was published in 1934.

"If one took no chances, one would not fly at all. Safety lies in the judgment of the chances one takes."

Charles A. Lindbergh
(*1902 in Detroit; †1974 in Hawaii)

storms. His carburetor-heater that's supposed to prevent engine icing in wet and cold conditions is permanently set to the "on" position. After 17 hours, he even falls asleep and only wakes up again by ocean spray entering through the side window. It's actually hard to believe that he was even able to fall asleep, considering the somewhat jittery performance of his "Spirit of St. Louis" that's difficult to control due to necessary modifications at the rear.

But there are more things that cause problems for Lindbergh such as hallucinations. After 22 hours of non-stop flying, he "sees mirages." Lindbergh only starts seeing reality again when he starts seeing real land: the south-western coast of Ireland. Across Southern England and Normandy, he flies to Paris where, flooded with euphoria, he flies an extra circle around the well-lit Eiffel Tower. Lindbergh allegedly even considered flying on to Rome because there was still enough fuel in the tank but, fortunately, chose not to do so. Who knows if he would have received an equally enthusiastic welcome in Italy as he did in Paris?

3 questions for …

… Armin Necker, Managing Director of Schaeffler Aerospace Germany – a unit that was established several decades after Lindbergh's feat and has since evolved into an innovative partner of the aerospace industry. Its worldwide customer base includes all renowned manufacturers of engines, helicopters and space systems. An example that proves Schaeffler's strong market position is the 40-year collaboration with Rolls-Royce, one of the leading engine manufacturers. The two partners most recently agreed to closely collaborate for another twelve years, starting in 2024.

What makes the partnership with Rolls-Royce a special one?
Armin Necker: A commitment lasting this long is unusual anywhere, not just in the aviation industry. It's a success story that's based on the trusting collaboration in recent years and that's underpinned by the engagement of the employees in both companies. For example, in 2021, Schaeffler was included in the "Rolls-Royce High Performance Supplier Group," so joining the exclusive ranks of Rolls-Royce's best suppliers and partners. In addition, RollsRoyce recognized Schaeffler with the "Best Practice Award" for exceptional performance in the UltraFan project, the latest development in engine technology geared to the future requirements of the aviation industry. Together, we will continue to pursue our ambitious goals for greater sustainability in aviation.

What is the collaboration focused on?
On rolling bearing systems for aircraft engines in the growth markets of business jet aircraft and widebody aircraft. Rolls-Royce thereby secures its supply chain for rolling bearings until 2035 with reliable products and leading manufacturing technologies. In turn, Schaeffler is taking an important step forward in its growth initiative by supporting Rolls-Royce in the long run with innovative solutions, research and development excellence as well as state-of-the-art manufacturing. Schaeffler will be responsible for 100 percent of Rolls-Royce's supply volume in Europe.

One of the next goals in the aviation industry is zero emissions …
That's correct. That's why, in addition to our 12-year contract, our agreement with Rolls-Royce encompasses intensified MRO (Maintenance, Repair & Overhaul) activities. In this context, the refurbishment of bearings makes a key contribution to extending product lifecycles as well as reducing CO_2 emissions and thus saving considerable amounts of resources. Both Rolls-Royce and Schaeffler are among the UN's 50 sustainability & climate leaders. Moreover, our solutions make an important contribution to achieving the goal of zero emissions in the aviation industry.

Shed your corset and mount a bike

Ever since it was invented the bicycle has reduced the way people get from A to B, freeing up time for other things. That's why this technological innovation not only revolutionized mobility but also massively drove the emancipation of women.

By Björn Carstens

"Improper," "indecent," utterly "vulgar" – in the 19th century, bike-riding women were facing icy-cold headwinds. If they were merely the targets of verbal abuse, they were lucky. "Bus drivers were not above flicking at me with the whip and cabmen thought it fun to converge upon me from behind," suffragist Helena Swanwick reported at the end of the 19th century, as Hannah Ross wrote in her book "Revolutions – How Women Changed the World on Two Wheels published in 2021 (see info box on page 35). Such adversity, though, did not deter Swanwick, a London women's rights activist, from cycling because "her life had been greatly enlarged by the activity." Many women back in those days felt exactly the same gain in quality of life. The bicycle as an emancipation booster!

Ride a bike and gain time

On bicycles, women symbolically rode toward freedom, enlarging their range of motion that previously had been restricted to their obligations at home. Bicycles made it possible for women to save time that they were now able to use for attending to personal needs such as education. Not least, though, cycling was also a symbol of protest against male guardianship because many men did not take kindly to women shedding their domestic shackles, fearing that they would literally ride away from them.

Incredible, but true: The arguments to discourage women from cycling which the prevailing patriarchy was using at that time could not be topped in terms of absurdity. The so-called bicycle face was publicized as a serious threat to female health in the late 19th century. Women spending too much time in a bicycle seat would have to expect an irreversible disfigurement of their face. Ross quotes a female doctor talking about a cycling "patient": "The haze, the elusiveness, the subtle suggestion of the face, are gone; it is the landscape without atmosphere."

Dr. Martin Mendelsohn, a Berlin university professor, didn't even shy away from touting sordid sexual theories that are utterly ludicrous from today's perspective but were meant to be a serious argument around the turn of the century. Other times, other manners!

However, the campaigners against female cyclists included some women as well. In 1896, for instance, Charlotte Smith of the Women's Rescue League petitioned the United States Congress to prohibit women from riding bicycles, calling bikes "the devil's advance agent morally and physically." Even more bizarre was her claim that cycling turned respectable women into prostitutes.

However, that and other forms of hostility achieved exactly the opposite of what was intended. The discourse that was taking place in the general public actually inspired many women to develop an identity as a self-confident cyclist.

This wood engraving shows that bicycle races with female participation existed in France as far back as in 1868

The history of women in bicycle racing

Amazingly, cycling races for women were established in Belgium and France as early as in the middle of the 19th century. **In 1868, the first known all-female bicycle race took place in Bordeaux, with four participants.** Officially, though, bicycle racing for women was established much later, in the nineteen-fifties. Most races were initially limited to national levels. 1958 was the first year in which women competed in world championships for bicycle road racing. The Olympics began to admit pedaling females to road cycling events in 1984, followed by track cycling in 1988 and, finally, mountain bike and BMX racing in 2008.

> **“The bicycle made a greater contribution to the emancipation of women from upper echelons of society than all the efforts of the women’s movement combined.”**
>
> **Rosa Mayreder, Austrian writer and women’s rights activist (1858–1938)**

Matching the political mainstream at the time, “the discovery of the bicycle for the female coincided with the emancipation history of women,” says Dr. Gudrun Maierhof, a professor of methodological competence and history of social work at Frankfurt University of Applied Sciences.

Resistance and rebellion

Women in Germany initially found themselves exposed to aversion by the world of men as well. Amelie Rother, a journalist, was unwilling to accept that. In Berlin, she was one of the first female cyclists, tired of the homebody existence of the typical big-city woman, and so became an icon of female mobility. Accompanied by hooting and ranting, she rode through the capital city’s streets making the case for more practical clothing while pedaling: “The first thing that belongs into the junk room is the corset. How should the unfortunate chest become wider when it’s stuck in steel armor!”

From head to toe, the dictates of fashion for females impeded pedaling. The long, multi-layered skirts made it difficult to get on and off a bike as well as riding it. Consequently, skirts were initially shortened and subsequently replaced by more comfortable models underneath which women would wear wide-leg cycling bloomers. In her book, Ross describes that the bicycle industry gradually began to notice that this new generation of self-confident women was decisively contributing to revenue.

Advertising campaigns were launched, celebrating strong women in “reform clothing.” Hannah Ross cites a salient example: “Adverts for ‘Elliman’s Universal Embrocation Ointment’ muscle rub featured athletic women in knickerbockers unashamedly speeding ahead of male cyclists, including one showing a male rider taking a tumble as a woman pedals past.”

Fascinated, the author tells stories about the first female endurance riders: of Fanny Bullock Workman, who in the eighteen-nineties rode across Europe and a large part of South-East Asia in long skirts and with loads of luggage. Or of Annie Kopchovsky, the first woman to have cycled around the world. Considering that the Latvian immigrant had learned how to ride a bike in Boston just a few weeks before her departure, that’s a really remarkable feat. All of these trailblazers encouraged other women to mount bicycles.

In terms of technology, the invention of the curved top tube in 1885 marked an incisive turning point that increasingly caused the bicycle to evolve into

E-bike revolution

Schaeffler is not only an automotive and industrial supplier, but the company is a player in the field of micro-mobility as well. Its novel **Free Drive system for electric cargo bikes** does not require any mechanical drive components such as a chain or belt. Similar to a dynamo, the system uses the pedaling power as input to generate electricity, which is directly forwarded to wheel hub motors via a mechanical unit. Surplus energy is stored in the battery. The system delivers 250 watts of continuous output that’s fit for pedelecs and enables a speed of 25 kilometers per hour (15 miles per hour).

More information can be found here

a must-have accessory in the ladies' world. It and the subsequently developed step-through frame made bicycles even more accessible to women.

Trailblazing female cyclists conquer the world

Toward the end of the 19th century bicycles experienced their first true boom, even though, initially, cycling still tended to be a pastime enjoyed by members of the middle class. A bicycle was something you had to be able to afford. Prices went down and bikes became a means of mass transportation only around the turn of the century when progressive industrialization enabled mass production. In the nineteen-twenties, droves of female workers would pedal to the factories in the morning and from the nineteen-fifties onward, if not earlier, cycling had become a normal activity for both genders.

However, not all regions in the world were hit by the bike-driven wave of emancipation. In Iran and Afghanistan, women are even completely prohibited from riding bikes in public. In staunchly conservative Saudi Arabia, they've been allowed to use bicycles only since 2013 – subject to severe restrictions and only if accompanied by a male. That year also saw the release of "Wadjda," a movie made by female Saudi Arabian writer and director Haifaa al-Mansour. It tells the story of a young girl dreaming of owning a bicycle.

Khothalang Leuta is a heroine on two wheels in the African country from which she hails. In Lesotho, women do not usually ride bicycles at all

"Revolutions – How Women Changed the World on Two Wheels"

Author Hannah Ross takes her readers on a journey starting with the beginnings of cycling in the 19th century, when women had to overcome incredible resistance, to the present age. The bicycle as a true "feminist freedom machine."

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That's something many girls and women in Africa can only dream of as well. Numerous initiatives worldwide are aiming to change that. For instance, since it was formed in 2005, World Bicycle Relief has delivered more than 635,000 bicycles to remote regions so that women there can get from A to B faster and use the gain in time for better access to education, healthcare and income opportunities.

The story of Khothalang Leuta from Lesotho, who used to be a shy girl living in poverty, is a deeply moving one. On a BMX track in her home town of Roma that was built with donations, Khothalang became part of a cultural transformation because women do not usually ride bicycles in Lesotho. By now, the 18-year-old is celebrating international success and has paved the way for other girls to venture out onto the race track. "I've become an inspiration to young girls here. It's amazing, and I just hope that I can do my best. I know I can," she said just before traveling to Portugal to participate in the 2021 Red Bull UCI Pump Track World Championships.

Think Green

Acting sustainably implies a lot more than reducing CO_2 – increasing scarcity of resources motivates rethinking processes on many levels.

Energy storage from the laboratory

Wouldn't it be great if the summer heat could be stored and retrieved again for heating in winter? Or if the heat generated in industrial processes could be captured in order to use it at another place or time? Exactly that is what scientists are working on around the world. Researchers at TU Vienna have now obtained a patent for a process in which boric acid is converted into oily boronic oxide with a high energy content inside a reactor under application of heat. The process releases water. **By adding water again to the boronic oxide that can be stored in tanks for months the chemical reaction takes place in reverse and the chemically stored thermal energy (70 to 200 °C / 158 to 392 °F) is released again.** Laboratory tests have proven that this process loop can be repeated several times. In the next stage, the Vienna scientists, together with partners from industry, are planning to find out how the reactor technology can be scaled up to industrial production – and the heat of the summer will really warm the winter months.

CO_2 filter

Climate researchers are in agreement that reducing CO_2 emissions just by no longer burning fossil raw materials will not be enough. **It's assumed that climate change can only be stopped by additionally removing CO_2 from the atmosphere** and initial plants designed to do so are already in operation. However, the most powerful one of them removes merely 4,000 metric tons (4,409 short tons) per year. That's not much considering annual global CO_2 emissions of 30 billion metric tons (33 billion short tons). Scientists at the Tokyo Metropolitan University have now developed a liquid filter based on isophorone diamine, or IPDA for short. **The filter not only works fast but also with 99-percent effectiveness,** at least, according to the researchers. The filtering liquid can then be stored together with bound climate gas. Or the CO_2 is separated again in a controlled process and fed into manufacturing processes as a raw material. The purged IPDA could subsequently be used again as a filter.

"Before you change the world, it might be more important not to destroy it"

Paul Claudel (1868–1955), French poet and dramatist

43 million

metric tons (47 short tons) of end-of-life wind turbine rotor blade waste may be generated by 2050, according to a forecast by the University of Cambridge. ZEBRA (Zero wastEBlade ReseArch), an international consortium of companies, wants to counteract that development and recently presented a 62-meter (203-foot) rotor blade made of fiber glass reinforced thermoplastics made by GE. **Thanks to a new depolymerization method it's not only 100% recyclable** but also delivers similar performance as current rotor blades. Sounds like "Winds of Change."

Turbo plastics eater

Up to now, the LCC enzyme discovered in Japan in 2012 was regarded as the champion among PET decomposers. In the space of 16 hours, the biocatalyst broke down 45 percent of the "indigestible" plastic material from which plastic bottles, fruit bowls and wrap are made. **Now, researchers at the University of Leipzig fielded an enzyme named PHL7 in the decomposition race against LCC.** The result was that PHL7 was twice as fast, i.e., achieving a 90-percent decomposition rate within 16 hours. The decomposed components can be used for making new PET – of better quality than the materials produced using the conventional, energy-hogging thermal technologies.

Dr. Christian Sonnendecker and his team discovered the decomposer enzyme PHL7 that degrades PET plastics at a record pace

More about "Bioengineering" at schaeffler-tomorrow.com

All-around green

Climate-neutral by 20XX ... many companies have set themselves ambitious sustainability goals, intend to adopt resource-saving practices and to reduce emissions. But that won't be enough if the partners in their supply chains don't follow suit. Here's an assessment of the current state in individual areas.

The source of a saving grace

By now, there's hardly a country that doesn't drive the expansion of renewable energies. These efforts have been effective: between 2014 and 2020, the wind power capacity installed worldwide has doubled, according to the WWF, and that of photovoltaics has nearly quadrupled. **In 2020, 70 percent of the new investments in power generation systems went to those using renewable energy sources.** While the fossil age isn't over yet all indications clearly point to a departure from it. Companies around the globe have long come to recognize that – not just for the purpose of polishing their image. Numerous automakers have established green factories using green electricity. For instance, Volvo's automotive plant in Chengdu, China, operates with 100 percent renewable energies. BMW even covers its worldwide demand with green electricity at a level of 100 percent and at Schaeffler, **all European production sites have been obtaining 100 percent of their purchased electricity from renewable sources since 2021. By 2024, that's planned to be the case for all production sites worldwide.** The world's tech giants have begun to embark on the same journey. More and more companies in Silicon Valley are entering into power purchase agreements (PPAs) providing for long-term purchases of green electricity for an agreed fixed price. For renewable energy sources, PPAs pave the way for long-awaited profitability and for corporations like Amazon they pave the way for a green conscience. So, what are the giant petroleum corporations doing in view of these developments? They're rethinking their business as well. BP is planning to increase its investments in renewable energies to five billion dollars annually by 2030 and its production of renewable energies to 50 GW, while the production of oil is supposed to decrease by 40 percent in the next ten years.

Klaus Rosenfeld, Chief Executive Officer at Schaeffler: "By 2040, we intend to become a climate-neutral company. That applies to the reduction of the emissions generated within our supply chain as well as to the electricity we purchase from renewable power providers. Since 2021, Schaeffler has been purchasing 100 percent of the electricity at its European production sites from renewable sources. As part of our energy efficiency program, we have implemented more than 200 actions since 2020 that, starting in 2022, will result in cumulative annual savings of around 47 gigawatt hours. This amount of energy roughly corresponds to the annual electricity requirement of 15,000 two-person households in Germany."

This is where green electricity is produced in-house

For Schaeffler, the new e-mobility plant in Szombathely, Hungary, marks a milestone achievement in terms of a sustainable manufacturing facility that's fit for the future.

- CO_2 neutral factory in an area of 15,000 square meters (3,7 acres)
- Purchasing of solar energy results in annual reductions of around 2,700 metric tons (3,000 short tons) of CO_2 when the plant operates at full capacity
- An in-house photovoltaic system on the factory's rooftop reduces CO_2 emissions by 179 metric tons (197 short tons) per year
- Recycling of purified waste water
- Rain water retention basin irrigates green and outdoor areas
- High energy efficiency due to use of heat pumps and heat recovery, plus smart heating and cooling management
- Low electric power consumption due to intelligently coordinated LED lighting

Who, where and how much?

Green supply chains are a complex subject in view of global, interconnected value chains and networks. Of what benefit to the climate are green factories in environmentally optimized, highly developed economies **if the purchased parts they use are produced with electric energy from brown coal power plants?** CO_2 emissions are generated in all upstream and downstream production stages. Experts classify these by Scopes: Scope 1 encompasses the direct emissions from a company's activities, Scope 2 the indirect emissions generated in the production of the energies used by the company (e.g., in coal-fired power plants), Scope 3 includes all other emissions of the upstream and downstream supply chains. According to the "Net-Zero Challenge: The supply chain opportunity" study of the Boston Consulting Group and the World Economic Forum, around 80 percent of the CO_2 emissions – depending on the sector – fall within the responsibility of the supply chain and therefore belong to Scope 3. In the automotive industry, that's even 87 percent, so there's massive savings potential in this sector. **Since climate protection is increasingly driven by a holistic approach the pressure exerted on suppliers along the supply chains has been increasing.** Sustainability and compliance ratings are becoming equally important selection criteria as price or quality. When a mandatory reduction of the carbon footprint or even carbon neutrality become a standard requirement the selection of potential suppliers might drop dramatically. However, practically all the key players are faced with the same problem of obtaining valid data that tells them how much CO_2 is contained in which component. At the most recent World Climate Conference, the open network Catena-X (previously the Automotive Alliance) presented a proposal of how such data exchange could work. At the push of a button, manufacturers might soon be able to determine not only the costs of a screw but also the CO_2 emissions caused during the lifecycle of this part.

