tomorrow

EXPERIENCING TECHNOLOGY WITH SCHAEFFLER

The big picture

Those who want to change the world have to think in global contexts

Issue 2/2019 · Holism

SCHAEFFLER

Ho|lism ['hoʊlɪzəm]

Holism (from Greek ὅλος holos “all, whole, entire”) is the idea that systems (physical, biological, chemical, social, economic, mental, linguistic) and their properties should be viewed as wholes, not just as a collection of parts.

Source: Wikipedia. Retrieved on August 26, 2019 from https://en.wikipedia.org/wiki/Holism

tomorrow
on the internet

tomorrow as a **digital magazine**
with additional features
www.schaeffler-tomorrow.com

tomorrow for downloading
as an **e-paper or PDF**
www.schaeffler.de/tomorrow

tomorrow
subscription

We’ll be pleased to include you
on our **distribution list**
tomorrow@schaeffler.com

DEAR **READER,**

The history of our Group reaches an important turning point during a nighttime car trip 70 years ago. At the wheel: Dr.-Ing. E.h. Georg Schaeffler. For months, Schaeffler, who has a business degree and is also well-versed in engineering, has been thinking about how needle bearings might be optimized. Now, in the car, he has the decisive flash of genius: the rollers have to be guided parallel to the axis. The cage-guided needle roller bearing is born: a global success on which many other innovations would be based and an outstanding example of how everything in life is interlinked. Would the Schaeffler Company have risen to the level of a global player without his invention? The answer to this is anyone's guess.

One cogwheel sets the next one in motion – life on our planet resembles a gearbox. That's why it's all the more important to keep an eye on the big picture rather than just focusing on individual cogs. With that, I'd like to welcome you to this issue of "tomorrow," which is dedicated to precisely this focus topic: the big picture, captured in the idea of holism.

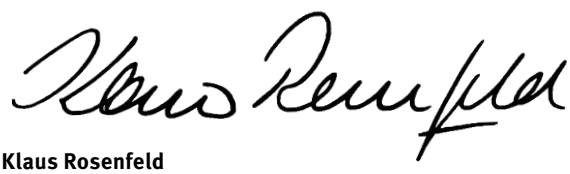
A wide range of scientific fields pursues holistic approaches. The core thesis of holism is that the whole is more than the sum of its parts, a proposition that's underpinned by Georg Schaeffler's needle bearing as well: The design he developed makes the rolling element lighter, more compact and more torque-resistant. It opens all-new doors to development engineers. The needle bearing – a "small cog in a large wheel" – causes a whole industry to rotate. As a result, just four years after Schaeffler's flash of genius, every car produced in Germany is on the road with his invention.

Currently, digitization is setting many things in motion, at breath-taking speed and with earthquake-like momentum. This is another recurring topic covered on the following pages: artificial intelligence for example, or 5G high-speed cellular networks by means of which an incredible 50 billion devices are planned to be interlinked in the Internet of Things. So-called biohackers are even working on interlinking our brains with machines. So it's within the realm of possibilities that a small robot will soon be serving you a cold drink because it has received a radio signal from your body saying that you're thirsty. And what will the robot do when it's thirsty? It'll head for a power outlet. But what if there's no current flowing from the socket? Game over. No juice, no energy. The energy flow from our power outlets is arguably the most important cogwheel in the gearbox of civilization. Any disruption there causes disruptions everywhere. Blackouts can have devastating consequences. What kind and how we can protect ourselves against them is described starting on page 48.

The sustainable generation and efficient use of energy is no doubt the key task in fighting climate change. Schaeffler is committed to making an important contribution to this effort with innovative and technologically excellent products. Our holistic strategy is centered on the four focus fields of eco-friendly propulsion systems, urban and interurban mobility, and energy chain – another topic you'll be able to read more about in this issue of "tomorrow."

But even Schaeffler as a Group with worldwide operations and more than 90,000 employees is just an individual cogwheel in the global gearbox. When it comes to the big picture – currently being unhinged by the powerful game changer of climate change – the whole world needs to join forces: the political, industrial and business community, and each and every one of us.

We'd be pleased if our technology magazine's look at the pig picture inspired you along those lines.



Klaus Rosenfeld
Chief Executive Officer

global

A glimpse of the world

8 **GOOD TO KNOW**
Facts, figures, oddities – a **360-degree view** of the "big picture"

12 **MODERN MOBILITY**
An interview with someone who shapes it: **Matthias Zink** is Schaeffler CEO Automotive OEM

18 **STOWAWAYS**
Technology not only hauls people and goods but also spreads **invasive species**

in motion

Innovations in the course of time

24 **REPURPOSING**
From a brown coal mine to a biotope – examples of wholesome **transformations**

28 **ECOLOGICAL RETIREMENT**
Even eco-friendly technology requires clean **end-of-life disposal.** Here's how it works

34 **IN A STATE OF FLUX**
Humanity has always looked ahead – but the **perspective** has dramatically changed

38 **DIGITAL BONANZA**
The new **5G networks** provide many new fields of digitalization with a long-awaited turbo boost

here and now

Living with progress

44 **AI'S ABILITIES**
Artificial intelligence is increasingly evolving into **nerve centers** of the technological playing field

48 **BLACKOUT**
When the lights go off. What are the consequences of **grid failures** and how can they be prevented?

52 **PLANET IN PERIL**
17 goals for a better world have been formulated in the **UN's Agenda 2030.** They result in a holistic solution

58 **ALL FOR TWO**
Great **teamwork,** perfect technology: the basis for triumphs in racing, also at Audi Sport ABT Schaeffler

outlook

Technology for tomorrow

66 **LOOKING AHEAD**
Uwe Wagner, Head of Research and Development Automotive OEM and Industry, in a big interview

72 **WORLD EXPLAINER**
Nobody wrote about the big picture with all of its intertwinements as wittily as **Douglas Adams**

76 **ECO-BUILDINGS**
Energy self-sufficient buildings are no longer a vision, but still the exception rather than the rule

80 **A TO Z**
Sustainable use of energy requires holistic optimization – from source to consumer

86 **SUPERPLANTS**
Amazing: inconspicuous **plants with (super)natural** powers could save the world

90 **MASTHEAD**

WORLD PREMIERE:
STEER-BY-WIRE IN RACING

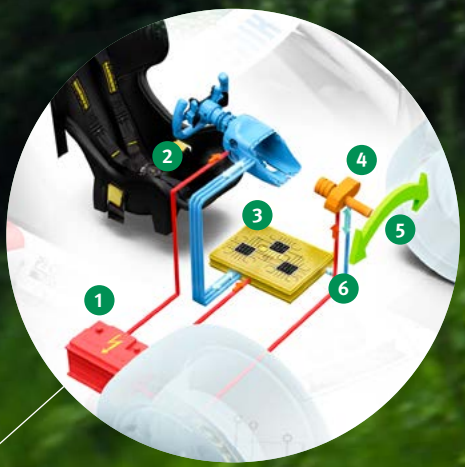
Race drivers are full-throttle acrobats performing at the limits of speed. In motorsport, "on the edge" is a frequently used expression for this. When approaching the edge, race drivers have to combine their skills and the conditions on the race track so perfectly that they come as closely to it as possible – while ALWAYS remaining on the right side of the edge. The other side is called "off-track excursion" and usually means crashing. In order to perfectly master the feat of driving on the edge, race drivers have to be able to rely on their "technical equipment" one hundred percent. In this context, a permanent mechanical connection between the steering wheel and the wheels – including feedback of forces – has been firmly anchored in automotive engineering design from the very beginning – up until now. The Schaeffler Paravan joint venture is celebrating the world premiere of a steer-by-wire system in motorsport – with a force-feedback function just like in simulator racing. The converted Audi R8 LMS GT3 sports car (max. 430 kW/585 hp) competes in the DMV GTC racing series and has been approved by the German Motor Sport Federation (DMSB) as the world's first race car without a steering column. The elimination of the steering column is enabled by components of the "Space Drive" system developed by Paravan for people with disabilities. The performance capabilities and robustness of the system are to be tested under extreme conditions in motor racing. Audi Sport and ex-Formula One racer Markus Winkelhock was one of the first race drivers behind the "electronic steering wheel." Was that strange? "No, I talked to the engineers for a long time. They told me about the triple safety and extra power supply. And when they mentioned a billion test kilometers having been driven without a single glitch I was convinced." And how does it feel to drive it? "After just a short time, we were on a top level with our lap times. Now, we need to do detailed work with the force-feedback system because I don't just turn the steering wheel but it also tells me something about the wheels." In the future, what exactly the system tells will be individually programmable for every driver: for even faster full-throttle acrobatics "on the edge."

global

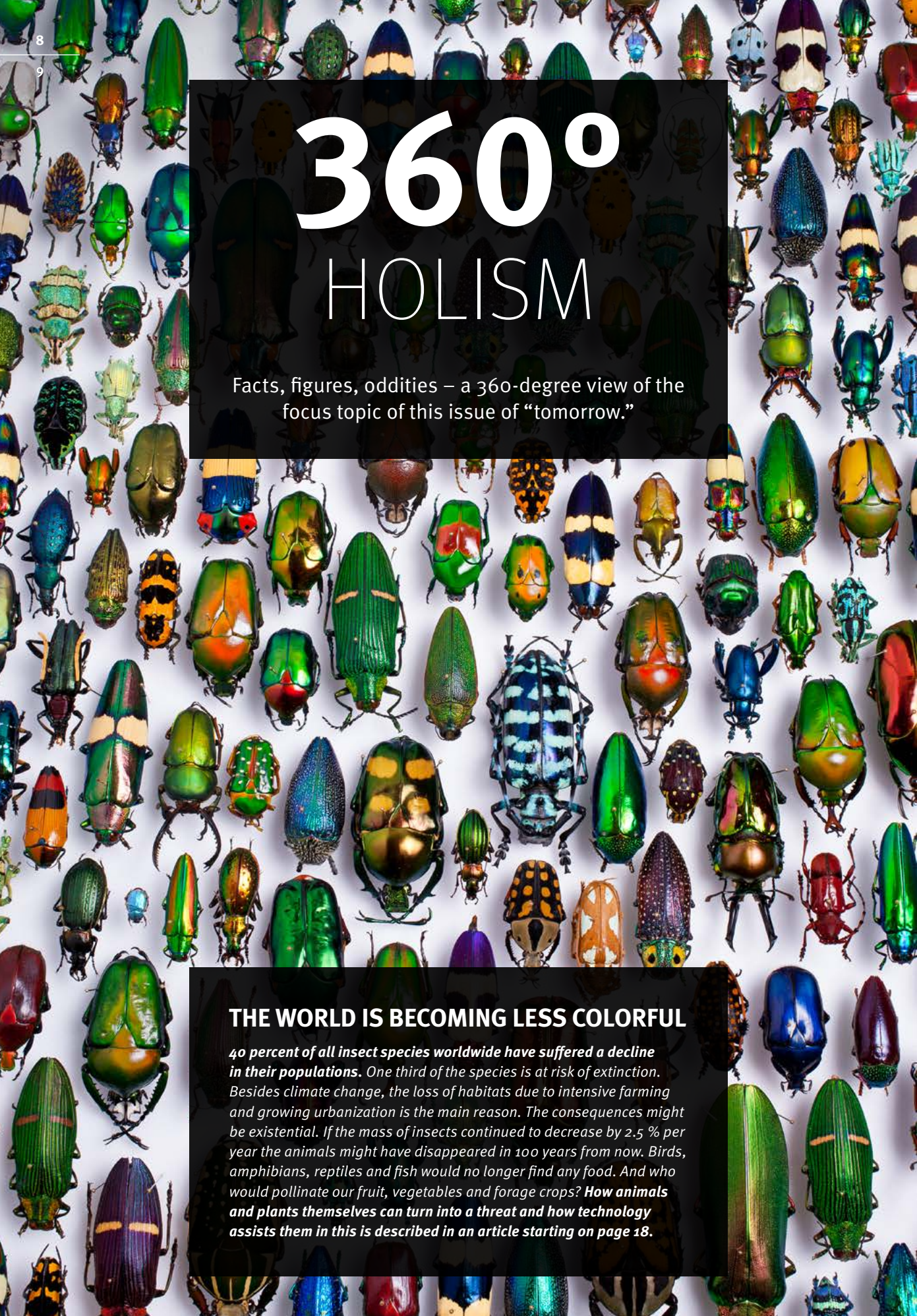
A glimpse of the world

STEER-BY-WIRE IN THE AUDI R8 LMS GT3 SCHAEFFLER-PARAVAN

The system is powered by the onboard electrical system. A second battery (1) serves as a backup. The steering signal (2) is transmitted with triple redundancy to the triple-redundant processor unit (3). The three processors always operate simultaneously, independently and check each other. The commands are forwarded according to the "2 out of 3" principle. This method has been derived from aviation where such redundancies have been standard for a long time and is called "fail operational." In the worst case, the system is still operational with just one functioning processor. In the actuator (4), the steering signal (5) is transmitted to the wheels. Responses of the wheels on the surface are fed back to the steering wheel via sensors (6) – the so-called force-feedback. This conveys a realistic steering feel. Its advantage: via software, force feedback can be individually adjusted according to the driver's preferences.