2040

is the year that Schaeffler has targeted for achieving **climate neutrality along the company's entire supply chain (Scopes 1 to 3, upstream).** The company intends to implement this goal in all of its own production sites by 2030 (Scopes 1 and 2). **By 2025, three quarters of the in-house production emissions** are planned to be reduced and by 2030, 25 percent of the emissions emanating from upstream products and raw materials in the supply chain.

Achim Döll, Purchasing & Supply Chain Management Sustainability at Schaeffler: "The consequences of our actions and the effects on our planet they entail were known as far back as in the 1980s. However, the resulting pressure to take action promoting sustainability across all value chains was not recognized or acutely perceived. Consequently, the best time for action would have been 40 years ago, the second-best time is now – which makes the challenge all the greater. Beyond the emission hotspots that have been identified in the supply chain in conjunction with the purchase of steel, aluminum and plastics, suppliers of all commodity groups have to contribute to CO_2 reductions. To emphasize that requirement, the CO_2 emissions are included in our procurement policies based on reliable CO_2 data and calculations of our suppliers that we insist on receiving. That puts us in a position to quantify and control the CO_2 impact of our value chains. In addition, we're already calling on our suppliers today to implement CO_2 reduction measures and to provide related data. Moreover, the communication of valid CO_2 data is already taken into account in our procurement decisions. That's the lynchpin and the expectation of our customers as well as our own standard. A successful transformation toward greater sustainability can only be achieved by working together in a spirit of partnership across the entire value chain."

Desirable repeat performance

The future belongs to a circular economy and does so with good reason. The growth of the world economy in the past 50 years has led to a massive increase in global resource consumption from 25 to more than 100 billion metric tons (28 to more than 110 billion short tons) per year. In view of climate change, this number alone illustrates that the days of unbridled consumption are over. Even before production starts, it must be clear what's supposed to happen at the end of a product's lifecycle other than just disposing of it on a sanitary landfill. Although a few things are already happening in terms of a circular economy, which in recent years has grown faster than the world market as a whole, there's still massive untapped potential. In 2021, **only 8.6 percent of the materials utilized worldwide were recycled for use as secondary raw materials,** according to the "Circularity Gap Report." The Netherlands is aiming to prove that clearly more is possible. The kingdom, which is in position eleven of the international per capita GDP ranking, is planning to fully convert its economy to reusable materials by 2050. Automaker BMW recently presented a good example showing that even complex products can be created based on a circular economy: 100 percent of the iVision Circular concept car was produced from recycled material and renewable raw materials. Swedish battery manufacturer Northvolt is developing a recycling method for EV traction batteries that, according to the company, enables up to 95 percent of the metals (nickel, manganese, cobalt and lithium) contained in a battery to be recovered at a level of purity equaling that of new materials. Statistics in a study of Fraunhofer Institute for Environmental, Safety and Energy Technology commissioned by Alba, one of the ten global leaders in the recycling sector, illustrate what positive effects consistent recycling can have on the environment. **By recycling 4.8 million metric tons (5.3 million short tons) of reusable materials in 2020 Alba reduced harmful greenhouse gas emissions by around 3.5 million metric tons** (3.9 million short tons, notably, the climate-compatible annual budget of 1.5 million people) and 28.8 million metric tons (31.7 short tons) of raw materials such as crude oil and iron ore.

Michael Lehanka, Sustainability & Projects Specialist at Schaeffler:
"Circular economy instruments provide Schaeffler with opportunities to support a sustainable and future-proof transformation effort in the spirit of active climate protection. With a long history of rebuilding and reconditioning industrial bearings, Schaeffler in recent years has developed a business segment that's consistently being expanded. In 2021, the 100-percent return service for axlebox bearings was recognized with the Railsponsible Supplier Award in the 'Climate Change and Circular Economy' category. However, a circular economy has clearly been gaining importance at Schaeffler in other areas as well: Schaeffler, for instance, minimizes risks on the supply side relating to secondary materials, recyclable design and refurbishing/remanufacturing and additionally develops new business segments or expands existing ones. With regard to growing resource requirements and more extensive legal frameworks, Schaeffler pursues the aim of driving a circular economy with strong partnerships."

Global material

A modern world without steel? That's hardly conceivable. **Almost 1.9 billion metric tons (2.1 million short tons) of new steel were produced worldwide** just in 2021 – enough for erecting 260,000 Eiffel towers. This entails a major problem: even though the required production energy has been cut in half in the past 50 years CO_2 emissions per ton of produced steel still amount to two metric tons (2.2 short tons). In total, iron and steel production currently still account for eleven percent of worldwide CO_2 emissions. That has to and is intended to change: the Paris Climate Agreement provides for an 80-percent reduction of sector-related CO_2 emissions by 2050 compared to 1990. **At the same time, experts expect another 60-percent increase of the global demand for steel by 2050.** Consequently, these emission goals are more than ambitious and can be achieved only by fundamental changes in the steel production processes. Clearly, this issue will not be resolved by a single solution but requires a combination of new ideas to tackle this mammoth task. Relevant approaches exist in the areas of CO_2 storage and use, the utilization of biomass, electrolysis or hydrogen in the oxygen reduction process of iron ore, in the transformation toward renewable energies for process heat or in the consistent increase of the recycling rate that's already high at this point in time. Swedish startup H2 Green Steel (H2GS) is planning to build an all-new greenfield steel mill in the north of the country by 2025 – the first one in Europe in about 40 years – in which many ideas for the production of "green" steel will be implemented, including integrated and digital manufacturing. Above all, H2GS intends to operate without fossil sources altogether. Instead, the young company relies on wind and hydropower, both of which are abundant in northern Sweden, to produce electricity and hydrogen for manufacturing steel. By 2030, H2GS is planning to produce five million metric tons (5.5 million short tons) of nearly CO_2-neutral steel per year for buyers such as various automakers and other corporations in the automotive environment, including the Schaeffler Group. In addition to newcomers like H2GS, incumbent corporations such as German steel giants Salzgitter and Thyssenkrupp as well as world market leader ArcelorMittal **have launched pioneering green steel projects,** not least because customers insist on receiving green steel enabling them to decarbonize their own products.

630

million metric tons (695 million short tons) of steel are recycled per year, which makes steel the material with the highest recycling rate in the world.

Source: Worldsteel Association

Martin Santer, Head of Production Material Purchasing at Schaeffler: "Starting in 2025, Schaeffler is going to purchase 100,000 metric tons (110,000 short tons) of strip steel from H2GS in Sweden. This purchasing agreement will enable us to reduce our annual CO_2 emissions by 200,000 metric tons (220,000 short tons). However, availability will be one of the main challenges on the road toward climate-neutral steel. Schaeffler currently requires 1.8 million metric tons (2 million short tons) per year, while the demand for and requirements made on steel keep increasing. At the end of 2020, we established a Task Force Green Steel that addresses the challenges in the company in a focused manner. We're looking at green steel on several levels, including market analyses, strategy determination, reporting and communication. With strategic partnerships, we contribute to the transformation in steel production. Here's a case in point: we return our 600,000 metric tons (660,000 short tons) of annual steel scrap into the scrap loop and make them available to the steel mills for the recycling process."

The bill, please!

Energy transition is a great thing. While a global majority shares this view, the pace and means of pursuing this transformation are equally debated as its economic consequences. On the latter issue, a study, the first joint one conducted by the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA), analyzed the financial effort that achievement of the Paris climate goals by 2050 would take. The analysis came up with a required **investment of around 29 trillion U.S. dollars to transform the worldwide energy sector within that period of time.** On the one hand, that's a huge sum but on the other hand it accounts for only 0.4 percent of the total global economic output, according to IRENA. Furthermore, the capital expenditures in the renewable energies sector would be contrasted by a growth impulse of 0.8 percent to the global economy. The study concludes that energy transition is affordable, especially since the construction of new solar power and wind power systems is becoming increasingly cheaper. In the solar power sector, costs dropped by 80 percent between 2010 and 2020, according to IRENA, and in the wind power sector by roughly 30 percent. In many markets today, the study says, the electricity from renewable sources is already cheaper than the one from fossil sources. Moreover, the World Economic Forum in its "Global Risks Report 2022" emphasized that failure to achieve the climate goals would cause enormous costs in the range of 4 to 18 percent of the gross domestic product, depending on the region. In view of these numbers, it's hardly surprising that the financial markets' response to energy transition has been positive too: while the "S&P 500 Energy Index" dropped by four percent between May 2016 and May 2021, the "S&P Global Clean Energy Index" went up by 22 percent. However, the above percentages are based on a global view. In individual countries and regions, energy transition may **definitely leave painful incisions, especially where the extracting industries such as oil, gas and coal account for a major share in economic output.** In this context, the German Institute for International and Security Affairs (SWP) says, "To the extent that energy supply increasingly becomes a technology- and innovation-driven process, it causes a shift in the participation of countries in the world trade and energy system. Gains in economic welfare are thus recalibrated, which has fundamental consequences for the world economic system." How do affected countries cope with the fact that their fossil resources will have to remain in the ground in the wake of decarbonization? How will the community of nations respond to these changing conditions? Questions like these have to be answered as well. Moreover, it must be prevented that individual countries, segments of the population or sectors suffer a disproportionately high burden due to energy transition or that energy, at least in the short term, becomes unaffordable.

Marcus Hoffmann, Head of Sustainability Strategy and Projects at Schaeffler: "The transformation toward sustainable resource management will be successful when ecology, social affairs and economy are harmonized. That's how we define sustainable action at Schaeffler. We believe that the sustainable alignment of our own value chain – that is our supply chain, our in-house production and our product portfolio – is essential to ensuring our economic success going forward. With our expertise and products, for instance in electric mobility and wind power, we're already supporting the energy and mobility transition effort today. They're important pillars on the pathway toward achieving the Paris climate goals. We make processes more efficient and ultimately more competitive and support our customers in achieving their goals and global transformation as a whole in this way. These processes require end-to-end and, preferably, circular thinking – and those are points of engagement for Schaeffler's sustainability roadmap as well: areas like a circular economy, energy efficiency and in-house generation of renewable energies are just some of the building blocks that clearly enhance our sustainability performance along the value chain while making economic sense as well."

Less is increasingly turning into more

Every year, Earth Overshoot Day serves as a warning. It's the day of the year on which the usable resources of our planet have been used up and we start living at the expense of future generations for the rest of that year. In 1970, Earth Overshoot Day was December 29; in 2000, it was September 23; and in 2022, it's an even earlier date in the summer. This trend clearly shows that it's high time we did a better job of managing our resources. **Conventional business models have to be reimagined to prevent that reduced consumption leads to inferior products or impaired quality of life.** That's what the Association of German Engineers (VDI) says too. Good examples of reimagining conventional business models can be found in the mobility sharing sector, where a large number of users share vehicles, be it cars, scooters or bicycles. In the tools and recreational products markets, rental offerings are spreading as well. In the United States, the number of rental product users nearly doubled from 44.8 to 86.5 million between 2016 and 2021. The smartphone as a case in point emphasizes that there's huge potential for resource conversation in the manufacturing sector as well. According to an analysis by Avfall Sverige, the Swedish waste management and recycling association, **almost**

74 million

metric tons (82 million short tons) of electronic waste might be generated by 2030, according to the Global E-waste Monitor, compared to 53.6 million metric tons (59 million short tons) in 2019. A major reason is the fact that **instead of being repaired many products are disposed of as waste** and have to be replaced by the production of new ones.

6 percent

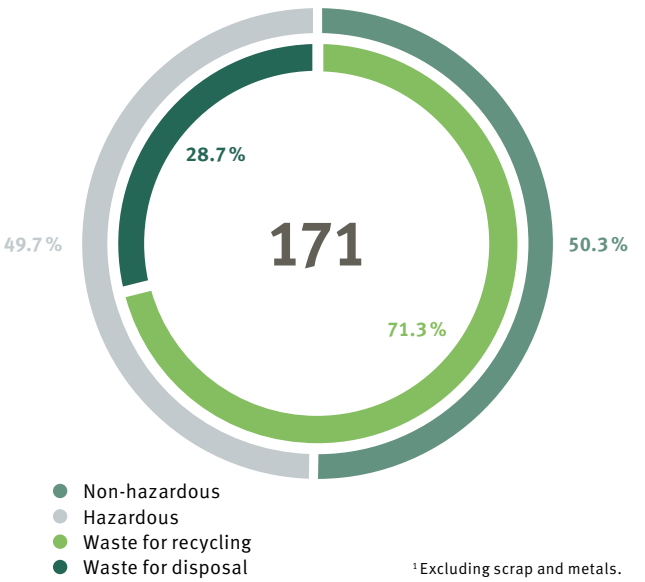
less CO_2 was emitted by the Schaeffler Group worldwide in 2021 compared to the prior year. This translates into 703,000 (774,000) instead of 744,000 metric tons (820,000 short tons) and was achieved **mainly by the utilization of green electricity.**

7 Schaeffler sites

worldwide are already **recycling 100 percent of their production waste.** The mid-term goal is to increase the recycling rate to a level where no production waste whatsoever has to be disposed of in landfills. Every manufacturing location works with the same waste database for the purposes of worldwide reporting and documentation.

Waste generated by the Schaeffler Group

in thousand metric tons[1]



[1] Excluding scrap and metals.

86 kilograms (190 lbs.) of waste are generated in the production of an average smartphone weighing 200 grams (7.1 oz). This example of inefficient resource utilization illustrates the urgency of further optimizing design and manufacturing processes using digitalization and technological innovations such as additive manufacturing (3D printing). The utilization of materials delivering higher performance helps conserve resources too – for instance due to longer lifecycles. In addition to reduced material consumption, the **reconditioning instead of the replacement of wearing parts** – as Schaeffler knows from experience in the field of axlebox bearings in the rail sector – can also reduce CO_2 emissions as well as energy and water consumption by far more than 90 percent. The list of other resource conservation actions is long and covers all sectors and all stations of the supply chain. This nurtures the hope that future generations won't have to worry about an Earth Overshoot Day anymore.

Roland Kuhla, Head of Energy Management at Schaeffler: "At Schaeffler, we've defined eight central sustainability goals for us to achieve the Paris climate goals. The implementation of energy efficiency actions by 2024 is one of our sustainability goals: from 2025 on, we plan to realize cumulative annual energy efficiency gains of 100 gigawatt hours (GWh) in this way. This energy efficiency program is based on our worldwide ISO50001 energy management system that has been in place for many years and ensures the continuous optimization of the energy consumption at Schaeffler's sites. To achieve a sustainable enhancement of energy efficiency, we use a wide variety of technologies: from optimized application of cooling lubricants in machining processes to heat recovery and efficient cooling systems through to smart facility and process control technologies. All plants of the Schaeffler Group develop innovative solutions locally that are scaled to specific conditions in the global network of our locations."

Talking about sustainability

About highlights of the reporting year, current challenges, and how the Schaeffler Group is responding to them: Corinna Schittenhelm, Member of the Executive Board responsible for Human Resources and responsible for sustainability, and Thomas Fußhöller, Head of Sustainability, in conversation.

Corinna Schittenhelm: *What was your personal sustainability highlight in 2021?*

Thomas Fußhöller: *My personal highlight was the fact that Schaeffler was chosen as one of the "50 Sustainability & Climate Leaders" by the United Nations. That is a fantastic accolade for Schaeffler. It shows that we are on the right track with the topics we are tackling. But of course this also requires us to consistently continue this path in the future.*

How do you involve your employees in the transformation to a climate-neutral company?

"Decarbonizing the Schaeffler Group and its supply chain is our top priority. Therefore, we have set ourselves specific reduction targets"

Thomas Fußhöller

Strong climate commitment of Schaeffler employees

Schaeffler has set itself ambitious corporate-wide climate goals. Achieving them requires engagement on all levels. That's why the Group organized a **Climate Action Day** in June with the objective of intensifying awareness of climate protection once more across the entire Schaeffler world. On that day, some 83,000 employees at all 200 locations in more than 50 countries spent 90 minutes focusing exclusively on this specific topic: **Some 9,000 leaders, who had received extensive advance training, and their teams developed ideas for reducing CO_2 emissions in their respective areas.** In addition, all employees were encouraged to use the most climate-friendly means of transportation to and from work – either on foot, by bike, bus or train or by using an electric car. Schaeffler converts the action points scored during the **Climate Ride** into donations to sustainable projects in the various regions. **"We created an interactive and inspiring experience to make Schaeffler's pathway toward climate neutrality tangible,"** says Schaeffler's CEO Klaus Rosenfeld.

“The health and safety of the workforce is a top priority for Schaeffler. With the Safe Work@Schaeffler project, we are succeeding in raising awareness for occupational safety”

Corinna Schittenhelm

Schittenhelm: *A lot of communication is certainly important, but we also need to show which goals we have set ourselves and make them transparent, and also give every one of our employees the opportunity to be involved in setting a personal sustainability goal or in a goal in their own department.*

The main raw material for Schaeffler products is steel. What is our strategy here to become more sustainable?

Fußhöller: *Steel is crucial for us if we want to reduce our carbon footprint. We need steel from “green” production, so we are talking intensively with our suppliers about this issue. We are trying to shorten the transport distances for steel. And in the development process, we are always going to endeavor to use materials in a way that conserves resources to the greatest possible extent.*

How does Schaeffler promote diversity and equal opportunities?

Schittenhelm: *It is important to establish a common understanding of diversity, inclusion and equal opportunities. We can achieve this above all through communication, but also through trainings, and ensuring that our managers have the right kinds of skills. And by offering our female talents a diverse range of opportunities to develop within the company. Of course, we have also set ourselves targets for more women in management positions. And that is something that I personally care about very much.*

German plants receive Corporate Health Award 2021

Corporate Health Management was described as innovative, integrative and participative at the awards ceremony. Considered in the selection for the award were the implementation of the **Schaeffler Health Coach** as well as long-standing programs such as “Boxenstopp Rücken aktiv” (active-back pit stop) or “Schaeffler Health & Ergo Scout.” The jury and advisory council were particularly impressed by the sustainable effectiveness and continuous further development of the programs.

10 percent on average

That’s the annual rate by which Schaeffler intends to reduce the frequency of industrial accidents by 2024. In the reporting period, the accident rate was reduced to 3.9 (prior year: 4.6) representing a reduction by at least 10 percent in the fifth consecutive year.

Hyped up by H

Hydrogen is the lightest of all elements but has a high energy density per mass – plus high innovation potential for the decarbonization of many sectors. The development of a global hydrogen economy is in full swing – but far from having reached its objectives. A status report.

By Volker Paulun

The Hamburg port is, literally speaking, a construction site of the energy transition process. In the decommissioned coal-fired powerplant Moorburg, a large-scale electrolyzer with a capacity of 100 megawatts is planned to split water into hydrogen and oxygen starting in 2025. The wind and the sun will supply the required energy, which is why the Moorburg hydrogen is supposed to be "green" and therefore CO_2-free. Green hydrogen is truly a multitalented substance. It's not only able to supply energy for industry, households and mobility but can also be used as a process gas, for instance in steel and fertilizer production. Because hydrogen has such versatile uses without causing CO_2 emissions that are harmful to the climate countless projects for producing, transporting, storing and using hydrogen are launched not only in Hamburg but around the globe. Seldom have governments, academia, the business community and environmental associations joined forces as intensively as in this area.

Based on a study by the consulting firm McKinsey, the Hydrogen Council in which the Schaeffler Group is a member of the steering committee estimates that in the field of hydrogen production projects with a volume of 500 billion U.S. dollars are currently in the pipeline, with new projects being added practically on a daily basis. In 2050, global revenue in the hydrogen economy could amount to 2.5 trillion U.S. dollars and over 30 million jobs might be created.

The crux of transportation and storage

However, before that happens numerous challenges remain to be mastered. That particularly applies to storage and transportation, both of which are crucial factors for a global hydrogen economy. Today, we're shipping oil and gas from producing to consuming countries or make it flow through pipelines. Hydrogen has to be transported, too – from countries in which green electricity for hydrogen production is cheap, enabling surplus production, to regions with a great hunger for energy.

However, hydrogen as the lightest of all elements is highly volatile, which makes transportation and storage considerably more difficult. In the form of gas, it can be stored in multi-layered pressure tanks (300 bar during transportation, 700 bar in a tank) and in underground caverns or in liquid form at –253 °C (–423.4 °F) in insulated cryogenic tanks. Both variants are technically complex and energy-intensive. Alternatively, hydrogen can be converted into methane, syngas or liquid synfuels, for example. This has the advantage of easier and more versatile handling, while the energy-intensive nature of the conversion process is a disadvantage. It takes a considerable surplus of green electricity to produce green hydrogen, to transform it and to subsequently use it in an energetically sensible way, for instance in an internal combustion engine with a maximum efficiency of 40 percent.

Adsorption, a process in which the hydrogen molecule is linked to solid or liquid carriers, is another possibility of storing and hauling hydrogen. The abbreviation LOHC, which stands for liquid organic hydrogen carrier, is frequently mentioned in this context. In this process, hydrogen is chemically linked to a viscous carrier in a hydrating reaction. As a result, the utilization of hydrogen becomes simpler, safer and available at lower cost because the current crude oil-based energy system could be adapted without major modifications to the new energy on which our hopes are pinned.

"Hydrogen can be transported as LOHC like crude oil or gasoline products are today, for instance in a tank vessel or the tank car of a train. The bound hydrogen can subsequently be stored and distributed in appropriate tanks and filling stations," explains LOHC expert Professor Peter Wasserscheid, Chair of Chemical Reaction Engineering at Friedrich-Alexander-Universität Erlangen-Nürnberg and Director of the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy (HI ERN). "Our approach is the use of hydrogen logistics 'clothed' in today's liquid fuels. This technology has now advanced to the level of industrial usability." In 100 liters (26.42 gallons) of LOHC around 5.7 kilograms (12.6 pounds) of hydrogen could be bound. For comparison: this amount of hydrogen equates to the fuel tank capacity of a Toyota Mirai with which that fuel cell car can cover a distance of up to 1,000 kilometers (621 miles).

Another advantage of LOHC is that at 1.9 kWh per liter the volumetric energy density of hydrogen is even slightly higher than that of gaseous hydrogen from a pressure tank (1.56 kWh/l).

Schaeffler is driving LOHC technology

A key technology is still lacking as an enabler for actually filling a tank with LOHC and using it like a conventional liquid fuel: a hydrogen fuel cell that can operate directly with LOHC. That's precisely what Schaeffler is developing together with Hydrogenious LOHC Technologies GmbH and HI ERN. Schaeffler's part in the project is the production of suitable bipolar plates in which the company uses synergies and draws on know-how from previously developed fuel cell technology. In conventional fuel cells as well as in LOHC versions, bipolar plates – as an integrated assembly between two membrane electrode units of a fuel cell stack – serve other purposes besides electrically connecting the cells: distributing gas across the surface of the plate, separating gas between adjoining cells, plus external sealing and cooling of the system.

Commenting on the current state of the joint LOHC project, Professor Peter Wasserscheid, who in

Ideally, green hydrogen is produced where plenty of low-cost electric power from sustainable sources exists

„Water will one day be employed as fuel. It will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable“

Jules Verne in 1874 in his novel "Mysterious Island"

addition to his role as the director of HI ERN is a co-founder and member of the scientific advisory council at Hydrogenious, says, "At the moment, this onboard technology cannot be accommodated underneath the hood of a small car yet but it definitely can be in the technical operations sections of a train or ship. Our goal is to make these units increasingly powerful, smaller and compact. Going forward, that may definitely be heading in the direction of trucks, buses, construction machinery, forestry machines or mine vehicles with prospects up to and including small trucks or large passenger cars."

Industrializing hydrogen technologies

No matter in which ways hydrogen will be transported, transformed or used: it has to be produced first. The 1.5-degree scenario of the International Organization for Renewable Energies (IRENA) predicts an electrolyzer capacity of 5,000 gigawatts for 2050, which would make enough hydrogen available to cover twelve percent of the global energy demand. That means that 50,000 large-scale electrolyzers the size of the plant in Hamburg-Moorburg would have to be established worldwide.

Technological innovations and their accelerated rollout are of crucial importance to ensuring that this will happen. Equally important is the achievement of competitive economic feasibility of carbon-free hydrogen as soon as possible. One of the keys to success in this regard is the provision of sufficient and low-priced green electricity by expanding renewable energies. The fact that, today, gray hydrogen produced with fossil energy costs only a fourth of what green hydrogen costs shows the need for action in this area. Potential cost reductions with a view toward scaling and market ramp-up of the technologies are another key to success.

Schaeffler intends to make important contributions to this effort based on its diversified technological know-how. "Due to our industrial and automotive divisions, we're optimally poised to address hydrogen on a broad base. We have a unique competitive advantage here, especially because an industrialized supplier landscape is still lacking in many areas of hydrogen technology," says Dr. Stefan Gossens, Vice President Hydrogen Strategy at Schaeffler. "We're already in contact with many potential hydrogen customers in a wide range of business activities. Our forte in industrialization enabling us to quickly transfer innovations into mass production – at top quality – is a major advantage."

60–75 %

is the **power-to-hydrogen efficiency** of current electrolyzers. The efficiency of reconverting hydrogen into electricity in a fuel cell is currently 60–80 %. In the end, about 50 % of the energy filled into the tank of a fuel cell car arrive at the wheels. That puts a hydrogen passenger car between a car with an IC engine (25–45 %) and a battery-electric car (75–90 %).

Sources: sfc.com; auto motor & sport

“We believe that hydrogen will play a vital role in enabling clean mobility in the future. The establishment of a hydrogen economy and the transition to sustainable energy resources will largely depend on the industrialization of reliable supply chains for the new technologies”

Klaus Rosenfeld, CEO of Schaeffler

Offshore hydrogen

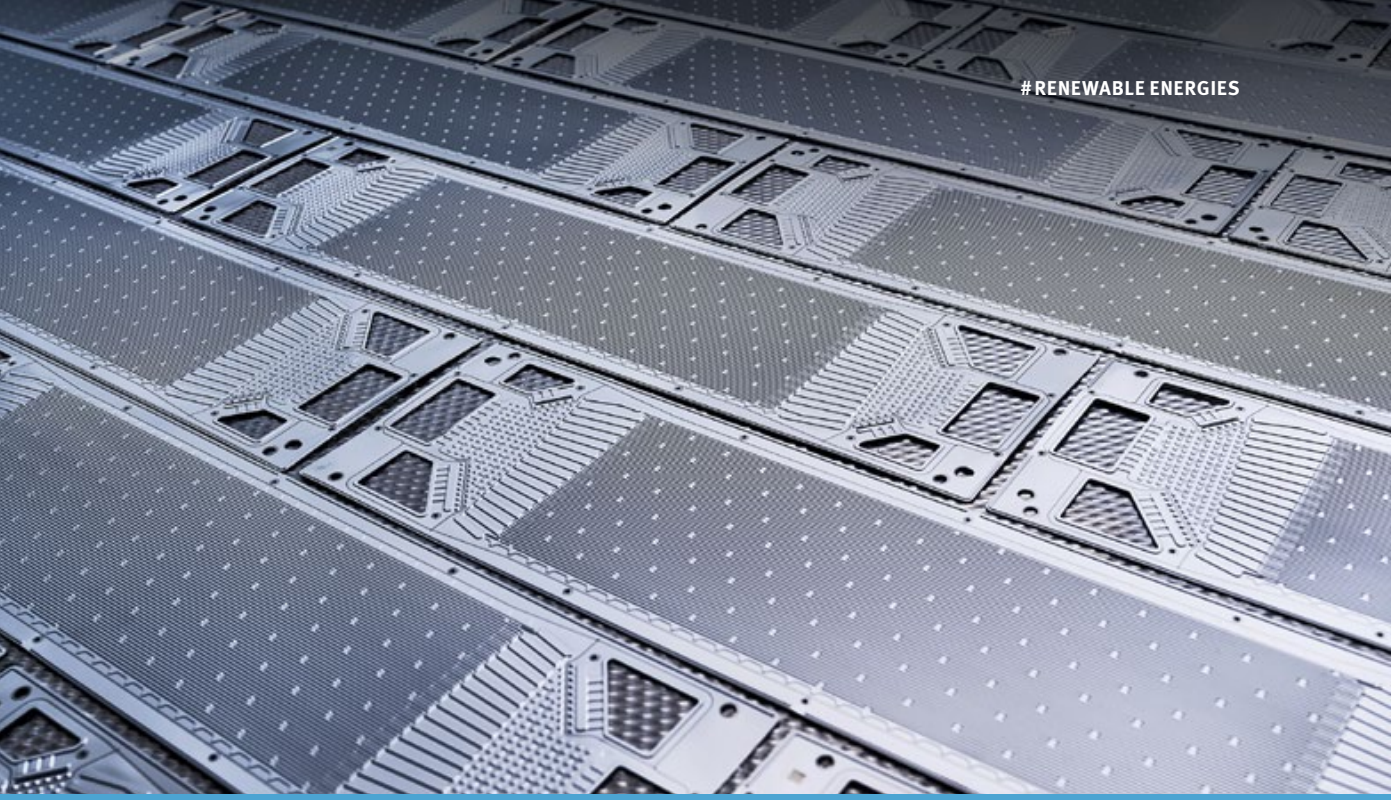
Ideally, green hydrogen is produced where green electricity is generated – for instance at offshore wind farms. There, out on the ocean, water exists in abundance as well, albeit in the form of salt water and is therefore unusable for conventional electrolyzers requiring ultra-pure liquids. **The SEA2H2 project, in which the Dutch start-up Hydron Energy B.V. that has belonged to Schaeffer since the summer of 2021 is involved, is developing a process that desalinates and purifies the seawater** – which, due to the utilization of waste heat from the electroylsis process, is very energy-efficient. Hydron has already demonstrated that its water treatment works in a test plant. The long-term objective is to produce green hydrogen using energy from offshore wind farms and to transport it ashore via pipelines.

The pilot plant for the production of hydrogen from seawater on the island of Texel in the Netherlands. In a similar design, the plant could be used at offshore wind farms within a few years

Strong connections accelerate innovations

In the field of hydrogen technology, Schaeffler benefits particularly from its core competencies in materials, forming and surface technologies. In addition, cross-divisional collaboration within the Group will be another crucial aspect. In the industrial division, for instance, hydrogen is a strategic business segment led by Bernd Hetterscheidt, who says, “In the industrial division, we have the major advantage of already working closely on the production of green energy, for instance from wind power. That means we’re located in areas where electrolyzers will subsequently be used to directly convert wind power into hydrogen. The contacts we enjoy there with our customers, our existing know-how in material transformation and electrochemistry, plus our expertise in industrialization will be helping us to be successful in the marketplace.”

Particularly in the area of bipolar plates, Schaeffler has become an in-demand partner within a short period of time. The previously mentioned LOHC project with HI ERN and Hydrogenious is just one of the collaborative partnerships in which Schaeffler is doing pioneering work. A research project launched this spring together with Bekaert, Johnson Matthey and TNO that aims to optimize electrolysis stacks with proton exchange membranes (PEMs) is another example. PEM units react very fast because they can process high densities of electric current. In addition, they’re very compact. However, the interior materials installed in them must be very robust due to the acidic medium in which they’re used. The consortium is planning



The new Schaeffer joint venture Innoplate is planning to produce such next-generation bipolar plates starting in 2024. In 2030, 50 million units per year are targeted

to create the basis on which a new generation of highly efficient, durable and less costly electrolyzers can be built within the next three years.

Another cooperation example at Schaeffler is the establishment of the 50:50 joint venture called Innoplate. The partner there is Symbio that itself is a joint venture between Faurecia and Michelin and one of the global market leaders in fuel cell technology for the automotive industry. At its headquarters in Haguenau, France, Innoplate is supposed to start producing bipolar plates for industrial-scale PEM fuel cells starting in early 2024 with a workforce of 120. The production target for 2030 is 50 million units for the global market. The alliance between the two big players, Schaeffler and Symbio, makes it possible to offer customers fuel cells with higher performance and greater capacities at a lower price.

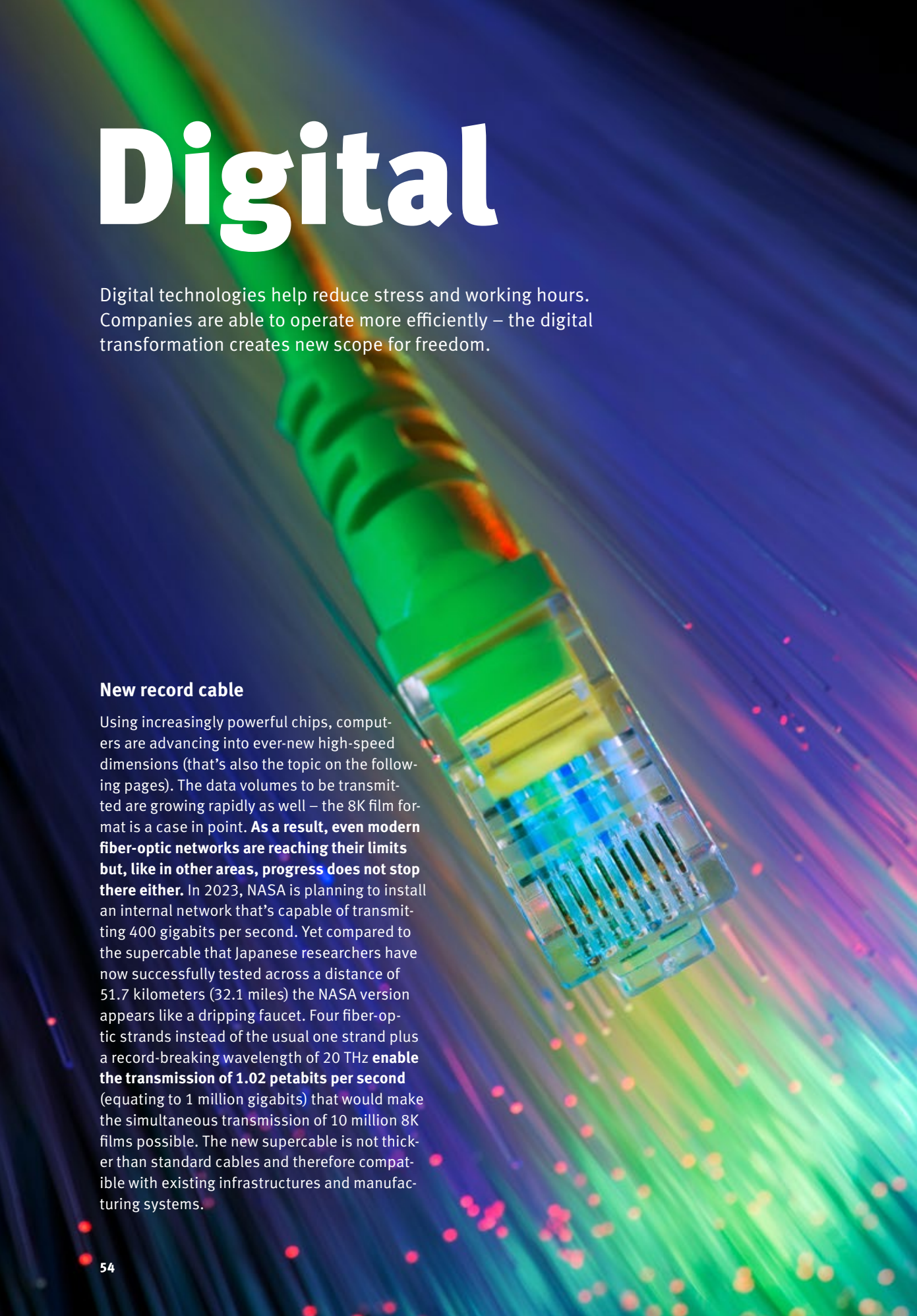
“We believe that hydrogen will play a vital role in enabling clean mobility in the future. The establishment of a hydrogen economy and the transition to sustainable energy resources will largely depend on the industrialization of reliable supply chains for the new technologies,” says Klaus Rosenfeld, Schaeffler’s CEO.