» You'll never overtake someone by treading in their footsteps François Truffaut



360° HOLISM

Facts, figures, oddities – a 360-degree view of the focus topic of this issue of "tomorrow."

THE WORLD IS BECOMING LESS COLORFUL

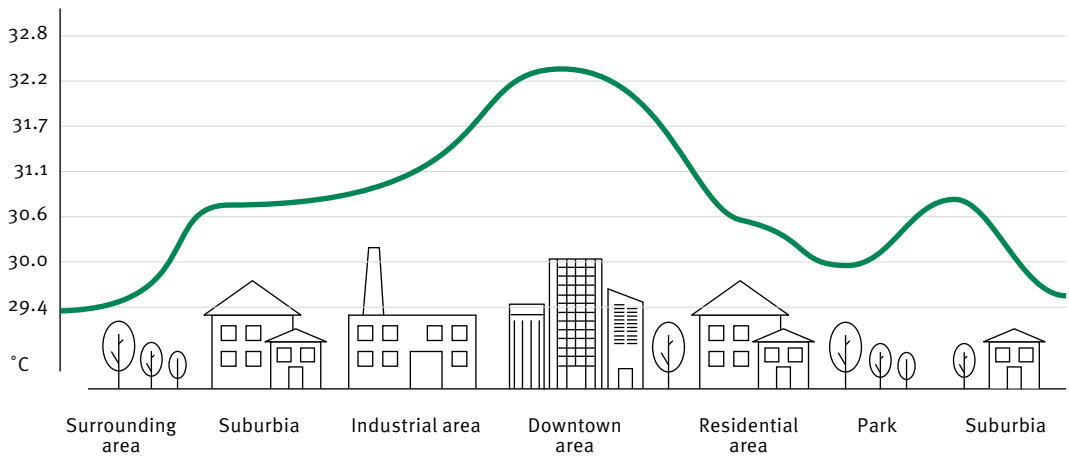
40 percent of all insect species worldwide have suffered a decline in their populations. *One third of the species is at risk of extinction. Besides climate change, the loss of habitats due to intensive farming and growing urbanization is the main reason. The consequences might be existential. If the mass of insects continued to decrease by 2.5 % per year the animals might have disappeared in 100 years from now. Birds, amphibians, reptiles and fish would no longer find any food. And who would pollinate our fruit, vegetables and forage crops?* ***How animals and plants themselves can turn into a threat and how technology assists them in this is described in an article starting on page 18.***

AWARD-WINNING **VEHICLE CONCEPT**

Holistic mobility ideas are increasingly moving into focus. The Schaeffler Mover is a case in point. The innovative electric self-driving concept vehicle was recently selected as the winner among 270 entries and recognized with the ***2019 German Mobility Award*** *of the Federal Ministry of Transportation and the "Germany – Land of Ideas" initiative.*

URBAN **HEAT ISLANDS**

Studies have shown that temperatures in the cities monitored have increased twice as much on average over the last six decades than in the surrounding rural areas. As a result, by the end of the century, a fourth of the global conurbations might be 7 °C (12.6 °F) warmer than today. Possible consequences: productivity in urban areas significantly drops while health risks rise. Remedial actions: making cities greener again and, ***of course, construction of more energy-efficient buildings. More on this topic starting on page 76.***



HIPPO SILICON **CYCLE**

Another example that shows how everything is related to everything else: *Hippopotamuses are not only some of the heaviest terrestrial animals but also make a significant contribution to the thriving of their surrounding ecosystem. While grazing, they absorb silicon stored in the plants which they subsequently excrete again while resting in water. The silicon in turn is important for the growth of diatoms, which are at the bottom of the food chain. This makes hippos nutrient pumps in African bodies of water. But here, too, the rule applies that the dose makes the poison. When water levels are low the hippos' excrements will soon over-fertilize the rivers, resulting in a lack of oxygen. So, something that was a positive just a little earlier suddenly turns into a negative. Everything is related to everything else.* ***Read more about plants that extract metals from soil starting on page 86.***

WORDS TO REMEMBER

» Science and technology revolutionize our lives, but memory, tradition and myth frame our response

Arthur M. Schlesinger (1917–2007), American historian

» Those who are unwilling to change things will lose the things they want to preserve

Gustav Heinemann (1899–1976), German politician

» Never confuse movement with action

Ernest Hemingway (1899–1961), American novelist

» To those who know the WHY of this world no HOW will be too difficult

Friedrich Nietzsche (1844–1900), German philosopher

BOTTLENECKS IN WATER CYCLES

A fourth of the world population suffers from water scarcity. This is one of the reasons why humans are now extracting twice as much groundwater from the Earth than they did 60 years ago. A non-existent or dilapidated water supply system exacerbates the situation. Jakarta (pictured) is a case in point. Some parts of Indonesia's capital have been sinking by as much as 20 centimeters (8 inches) per year due to excessive well construction and water extraction. However, global warming has also caused the sea level to rise. By 2050, a third of the city might be flooded, according to forecasts. Desalination plants that turn seawater into drinking water are one of the global approaches pursued in order to solve the problem of water scarcity. However, current desalination technology is extremely energy-intensive and operates with chemical additives. Plus, feeding brine back into the sea in environmentally compatible ways poses another challenge. Experts are investigating alternatives such as more effective separating membranes and utilization of solar energy. **Water supply, sanitation and global warming are just three areas addressed in the total of 17 UN goals for sustainable development. More on this starting at page 52.**

SATELLITE FLOOD

If Elon Musk, CEO of SpaceX, has his way our firmament will change in the next few years. By 2027, SpaceX intends to make the "Starlink" project reality. At that time, the number of satellites is supposed to more than triple for the purpose of providing complete high-speed internet access around the globe. Critics fear littering in outer space. Scientists might be led astray by the Starlink swarm when the flood of satellites obscures far-away stars and galaxies. ***On the other hand, a powerful wireless network is becoming increasingly important, as the report starting on page 38 shows.***

2,000
active satellites now

5,000
satellites in total

17,000
satellites with Starlink

THE REALLY, REALLY BIG PICTURE

In terms of cosmic dimensions, humans are merely insignificant walk-ons in the universe. Trillions of galaxies, quintillions of stars: between 200 and 400 billion stars are shining just in our home galaxy, the Milky Way.

Outer space, an infinitely vast expanse in the exploration of which Schaeffler has been assisting for decades: with bearing solutions for heavy telescopes, with precision-components for rocket engines or with bearings used in the Mars Rovers.

“WE HAVE TO **THINK HOLISTICALLY!**”

Schaeffler’s Automotive OEM CEO Matthias Zink talks about the future of the automobile in the context of mobility for tomorrow.

Interview: Roland Löwisch

Mr. Zink, from clogged streets to emission discussions: The automobile, today, is often associated with negative headlines. Do you enjoy driving?
Yes, very much. I’m a passionate driver – always have been. The automobile involves dynamism, design, technology and emotion. All this suits me to a T: on the one hand, I’m an engineer and on the other, an emotional person.

If you had to buy a private car now – which propulsion concept would you choose?
I’d buy a hybrid – or a diesel. Among IC engines, the modern diesel is an engine with good efficiency, first-rate fuel economy and first-rate NO_x emission performance. However, looking at my private driving profile with a 30-kilometer (19-mile) commute, a hybrid powertrain is probably the better solution – provided it offers reasonable electric range.

Schaeffler’s slogan at IAA is “Making Mobility Sustainable and Autonomous.” What are you going to display at the pinnacle event of Frankfurt’s trade show calendar this time?
A cross section from Schaeffler’s sustainable and diverse mobility world. We develop entire powertrains for hybrid vehicles and vehicles with IC engines, and highly integrated electric drive systems including transmissions and control software. In addition, we’ll be showcasing mobility concepts for the future such as the Schaeffler Mover. Digitization will play a central role, too. At our booth, we’re going to show these components and systems for IC engines, hybrids and all-electric vehicles. In terms of autonomous driving, we’re going to present by-wire technology and redundant control unit technology. In addition, a self-driving Schaeffler Mover with 90-degree steering thanks to innovative electric wheel hub drive will be traveling in the outdoor area.

» Autonomous driving is part of our components and systems strategy

Matthias Zink

Battery-electric or hybrid-electric, an IC engine or perhaps even a fuel cell? Just like you, many customers are uncertain which technology to choose when buying a car. The uncertainty of the market is also reflected in the development departments of the OEMs. For a supplier, this probably doesn't make it any easier either to make decisions for the future.

That's why we're pursuing a multi-pronged course of action, based on scenarios. We're deliberately preparing ourselves for the transformation, but continue to invest in the further development of the IC engine. The issue of reducing CO_2 and pollutant emissions is going to challenge technology development for a few more years. Particularly the discussion about the testing procedures for exhaust emissions and fuel consumption of motor vehicles – talking about WLTP – versus real-world consumption requires a systematic optimization of powertrains with IC engines. At the same time, we're intensively preparing ourselves for the new hybridized and electromotive propulsion systems: for one, we're developing an in-depth systemic understanding for new propulsion systems, and for the other we're taking a detailed look at technologies and products in the area of electric motors and electronics that are new for Schaeffler.

Is the Paris climate goal of plus-two degrees achievable in the transportation sector? What propulsion technologies does this require?

To achieve the goals that have been agreed at the Paris climate conference, a mix of fully electric, hybridized and eco-friendly ICE powertrains is indispensable. For instance, we proposed the "30/40/30" scenario that has since come to be viewed as realistic by the industry. We expect that about 30 percent of the automobiles built in 2030 will have an all-electric powertrain. At least 40 percent will be equipped with hybrid drive systems. 30 percent will exclusively use an IC engine. In the end, this means that 70 percent of the roughly 120 million vehicles produced per year will contain an IC engine, but that 70 percent will also be equipped with an electric drive system. In the light of this scenario, the successive further development of conventional propulsion systems and hybrid technologies is essential to achieving necessary climate

Exchange of information: Matthias Zink, CEO Klaus Rosenfeld and Chancellor Angela Merkel (from right)

goals. However, alongside the propulsion systems, the primary energy structure has to be systematically developed further, too. Only then will the goals of the Paris Agreement be achievable in a truly sustainable way; a pure tank-to-wheel view cannot and will not solve the problem. We have to think holistically.

Consequently, the IC engine will continue to play a major role. However, this will only be the case if it becomes even cleaner and more efficient?

Yes, we see enormous potential for the internal combustion engine, both in powertrains exclusively using IC engines and particularly in hybridized systems – with significant optimizations in terms of CO_2 and NO_x compared to today. We're also seeing this reflected in the current contracts awarded in the areas of valve train and thermal management – the latest generations of internal combustion engines are, once again, being equipped with innovative technology.

The whole world is talking about autonomous driving. Is Schaeffler, too?