1–1.5 %

of the hydrogen produced escapes into the atmosphere, according to a study by the UK Department of Energy, with transportation accounting for half of that and production and consumption each accounting for about one fourth. Other surveys even assume a 10 % loss. In the atmosphere, this hydrogen prevents the degradation of the highly effective climate gas methane. But even if the pessimistic 10 % loss rate were used as the basis, the avoidance of CO_2 equivalent emissions due to that hydrogen would still be 25 times as high, according to the study.

Digital

Digital technologies help reduce stress and working hours. Companies are able to operate more efficiently – the digital transformation creates new scope for freedom.



New record cable

Using increasingly powerful chips, computers are advancing into ever-new high-speed dimensions (that's also the topic on the following pages). The data volumes to be transmitted are growing rapidly as well – the 8K film format is a case in point. **As a result, even modern fiber-optic networks are reaching their limits but, like in other areas, progress does not stop there either.** In 2023, NASA is planning to install an internal network that's capable of transmitting 400 gigabits per second. Yet compared to the supercable that Japanese researchers have now successfully tested across a distance of 51.7 kilometers (32.1 miles) the NASA version appears like a dripping faucet. Four fiber-optic strands instead of the usual one strand plus a record-breaking wavelength of 20 THz **enable the transmission of 1.02 petabits per second** (equating to 1 million gigabits) that would make the simultaneous transmission of 10 million 8K films possible. The new supercable is not thicker than standard cables and therefore compatible with existing infrastructures and manufacturing systems.

147 minutes

That's the average time internet users spend on Instagram, Facebook & company per day. Nigeria (247 min) holds the top spot, closely followed by the Philippines (246 min). In countries with an aging population, social media usage was much shorter – only three quarters of an hour in Japan, whereas the statistics for Germany reflect an hour and a half.

Source: Global Web Index via DataReportal

Digital can be so "hygge"

In terms of digital quality of life, Denmark secured the top spot among 110 nations surveyed worldwide.

Denmark	0.83 Index points*
South Korea	0.76
Finland	0.76
Israel	0.74
USA	0.74
Singapore	0.72
France	0.71
Switzerland	0.71
Germany	0.71

* Evaluated by affordability and quality of internet connections, e-infrastructure, e-security, e-government. Best achievable rating: 1

Source: VPN provider Surfshark

"You can have data without information, but you cannot have information without data"

Daniel Keys Moran (*1962), computer programmer and science fiction author

Digital purchasing agent

Truck garages are increasingly using digital solutions enabling them to work more efficiently, too, in keeping with the maxim: save time, make money. **The collaboration between Schaeffler Automotive Aftermarket and Munich-based startup truckoo helps achieve this objective by clearly simplifying the purchase and sale of commercial vehicles.** Here's how it works: Garages using Schaeffler's service portal REPXPERT can join truckoo's international network. As soon as a customer wants to sell a vehicle – garages typically act as intermediaries in this sector – the customer's trusted garage inspects the vehicle according to a standardized procedure using the truckoo app that has been developed specifically for this purpose. In the next step, the vehicle is offered to potential buyers in 27 countries together with a digital status report in real time. If a customer is interested and asks about necessary repairs Schaeffler offers an extensive portfolio of repair solutions. The subsequent sale is handled by truckoo.

Sources: repxpert.de, truckoo.com

Quantum computing coming soon

An interview with Professor Sabina Jeschke about the current state in the area of quantum supercomputers and what doors this fascinating technology is going to open: from Qphones to Edge AI to autonomous driving.

Sabina Jeschke's many activities include chairing the board of KI Park e. V., a Berlin-based think tank for artificial intelligence that Schaeffler founded in 2021 together with eleven other partners

Interview: Dr. Lorenz Steinke

Professor Sabina Jeschke is one of Germany's leading experts in quantum computing and plans to make these supercomputers fit for everyday use with her startup company called Quantagonia. As a physicist and mathematician, she teaches Information Sciences in Mechanical Engineering at RWTH Aachen and Entrepreneurship at TU Berlin. As a member of the executive board of Deutsche Bahn AG, she was responsible for digitalization and technology from 2017 to 2021.

You're planning to bring quantum computing into everyday life. Today's quantum computers are big, reputed to be error-prone and energy-hungry and will only start operating at temperatures close to absolute zero. Those aren't exactly perfect prerequisites for a technology that's supposed to be suitable for everyday use, are they?

It's true that quantum computers are still error-prone at the moment but they're not energy-hungry. Current quantum computing systems have to be run at millikelvin temperatures, in other words at minus 273 degrees centigrade (–459.4 degrees Fahrenheit) but because the actual computing effort is minimal, because many people can share these computers in a cloud and because the computing speed of this technology is so much higher its energy balance is often already much better today than that of traditional computers. Plus, there are some prototypes now that run at room temperature and are less error-prone. We anticipate marketable systems to be available by 2028 or 2029. Consequently, while today's data centers are consuming increasingly larger amounts of energy, quantum computing can turn the trend and help us in areas like sustainability. That's why it's possible that in the future everything that's algorithmically feasible will be processed on quantum computers and classic computers will be used primarily in areas where algorithms cannot – or only inefficiently – be transferred to quantum computers. By the way, that also provides new impetus to so-called edge artificial intelligence, in other words the use of artificial intelligence (AI) at the edges of networks. The mobile sensors that are frequently used there often have just tiny batteries and therefore insufficient energy for complex computing tasks. However, for quantum computing, the minimal amount of energy that's required can be obtained as a waste product from the vibrations of machines. That enables all-new AI applications.

In classic computer technology, decades passed between the mammoth ENIAC vacuum-tube computer and chips using conductive traces with nanometer widths in every cell phone. Are we going to see similar kind of progress with quantum computing? Will the iPhone become a Qphone?

Yes, you can clearly put it that way. One of the major trends in quantum computing going forward is moving away from the low temperature and

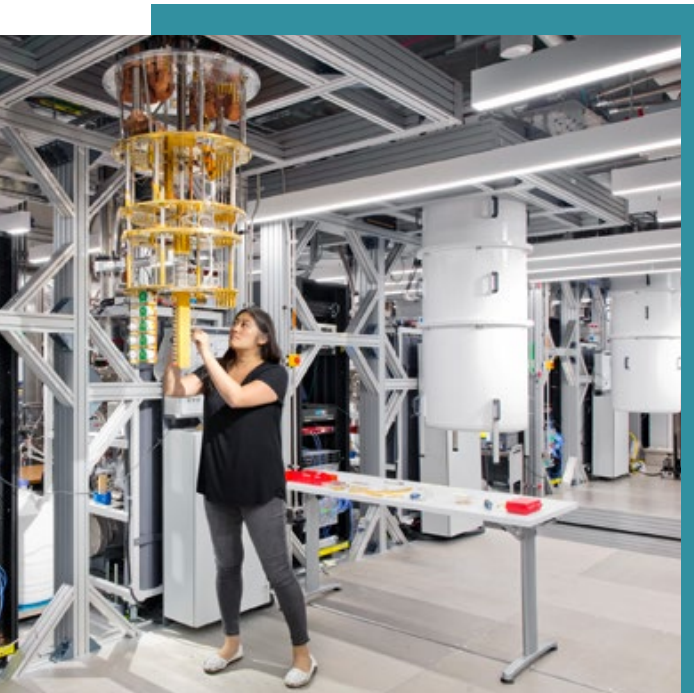
error-proneness toward more robust systems – ideally operating at room temperature. Once error-proneness has ceased and I no longer have to cool quantum computers in large underground centers, I expect to see devices that I can carry around with me, such as a Qphone.

Every new technology affects existing ones. Will quantum computing become a disruptive technology and will the big data centers like those operated by Google and Amazon soon no longer be needed?

Quite the opposite is the case: We're going to see that the big providers of high-performance computing will be buying quantum computers, putting them in their data centers and offering that computing power to their customers. Schaeffler, for instance, uses Microsoft's Azure cloud computing platform. In that cloud, you can already access a diverse offering of quantum computing today. Amazon does that in very similar ways with AWS, so quantum computing will in fact become a disruptive technology because you can use it to address problems, such as complex simulation at high speed, that you couldn't do before. The big data centers are not going to be the losers but will put quantum computers next to their existing computers. We're going to see a very heterogeneous computer landscape in the data centers and we're going to distribute computing tasks precisely to the computing architecture that's ideally suited for them.

One of your research objectives is to harmonize quantum technology with conventional information sciences and existing programming languages. How do you teach something like that to existing software architectures that think in zeros and ones and don't tolerate any intermediate states?

In fact, the exciting question here is: What am I going to do with existing codes? In science and in business, we've been using some codes for 40 years and keep developing them because they're stable and work incredibly well. How can I manage to preserve our grown structure of simulation, optimization methods and artificial intelligence? In our startup Quantagonia, we're building a "Low Level Virtual Machine" or LLVW for short, a virtual computer



Quantum computers like this one from IBM are still mammoth high-tech systems

Schrödinger's computer

Whereas current digital computers only compute with the values of "0" and "1", quantum computers achieve what seems to be a paradox: In addition to "0" and "1," their informational units, the qubits, can assume any intermediate states – and even simultaneously. The computers take advantage of the laws of Erwin Schrödinger's quantum mechanics using ions or electrons as qubits for instance. When interleaving several qubits into a larger unit and asking each qubit a subquestion of a complex overall task the quantum computer will find the best possible combination of answers by taking all subquestions into account. As a result, a quantum computer in a search for new materials or medications can compare millions of molecular combinations within fractions of a second. At this juncture, quantum computers only have few qubits and are prone to computing errors and interferences, but the development is progressing rapidly.

that exists on another system only as software. We then feed that with existing code. Simply put: "input X86 code, output Q code," so we transfer the existing code to a machine-independent intermediate level and distribute it from there to the various computers with various modifications. In that way, we create a "middleware" that makes the existing software compatible with quantum computing and simultaneously enables an ideal utilization of heterogeneous resources in a data center by means of dynamic allocations.

Your research areas also include transportation and mobility as well as the Internet of Things (IoT). Will the autonomous automobile of the future with a quantum computer on board find a better route through big city traffic? What can a quantum computer do that conventional circuit logic in navigation systems couldn't do?

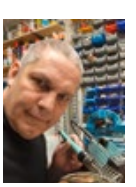
Fleet intelligence. At this juncture, you can use existing computers to optimize individual vehicles or small groups but not the entire traffic of a big city. The more quantum intelligence is in the navigation systems the better their predictions become, plus, the better the drivers' compliance with the systems' predictions. That, in turn, decongests traffic. Traffic jams, not least, develop because, as a human, I don't have enough possibilities to see how my behavior contributes to congestion in the first place. In the future, thanks to quantum computers, I'll know that I'd better leave ten minutes later, that that will reduce overall congestion and that I'll arrive earlier in spite of having left later. The prospect is for autonomous vehicles, which will become increasingly prevalent in the coming years, to be fully controlled by fleet intelligence.

What can corporations like Schaeffler as one of the globally leading automotive and industrial suppliers expect of the quantum revolution? Are you seeing new business segments and sales markets in mobility? Or will the revolution tend to take place behind the scenes, for instance in research and development using quantum computing or in all-new manufacturing technologies in Industry 4.0 factories?

Quantum computing, for instance, will provide new opportunities for material research, tribology and the search for new lubricants. Going forward, it will be possible to create simulation environments in which parameters can be changed in real time and the results are available immediately. That hasn't been working so far because such calculations on the molecular level have response times ranging from days to weeks. In the future, quantum computing will do that in real time. I've already addressed edge artificial intelligence, where unique selling propositions in the automotive sector may emerge for companies like Schaeffler, for instance with new components using artificial intelligence even without a cloud connection via 5G mobile telecommunications. Such systems could then assume complex control tasks in vehicles offline in real time thanks to quantum intelligence.

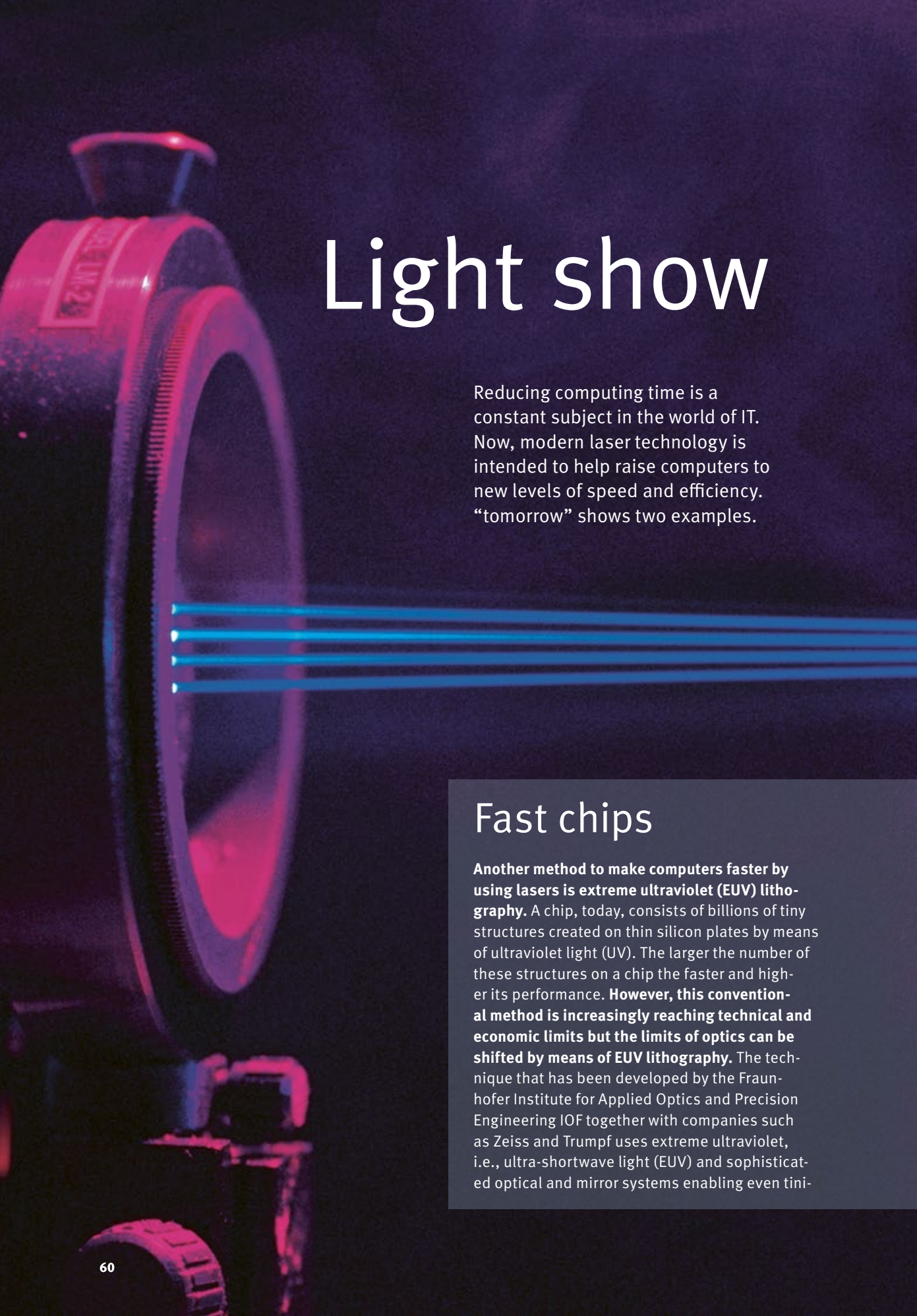
How do you judge the industry's innovative prowess in terms of quantum computing? Are the opportunities of this technology adequately recognized or would you occasionally like to see a faster pace here?

Germany is a country of engineers and technologists. Even so, we've missed incredibly many trends in the area of technology, with cell phones and, very generally speaking, with hardware. We've also recognized the potential of AI far too late. But I do see a tendency to embrace change. For instance, the EU and the German federal government have launched major funding programs for quantum research. At Schaeffler, I'm currently engaged in many conversations about quantum computing on the factory floor, quantum computing in the product and in relation to talent development. That's another reason why my outlook is generally positive.



The interviewer

IT journalist **Dr. Lorenz Steinke** gathered initial programming experience as a teenager with Superboard II, Apple IIe and Commodore 64. In those days, RAM size was still measured in Kbytes. While the computers changed, his love of them remained, so quantum computers have been fascinating Steinke for a long time. He's looking forward to the possibilities of these new supercomputers with eager anticipation.



Light show

Reducing computing time is a constant subject in the world of IT. Now, modern laser technology is intended to help raise computers to new levels of speed and efficiency. “tomorrow” shows two examples.

Fast chips

Another method to make computers faster by using lasers is extreme ultraviolet (EUV) lithography. A chip, today, consists of billions of tiny structures created on thin silicon plates by means of ultraviolet light (UV). The larger the number of these structures on a chip the faster and higher its performance. **However, this conventional method is increasingly reaching technical and economic limits but the limits of optics can be shifted by means of EUV lithography.** The technique that has been developed by the Fraunhofer Institute for Applied Optics and Precision Engineering IOF together with companies such as Zeiss and Trumpf uses extreme ultraviolet, i.e., ultra-shortwave light (EUV) and sophisticated optical and mirror systems enabling even tini-

High-speed transistors

Complex simulations or processing of large data volumes require computing power of a magnitude **that's causing today's computers to reach their limits.** Responsible for the speed of computer operations are so-called field effect transistors (FETs). In order to become faster and faster, these transistors are becoming smaller and smaller so that as many of them as possible can be installed side by side. Current computers are already operating with impressive clock speeds of several gigahertz, in other words several billion computer operations per second. Latest-generation transistors have a size of merely 0.000005 millimeters ($1.97e^{-7}$ inches) – that's about the limit of their possible miniaturization and that's where laser technology comes into play: In an experiment, scientists at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) and the University of Rochester in the U.S. state of New York **have shown for the first time how signals can be transmitted via light waves instead of by electricity and transformers, and how computer operations using laser impulses could be executed up to one million times faster than before** in this way. One oscillation of a light wave lasts only about one femtosecond equating to one millionth of one billionth second.

"This is a great example of how fundamental science can lead to new technologies. We clarified the role of virtual and real charge carriers in laser-induced currents, and that opened the way to the creation of ultrafast logic gates," said Ignacio Franco from the University of Rochester. Albeit: "It will probably be a very long time before this technique can be used in a computer chip, but at least **we know that light wave electronics is practically possible,"** Tobias Boolakee from FAU added.

er structures. Whereas the conventional method uses light sources with a wavelength of 193 nanometers ($7.60e^{-6}$ inches) the new manufacturing method operates with merely 13.5 nanometers ($5.31e^{-7}$ inches). 1 nanometer is one millionth of one millimeter (0.03 inches). It takes very powerful lasers firing at tin droplets rushing past inside a vacuum chamber 50,000 times per second to generate a plasma flash of this wavelength. **As a result, EUV lithography enables a more delicate resolution due to which chip manufacturers can produce smaller, faster and more powerful chips with manufacturing complexity and costs remaining within reason.** By now, cell phones using chips produced with EUV light are available. Another field in which such high-performance chips might play an important role is autonomous driving because these chips are able to provide the system with the data required for driving safety at the requisite speed.

The EUV project leaders in front of the world's most powerful pulsed industrial laser that is used for generating the light enabling EUV lithography

Future Life

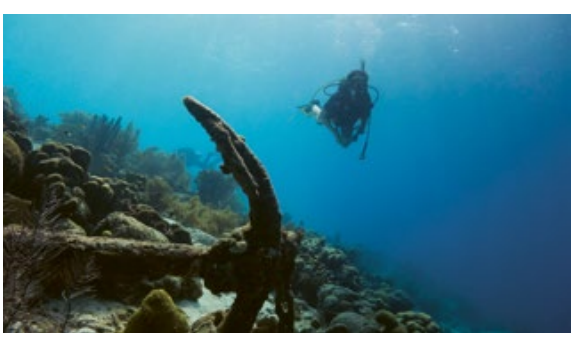
Conserving resources, reducing the environmental burden – the credo “making more out of less” will increasingly shape our everyday lives in all areas.

Energy checkout

This hotel facility in Norway might become a hotspot for eco-conscious tourists. The accommodation for vacationers is named Svart and located at the base of the Svartisen glacier. Now nearing completion, it’s **the world’s first energy-positive hotel, according to the architectural firm Snøhetta.** Due to its design, the ring-shaped building resting on stilts is supposed to ensure an optimal yield of natural thermal energy and lighting. A projecting roof provides protection against direct solar irradiation so that, according to the plan, no air conditioning system will be needed in the summer. Core elements of the sustainable concept also include two high-capacity solar collectors, an efficient passive-house design and geothermal energy for heating. In addition, it’s planned to capture and reuse part of the heat in the kitchens. Sewage and rainwater will be treated and recycled as well. **After 60 years of operation, the hotel is supposed to have generated more energy than it’s going to use during its entire lifecycle.**

U pharmacy

The idea of tapping nature's resources to develop medications has been around for a while. Aspirin, for instance, is based on a substance with origins in nature, whose predecessor, salicin, is found in willow bark. **However, since more and more medicines are losing their efficacy researchers around the world have been exploring what else mother nature's medicine chest may contain.** Scientists at the University of Illinois in Chicago dove deep into the underwater world seeking sediments at the bottom of lakes and sponges clinging to shipwrecks. **In the mud of Lake Michigan, they found bacteria which kill the bacterium that causes tuberculosis.** "For millions of years bacteria have fought one another," says Professor Brian Murphy from Chicago. "We're just harnessing that power." He and his fellow researchers assume that around 90 percent of oceanic life is microscopically small, which may hold plenty of potential for new drugs.



"Thrift is of great revenue"

Cicero (106–43 BC),
Roman statesman and philosopher

845,000

metric tons (930,000 short tons) of highly toxic waste are caused by cigarette butts worldwide every year. **Some five trillion filters consisting of persistent synthetic cellulose acetate end up in our natural environment.** Via channels and rivers, nicotine, heavy metals and other harmful substances clinging to them are flushed into the ocean where they pose an increasing threat to animals. Even at a concentration of just one cigarette butt per liter (34 fl. oz) the toxic substances are lethal to small fish.

Source: sciencefocus.com

Air as a source of drinking water

Around 785 million people have no basic supply of clean drinking water. **A group of researchers at the University of Texas is working on a method that might remedy this problem, provided that it will be scalable. The idea is to use a saline hydrogel to extract water from air.** Hydrogels consist of a polymer that can bind water. In daily life, they're already being used in diapers. In the experiment, the gel was left for an hour before being dried in a condenser to collect the condensed water. Afterwards the scientists repeated the process and found that the absorption capacity did not degrade even after several cycles. As a result, they obtained almost six liters (1.6 gallons) of water per day, even in arid conditions of just 30 percent relative humidity.

Skipper Corentin de Chatelperron at Trincomalee Harbour in the north-east of Sri Lanka with a low-tech pyrolysis machine that can produce fuel from plastics. Shown in the background is the “Nomade des Mers” catamaran

Setting a course for “simply ingenious”!

His mission carries reduction to extremes. Circumnavigator Corentin de Chatelperron is looking for masters of low tech around the globe. With inventions that are easy to replicate by doing it yourself, the engineer wants to show that a self-sufficient and sustainable way of life is possible for everyone.

By Björn Carstens

The cherry red catamaran is rocking gently in the dark blue sea. Towering behind a gradually clearing wall of fog are the "fire mountains" of the Cape Verde Islands, mammoth massifs of volcanic origin in front of Africa's north-western coast. Corentin and his crew are overwhelmed – and dead tired at the same time. The stormy passage from Senegal nearly took them to their limits. "Miserable" is how they all felt, relates the sailing adventurer. Three days on the high seas, with lashing spray and heavy swell. And what for? Sailing just for kicks? Far from it!

Corentin de Chatelperron – a man with curly hair and a warm smile, who appears to be a lot younger than his 38 years of age – is a skipper and navigator merely in a secondary role. The engineer's primary passion is tinkering. Since 2016, he's been sailing from continent to continent with changing crews, setting course for simplest inventions that could be used to fight poverty in the world – if only they were more widely known. Corentin and his like-minded sailing companions are on a mission: they want to find, try out, refine and spread solutions for a self-sufficient way of life that are technically simple and, for that very reason, efficient and sustainable. "For us, this is not about inventing something new, but about documenting and adapting previously proven solutions," says the world traveler.

In pursuit of self-sufficient onshore and offshore living

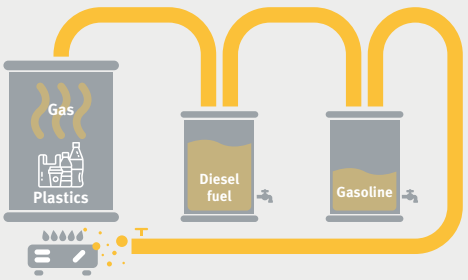
Such solutions that are easy to create and easy to repair are referred to as low tech. The "survival tinkerer" and his team track them down and test them all over the world. Corentin shares each of his discoveries with others on an online platform for the low-tech community (www.lowtechlab.org).

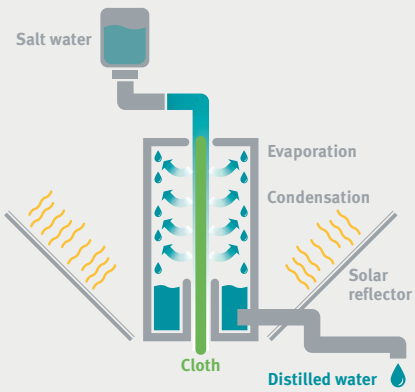
His high-seas Kennex 445 catamaran named "Nomade des Mers" (French for "Ocean Nomade") is a floating laboratory, the foreship is a greenhouse, four chickens lay eggs in a cage at the boat's stern and one of the cabins is home to an insect farm supplying the crew with necessary proteins. "In Thailand, we met someone who helped us create a miniature mushroom cultivation, enabling us to harvest up to twelve kilograms (26 pounds) per month. I could hardly wait to make an omelet using the eggs from our chickens, with mushrooms, insects … and a little arugula," recalls the ingenious engineer.

The Frenchman's big mission began more than ten years ago at a shipyard in Bangladesh, where he came up with the idea of using jute and resin as basic materials for ship hulls. It resulted in an initial boat using natural fibers. He replaced glass fiber by grass stalks, a natural local resource. Shortly afterwards, the "Gold of Bengal," the prototype of a sailboat constructed exclusively of a jute fiber composite, was afloat and Corentin de Chatelperron set

Plastic pyrolysis

How it works: This technology serves to convert plastics into fuel. Various grades of petroleum-based plastics are heated to more than 400 °C (752 °F) in a container. The resulting gases can escape only via a single pipe in the cover that connects this container with two other containers. The gases cool down gradually and in the second container – still at 300 °C (572 °F) – condense into diesel fuel and in the third one – at 150 °C (302 °F) – into gasoline. "Using this system, up to 800 grams (28 ounces) of fuel can be obtained from one kilogram (2.2 pounds) of plastics," says Corentin de Chatelperron. However, it has the disadvantage of consuming a lot of energy.
Why it's needed: This low-tech solution seems to be a simple response to one of humanity's pressing problems: environmental pollution by plastics. Each minute, 18 metric tons (20 short tons) are flushed into the oceans.
Supporting encounter: Rohan Edirisooriya works as a scientist in Sri Lanka and wants to optimize his plastics pyrolizer so that every inhabitant can convert plastic waste into fuel even in the remotest villages.





Solar-powered seawater salt remover

How it works: A piece of cloth is soaked in seawater and clamped between two frames covered with transparent tarpaulins. Two reflectors intensify the power of the Sun, the water evaporates and condenses on the tarpaulin while the salt remains in the cloth. The water is collected in a container by a means of a tube. With a frame the size of one square meter (11 square feet), five liters (5.3 quarts) can be obtained per day.

Why it's needed: 2.2 billion people worldwide have no regular access to clean water, according to Unicef. Some 785 million people not even have a basic supply of drinking water.

Supporting encounter: Mehdi Berrada runs a company in Morocco that is engaged in alternative water resources. "Morocco is the kingdom of seawater salt removal. By 2030, the water supply of the entire Agadir region is planned to be guaranteed in this way," says Corentin de Chatelperron.

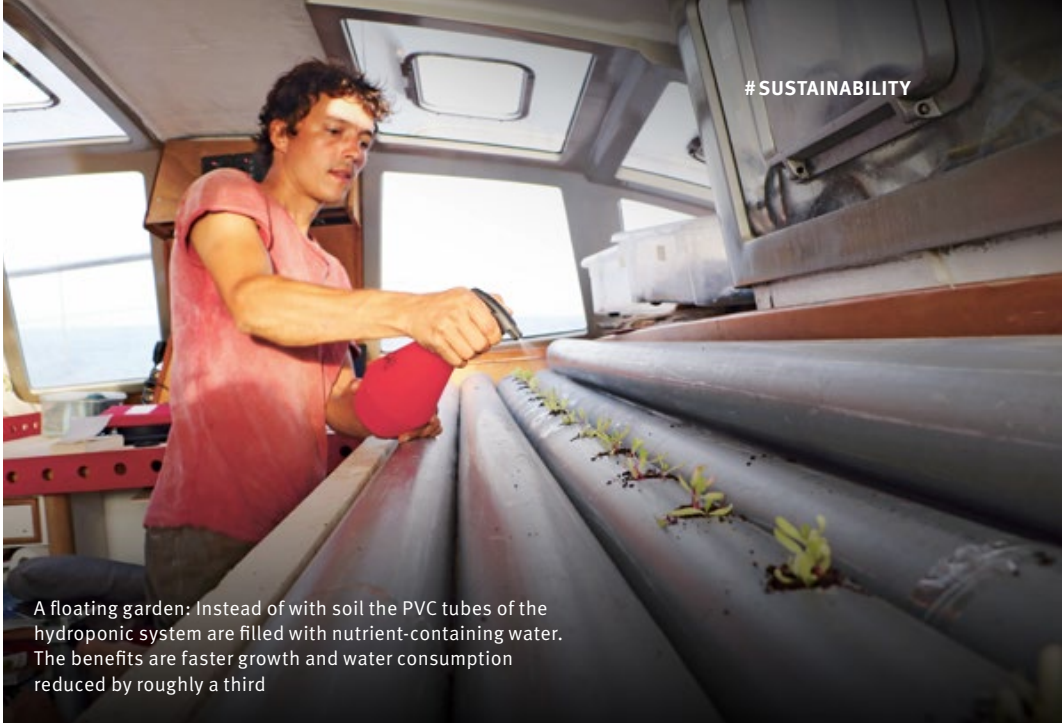
sail for an expedition back to France – in constant pursuit of a self-sufficient existence. In the greenhouse below the deck, he cultivated vegetables using the Sun as an energy source. But a long period of time would pass before everything worked out. "My plants were withering away. And then, while gathering wood on remote islands, I brought termites into the boat that attacked my bamboo mast, so it broke down in the first storm. I, who had already seen myself as a modern Robinson Crusoe, soon felt like a stray of the seas," says Corentin, describing his beginnings. With the benefit of these experiences from the class of "constructive failures," he continued his journey on board of the catamaran, accompanied by a crew, in 2016 – albeit this time around the world.

Spreading knowledge gained

By that time, they'd long become a focus of media attention. In his native France, the sailor and his companions are celebrated as environmental heroes. In exhibitions and road shows, in appearances at special events and with massive media presence, they're spreading their ideas for climate and environmental protection and for energy transition. Corentin de Chatelperron is fascinated by the low-tech design philosophy and has implemented a wealth of clever ideas on board of the exhibition boat. For instance, the crew managed to employ a special seawater salt removal system to obtain drinking water, to use a solar stove and to produce energy by means of a do-it-yourself wind turbine (see examples). The young explorers have also tried out alternative forms of nutrition such as cultivating edible algae. Numerous stops, encounters, adventures and inventions have marked the crew's journey.

They impart the knowledge they've gained to others: by the personal example they're setting as well as by sharing tips – not only on their journey, but also by teaming up with NGOs that in turn offer assistance in capacity building to refugee camps, regions in crisis or poverty-stricken parts of the world, for example.

The team converted the "Nomade des Mers" catamaran into a floating low-tech lab with an insect farm, greenhouse and chicken coop



A floating garden: Instead of with soil the PVC tubes of the hydroponic system are filled with nutrient-containing water. The benefits are faster growth and water consumption reduced by roughly a third

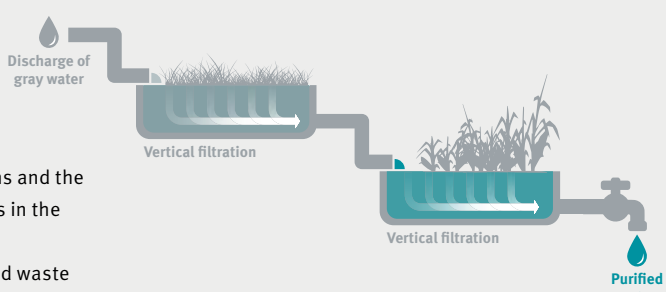
After more than five years and more than 50 documented low-tech solutions, the exploratory journey will be ending this summer for the time being. The team of its “low-tech lab” announced that the “Nomade des Mers” is going to return to Concarneau, its home port in France. On board of the boat will be a huge bag filled to the brim with know-how intended to enable fighting some of the poverty in the world.

Reed bed for wastewater treatment

How it works: Two pits are dug into which gray water from a kitchen and bath (not black water from a toilet) is conducted across a sand and gravel substrate. The pits, for instance, are planted with reed and are home to naturally existing microorganisms. The interaction between these organisms and the plants enables the degradation of the harmful substances in the water. The system requires no chemical agents.

Why it’s needed: There are many places in which untreated waste water is discharged into ecosystems. In India, only about 30 percent of waste water is treated, which impairs the ground water as well. Worldwide, 3.1 percent of all deaths can be attributed to poor water quality as well as to inadequate waste water purification and sanitation, according to the World Health Organization (WHO).

Supporting encounter: Ligy Philip is a professor at a university in Chennai, India, and dedicated to researching solutions for waste water treatment. Among other things, she invented a simple, low-cost test kit that detects contaminated water from which more than 100,000 Indians have benefited so far.



Countless DIY tips can be watched on the low-tech lab’s YouTube channel

“Recalibrating, reinventing – in all directions”

Supply chains under permanent stress – production processes in a state of flux, plus everything should become sustainable. Schaeffler’s COO Andreas Schick, who is responsible for Production, Supply Chain Management and Purchasing, explains how forward-thinking technologies – from digitalization to hydrogen and green steel to bioengineering – can be leveraged for recalibration.

Interview: Volker Paulun

We appreciate your taking the time for this interview because we can imagine that it’s currently in scarcer supply than ever, considering how one crisis after another – like the pandemic or the war in Ukraine – has been putting supply chains under permanent stress. What’s the current state?

It’s true that the situation around supply chains is very tense. Every day, we can tell that that’s the case – both in our personal lives and in business. However, looking at the sectors of relevance to Schaeffler – Industrials and especially Automotive – we can say that our supply chains are stable. They’ve been obstructed under the prevailing stress here and there but they didn’t break down.

Stress tests provide opportunities to recognize strengths and weaknesses and to learn from them. What knowledge have you gained in recent months?

All of us have become even more acutely aware of the system-critical nature of transportation or supply chains. Most supply chains, as far as I can tell from my areas of responsibility, have held up to the stress they’ve been exposed to in recent months. However, it has taken massive efforts to keep the systems running because many modes of transportation are not designed for modern production processes yet.

In what respect?

Take a current container ship, for example. It has mammoth dimensions. That’s very impressive – but also way too rigid, way too inflexible. That no longer fits modern production processes in which customization rather than large volume is playing an increasingly important role. So, how long of a wait until such a giant container vessel has been loaded to capacity is reasonable? Yet that’s a prerequisite for its profitability, not to even mention sustainability aspects. Highly complex supply chains trimmed for volume also become unhinged quickly when freight routes change due to market movements, trade restrictions or scarcity of supply, which has frequently been the case recently. That’s when the situation becomes expensive and inefficient. That’s why – using the maritime example again – we need a larger number of efficient speedboats and fewer of the costly giant container ships – in all areas. Supply chains have to recalibrate and reinvent themselves – in all directions.