We're not only talking about it. It's part of our component and systems strategy, because in addition to our activities in the powertrain arena, we're expanding our technology portfolio in the area of the chassis. We focus particularly on technologies in the field of autonomous driving and

the related products. However, even 20 years down the road, I don't see a scenario in which we'll exclusively be using autonomous vehicles. There'll still be too many old vehicles in existence. Those aren't perfect conditions. Level 5 – in other words autonomous driving – will not be feasible under those circumstances. But perhaps it'll be possible to at least equip specific major roads traversing the country with traffic guidance systems. Schaeffler contributes all kinds of assistance systems to this. We'll offer Level 5 components and systems as soon as the market demands them. However, due to our activities with Schaeffler Paravan, we also see new markets and fields of application, for instance in the area of logistics or for special-purpose vehicles.

So Level 5 is currently not a topic for Schaeffler?
Today, with mechanical systems in the chassis area, we're at Level 0, but would like to move to Level 3 with new, innovative components and systems. In the future, for instance, we're planning to offer mechatronics, actuating elements and rear-axle steering systems to enable automobile manufacturers to autonomously operate a chassis on each level. At the moment, mobility patterns and providers are in a constant state of flux. We're keeping a close eye on that.

» Mobility will change especially in the big cities

Matthias Zink

This year's IAA is billed as "Driving tomorrow." What are your views on what mobility will look like in our region in the future?
Especially in the big cities, mobility will change – I'm sure there'll be more shared vehicles, but they won't necessarily be self-driving ones. Some people will continue to prefer personal mobility. Arguably, in the Black Forest, where I come from, I'll still be driving my car at least to the train station in 20 years from now, similar to today.

What opportunities or which end do you see for gasoline, diesel and gas engines, electric and hybrid powertrains, the fuel cell and SynFuel?
I feel that each of these alternatives you named will have a chance in the future. Schaeffler continues to believe in an open, unbiased approach to technology – even though some automobile manufacturers no longer do so to the same extent. However, I clearly see some trending toward hydrogen and the fuel cell, currently especially in China, Japan and Korea. Synthetic fuels will play

A wide range of topics: in addition to automotive developments, Zink is responsible for future projects (Schaeffler Mover, left-hand page) and for the motorsport commitment (pictured below: unveiling of the Schaeffler BMW M4 DTM, above: Formula E driver Lucas di Grassi in front of the Schaeffler grandstand at the Berlin E-Prix)

an important role, too. If, in the long run, we want to travel long distances in sustainably clean ways hydrogen and SynFuels are two important fields. Aviation and the transportation sector will play a role here as well because battery-operated electric vehicles are hardly conceivable there at the moment.

Talking about vertical mobility: What future will drones have? Could this become a new business segment for Schaeffler?
We're already supporting this: Two years ago, we bought a small jewel named Compact Dynamics. They're absolute specialists in the field of electric motors and also drive projects in the area of drones. I don't see drones as a solution for personal mobility, but in many areas, vertical mobility is a topic we're looking at closely.

Along with the forms of mobility, will Schaeffler's role as a supplier change, too?
We'd like to be decisively involved in shaping mobility for tomorrow, but we're not going to enter into competition with our customers – we're not even doing that with our complete concepts of the Schaeffler Mover and the Bio-Hybrid. But we do want to learn from such projects and continue to primarily sell components and systems.

ABOUT MATTHIAS ZINK

Matthias Zink *(born in 1969) studied mechanical engineering in Karlsruhe, majoring in automotive engineering. In 1994, he joined LuK as a research and test engineer. As CEO Automotive OEM at Schaeffler, Zink is currently responsible for transmission systems, as well as research & development of the Automotive OEM division and the E-Mobility unit. In addition, since 2019, he has been in charge of the Engine and Chassis Systems unit and Global Key Account Management.*

900 tick species exist worldwide. Many of them transmit dangerous diseases

I'LL JUST HITCH A RIDE

Technological progress accelerates our lives – and the spreading of invasive species: a threat to our ecological and economic cycles that should by all means be taken seriously.

by Wolfgang Karg

More than 500 ticks were found on the carcass of a young cow that was lying dead in a field in the U.S. state of North Carolina. Just by their large number of bites, they had weakened their prey to the point that it perished. By the middle of 2019, half a dozen calves in the United States had fallen victim to the voracious bloodsuckers. Media have already begun dubbing the micromonsters "vampire ticks." Apparently, the Asian member of the family of hard ticks that's found all over the world had been brought into the country by air or sea freight shipments.

U.S. authorities are alarmed. "Agencies involved in animal and public health are working together to monitor the distribution of the tick, test for pathogens, and treat for the tick when necessary to potentially stop the spread to new areas in the US," says Joelle R. Hayden from the U.S. Department of Agriculture. However, keeping the arachnids that have a size of just a few millimeters from spreading will be just as difficult as keeping them out in the first place.

The advance of the vampire tick is one of the most current examples of how non-indigenous species (aka neobiota) are spreading to new regions of the world – albeit this is by no means a new phenomenon. Plants and animals have changed their distribution ranges ever since the beginning of evolution and adapted themselves to their respective environmental conditions. Humans intervened in the migration of species early on. As hunters and gatherers in the Stone Age and later as farmers or merchants, humans promoted the presence

of some animal and plant species and displaced others – and are still doing so today. "Humans are the main reason for the spread of species beyond their native ranges," emphasizes Dr. Sabrina Kumschick from the Centre for Invasion Biology at Stellenbosch University in South Africa. But while in the past even human-induced changes in the world of animals and plants would typically occur over long periods of time like centuries and millennia, technological progress has accelerated change in this area as well. Kumschick: "New technologies which enable us to travel faster also enable the faster spread of hitchhikers and transported goods, and therefore the faster spread of neobiota." With severe consequences for entire ecosystems.

Useful and harmful invaders

Now before we condemn all alien species across the board let's keep in mind that some of these travelers should not be regarded as a strictly negative phenomenon. After all, three fourths of all crop and ornamental plants in Europe are introduced species. The potato plant was imported from America to Europe by ships in times of poor harvests and evolved into a staple. Unfortunately, along with the plant came the Colorado potato beetle and potato blight caused by a fungus. In the 19th century, the resulting harvest losses led to the Great Famine in Ireland and other countries in Europe were affected as well.

According to scientists and environmentalists, introduced species are deemed to be invasive when they spread beyond their original distribution ranges and displace and harm other species or even destroy established ecological cycles.

An example from southern Africa shows how alien tree species cause problems. "These acacias, eucalyptus and pines use much more water than the native species, which also affects people in this dry environment and has contributed to a massive drought in the last few years leading to drastic water restrictions for every household in the Western Cape province," warns Dr. Sabrina Kumschick.

Inviting the enemy in

Another issue that gives rise to concern is the growing number of ornamental and crop plants or animals we first invite into our homes and farms and that subsequently find their way to freedom, like Ailanthus altissima, also known as the tree of heaven. Originally

In urban habitats, the tree of heaven requires care and causes costly damage to buildings

HUGE LOSSES

In European countries alone, ***some 14,000 non-indigenous species*** *have been found of which an estimated 10 to 15 percent is deemed to be invasive. According to estimates by the European Commission, they cause economic losses of more than twelve billion euros per year. The United States has recorded more than 50,000 introduced species of which about 4,300 are deemed to be dangerous. Estimated damage: more than 100 billion euros per year. According to a survey published in the science journal "Nature" in 2015,* ***North America has been seeing the greatest growth in alien species.*** *Tropical regions, as might be suspected, are not the most important source of invasive species, but the shipping routes from Europe.*

imported to Europe from China as an ornamental plant, the tree is highly resistant and with its roots has begun to destroy historic buildings and roads. That's why in Austria, Hungary, Italy and Switzerland, it's now being cut down in many places.

In North America, filter-feeding Asian carp that escaped after they were introduced as "vacuum cleaners" to keep fish farms clean have virtually become pests. According to Stacey Solano from the Illinois Department of Natural Resources, there are sections of the Mississippi and the Illinois rivers where they changed the entire ecosystem. The fish that are up to one meter (3 feet) long and weigh up to 25 kilos (55 lbs) are able to jump several meters high and so have already injured a number of people who were fishing or engaged in other outdoor activities. Like in the case of other aqueous species, the human drive to create river-canal networks has accelerated their spreading.

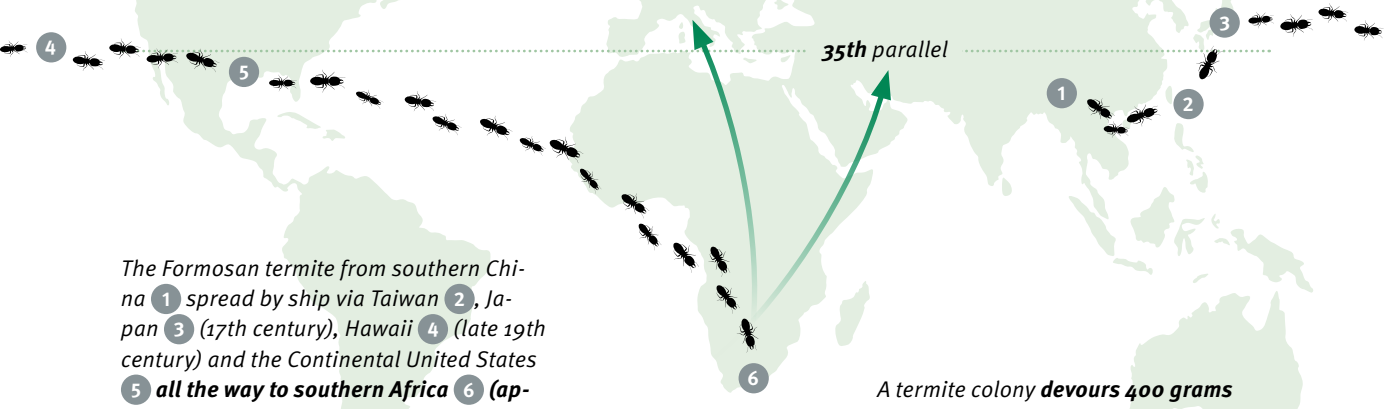
Technology overcomes climatic barriers

Today, alien species not only get around faster due to our help, but the climatic changes we've triggered also help them become sedentary. "Global warming will likely increase the effects of invasions at least in some regions such as Europe, North America and Australia," says Dr. Piero Genovesi from the Italian Environmental Agency ISPRA. "It is quite evident that the rise of temperatures in some regions increases the feasibility for many exotic species coming from tropical regions."

Today, the continental leap in the human slipstream is a snap for alien species. It takes aircraft only hours to travel between climatic zones. Ships are at sea for only a few weeks. And the new train connections between Europe and Asia along the New Silk Road deliver goods within a few days. They all provide gateways to invasive species. Professor Ingolf Kühn, PhD, from the Helmholtz Centre for Environmental Research warns that the number of species and the speed at which species are spreading keeps increasing.