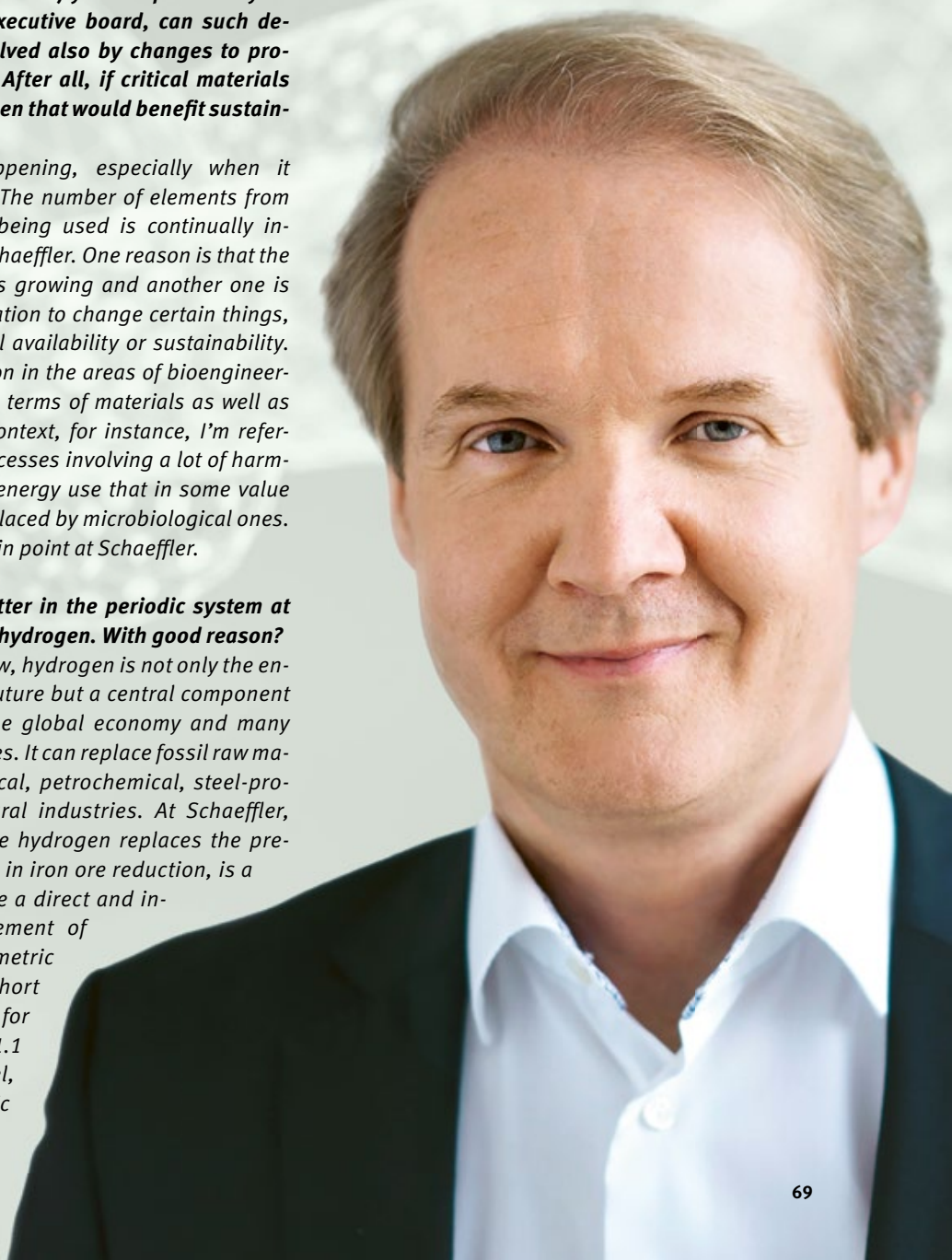
Also in terms of locations?
Yes. In my view, some things have to change – and will – especially in this area. Supply chains will become less global and more regional or even local and therefore more crisis-proof. That's another thing we've learned in the past two and a half years.

What else?
Extrication from dependencies on suppliers both in terms of goods and raw materials. Supply chains have to become diversified for greater resilience in the case of disruptions.

Turning to another area of your responsibility as a member of the executive board, can such dependencies be resolved also by changes to production processes? After all, if critical materials could be replaced then that would benefit sustainability as well.
That's already happening, especially when it comes to products. The number of elements from the period system being used is continually increasing – also at Schaeffler. One reason is that the product range keeps growing and another one is that there's a motivation to change certain things, be it due to material availability or sustainability. There's a lot going on in the areas of bioengineering and biomass, in terms of materials as well as processes. In this context, for instance, I'm referring to chemical processes involving a lot of harmful substances and energy use that in some value chains are being replaced by microbiological ones. That's another case in point at Schaeffler.

A highly popular letter in the periodic system at the moment is H for hydrogen. With good reason?
Definitely. In our view, hydrogen is not only the energy source of the future but a central component of decarbonizing the global economy and many production processes. It can replace fossil raw materials in the chemical, petrochemical, steel-producing or agricultural industries. At Schaeffler, "green steel," where hydrogen replaces the previously used carbon in iron ore reduction, is a focus topic. We have a direct and indirect steel requirement of around two million metric tons (2.2 million short tons) per year and for each metric ton (1.1 short ton) of steel, roughly two metric tons (2.2 short tons) of CO_2 emissions are generated. These statistics illustrate how that translates into a large lever when, at Schaeffler, we're talking about 2040 as a target year for climate-neutral production. The purchase of steel and other materials, referred to as Scope-3 Upstream, accounts for 85 percent of our carbon footprint. That's why we focus on this area.

Andreas Schick (b. 1970) joined the Schaeffler Group in 1994 as a development engineer. In April 2018, he was appointed Chief Operating Officer, Production, Supply Chain Management and Purchasing



17 suppliers were recognized for outstanding collaboration performance at this year's Schaeffler Supplier Day. Andreas Schick said: **"Our suppliers provide major leverage in the bid to reduce greenhouse gases.** We are having to rethink materials and reconfigure the processes used to produce them. We expect our suppliers to follow suit. By working together in this way, we will succeed in achieving climate neutrality by 2040."

Are there any specific examples of related countermeasures taken by Schaeffler?
In an initial appreciable step in the area of material purchasing, we recently agreed a collaborative partnership with Swedish green steel startup H2GS including the delivery of 100,000 metric tons (110,000 short tons) of green steel starting in 2025. But since that doesn't cover our requirement we're also going to pursue a consistent path toward carbon-neutral steel with other suppliers as well. Plus, the decarbonization of steel is only the first step to be followed by plastics and alumuminum.

What effect does hydrogen have on global supply chains?
On the one hand, it can be used as propulsion energy for hauling goods. Logistics accounts for five to seven percent of the global carbon footprint, and counting. Here, hydrogen can help reduce emissions especially in medium- and long-haul transportation. On the other hand, the structual changes that will be required to adapt supply chains to a hydrogen economy should not be underestimated.

What exactly do you mean by that?
We need to not only address the production, transportation and utilization of hydrogen – which Schaeffler is doing in the areas of hydrogen fuel cell technology as well as with the development of LOHC, in other words liquid organic hydrogen carriers – but also the question of whether transportation of hydrogen even makes sense. In some cases, it will, but definitely not across the board. There will also be production processes for which local use of hydrogen will make more sense. Again, let's take steel for example. In the old days, the steel industry established its mills at locations providing the coal for iron ore reduction. In Germany, that was the Ruhr region. Going forward, the steel industry, or at least some of it, will be located where green hydrogen can be produced or at least will be easily available. In such considerations, it may definitely make sense to think about splitting up integrated steel mills. In that case, the iron ore reduction process would take place close to the hydrogen source and the steel production process closer to the user. It will be necessary to adapt various supply chains to the production scenarios that will have to be reorganized in the wake of a hydrogen economy.

Let's turn from hydrogen to the perennial technology theme of digitalization. How can that help make supply chains more efficient and sustainable?
Digitalization can be of particular help in making the complex flow-of-goods systems more transparent. How? Well, we all know Google Maps and use it when we travel on the road. Because all vehicles and their occupants constantly supply data in real time Google Maps is the perfect digital twin of real-world traffic situations. As a result, we're always able to see if there are any traffic problems on our route and when we're going to arrive at our destination. Such a holistic digital twin in which the data of all the players involved are merged and analyzed is lacking in relation to the flow of goods. It would be of huge help for synchronizing the complex systems

of the supply chain and for making them more efficient and sustainable.

Has digitalization on the factory floor become more advanced than that?
At least for Schaeffler, I can answer that with a clear yes. We've been integrating several thousand machines in networks per year and keep doing so. In three years' time, we plan to have achieved one hundred percent network integration. That means we're going to have an exact overview of which machine is working where on what and how much and will be able to intervene immediately in the event of idle times, excessive workloads or machine trouble. Through network integration we optimize the efficiency of our internal flows of goods and energy consumption.

But not the consumption of materials?
In that area, action must be taken much earlier – in the product development stage, where performance and costs used to be the focus of attention. Today, we're increasingly focusing on usage of materials, resource conservation and CO_2 efficiency, not least because that has become more important to our customers as well. Digitalization helps optimize processes based on recorded performance indicators as well as in synchronizing product development and production. At Schaeffler, these control loops have traditionally been interlinked very closely – but, obviously, that doesn't mean that we don't want to improve in that area, too. When talking about the optimization of processes we mustn't lose sight of our upstream and downstream partners, where closer digital integration will help conserve resources as well.

You mentioned partners. How important are they for achieving your own sustainability goals?
We feel that it's our responsibility to understand and to continue developing the new supply chains across their entire lengths together with our partners. That's why finding the right partners for the required processes will be of crucial importance, not only in terms of their professional or technical expertise but also based on the firm conviction that the pathway toward a sustainable world has to be pursued with no ifs and buts. Equally important is the consensus that that will be associated with massive additional costs that, ultimately, will also have to be borne by the consumer, in other words by all of us. We have to understand that as well.

The success of changes always heavily depends on people, too. How do you stimulate the pioneering spirit of your employeees?
Actually, it doesn't have to be stimulated. A pioneering spirit is firmly anchored in Schaeffler's DNA. We're sensing a very, very high motivation among our employees to develop and implement sustainable solutions at all of our plants and at all of our locations. Our people are proud of pursuing new pathways, be it in product development, on the factory floor or in relation to establishing the things that are necessary in the supply chains. To actively promote and appreciate top performances delivered by our employees, the executive board together with the family shareholders created the Schaeffler Award a few years ago. Mr. Schaeffler personally presents the award to the winners in four categories reflecting our corporate values "Sustainable," "Innovative," "Excellent" and "Passionate." That's another example that shows how much the company values the pioneering spirit of its workforce.

In closing, would you share with us where Schaeffler currently stands on the road toward "zero emissions"?
We plan to achieve climate-neutral operations starting in 2040. This target includes the entire supply chain and is underpinned by ambitious mid-term goals. Our own manufacturing operations, that is Scope 1 and 2, will be climate-neutral as early as by 2030. We're definitely headed in the right direction because we're executing our plans consistently. Since 2021, Schaeffler has been purchasing 100 percent of its electric power from renewable sources at its European production sites. By 2024, we plan to do so at all of our locations worldwide. We're making good progress also in terms of energy efficiency. Before the end of the year, we're going to save around 47 gigawatthours, which roughly equates to the annual electricity consumption of 15,000 two-person households in Germany. The implementation of our Sustainability Roadmap is progressing as planned. The international Carbon Disclosure Project non-profit organization has upgraded us in a special water rating from "B–" to "A–" and awarded us with an overall "A–" rating as well. In the EcoVadis sustainability rating, the Schaeffler Group scored 75 out of 100 possible points equating to Platinum status. As a result, we're now in the top one percent of our peer group.

Masthead

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"tomorrow" Project Management
Nadja Lemke
(Senior Vice President Global Branding & Corporate Marketing),
Martin Mai
(Head of Newsroom, Global Editor-in-Chief Schaeffler Group)

Contact the Editorial Team
tomorrow@speedpool.com

Executive Editors
Volker Paulun,
Stefan Pajung (Deputy)

Coordination
Carina Chowanek,
Gina Fernandez

Pre-press Stage
Julien Gradtke,
Anke von Lübken

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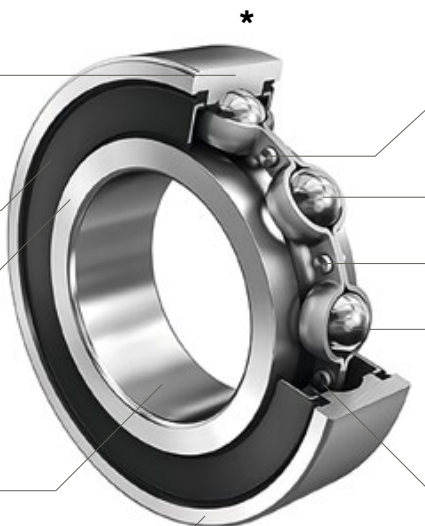
Hofmann Druck Nürnberg GmbH & Co. KG

Authors
Björn Carstens, Kay Dohnke,
Lars Krone, Dr. Lorenz Steinke



Editor-in-Chief
Martin Mai

Editorial Team and Production
Speedpool GmbH

Copy Editors
David Feist,
Christoph Kirchner

Graphic Design
Ivo Christov, Janina Roll,
Julian Schmaljohann,
Thomas Wildelau

English Translation
Helga Oberländer

* Schaeffler is offering a range of single row deep groove ball bearings specifically for food production applications, as part of its new Food program. The lubricating grease used is non-toxic, allergen-free, neutral in taste and odor, and suitable for applications where contact between food and lubricant cannot always be ruled out.

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tomorrow

Experiencing technology with Schaeffler

Schaeffler Kolloquium 2022
Coverage of the key topics

Energizing the next generation

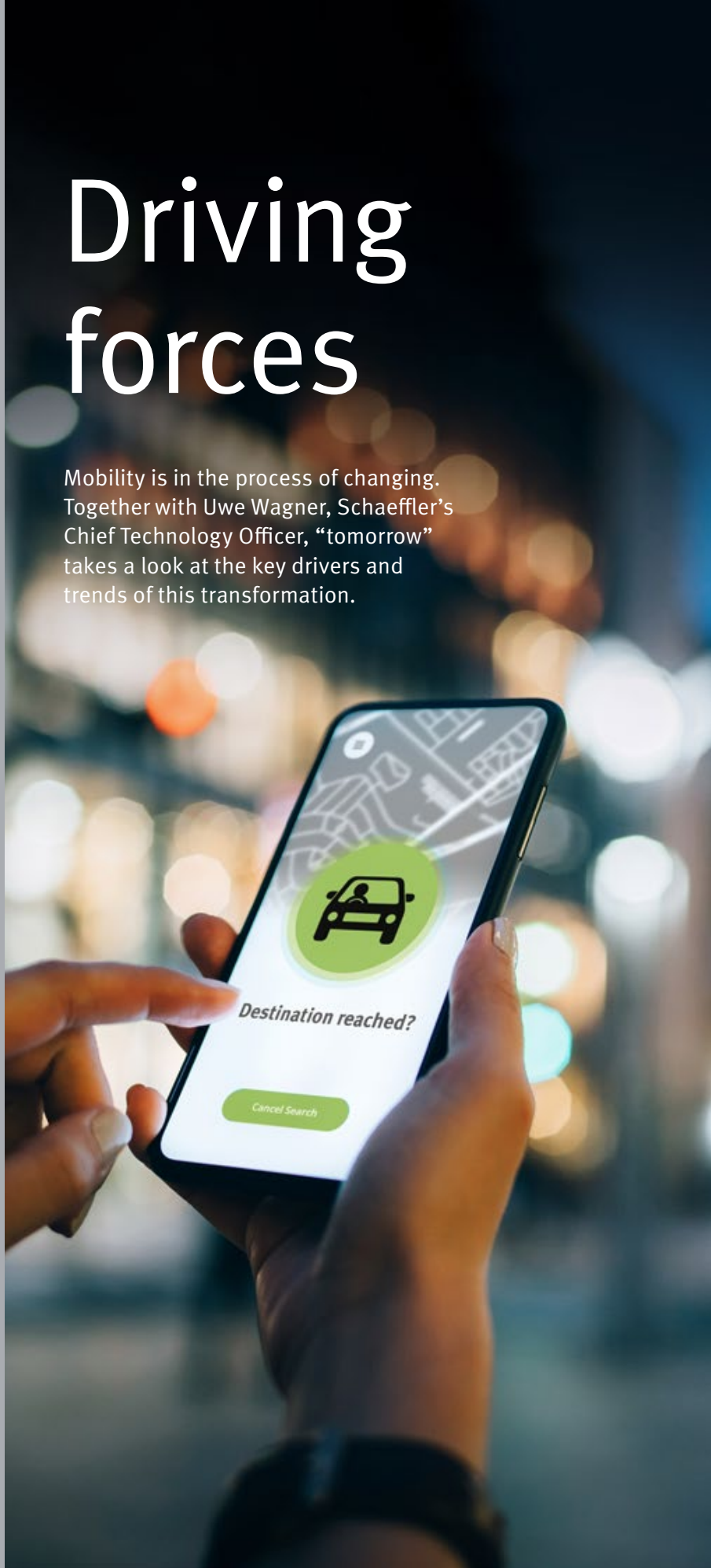
Technologies for the future: efficient, electrical powertrains, innovative chassis systems, intelligent mobility solutions

Special section Schaeffler Kolloquium 2022

SCHAEFFLER

Driving forces

Mobility is in the process of changing. Together with Uwe Wagner, Schaeffler's Chief Technology Officer, "tomorrow" takes a look at the key drivers and trends of this transformation.



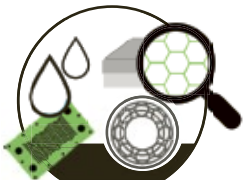
Schaeffler Kolloquium 2022: Energizing the next generation

The world is in high-speed transformation mode. Global warming, demographic change and digitalization are key drivers. Mobility, as well, must change in order to adjust to the new conditions. What role do electric mobility and the utilization of renewable energy sources play in this context? What contribution do intelligent, interlinked and self-driving mobility solutions based on modular platforms make in this regard? What new means of transportation will be used? The innovations shown by Schaeffler at the Kolloquium 2022 provide answers to these questions. In this special section, the members of Schaeffler's management board Uwe Wagner (Research and Development) and Matthias Zink (Automotive Technologies) as well as the President of the E-Mobility Business Division Dr. Jochen Schröder look at the most important product news of the colloquium, the decisive trends in mobility of the future and the challenges to be mastered on that journey.

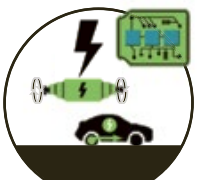
For more than 75 years, Schaeffler has been involved in decisively defining the technological transformation of mobility. To successfully master that change, innovations must be implemented systematically and fast. At the Schaeffler Kolloquium 2022, Chief Technology Officer Uwe Wagner presents six innovation fields with which Schaeffler consistently aligns its research and development activities. Uwe Wagner: "Transformation calls for innovation – and innovation accelerates transformation. By means of focused innovation management we will succeed in helping to shape and accelerate transformation with successful products. In fact, innovative prowess is a prerequisite for meeting the challenges of the future and for shaping the transition toward a sustainable, CO_2-neutral future."

Schaeffler's six innovation fields

Energy Solutions



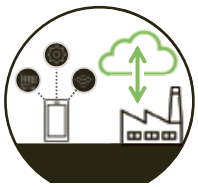
Material Solutions



eDrive Solutions

Mobility Solutions

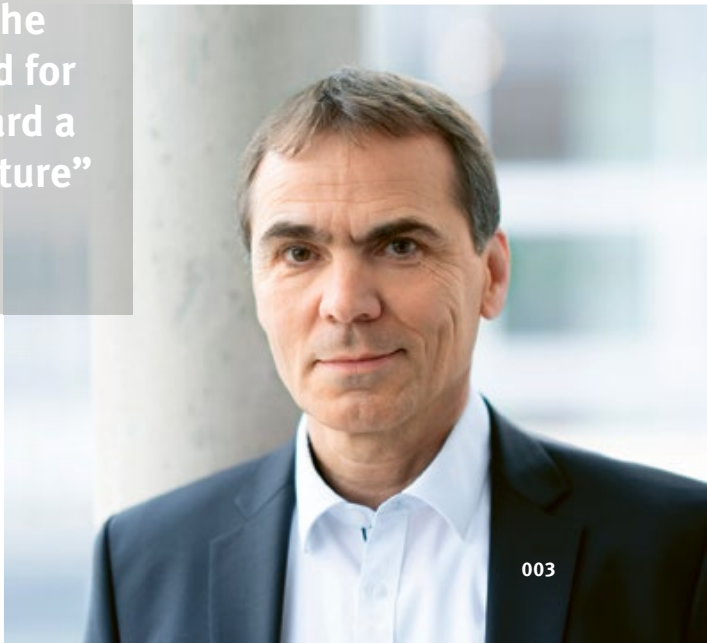
Robotics Solutions



Digital Solutions

"In fact, innovative prowess is a prerequisite for meeting the challenges of the future and for shaping the transition toward a sustainable, CO_2-neutral future"

Uwe Wagner,
Chief Technology Officer at Schaeffler AG



Energy Solutions

A holistic view of the entire energy chain is essential to a climate-neutral design of mobility and motion. Fossil energy sources must be substituted by sustainable ones as fast as possible. “Schaeffler has set itself the target of achieving completely climate-neutral operations by 2040,” says Uwe Wagner, with an increasingly strong focus on hydrogen technology. “Hydrogen is going to play a crucial role in sustainable mobility of the future. We make a key contribution to this effort particularly with our development and industrialization of bipolar plates for electrolyzers and fuel cells,” Uwe Wagner adds. Schaeffler’s high vertical integration in the field of forming technology and sophisticated coating technologies are the basis of this in-depth process know-how and for the large-scale production of bipolar plates. More on the subject of hydrogen can be found in the main section of the magazine starting on page 48.

In the field of hydrogen technologies, Schaeffler scores with its expertise in the areas of materials, forming and surface technologies

Sustainable energy production and storage are key factors of successful decarbonization also in the field of mobility

Center of innovation

The automotive and industrial supplier Schaeffler has **laid the foundation stone for its state-of-the-art central laboratory** at its Herzogenaurach campus. The 80 million euro investment in the building is a **key element of the Roadmap 2025.**

The cross-divisional central laboratory complex in Herzogenaurach will span more than **17,000 square meters of total floor area and house 15 laboratories and more than 360 employees.** "Schaeffler has consistently delivered the highest levels of innovative ability and development excellence", says Uwe Wagner, Chief Technology Officer at Schaeffler AG. "The central laboratory will allow us to strengthen our expertise in the long term and to shape progress in the automotive and industrial sectors thanks to the solutions which will be developed there. The synergies in the development process will enable Schaeffler to optimize technologies in the future fields e-mobility, hydrogen and renewable energies and to ultimately bring product solutions on to the market even faster."

The new central laboratory will cover a **wide range of topics related to the company's research and development activities,** particularly in key areas of technology, including measurement, testing, and calibration systems, material, chemical, coating and nanotechnologies as well as the optimization of operating life and system reliability. The focus here is on material, chemical, coating and nanotechnologies with the corresponding high resolution measurement technologies (metrology, chemistry, physics, electronics, and analysis).

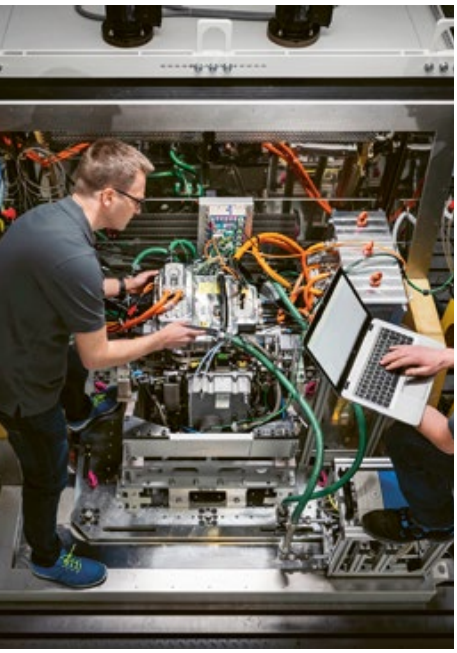
The new central laboratory will be completed in 2023 and occupied by employees at the beginning of 2024

Material Solutions

Motion and the requisite energy are not the only aspects that determine how sustainable mobility is, but so are the materials used to support it. At Schaeffler, these aspects are the focus of attention as early as in the product development stage. Uwe Wagner: "Schaeffler's high expertise in the fields of materials and surfaces prove to be a competitive advantage and innovation accelerator. The Schaeffler Coating Toolbox offers an extensive portfolio of coatings enabling us to design the surfaces of components and systems exactly according to the specific requirements of our customers."


Material as an innovation factor: a young engineer analyzing a material

Steel, for instance, as one of the most frequently used materials, is of high relevance to sustainable mobility. The utilization of green hydrogen for the direct reduction of iron ore is a key component in the effort to make steel clean and sustainable going forward. That's another reason why hydrogen is an important technology and growth field.



System development for Schaeffler's 4in1 e-axle

eDrive Solutions

Schaeffler has been engaged in electric mobility for more than 20 years and in 2018 established the E-Mobility business division in order to concentrate all competencies. This early focus is now paying off because the sales statistics of electric cars are rapidly increasing. The share of related sales at Schaeffler is steadily growing accordingly and the economic importance of the E-Mobility business division is increasing. Technologically, by consistently pursuing the further development of competencies such as systemic understanding and manufacturing excellence, Schaeffler has been developing new expertise at high speed. At the Schaeffler Kolloquium 2022, the company presents the latest innovations in this field. Uwe Wagner: "The electrification of the powertrains is the key to the defossilization and decarbonization of mobility and therefore a central innovation and growth field for Schaeffler. By concentrating our competencies, we very quickly evolved from a supplier of components and subsystems into a specialist in complex total systems including software. The 4in1 e-axle displayed at the Kolloquium is an impressive example of that. In addition, Schaeffler, as an automotive and industrial supplier, makes use of synergies: our know-how from the E-Mobility business division is also fed into industrial applications such as motors for robotics."

Mobility Solutions

Like climate change, increasing urbanization is a decisive driver of the mobility transformation. This area requires not only new, emission-free propulsion concepts but the effective implementation of new mobility concepts. Alongside cars, new concepts such as autonomous people or logistics movers will increasingly become a focus of attention. Uwe Wagner: "The Space Drive steer-by-wire technology from Schaeffler Paravan provides a good base in this area and is part of the more extensive drive-by-wire system that, in addition to the steering system, also controls the brakes and the drive system of the vehicle electronically." The future of urban mobility will also take place in the airspace. Concepts for air taxis hauling passengers or delivery drones are being developed and tested all over the world. "Due to our expertise in electric drive systems and in the aerospace sector, relevant market potential for Schaeffler might develop when volumes in this area are ramped up. Our subsidiary Compact Dynamics offers innovative technologies particularly for electric drive systems with exacting requirements for power density," says Wagner.

Autonomous, electric and even airborne: Urbanization is a driving force in the development of new vehicle concepts

Autonomous platforms are playing an increasingly important role also in automated manufacturing worlds

Robotics Solutions

Smart technologies based on artificial intelligence and higher levels of automation enable lean, agile processes – also for the production of new mobility products. For Schaeffler as a supplier of key components and systems, robotics is an important business segment. Even at this juncture, the range of rolling bearings extends from system components such as precision gearboxes, rotary bearings, drive motors and sensor systems (see also main section, starting on page 8) all the way to complete "smart" robot joints. Uwe Wagner: "We are collaborating with leading universities worldwide, such as the Nanyang Technological University in Singapore at which our Schaeffler Hub for Advanced Research (SHARE) is focused on the development of innovative Industry 4.0 and robotics solutions. These solutions help our customers optimize their processes, increase their efficiency and flexibility, and support them in becoming more resilient and sustainable." Moreover, most recently at automatica 2022 in Munich, Schaeffler announced a strategic partnership with the Institute for Robotics and Mechatronics of the German Aerospace Center (DLR). The objective is to accelerate the development of application-oriented robotics solutions through intensive strategic cooperation.

People, vehicles, infrastructure: The digital connectivity of mobility is an innovation driver

Digital Solutions

Digitalization is another key innovation driver in mobility. Whether fleet management, traffic control, ticketing, shared mobility, car-to-car or car-to-infrastructure communication, the data networks are becoming increasingly larger and denser. Steadily growing computing power and faster wireless networks support this trend. "For Schaeffler, digitalization in general, but particularly in mobility, is an innovation driver and growth field," says Uwe Wagner, "for instance with drive-by-wire systems, repair solutions of our Automotive Aftermarket market unit or condition monitoring systems for axle-box bearings." The products of the automotive and industrial supplier are found wherever things are in motion – and thus in the key areas where data are collected.

“We’re showing a festival of innovations”

For Matthias Zink, the Schaeffler Kolloquium 2022 will be the most spectacular one to be held to date. An interview with the CEO Automotive Technologies about the highlights of the event and how to successfully achieve the transformation toward greater sustainability.

Interview: Stefan Pajung

Matthias Zink has been CEO Automotive at Schaeffler since 2017. Since 2019 he has held this role solely and has been responsible for the Engine and Transmission Systems, E-Mobility, Bearings, Chassis Systems and New Mobility business divisions, plus Research and Development of the Automotive Technologies division and Global Key Account Management. Zink, who has a degree in mechanical engineering with a major in automotive engineering, calls himself a “car guy.” He started his career with Schaeffler at LuK in 1994 and soon afterwards assumed leadership responsibilities and corresponding roles in the company. We talked with him about the automotive highlights at the Schaeffler Kolloquium 2022.

Let’s start with a question to put things in perspective: Going forward, what significance will the automobile continue to have in the mobility mix?
Matthias Zink: Basically, I feel that people’s desire for mobility, especially personal mobility, has remained unbroken. The declining automotive market in the past three years can be attributed to

issues like the pandemic and shortages in the supply chain, but not to people wanting to be less mobile. A look at the global markets shows that the number of vehicles per 1,000 people remains as high as ever. However, we're seeing that personal mobility has changed quite a bit and will continue to do so. Sharing services, for instance, are going to play an increasingly important role and the difference between interurban and urban mobility will increase. That means that in the future the mobility mix will become more varied and "colorful."

From the mobility mix to the powertrain mix: In 2017, Schaeffler put its head above the parapet, predicting that, in 2030, 30 percent of new vehicles sold will have all-electric powertrains, 40 percent will have hybrid-electric powertrains and 30 percent will continue to have ICE powertrains. That's the Schaeffler 30/40/30 formula. Now you're re-honing your prediction by increasing the ratio to 40/40/20 in favor of battery-electric vehicles. What's the source of such certainty?
Certainty is a great thing in times like these (laughs). *Obviously, we're not 100 percent certain, but the following consideration explains it: At the most recent Schaeffler Kolloquium four years ago, we put our head far above the parapet because our statistics encouraged us to make that prediction – albeit with large unknown quantities for our scenario. Now – about five years later – this forecast has almost become a reality. That's the reason why we've re-honed this formula. Sustainable mobility is here to stay and will clearly increase. We're convinced of that. By the way, we're reviewing this powertrain mix scenario on an annual basis and obviously by using a magnifying glass for the various regions – the American market has a totally different development than the Chinese and especially the European markets. But aside from looking at the realities there's a second reason – which is very important to me from my perspective as the executive who's responsible for Automotive: issuing this bold scenario has been beneficial for our own transformation. We want to keep this positive intensity at a high level in relation to our employees and continue to fuel the courage for change. That's another reason why we've 'honed' our prediction to 40/40/20.*

"We want to maintain this positive intensity at high levels and continue to fuel the courage for change"

Matthias Zink,
CEO Automotive Technologies,
Schaeffler AG

Especially in times of change, effective communication with employees is becoming even more important than before. How can that be achieved?
Subjectively, this is the most challenging as well as the most exciting time in my 27 years in this business. We have a market crisis and, especially in the Automotive sector, a reputation crisis as well. Plus, there's a transformation process toward electric mobility with which we show how important achievement of the climate goals is. We want to and have to engage our employees in this process. We've been on a consistent course for growth for 75 years, have always been successful with mechanical components and suddenly many products in the

Visionary motor racing: Schaeffler is developing the drive system for a fully electric DTM racing series. From left: Dr. Jochen Schröder, Matthias Zink (both Schaeffler), Gerhard Berger (ITR chairman) and Fred Türk (Mahle)

marketplace are no longer needed due to electric mobility. Whether I'm a mechanic or electronics specialist makes a difference. People have two fears that we want to dispel: a general fear of the future and the fear of having to pursue further education, in other words to creatively deal with what's going to be required of them in the new world. We actively take on this transformation and team up in making plans for the future. A willingness to work together and to embrace change within the company develops not least with a view toward forward-thinking scenarios such as 40/40/20.

Your forward-thinking plans also include the fact that Schaeffler does not exclusively focus on electric mobility …
Exactly. We're talking about sustainability in general and that discussion is no longer strictly about sustainable powertrains for vehicles. It's about the big picture and the energy transition process with all of its facets. When you analyze sustainability, you'll soon get to the subject of hydrogen and, in the automotive sector, to the short-term use of synthetic fuels as well. At Schaeffler, we strongly advocate an unbiased approach to technology – including an unbiased approach to energy – if you could put it like that. Especially in view of the current political discussions that's absolutely necessary.

Let's talk about technologies. What is Schaeffler going to show at the Kolloquium?
A festival of innovations. Let's start on a small scale – with major effects. We're going to show two innovations in the area of our core competency, with bearings. With our **high-performance ball bearing with an integrated centrifugal disc** ❶ *and our TriFinity product, we've achieved innovations that have been optimized once again in terms of mechanical precision, performance and efficiency. Many manufacturers are systematically searching for every gram of CO_2 savings and inquire about relevant bearings enabling them to achieve that. In the area of transmissions, as well, we're going to show innovations, for instance* **dedicated MultiMode hybrid transmissions** ❷ *with which we're reimagining the combination of electrical drive and mechanical systems using all-new approaches.*

Let's jump to something "large": autonomous driving. What progress is Schaeffler making here?

Automotive innovations

An endurance and smooth-running performer

❶ A world-first: The **high-performance ball bearing** with an integrated centrifugal disc is the first unit to combine benefits of two bearing designs. In vehicles with an ICE and hybrid powertrain, it reduces CO_2 emissions – by up to 0.3 grams (0.01 ounces) per kilometer (0.62 miles) and vehicle. In addition, the reduction of losses by up to 30 watts per bearing can increase the range of electric vehicles by one to two percent. The special feature of the bearing is that the rubber seals that are normally firmly located on the outer sides are replaced by a specially designed centrifugal disc on the inner ring. The bearing generates about 80 percent less friction. Compared to an open bearing, service life increases by a factor of up to ten and doubles in comparison to conventionally sealed ball bearings.

Dedicated "MultiMode" hybrid transmissions

❷ The increasing electrification of the powertrain enables and requires the **transmission** in the **combination of electrical drive and mechanical systems** to be reimagined and adapted to current market requirements. Consequently, Schaeffler has developed an innovative hybrid transmission with low mechanical complexity combined with high performance and efficiency. Due to the system's very high efficiency, a consumption benefit of up to 16 percent can be achieved. The "MultiMode" transmission is equally usable for full and plug-in hybrids operating with two electric motors, one 110 kW-generator and one 125 kW-traction motor that are geometrically and functionally integrated into the transmission. Other technological highlights are the water-cooled, integrated inverter and the Schaeffler Smart Hydraulic System.

Modular platform

❸ Schaeffler's **Rolling Chassis** is a flexible, scalable platform for new, driverless mobility solutions for hauling passengers or goods, or for specialty applications such as mobile charging solutions or pop-up stores. The modular platform exhibits the wide range of technologies from Schaeffler and offers a flexible architecture: In terms of steering and propulsion, various versions can be implemented, depending on customer requirements – from a simple drive system via an electric axle and central steering system through to the use of four "Schaeffler Corner Modules," each enabling a wheel turn of up to 90 degrees. They encompass the wheel hub motor, the wheel suspension including air springs enabling the vehicle to be lowered for ingress, the actuator for the electromechanical steering system and a brake.