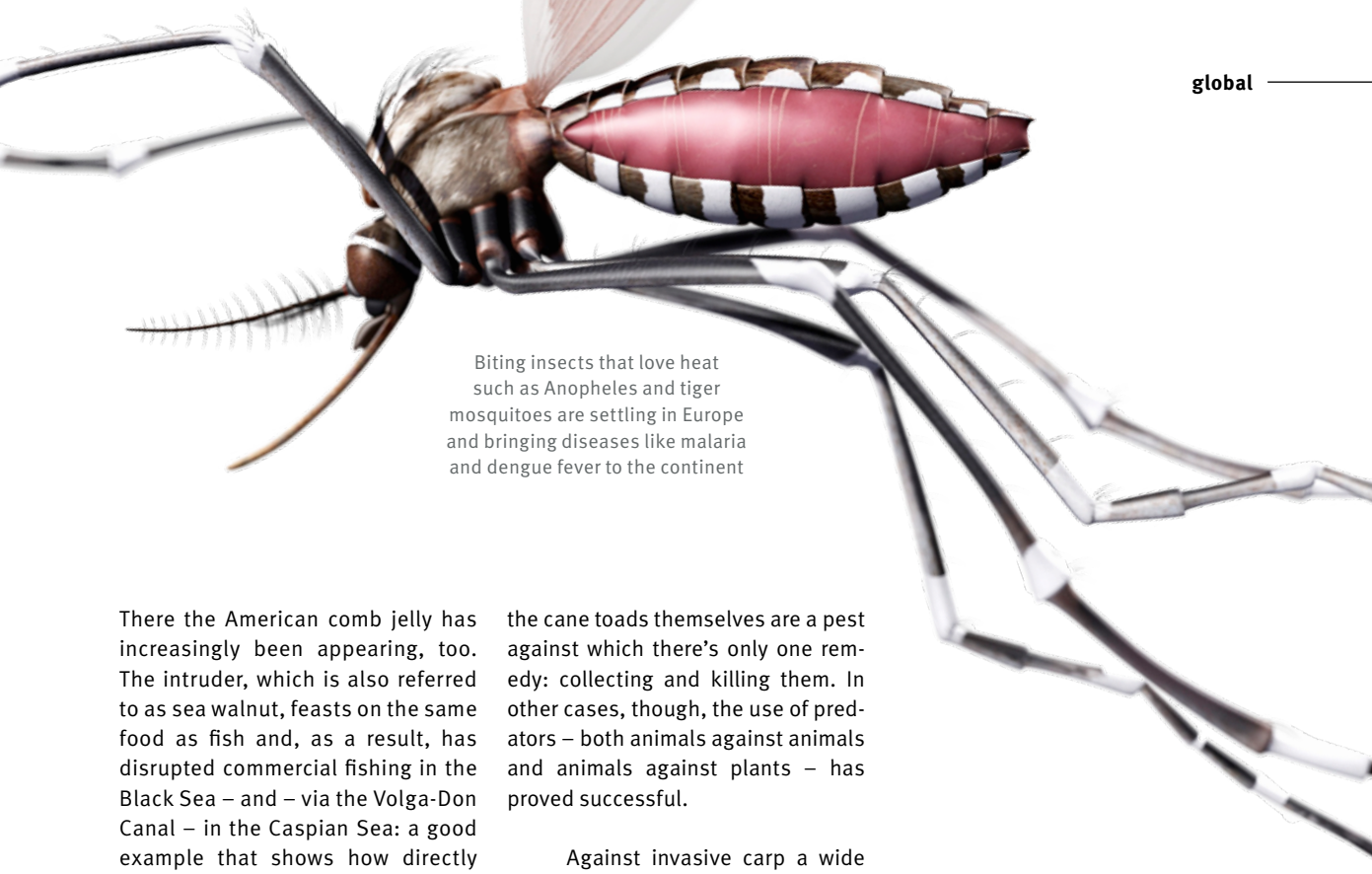
In more and more marine areas, non-indigenous species are emerging that have been introduced by ballast water or clinging to the ships' hulls. In the wake of rising average temperatures of the sea water, they're now able to permanently survive and upset the balance of the ecosystem. In the Wadden Sea mudflats on the German North Sea coast, one in six species is already deemed to be non-indigenous.

THE VORACIOUS GLOBAL JOURNEY **OF THE FORMOSA TERMITE**



The Formosan termite from southern China 1 *spread by ship via Taiwan* 2*, Japan* 3 *(17th century), Hawaii* 4 *(late 19th century) and the Continental United States* 5 ***all the way to southern Africa*** 6 ***(approx. 1950).*** *Due to global warming,* ***it's threatening to cross the 35th parallel.*** *Currently, this troublemaker, if at all, is only found there in consistently warm regions because its eggs die below 20 °C (68 °F).*

A termite colony ***devours 400 grams (14 ounces) of wood per day and can cause a house to collapse within three months.*** *Worldwide, damage amounting to one billion U.S. dollars is attributed to the Formosan termite.*



Biting insects that love heat such as Anopheles and tiger mosquitoes are settling in Europe and bringing diseases like malaria and dengue fever to the continent

There the American comb jelly has increasingly been appearing, too. The intruder, which is also referred to as sea walnut, feasts on the same food as fish and, as a result, has disrupted commercial fishing in the Black Sea – and – via the Volga-Don Canal – in the Caspian Sea: a good example that shows how directly ecological and economic cycles can be interlinked.

Dr. Achim Wehrmann from the Senckenberg Institute in Wilhelmshaven warns that the warming of the climate generally favors the establishment of subtropical species. The losers, clearly, he says, are the species from colder climatic zones because their habitats are becoming more and more confined or lost completely.

Prevention is costly, control even costlier

The threat scenario that also has financial implications (see info box on p. 19) raises an obvious question: what should be done? In the 1930s, Australian farmers tried to set one invasive species against another one. That wasn't a good idea in this case. They imported cane toads in order to fight voracious cane beetles. However, the poisonous and highly reproductive large toads not only turned against their target prey, but also against birds, lizards and monitor lizards, snakes and quolls, who touched or ate them and died. Today, the cane toads themselves are a pest against which there's only one remedy: collecting and killing them. In other cases, though, the use of predators – both animals against animals and animals against plants – has proved successful.

Against invasive carp a wide variety of actions is taken. In Australia, a koi herpes virus that poses no risk to other fish species is supposed to eliminate 95 percent of the existing invasive carp in the coming decades. The U.S. government has appropriated 200 million dollars to control the carp pest there. The range of technical means extends from the use of underwater sound waves, carbon dioxide, odorous substances and poisons to electric barriers.

Better yet than control is prevention. Since 2017, an international "Ballast Water Agreement" has been in existence to which 80 countries accounting for the 81 percent of shipping tonnage have committed. The International Plant Protection Convention (IPPC) has even been ratified since 1952. It establishes requirements for the treatment of wooden packaging in order to prevent the spreading of pests. The problem: Implementing these measures costs money which some players are inclined to save. And that's how alien species like the vampire tick manage to enter the United States and other places.

THE AUTHOR

Wolfgang Karg *has been working as a science journalist for print and TV formats for nearly 25 years. On two occasions, projects took him to the Antarctic and to American and Russian spaceports. His most recent project was a three-year stay in China to enhance his understanding of the technology trends there. During the research for this article he asked himself if he ever had a traveling companion of the kind he'd be writing about.*

GROWING BRAND VALUE

Cumulative growth of the ten top brands according to the brand equity database BrandZ

INDUSTRY COMPARISON: TECHNOLOGY CLEARLY IN FRONT

Brand equity of selected sectors in billions of U.S. dollars, acc. to BrandZ

Apple, Google and Microsoft combined account for 53 % of the value of all technology brands

in motion

Innovations in the course of time

» *Increasingly, the lack of courage to change poses the biggest risk to brands today*

Simon Thun, CEO Interbrand
Central & Eastern Europe

STRONG **BRAND**

"Brand" and "brand value" are on everyone's lips, but people, in their own minds, decide what truly constitutes a brand. A brand has been created whenever companies manage to anchor their services or products in people's minds through positive experiences and associations. A strong brand makes products visible that would otherwise often remain behind the scenes – like the average number of about 60 parts, components and systems from the Schaeffler technology group that ensure driving pleasure and efficiency in every automobile. Instead of creating individual brands, Schaeffler pools its product and service worlds under the name of the company's founders: Dr. Wilhelm Schaeffler and Dr.-Ing. E.h. Georg Schaeffler. Companies that, like Schaeffler, think globally and holistically have to demonstrate this externally, too – with a strong brand. In doing so, Schaeffler provides orientation to its customers and globally positions itself as a preferred technology partner. This brand philosophy is so important to Schaeffler that the family-owned company has integrated it into its "Agenda 4 plus One" excellence program as one of 20 strategic initiatives. It is intended to ensure the company's long-term competitiveness and increase in value. In addition, the Schaeffler brand is supposed to have an internal impact as well: "As a publicly traded family business we want to grow together even more intensively. This can only be achieved with shared values and leadership principles, a common strategy with a strong corporate brand – the 'Schaeffler' brand," says Klaus Rosenfeld, Chief Executive Officer of Schaeffler AG.

RESURRECTED
FROM LUNAR LANDSCAPES

Coal phase-out and energy transition have sealed the fate of many coal mining regions in the world. However, the industrial wastelands are not going to waste: transformed into recreational areas for local residents, biotopes and sites for pumped storage power plants, wind and solar farms, they can help heal the wounds inflicted by the coal era.

by Denis Dilba

Behind the huge canyon-like valley that can be seen from the Lakoma observation deck is a vast expanse of sand: brown and ocher-colored land as far as the eye can see. Countless wind turbines are discernible on the horizon and that's exactly how far the body of water is supposed to extend. At the moment, though, it takes quite a bit of imagination to picture the lake that's in the making here in the lunar landscape of the former Cottbus-Nord open-pit mine. Flooding the area began this April. By 2025, the huge pit is planned to have been filled by about 280 million cubic meters (9,9 billion cubic feet) of water. 20 percent will be supplied by rising groundwater and about 80 percent will be taken from the river Spree. The river, though, will only be tapped if it carries enough water, which, so far, has frequently not been the case. With an area of 19 square kilometers (7 square miles) the mammoth, 300-million-euro project will be Germany's largest artificial lake. Along the edges, like here at the intake structure, the water may be as deep as 30 meters (98 feet) due to the valleys, according to the energy and mining company Leag, the lake's operator.

Cash from tourism instead of cash from coal

Construction of a pier in the planned marina district has begun, too. Holger Kech, the lord mayor of Cottbus, has CO_2-neutral plans for the new district: "High-rise timber buildings are conceivable there, bicycle paths on photovoltaic panels, connections between local public transportation and autonomous vehicles, district heat from lake water pumps, and more," he said during a presentation of his ideas for the new district. Residential buildings are planned, and business, tourism and water sports to be attracted to the area. Like here in Cottbus, hopes for a flourishing future are pinned on the legacies of coal mining and raw material extraction around the world. New recreational areas, and tourism along with them, promise to crank up the local economy again and to create jobs. The evolving biotopes are supposed to provide shelter for protected animal and plant species. Last but not least, completely new possible uses for open-pit mines, tailing heaps and brownfields also open up in the wake of energy transition.

The example of the "Neuseenland" ("New Lake District") in Leipzig shows that such projects aren't pie in the sky but offer promising prospects. Up until 1990, an area of 200 square kilometers (77 square miles) in the southern part of Leizig was still shaped by the gaping wounds of open-pit mining. Today, the eight lakes that have been created there are an attractive place for water sports, hiking and cycling. In 2017, the Leipzig Neuseenland tourist association recorded some 700,000 overnight stays in the member communities. Consequently, not only Cottbus or the open-pit mines in the Rhineland between Aachen and Cologne would like to copy Leipzig's success, but coal mines in Australia and Canada are planning similar projects, too.

It's also conceivable to use such artificial bodies of water as storage lakes for renewable energies. Especially if they had the size of the "Ostsee" lake in Cottbus, says the "Grüne Liga" environmental association and criticizes the fact that this was not done there.

Mines turn into energy storage systems

Detlef Schulz, Head of the Electrical Energy Systems department at the University of the German Federal Armed Forces in Hamburg, proposed a totally different idea for the shut-down open-pit brown coal mines a few

VITICULTURE FOLLOWS MINING

Wine from open-pit mining regions? Sounds strange, but actually works. *At the Wolkenberg mountain in the re-cultivated part of the Welzow-Süd open-pit mine near Cottbus, seven varieties of grapes are grown, five white and two red, amounting to a total of 26,000 vines in an area of six hectares (15 acres), planted in 2010. The artificial 30 meter (98 feet) high mountain has everything that grapevines love: an eleven-percent slope, a south-southwesterly orientation, a till layer with a thickness of about half a meter (1.5 feet) and a slightly raised pH level of the soil. Only natural precipitation has to be augmented by irrigation. The latter also applies to the slightly smaller vineyard in the former coal mining districts Geiseltal and Meuro. Harvest is planned to begin in early/mid-September and the winegrowers expect 2019 to be a good year.*

One of the few winners: growing good wine in northern regions is only made possible by the changing climate

COTTBUS **OSTSEE**

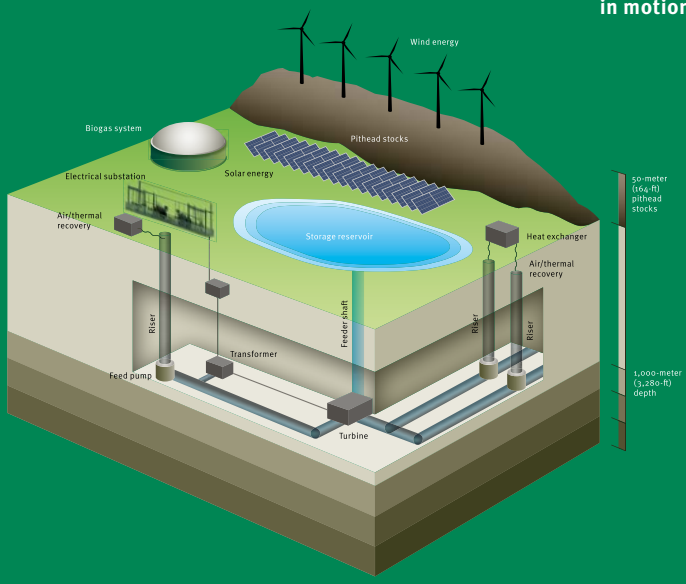
The so-called intake structure is located below a visitors' deck. Here the flooding water flows from the feeder pipeline in a wide, flat channel across the embankment down to the floor of the former mine. 280 million cubic meters (9,9 billion cubic feet) of water will have to rush down here before the lake is completely filled

years ago: since the floors of the residual holes are between 100 and 400 meters (330 and 1,300 feet) below the surrounding surface, they offer a sufficient vertical difference for pumped storage power stations.

Their principle is simple: Whenever the generation of power exceeds demand, the surplus is used to operate pumps that elevate water from a lower basin into a higher one. When electricity is needed again, the water is made to flow back via a turbine. Thus, pumped storage power stations are ideally suited for balancing the fluctuating generation of electricity from wind power and photovoltaic systems. That the technology has not been implemented in open-pit mines so far is due to the fact that the proportion of fluctuating renewable energies was initially small and, for a long time, an end of coal mining not foreseeable, says ETC Energietechnik, the company that has held the patent on the idea since 1998. Now, following the decision to phase out coal and the progressing expansion of renewable energies, this approach might be given a new chance: research scientists from the Wuppertal Institute for Climate, Environment and Energy

have calculated that a pumped storage power station in today's open-pit mines Hambach, Garzweiler and Inden in the Rhineland would have significant technical storage potential of up to 400 gigawatt hours.

This amount of energy could supply some 100,000 four-person households with electricity for one year. Due to the enormous storage capacity, the scientists wrote in their paper published at the beginning of this year, "a more detailed investigation of the technical, environmental and legal feasibility, as well as public acceptance, would be worthwhile."



Design for the pumped storage power station with a capacity of 360 MW in the former Prosper-Haniel mine. The project has not been implemented there but other countries have shown interest

Another opportunity to convert a future coal wasteland into an innovative large-scale storage system for wind and solar power was just recently missed when the Prosper-Haniel coal mine in Bottrop was shut down at the end of 2018. It was the last active hard coal mining site in the Ruhr region and, according to the ideas of Hermann-Josef Wagner, Chair of Energy Systems and Energy Economics Mechanical Engineering at Ruhr University Bochum, and André Niemann, Chair of the Institute of Hydraulic Engineering and Water Resources Management at University Duisburg-Essen, was to be converted into the first underground pumped storage power station in the world. In such a project, an artificial lake is created above ground. Instead of a second lake, the lower water reservoir is located deep down underground. The existing system of mining tunnels and shafts, plus the available mining equipment, predestines deactivated mines for such conversions. However, since the shafts at Prosper-Haniel are now progressively being backfilled following the shutdown, the mine is no longer usable as a huge storage system. This has not stopped interest in the project, though, because a large number of suitable mines exist around the world. Particularly Wales and China are showing keen interest in the project, according to Wagner.

Viable symbols of structural change

The fact that the plans for pumped storage were not realized doesn't mean that the former mines in the Ruhr region have remained unused. The dumps that were piled up from the waste removed from the mining tunnels in the Ruhr region have long established themselves as attractive areas for outdoor recreation. Hikers and mountain bikers can be found here just like paragliders. Art installations and observation towers are located alongside nature preserves and wind turbines. "Due to the transformation of the waste dumps into recreational areas and landmarks, the heaps symbolize the completion of the structural change and the unparalleled repurposing and conversion of former industrial wastelands," says Jan Pass from Ruhr Tourismus GmbH. The same objectives are pursued by the Ostsee project in Cottbus. Work on the lakeshores and in other areas is still pending completion there while the surrounding communities are also avidly planning and building so that marinas, water ski facilities, roads and bicycle paths will be finished on time.

The eastern lakeshore with its two islands, though, will not be developed for buildings, but reserved to fauna and flora, providing a new home to water birds such as bean and white-fronted geese, gray herons, great crested grebes and other species. However, the feathered animals also have to be patient for a while, as only eight percent of the total amount of water has flown into the lake so far. Even so, the loop is closing. Places that once were idylls of nature will, ideally, return to that state in the near future – or provide energy in more sustainable ways.

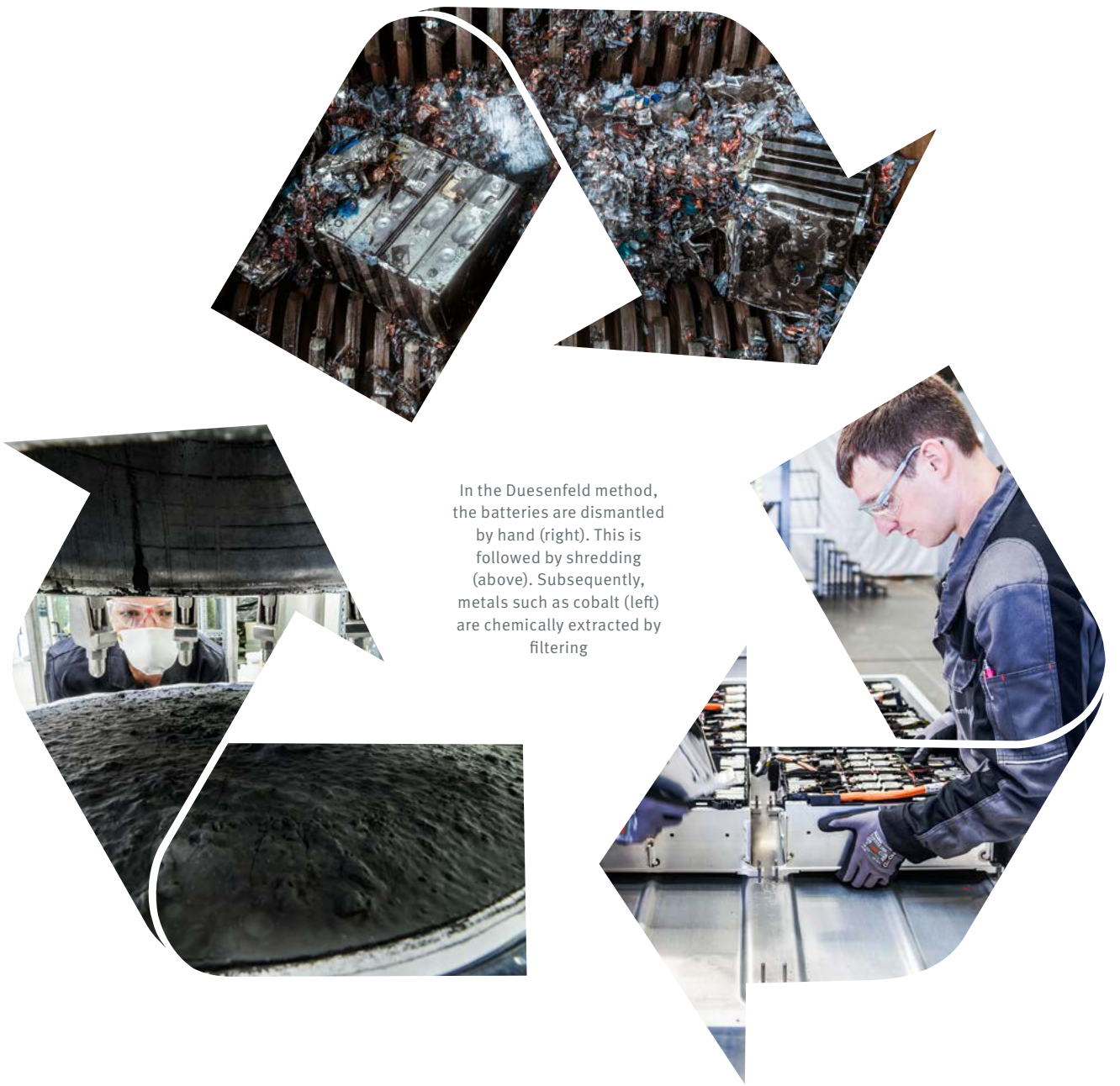
THE AUTHOR

Following his research about the second life of industrial wastelands, journalist and avowed BVB fan ***Denis Dilba*** *is planning to visit a tailing heap before one of the next home matches in Dortmund. The Leipzig Lake District tempts him as well but will have to wait: BVB will not be playing against RB Leipzig in an away game until May 2020.*

CLOSING **THE LOOP**

Ecological retirement – what happens to old batteries of electric vehicles or decommissioned wind turbines and solar energy systems?

by Kay Dohnke



In the Duesenfeld method, the batteries are dismantled by hand (right). This is followed by shredding (above). Subsequently, metals such as cobalt (left) are chemically extracted by filtering

E-MOBILITY **BATTERIES**

Electric mobility is picking up momentum worldwide. All traffic lights around the globe have been switched to green for this "silent innovation." Automotive supplier Schaeffler, for instance, expects that an electric motor will propel 70 percent of all new cars by 2030, either alone or as a component of a hybrid system. At that time, millions of vehicles will draw their power from millions of large traction batteries and since they have an estimated life of eight years, millions of old lithium-ion batteries will have to be sensibly recycled. Even the "second life" idea – proposing that traction batteries would still be used for about another ten years as storage systems for electricity from renewable sources and to stabilize the grid – can only delay the scrapping of these batteries.

Raw materials are scarce

End-of-life lithium-ion batteries have to be recycled in sensible ways for both environmental and economic reasons. If their components were not recovered, the enormous anticipated worldwide demand for cobalt, nickel and rare-earth elements could not be met by the available raw material supply. By 2020, there will be more than 100,000 metric tons (110,000 short tons) of old batteries from electric vehicles, according to current estimates. And that would just be the beginning. That's why research institutions and manufacturers are already developing efficient recycling technologies.

Tesla Europe has old traction batteries recycled in an ultra-high temperature smelting (UHT) process at Umicore in Belgium. During the incineration of the entire battery cobalt and nickel are extracted. The cobalt – transformed into cobalt-lithium-oxide – is used again for batteries. The slag with calcium-oxides and lithium is used in concrete production.