Innovative chassis systems

❹ With **innovative steer-by-wire solutions,** Schaeffler is advancing the development of highly automated driving. The innovative steering technology for automotive mass production, consisting of the new components, Hand Wheel Actuator and Road Wheel Actuator, respectively, enables all-new scope for freedom in automotive interior design as well as new functions for enhanced safety, comfort and agility. Because steer-by-wire requires no mechanical connection between the steering system and the wheel axle diverse solutions for adjusting the steering feel can be achieved – all depending on the customer's wish and interior design of the vehicle.

This is another area for which we've defined a scenario and objectives for the various automation levels. It's generally harder to make specific predictions than in the case of electric mobility but it's clear that automated driving will arrive. For the highest level of automated driving, for instance, we're developing our **Rolling Chassis** ❸ *, a flexible, scalable platform for driverless mobility solutions – for hauling passengers as well as goods.*

Let's take a look underneath the car, into the area of the chassis. What's ready to go there?
Our intelligent rear-axle steering system iRWS, for example. In the context of electric mobility, that's an increasingly important subject, starting as early as in the upper mid-size car class. Due to the batteries in the underfloor, wheelbases are getting larger and larger, which reduces maneuverability. Rear-axle steering compensates for that. We've got several projects for the automotive industry ready to go there. **Steer-by-wire technology without a steering wheel** ❹ *is another subject. We've been working on that for quite some time and are also using it in motorsport. An electronic instead of a mechanical transfer of the steering motion is a prerequisite for autonomous driving. I'd say that in ten years' time, we're no longer going to have a steering wheel in every automobile.*

Then let's take a general look at the Kolloquium: How would you classify this event – compared to the previous one and in general terms?
Compared to our Kolloquium four years ago, I'd say that this event represents the so far largest technological leap in the direction of future mobility. Plus, overall – after half a century of colloquiums – it's the one featuring the largest number of innovations. It's really – and I don't mind repeating myself – a festival of innovations we're going to celebrate there. Only one of the 18 presentations at the Kolloquium will be about the classic internal combustion engine. Just in terms of demo vehicles, we're going to have twelve of them – which sets another record. We can all justifiably be proud of what we've established in terms of new fields of activity and dared to do in terms of innovations in the four years since our last Kolloquium – in partly very difficult times. By the way, that also shows our consistent execution of the Roadmap 2025 for our division, and I'm pleased to show that to our customers at the Kolloquium.

Honored for innovation: Matthias Zink (right) accepts the "Golden Steering Wheel" for Schaeffler's 3in1 e-axle from Tom Drechsler, "Auto Bild's" editor-in-chief, and MC Barbara Schöneberger

But it's also simply a great pleasure to see how our employees drive and live these innovations and Schaeffler's transformation. Let me tell a little story in this context: I test-drove our demo vehicle with a fuel cell drive system from Schaeffler today. The on-site team included two electrical engineers, one of them a clutch engineer and the other one from the transmission team – so both of them were from the 'old guard.' I was totally thrilled to see their enthusiastic engagement in this project. Exactly that is the typical Schaeffler DNA and the strength of our company. That was an absolute highlight for me. At Schaeffler, we've always gone into the next responsibility of the system levels in evolutionary ways, but the change in the past four years has really been exceptional. I'd like to also thank our employees for that.

In closing, we'd like to venture a look into your crystal ball: What will be shown at the Kolloquium 2026?

I think that we're going to talk a lot more about energy storage systems then. Of course, we'll continue to optimize drive systems, but storage systems and the entire area of energy engineering will be topics on the agenda. Automated driving is a second major topic that I'm seeing. I think that we're going to see the first production vehicles in four years' time that will be operating autonomously in separate areas. Vehicles without steering wheels with all-new controls – I can also imagine that really well.

Thank you for the interview!

“Due to the many question marks that still exist, we develop without limitation to any specific technology”

The E-Mobility division he leads is one of the key protagonists at the Schaeffler Kolloquium 2022. An interview with Dr. Jochen Schröder about challenges that have been mastered and potential that’s yet to be tapped in the field of electrified mobility.

Interview: Volker Paulun

Dr. Jochen Schröder assumed responsibility for the newly established E-Mobility division at Schaeffler on April 1, 2018. He's been "charged up" ever since his days as a student of electrical engineering at the Hamburg University of Technology. Schröder subsequently earned a doctorate in the field of control technology. Following a more than 15-year successful career in various leadership roles, including predevelopment of electrical drive systems and full-vehicle energy management, at BMW, Schröder became head of development at Valeo Siemens eAutomotive GmbH in 2016. From there, he joined Schaeffer where, among other things, he's making sure that electric mobility is literally put on pole position: in the future DTM Electric.

In the past, Schaeffler was primarily known for technology serving internal combustion (IC) engines. Today, the company is an established player in electric mobility. How has that been achieved? Is there a success formula?

I can't judge whether there's a general formula for achieving successful transformation. We started out by analyzing what strengths we have. That's the foundation. Ideally, you then manage to develop a strategy based on that in which medium- and long-term goals are defined and ways of achieving them are identified. The transformation of mobility is one of the forward-thinking trends with which Schaeffler's "Roadmap 2025" is aligned. That provides our direction. Building on that, we've defined five focus fields in which we can optimally use our existing know-how including, for instance, electric motors as well as CO_2 efficient powertrains with hybrid transmissions or electric final drive systems. That's where we rely on our in-depth systemic understanding of individual manufacturing technologies up to vehicle level. Based on that, we manage to offer high-level competitive developments very fast also in electric mobility.

Can you illustrate that by providing some practical examples?

Schaeffler has developed a lot of know-how in the area of transmission technologies for IC engines in the past 50 years. Now an electric car no longer uses a manually shifted transmission but, even so, an electric motor transfers its power to the wheels via a transmission. Hybrid electric vehicles need transmissions as well for ideally combining the propulsion energy of the electric motor and the IC engine and to put it on the road. That's why transmission technology was an ideal starting base for us in terms of new developments for electric mobility. Building on that, we've developed hybrid modules and transmissions for electric drive axles, for example. We initially purchased the required electric motors but soon recognized that even though an electric motor ultimately operates electromagnetically its composition is defined mechanically. It contains stamped sheet metal and in its production process utmost stamping precision is crucial. That's something that Schaeffler has been doing really well for decades. In addition, manufacturing processes such as forming, joining, adhesion bonding and assembling are used. That calls for manufacturing excellence – which is another one of Schaeffler's strengths. From that perspective, manufacturing electric motors in-house was ultimately a logical move. So, based on our strengths, we've developed new competencies step by step and consistently transferred them into new products.

… and regarded change as an opportunity rather than a risk?

In view of climate change and the resulting pressure for action, we soon realized that remaining strictly in the IC engine world was not an option. However, our own, intrinsic motivation of wanting to be agile is a stronger driver than the realization of having to be agile. This pioneering spirit that's typical of Schaeffler unleashes a lot of energy in the entire team. In addition, we've provided the means for the investments that are necessary for developing know-how in electric mobility. Plus, we emphasized product ideas that are a good fit for us and have developed them further. Looking back on what we've achieved so far, I can say that we've addressed the right areas and got tremendous products and innovations off the ground that are meeting with very positive response by the market and our customers.

In other words, a true success story?

Let's put it this way: Although there's still quite a bit of road to travel ahead of us, I no longer question that we'll succeed in establishing ourselves as a supplier in electric mobility as we have with the

internal combustion engine. The current volume of incoming orders in the electric mobility business confirms my optimism. In the first quarter of 2022 alone, the Automotive Technologies division was awarded contracts worth two billion euros for the electric mobility unit. In 2021, the entire Automotive division generated 10.2 billion euros in incoming orders, with electric mobility accounting for 3.2 billion of that.

Looking at Schaeffler's now extensive electric mobility product portfolio, which current highlight would you want to emphasize?
Our 4in1 e-axle. I feel that the level of integration that has been achieved there is revolutionary and reflects the full gamut of our expertise as an automotive supplier: our experience in classic transmission engineering and our know-how in thermal management that we've developed in relation to IC engines as well as our new expertise in electric motors and power electronics. In addition, combining the four subsystems, motor, transmission, power electronics and now thermal management for the first time as well, into a perfect unit requires a high level of systemic understanding. This interdisciplinary understanding of systems is one of Schaeffler's strengths that has grown across decades. We're one of the few suppliers worldwide that understand the whole gamut of domains, from thermal systems to drive systems, and the resulting complexity and, based on that understanding, are able to define, produce and offer total systems that are better than their individual parts.

What exactly is the customer's benefit of buying such a complete system as the 4in1 axle instead of its individual components?
The 4in1 e-axle is more compact, which opens up all-new possibilities of space utilization in the architecture of the whole vehicle. In addition, such a total system offers cost benefits compared to a combination of independent subsystems, is perfectly coordinated and therefore even more efficient while delivering higher performance. Even so, irrespective of total systems like the 4in1 e-axle, with our diversified modular electric mobility kit, we continue to offer subsystems that are combinable in modular ways when customers wish to implement their own developments. However, be it total systems or subsystems, a successful integration into the vehicle's overall configuration can only be achieved in an open and intensive exchange with the customer. That was the case with vehicles using internal combustion engines and continues to be the case with electric cars. In addition, those dialogs, both internally and externally, are fertile soil for creating innovations and new ideas.

IC engines had many different variants: gasoline, diesel, units with and without turbocharging, with two to twelve or even 16 cylinders, in-line, V and Boxer engines or exotic designs such as the Wankel engine. By contrast, an e-car has an e-motor, that's it. Are there really no differences?
There are differences, in fact there are a lot of them. That that's not part of the current public perception still tends to be due to the fact that all of us

"We are among the few suppliers that are able to define, produce and offer total systems that are better than their individual parts"

Dr. Jochen Schröder

may still have to learn to understand the underlying technical aspects of electric mobility to some extent. We've all grown up with the IC engine. We used to already swap tech terms on the schoolyard while playing Top Trumps with car cards and everyone knew that a four-cylinder doesn't have as much power as a twelve-cylinder. This widespread understanding has to develop first with e-mobility and I'm sure that once it has, word will get around that there are big technological differences between various electric motors.

What are those differences?
You could write entire books about that. Depending on the type of electrified powertrain, e-motors, in terms of their topology, have major technical differences, for instance in the type of winding, installation space, torque, permanent output and operating behavior. However, for some basic knowledge, a few key terms are sufficient. For instance, there are synchronous and asynchronous motors with major differences in their respective performance. An asynchronous motor is economical, robust and hard-wearing, whereas the synchronous machine delivers about 30 percent higher performance and achieves high efficiency even at low output levels. But it has the disadvantage, for instance, that it typically requires the use of rare earths at the moment. Most of these synchronous and asynchronous motors are conventionally built radial flux motors, which means that the magnetic flow is in the rotational direction. However, there are also some highly innovative motors with axial magnetic flow. They're very flat because the stator and rotor are arranged on top of each other like slices of a sandwich and they have extremely high levels of power density. That's not the only reason why such axial flux motors can be compared with classic twelve-cylinder engines but also because their design is of similar complexity. I'm sure that sooner or later people with an interest in technology will discover the wide range of existing technical differences, from motors that function in rather simple ways to performance motors.

In what areas does Schaeffler intend to position itself?
At Schaeffler, we essentially want to offer a wide variety of electric motors – across all electrification levels for hybrid modules, hybrid transmissions and fully electric final drive systems with a wide output range from 20 to more than 300 kW, even though we definitely see a focal area for ourselves in the highly innovative high-performance motors.

Being able to offer such a wide variety is, no doubt, a major challenge. Why is Schaeffler pursuing this pathway?
Because the transformation of mobility is still associated with major uncertainties. We know by now that electric mobility is coming. But how fast will it come? In what regions? And in what segments? Are we going to have more hybrids or more fully electric vehicles? In what markets of the world can we expect what volumes? And how are hydrogen and fuel cells going to develop? Because there are no reliable answers to any of these questions, we develop without limitation

More range, more convenience

In the 4in1 e-axle, Schaeffler, for the first time, combines the components "motor, gearbox, power electronics and thermal management" into an innovative total system. The **high level of integration of the components,** in combination with intelligent control and a highly engineered architecture, enables optimum use of existing thermal energy. The system therefore stands for both an increase in electric range and an enhancement of convenience.

Key component for numerous applications

Whether in double-clutch transmissions, hybrid transmissions, rear-axle steering systems, in thermal management or in seat adjustment mechanisms: Electric motors are used in many places on modern vehicles (and not only there) aside from the powertrain. The motors we're referring to are **brushless EC motors.** In Bühl, Schaeffler is now producing these multitalented devices in-house for use in a mass-produced hydrostatic clutch actuator. The motor serves to generate the pressure required to actuate the clutch. **"EC motors are definitely all-rounders and have become indispensable in modern vehicles,"** says Dr. Jochen Schröder, President of Schaeffler's E-Mobility Division in Bühl, "because compared to motors with mechanical sliding contacts, brushless EC motors have clearly longer life spans, deliver higher efficiency as well as clearly more reliable service. **The abbreviation EC stands for electronically commutated,** i.e., the electronic alternation of voltage from one motor winding to the next.

to any specific technologies. Besides that, our customers are asking themselves those questions as well. At Schaeffler, not least due to our determination of being our customers' preferred automotive supplier, we regard offering powerful solutions in all segments as an obligation to some extent.

Doesn't the ability to offer such a wide and variable product range also pose a manufacturing challenge?

It does indeed. We can only respond to the diversity of variants and the volatility of volumes with an agile way of manufacturing. This is another area in which we must drive digitalization and automation as keys to flexible and sustainable production. Schaeffler, for instance, does this in the research project "AgiloDrive2" for e-motors. In this project that's funded by the German Federal Ministry for Economic Affairs and Climate Protection we are the leader of the consortium and engaged in exchanges with 17 partners. It was launched at the end of 2021 for a term of three years. Following its completion, we plan to transfer the findings gained from this project directly into electric motor production at our Bühl location. There, at the headquarters of the Automotive Technologies division, a state-of-the-art, globally leading, pioneering plant for manufacturing electric motors is being established.

What makes this e-motor factory a globally leading, pioneering plant, as you call it, in this area?
Instead of rigid production lines we emphasize highly flexible, digitized and efficient technology modules there. In the spirit of a "plug and produce" approach, they're easily scalable, can be flexibly configured thanks to standardized machine connections, hardware and software interfaces and enable software-based interlinking and setup. The modular design of the machines allows for a reutilization of the production equipment, which is not only economical but also sustainable. In all of this, the fact that we can directly draw on a lot of know-how with our in-house special-machinery engineering unit is a major advantage. But, of course, such forward-thinking production facilities are not just about machines but also about people. With new qualification methods, we plan to facilitate and accelerate the learning process for our colleagues working there.

Let's get back from manufacturing to the motors themselves once more. With IC engines, engine power per unit cc and efficiency have made major leaps in the course of time. Can we expect that to be the case with e-motors, too?
These propulsion systems and their evolution cannot be compared as easily as that. With ICE systems, the propulsion power is almost exclusively focused on the engine. In electric cars, it's important to always look at the entire electrical

system consisting of the battery, motor, electronics, system integration, etc., etc., etc. This total system is going to see considerable further development, for instance with solid-state batteries. With the electric motor itself, there's still further potential to be tapped in terms of its optional dimensioning and integration into the system. We talked about the axial flux motor earlier. That's a good example of how the design of the e-motor can also serve to increase power output and efficiency. So, yes, a lot is still going to happen in many areas of the total system of electric powertrains. Power density will improve, costs will decrease, range and weight will continue to be optimized.

Talking about the total system. What will change when the battery is replaced by a fuel cell?
The motor itself doesn't care where its power comes from, especially since even fuel cell cars use a smaller intermediate battery as a buffer. However, there are big differences in the design of the onboard electrical system and the way in which the voltage is stabilized. The thermal management system has to be modified as well. A fuel cell produces more waste heat requiring dedicated loops for controlling and using it. Generally speaking, hydrogen technology is of strategic importance to Schaeffler, resulting in a corresponding commitment on our part to drive developments in this area with innovative ideas and products. Just recently, we announced that together with Symbio, a joint venture of Faurecia and Michelin, we're establishing a joint venture for the production of bipolar plates for fuel cell systems. Bipolar plates are a key component of fuel cell stacks. We contribute our comprehensive expertise in the area of precision forming and stamping technology as well as our process know-how for mass production of metallic bipolar plates. We're planning to launch production together with Symbio in our joint venture Innoplate at the beginning of 2024.

This, no doubt, is a major endeavor. What are your views on the market development?
Basically, we're convinced that hydrogen is going to play a crucial role in sustainable mobility going forward. The development of a hydrogen economy and the conversion process toward sustainable energy resources will decisively depend on new technologies and the industrialization of reliable supply chains. Symbio has already been awarded a major contract for a fuel cell system by a leading vehicle manufacturer. In our joint venture, we're going to produce the bipolar plates for that system together. The question of whether enough green hydrogen will be available for all sectors in the medium run still remains to be answered. That will inevitably determine the markets and vehicle segments in which fuel cell systems will tend to be used. For instance, transportation of heavy goods and long-distance hauling would clearly have to be given preference – at least from a technical perspective. However, at this juncture, it's extremely difficult to predict whether reality will actually reflect this theory. Exactly such imponderables are the reason why at Schaeffler we're preparing ourselves for as many contingencies as possible.

"I am proud of my team": Dr. Jochen Schröder celebrates the win of the prestigious "Golden Steering Wheel" automotive award for the e-axle together with his colleagues

Thank you very much for these many interesting insights.

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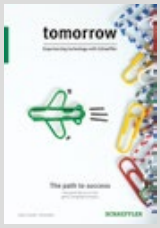

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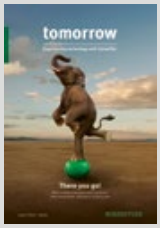

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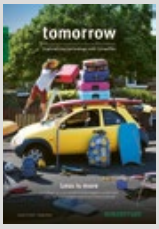

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