Reducing the carbon footprint

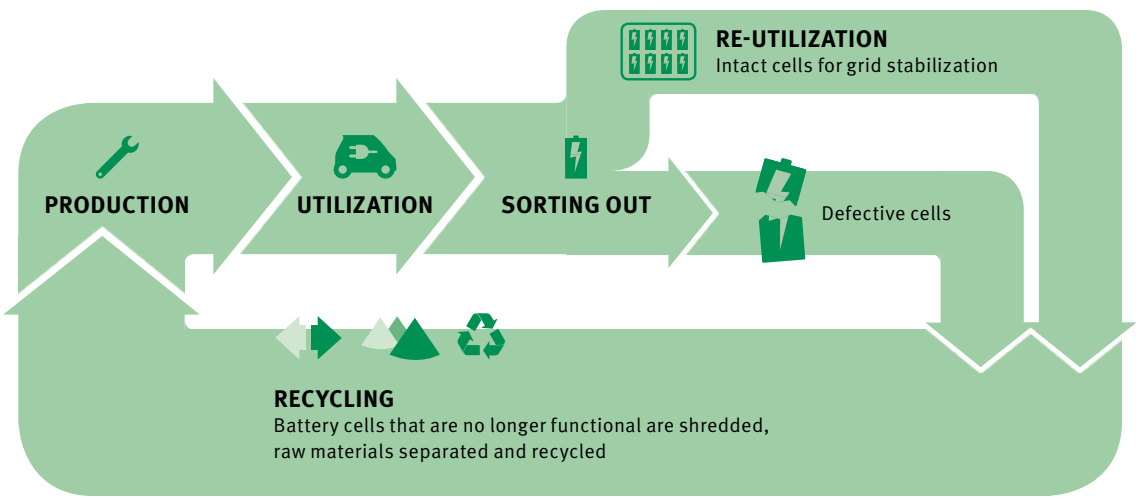
There are other methods besides this high-energy technology. In the hydrometallurgical process of Duesenfeld GmbH, the battery is initially shredded mechanically. Subsequently, the metals it contains are chemically extracted. In this way, it is possible to salvage copper at rates of 100, manganese of 99, cobalt of nearly 98, nickel of 99, and lithium of nearly 96 percent for future uses. Compared with incineration, this technology reduces the battery's carbon footprint by 40 percent. Duesenfeld is currently able to recycle 3,000 metric tons (3,300 short tons) of old batteries in this way.

In the electrohydraulic fragmentation (EHF) process of Fraunhofer Institute for Silicate Research (ISC), a shock wave generated by electrical discharges is sent through a medium – the process works with normal water. As a result, the material interfaces of the battery become brittle and the individual components can be easily separated without significant heating.

There are many international regulations that require battery recycling, but at this juncture nobody can tell which technology will prevail, plus batteries with other components may require different technologies.

Fuel cell?

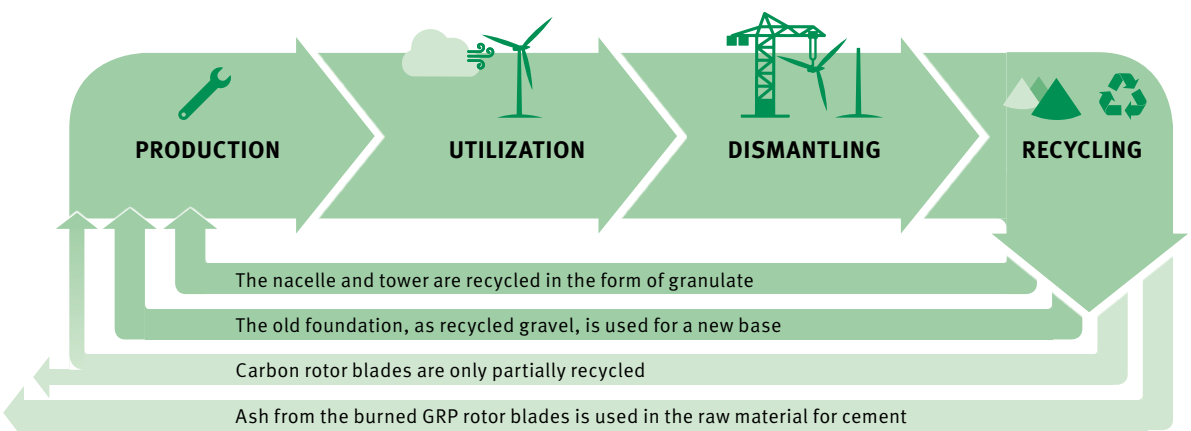
A solution that eliminates the need for traction batteries and practically makes the disposal chain superfluous is the fuel cell. It generates electricity without any significant environmental impact even after the end of its life.



WIND**POWER**

In the Irish Sea, in Europe's largest onshore wind farm Markbygden in northern Sweden or in the countless wind farms sprouting up from the ground around the globe: In all of them, huge rotors are spinning, milling the energy out of the air, pumping electric current through the constantly hungry transmission lines into insatiable megacities and the machinery of manufacturing industries. Worldwide, hundreds of thousands of these systems are in operation, eliminating the need for coal-fired power stations and nuclear power plants, albeit even clean electricity will ultimately produce waste: aging on the one hand and progress and dwindling profitability on the other cause more and more wind turbines to reach the end of their service life and being decommissioned.

Performance and profitability pressures are high: Where possible, smaller wind turbines are replaced by more efficient larger systems as part of repowering processes. When government funding programs expire, if not earlier, the continuing operation of old, repair-prone systems is no longer considered to be lucrative, so they have to go. Dismantling them



After the wind power system has been torn down (left), the rotor blades are cut into transportable pieces (center) and subsequently dissected into further individual elements (right)

is routine technical work done with the same huge cranes that were used to erect them. Down on the ground, things of diverse uses are gathered: The nacelle including its technology, the tower segments and the foundation can be easily dismantled, shredded and 98 percent of them reused. The extremely long rotor blades are cut into transportable pieces at the site.

Rotor blades pose problems

But this is where the secondary raw materials chain stops moving: No further use has been found yet for the substances contained in the blades. The vast majority of the older rotor blades consists of composite materials that are practically inseparable. A viable sorting process for fiber glass reinforced plastic (FRP), balsa wood, resins and steel, in which all material fractions are generated in reusable form, is not available yet. Rotor blades will never turn into rotor blades again but are finely shredded in special machines and incinerated in the kilns of the cement industry. The ash is used as part of the raw material for cement.

Rotor blades of more recent generations with carbon components do not end up in the fire because the ash of carbon-fiber reinforced plastics (CFRP) clogs the filters of the incineration plants and is highly harmful. By means of thermochemical fission the organic compound of the fiber is separated from the thermally resistant silicon dioxide and recycled into production. However, this costly pyrolysis process is not economically feasible for the cheap first rotor blade generation and is used in just a few countries.

For instance, in the United States and China, due to the high recycling costs and a lack of regulations, end-of-life wind power systems typically end up in landfills.

225,000 tons of waste

The recycling issue will soon prominently emerge and incineration has a poorer image than recycling of materials. The Danish research project Genvid expects some 50,000 metric tons (55,000 short tons) of plastic waste from old rotors being generated by 2020 and more than likely 225,000 metric tons (275,000 short tons) annually by 2035. Denmark is particularly active in this area because as early as in 2017, 43.6 percent of the country's electricity was generated by wind farms. Manufacturers such as Vestas and Siemens, Fraunhofer Institute for Chemical Technology ICT, TU Brandenburg, Aalborg University and the University of Nottingham are all intensively looking for a solution to prevent the positive potential of wind power from having to turn into ashes on the last mile.

The recycling of photovoltaic modules also starts with manual work. After employees have dismantled the frame and glass, the photo cells are sent to an acid bath. The silicon extracted in this process (below) is recycled into production as granulate

PHOTO**VOLTAICS**

They've long become a familiar sight. Whether in villages, cities or industrial parks, solar collectors shine on the roofs of houses, halls and production facilities. As a renewable source of energy photovoltaics has become mainstream and is virtually obligatory on new buildings in many countries like Germany. The solar future is the solar present, and will soon be the past: The first generation of solar modules reaches the end of its lifespan after 25 to 30 years and will be discarded. In 2017, as many as four million metric tons (4.4 million short tons) of modules were installed Europe-wide, resulting in 43,500 metric tons (48,000 short tons) of special waste. In 2050, 60 million metric tons (66 million short tons) of waste will be generated, according to the UK environmental portal GreenMatch.

"Waste," though, is not really the right category in this case: The product design of solar modules allows for extensive recycling – with recycling rates of up to 95 percent. Based on GreenMatch's calculations for the 2050 scenario, the recovered material worth 15 billion U.S. dollars could be used to produce two billion new solar modules.

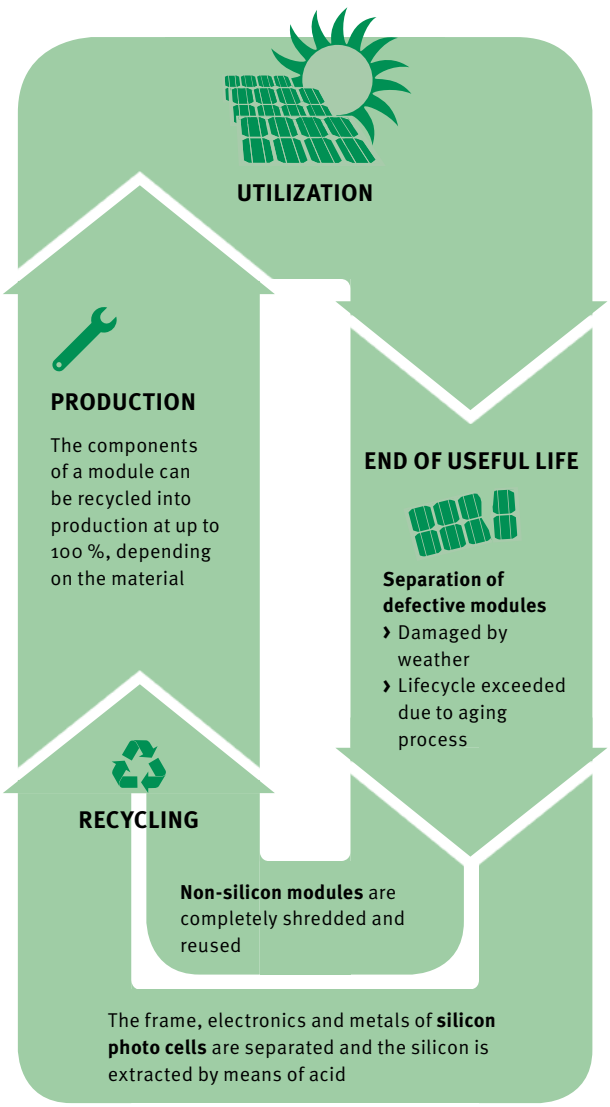
Up to 100 percent recycling

In a cooperation project of manufacturers, research scientists and disposal companies, two methods for decomposing low-efficiency or defective solar panels have been developed. Silicon-based solar cells are disassembled by hand; their glass content can be reused at 95 percent and the aluminum of the frames at 100 percent. Heated to 500 °C (932 °F), the plastic components evaporate and serve as a source of process heat. Afterwards, the cell modules are dismantled and can be reused at 80 percent. The silicon is extracted by means of acid and can subsequently be recycled into the manufacturing process for new solar panels at rates of up to 85 percent.

Global regulations are lacking

A different method is used for thin-film modules (market share: about 10 percent). They're initially shredded. Subsequently, the components can be separated mechanically, by floating and by vibration. As much as 95 percent of the semiconductor material and 90 percent of the glass can be recovered in this way.

In spite of practicable technologies, the recycling challenge for photovoltaics is far from having been resolved on a global scale due to a lack of returned modules. Across Europe, the PV Cycle industry association organizes the return and recycling of the modules but in many industrialized countries such as the United States there are typically no specific regulatory disposal requirements, so that defective or worn out solar panels are just sent to landfills.



THE AUTHOR

*Ever since sustainability journalist **Kay Dohnke** saw the "Large-Scale Wind Farm" Growian in North Germany in the early eighties, he's been fascinated by wind power – and by the fact that, like the recycling of other technologies, the end of the systems' useful life raises a new environmental question.*

THE LONG JOURNEY **OF THE FUTURE**

The future has its origins on the banks of the Euphrates. Via the Roman Forum and ancient Judea, it reached the Christian Occident before its path ramified into every corner of the world. On this long journey, the future evolved into the concept we have of it today: the course of the world influenced by humans.

by Jan Martin Ogiermann

In the ancient world, every city lived with its own future. Mesopotamian seers helped make political decisions by examining the livers of sacrificed animals. They'd regularly provide differing or vague answers to the same questions – classically those about war and peace. The political discourse among the citizens of Rome or Athens also took place within this room for interpretation. What were the prospects of going to battle? Did signs from the gods augur victory or defeat?

Jews and Christians imagined that the future was in the hands of the one and only God. The Book of Revelation unfolds a drama of the anticipated apocalypse; it talks about battles between Good and Evil and of Judgment Day. Now the future had a defined destiny: the impending Last Day of the whole world and every individual. It could occur at any time and everyone was paying close attention to its omens. Politically, the question arose about who was on God's side and who on the side of the Antichrist. The pope and the emperor fought a propaganda war about it.

The future becomes demystified

During the transition from the Middle Ages to modern history, the discovery expeditions across the ocean provided the view of utopia with a new, intriguing stimulus: if European seafarers were able to find new worlds beyond the oceans why shouldn't new worlds also exist beyond the here and now? The fast, massive and mostly disastrous changes the Europeans caused overseas demonstrated their own resolve and vigor to them. If it was possible to reshape the conquered regions, wouldn't this have to be possible at home, too?

The new idea of the world was defined not only by conquests, but also by trade and, increasingly, science, above all astronomy and physics. The realization that nature behaved according to laws that could be formulated in mathematical terms permitted much more precise predictions, for instance regarding the movement of planets. The celestial bodies moved according to a precise mechanical system and thus could impossibly continue to be regarded as quasi-divine forces acting on the earthly sphere. The age-old science of astrology slipped from the educational canon down into the depths of popular superstitions.

At the same time, technological development was picking up momentum. Many innovations dovetailed: Book printing caused thoughts to spread much faster and those who wanted to read them more than likely had a demand for glasses. The lens grinders' work became


AJK5545001J-JK
AD-58457-DJ-JK

» Those who want to read the future must browse through the past

André Malraux

better and better, and enabled the first telescopes. The new optical tools fertilized astronomy as well as navigation. The demand for innovative nautical instruments was covered by large trading companies whose shares were traded on financial markets. Particularly the stock exchange required a new attitude vis-à-vis the future – those who wished to make a profit had to perform level-headed calculations and avoid risks.

The future becomes enlightened

More and more thinkers in Europe began to ask themselves: If the laws of nature that shape the future are tangible then why shouldn't those in society and history be as well? Those who recognized them would be able to reshape the way people live together – or rely on what will be will be. For many proponents of Enlightenment, it was clear that everything would get better. They expected a world that would become increasingly peaceful, affluent and educated. A happy life for all just seemed to be a matter of time. The idea of progress was born.

One reason why the French Revolution has left an indelible impression as a historical turning point was the fact that it had been anticipated with certainty – hundreds of utopian writings had been published during the decades before 1789. There were high expectations of the French Revolution leading humanity into the light. But the belief in a rosy future and in reason that supposedly prevailed in history was bitterly disappointed. The dream of a free and fraternal human race descended into terror and the war for supremacy.

However, this did not deter those who assumed that progress was merely taking a detour, which – via conflicts – would ultimately lead to achieving its goal. This idea was espoused by the representatives of socialism. The advocates of liberalism on the other hand were less interested in the goal of progress than in its irresistibility. By contrast, conservatives – occasionally reformist, occasionally hardheaded – wanted to slow down progress. As diversely as socialists, liberals and conservatives looked toward the future, hardly anyone basically closed their mind to the positive aspects of progress: more knowledge, more wealth, more peace, more freedom. But who was supposed to make all this reality? Monarchs, bourgeois governments or the workers' movement?

The future is bombed to pieces

Toward the end of the 19th century, the belief in progress began to show signs of weakness. Industrialization was turning the social order upside down. Some feared and others longed for the socialist society. Tensions within the populations and among the European powers seemed to exclude the continued pursuit of the previous path. Even so, progress kept on marching. The big bang came in 1914 to the dismay of a continent

that in the preceding years had experienced more wealth, knowledge growth and freedom than ever before.

From a mid-term perspective, the First World War created more problems than it had solved. Following the demystification of technological progress in the "machine war," many people in Germany, Russia and elsewhere became receptive to radical answers to the modern-day crisis. This crisis culminated within the Second World War (1939–1945) from 1941 on in the German-Soviet war and in the genocide of the European Jews. In it, driven by annihilation fears, misanthropic National Socialism tried to preventively destroy the – supposedly Jewish – Soviet Communism that had previously gone through a stage of modernization with mass killings. Apocalyptic right-wing extremists were battling against leftwing extremists with a zest for progress. But this war not only left behind 60 million dead but – like many conflicts before it – big questions unresolved. Between the liberal West and the socialist East, the vision of the future remained controversial.

The future on the way to the present

In the sixties, the future became a subject of scientific research. Futurology aimed to make objective-scientific statements about what would happen in the next decades. Many experts in the East and West were filled with optimism by the big leaps made in space travel, data processing and nuclear technology. The latter, though, inspired deeply ambivalent expectations: The "friendly" atom promised cheap and clean energy and the hydrogen bomb total destruction. Yet the danger of general annihilation was exactly what promoted humanity's awareness of living on a common planet in spite of its division into three worlds.

The big war did not happen. At the end of the eighties, the socialist utopia and the Iron Curtain along with it began to falter. Victory went to the model of the market economy and democracy. The experience of radical movements and the ideologically driven Second World War had eroded people's willingness to defend a "true" future. Instead, there was a tendency to moderately accept diverse possible futures that found a place within the democratic discourse.

The fears that began to bud in the seventies that the Earth was headed toward an environmental catastrophe reached more and more social circles. The fear is that the planet's resources are limited and that feeding an arbitrarily large number of people would overtax it. Consumption that brought "wealth for all" now threatens to cause environmental problems that will hit many people hard. And even the liberal promise of wealth itself has suffered damage, as unemployment and an unequal development of income from capital and income from work pose a burden to societies.

The future of the future

None of the many stations on the way to the future is just a thing of the past. Liver examinations are performed in parts of Africa and India. Evangelical Christians are awaiting the end of the world. Residents of big western cities with college degrees are consulting astrologers. But the most important thing for us is that the development of science and technology is accelerating. Some prophets claim that as soon as artificial intelligence starts to improve itself this second autonomous existence on Earth will fundamentally change the human species and its world. The big tech corporations have long begun to work on artificial intelligence and even on overcoming our mortality. What are we doing in view of such ambitions? Mother future has many children. But which of them should we trust?

THE AUTHOR

Jan Martin Ogiermann *studied History, Jewish Studies and Holocaust Studies in Frankfurt, Jerusalem, Potsdam and Berlin. Today he works as a reader and exhibition explainer in Berlin and writes historical nonfiction books whenever he finds time. Not long ago, he found time again: his book "Zukunft – eine Biografie" ("Future – a Biography") was published by Brandstätter Verlag.*

5G AINS

The new 5G cellular network standard is intended to boost the digital transformation process by connecting industrial facilities and autonomous vehicles and, for the time being, marks the peak of the fast-paced evolution of mobile communications.

by Dr. Lorenz Steinke

Making phone calls from a moving train – the idea for which the American inventor Nathan Stubblefield was awarded a patent in 1908 must have seemed like magic to his contemporaries. The experimenter from Kentucky had found a way to achieve the wireless transmission of voice between telephones using long antenna structures and magnetic induction – at a time when wireless technology was still in its infancy and the radio had not been invented yet. However, Stubblefield was deprived of commercial success and ridiculed

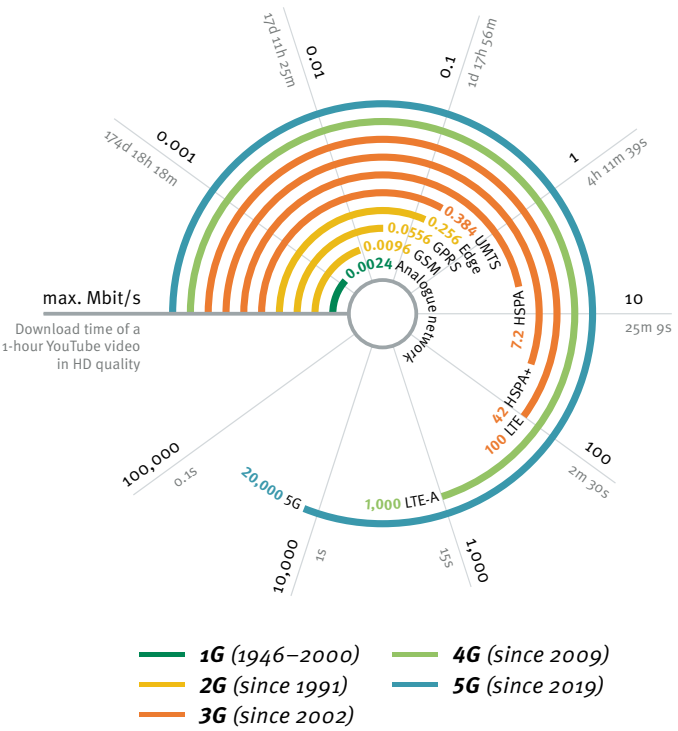
as a trickster when he presented his invention in public for the first time. His patent fell into oblivion.

Mobile communications only for VIPs

Nevertheless, in 1926, passengers traveling on the Hamburg–Berlin railroad line were able to use the first train telephones of the Deutsche Reichspost (German Imperial Postal Service). Two restrooms on the train were converted into phone booths specifically for this purpose. 1946 marked the beginning of the era of car telephones in St. Louis and Chicago. Installed devices filling an entire trunk and costing as much as a compact car were initally reserved to business tycoons and political leaders such as the German chancellor, Konrad Adenauer. But even VIPs had to obey the rule of keeping their conversations short. For instance, any connection in the German A network was cut off after just three minutes. The postal authorities as the telecom operator discouraged lengthy conversations and usable radio frequency channels were in scarce supply. Making mobile phone calls in the first analogue networks was tedious in other respects, too: external callers had to know which cell the party they wanted to call happened to be in and handovers between cells without cutting off the connection only became standard much later. Cross-border roaming was hardly possible.

In the 1990s, mobile telecommunications went digital. The GSM standard provided billions of people with mobility and, starting at the turn of the millennium, lent wings to the internet – initially with the slow WAP standard that wasn't a great success, though. Smartphones such as the Apple iPhone launched in 2007 ushered in the age of digital nomads. Creative professionals and programmers around the world would swap their office cubicles for mobile workspaces, henceforth working from a beach bar in Bali or a coffee shop on 5th Avenue. Since 2010, even Mount Everest has been provided with cellular coverage. Initially from Africa, services such as M-Pesa and yuCash went on to revolutionize mobile payments in all parts of the world where banks are hardly available or too expensive. Thanks to mobile telecommunications, regions with few, if any, landlines are catching up in terms of communications.

5G: DATA SWITCH TO TURBO MODE

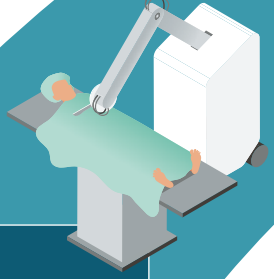


5G connects 50 billion devices

In 2009, in Stockholm and Oslo, the success story of LTE (Long Term Evolution) with transmission rates of up to 100 Mbit/s began. Ten years later, the 5th mobile communications generation (5G) with up to 20 Gbit/s was rolled out in the Unites States, South Korea and Switzerland.

Currently, 5G mainly addresses commercial clients: Industry and Agriculture 4.0, logistics or telemedicine are to benefit from the new network. In 2019, Catalonian doctors streamed the first cancer surgery in real time via 5G. In the future, specialists around the world are supposed to be virtually consulted at the operating table and thereby help improve the therapeutic prospects for patients, for instance in remote parts of the world.

High data rates and secure connections are supposed to enable autonomous driving or the remote control of entire factories. Thanks to short signal propagation delays (latencies), engineers can have three-dimensional construction plans of local buildings projected directly onto their smartglasses. Tests at the Hamburg port have shown that only the quasi-real-time transmission via 5G prevents the dreaded simulator sickness that occurs due to delays between the sensory



The 5th mobile telecommunications generation (5G) scores not only with high data rates (up to 20 Gbit/s) but also with **short signal propagation delays (latencies) in the single-digit milliseconds range.** In interaction with a highly stable network connection, they enable **real-time applications.** This makes the network attractive for mobile use (autonomous road vehicles, remote-controlled aircraft) and precision robots. Telesurgery is also possible only with low latency.

Android Auto and Apple CarPlay **fuse automobiles and smartphones.**

Digital revolution: the iPhone (from 2007 on) and the App Store (2008) start the **disruptive campaign of the smartphone.** Entire sectors, from mobility to music to tourism, have to reposition themselves.

With data rates of up to 4 Gbit/s, mobile telecommunications can **take wireless high-speed internet to remote areas.**

Increasingly powerful phones and networks turn the mobile telecommunications sector into a **growth engine** – especially in developing countries. There, according to the 2009 World Bank Report, one additional cell phone per 100 people results in 0.8 percent of additional economic growth.

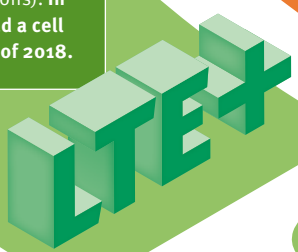
Devices in the Internet of Things communicate with cloud-based AI (artificial intelligence) systems. As the subsequent data processing takes place in the cloud, **every machine can become "smart"** even without its own high-performance computers.

Moneymaker: in 2018, mobile telecommunications (technology/services) contribute 3.9 quadrillion U.S. dollars (4.6 %) to the world economy.

Permanent internet access using cell phones enables **a mobile emails from 1999 on.** The first device: Blackberry 850.

Surprisingly, more 4G than 2G connections are established only as late as in 2018 (43% market share, 3.4 billion connections). **In total, 5.1 billion people had a cell phone contract at the end of 2018.**

According to the World Bank, mobile telecommunications providers will **invest $ 480 million in 5G expansion by 2020** worldwide.



For industrial applications, companies can establish their own **local 5G network.** Small operators and startups are also to be encouraged to set up regional networks of their own in order to also roll out 5G to rural areas.

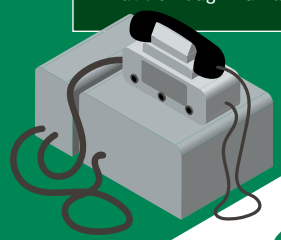
4G since 2009

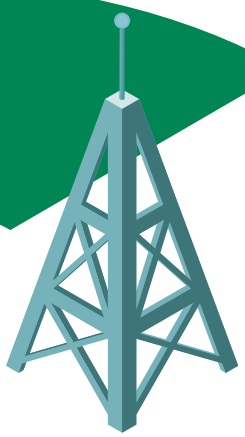
5G since 2019

MOBILE COMMUNICATIONS
AS PART OF THE BIG PICTURE

1G
1946–2000

In the 40s and 50s, the **first analogue networks** emerge in the United States and Europe, with high prices for the devices and expensive per-minute rates, receivers the size of a suitcase and calls made through human operators.





2G
since 1991

Mobile telecommunications goes digital. Because Europe is the worldwide leader in 2G network expansion it's also home to the **biggest cell phone manufacturers** at the time.

1001101000101101001110100001010

A new way to communicate: in 1993, the first text by SMS (Short Message Service) is sent. The first messages are limited to 160 characters.

In 1999, a U.S. survey documents that the **rate of violent crime drops.** along with the spreading of mobile telecommunications due to better means of making emergency calls.

Smaller and **cheaper phones, better voice quality and lower per-call rates** help digital wireless communication to achieve its worldwide breakthrough.

3G
since 2002

The UMTS (Universal Mobile Telecommunications System) broadband standard makes the **internet mobile once and for all from 2001 on.** Online banking gets off to a flying start and working on the move becomes possible.

Video transmission due to high data rates – **social networks are booming.**

Sand in the gears of roaming: Europe, Asia and Africa use the 900 and 1,800 MHz frequency bands, America 850 and 1,900 MHz. Only quad-band phones can be used around the world.

In 1996, General Motors launches **Car-to-X communication** with OnStar for automatic emergency calls and other purposes.

impressions received by the eye and the sense of balance. By 2022, more than 50 billion devices are supposed to be connected with each other on the Internet of Things. A world in which people not only use telephones on trains but the trains themselves are remote-controlled by mobile devices would more than likely have thrilled the inventor Nathan Stubblefield.

THE AUTHOR

*As an IT journalist **Dr. Lorenz Steinke** has been writing about mobile telecommunications for decades. His first cell phone was a Nokia PT 11. Even today, he sometimes wishes to have its legendary ruggedness and incredible battery power back. Tipping the scales at 236 grams (8 ounces), it was also a real lightweight at the time.*

DIGITAL RENAISSANCE
OF A MASTERPIECE

Art fuses with artificial worlds. Apps and Virtual Reality (VR) headsets enable visitors to delve into classic paintings and dead artists are brought to life by means of artificial intelligence (AI). Century-old events merge with the here and now into a big picture. Art lovers travel into the past with consummate ease. In October, they'll be able to enjoy an exceptionally futuristic VR experience in the venerable Louvre in Paris: "Mona Lisa: Beyond the Glass" is the name of the project that allows the audience to get as close to the world's most famous smile as never before. Visitors, or, perhaps more precisely, users interact with the painting in a virtual room. HTC Vive VR headsets provide them with an unusual view of da Vinci's "La Gioconda." By means of a magnifier, users can recognize the various techniques and coats of paint applied by the master. Owners of such a headset can access this special Mona Lisa experience from anywhere in the world. A similar experience awaits art lovers when using the "Rembrandt Reality App" to travel back into the year of 1632 and enter "The Anatomy Lesson of Dr. Nicolaes Tulp." By means of an Augmented Reality projection they suddenly find themselves standing in the same room as the doctors: virtual experiences that will more than likely soon become standard in the museums of the future.

here and now

Living with progress

» Art does not reproduce the visible but makes visible Paul Klee

MILESTONES OF AI
IN THE WORLD OF ART

2004

Hearing a traffic light: The color-blind Cyborg artist Neil Harbisson has a color antenna implanted in his brain that recognizes the wavelength of light. When a traffic light is red Harbisson hears the musical note A.

2017

VR journey into the Middle Ages: the "Historium VR" app takes art historians on a quasi-live journey back into the dark days of the Belgian city of Bruges.

2018

AI prints art: A French group of artists has programmed two algorithms that complement each other. One of them paints pictures based on known portraits and the other one corrects them if it assumes them to be the work of a machine, which continually improves the work of the former. The work of the "artist pairing" signed "min G max D Ex[log(D(x))]+Ez[log(1-D(G(z)))]" is the first-ever AI painting to have been auctioned at Christie's – for about 380,000 euros.

2019

Dalí's face: An AI in a museum in Florida fuses the facial expressions of an actor with Salvador Dalí's face. Almost more surreal than Dalí's works.

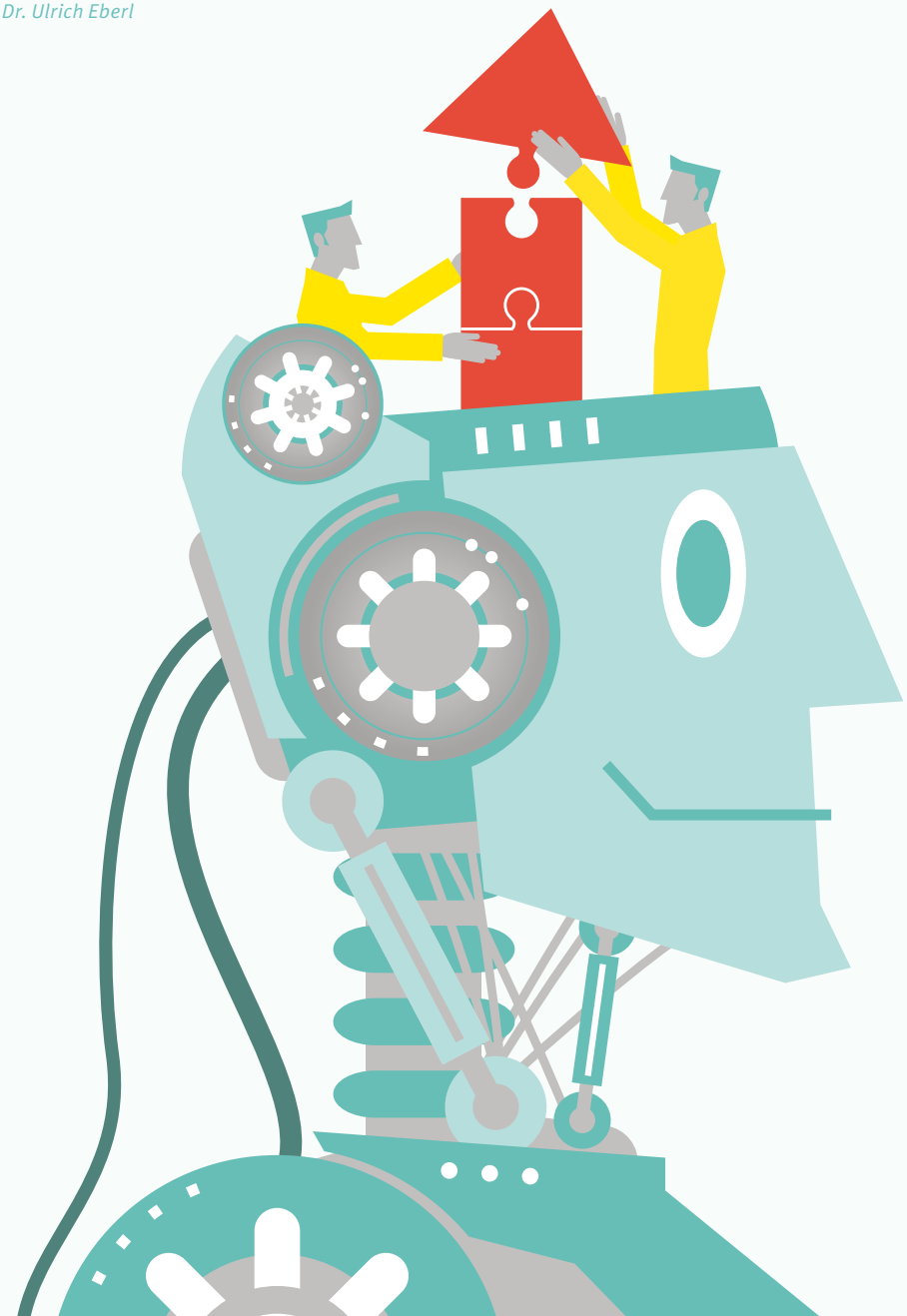
2019

Algorithms in a studio: Ai-Da – a humanoid robot artist created by Engineered Arts – paints what she sees with her camera eyes. The reward for her efforts: her first exhibition this summer.

IN DIALOG WITH SMART MACHINES

Machines are learning to speak, read and interpret images at breathtaking speed. Artificial intelligence suddenly seems to be all around us – it will radically change our jobs and everyday lives. Even so, machines are far from truly understanding the world. There's no need to fear them.

by Dr. Ulrich Eberl



Even robots are becoming increasingly cheeky. When, at an investors' conference about artificial intelligence (AI), the elegant robotic lady Sophia was asked if she knew that she was a robot, she pertly responded to the moderator's question: "Why don't you tell me how you know that you're a human!" And when the small robotic boy iCub lost against a human opponent in a video game, he angrily uttered: "Someday we robots are going to take over and then you'll have to pay for it."

More than likely, some observers found themselves choking on their laughter, especially since prominent critics – such as Tesla CEO Elon Musk and the late astrophysicist Stephen Hawking – have frequently expressed warnings of a superintelligence. But those of us who, in the light of this, fear that machines will soon start ruling the world may find some comfort in comments by Ben Goertzel, Chief Scientist of Hanson Robotics where Sophia was developed. The robot lady, he says, is merely "a chatbot with a human face." She can use gestures and facial expressions and answer simple questions, which includes her accessing data on the internet. Everything else is pre-scripted dialogs like those in docusoaps on TV.

Lifelong learning is for robots, too

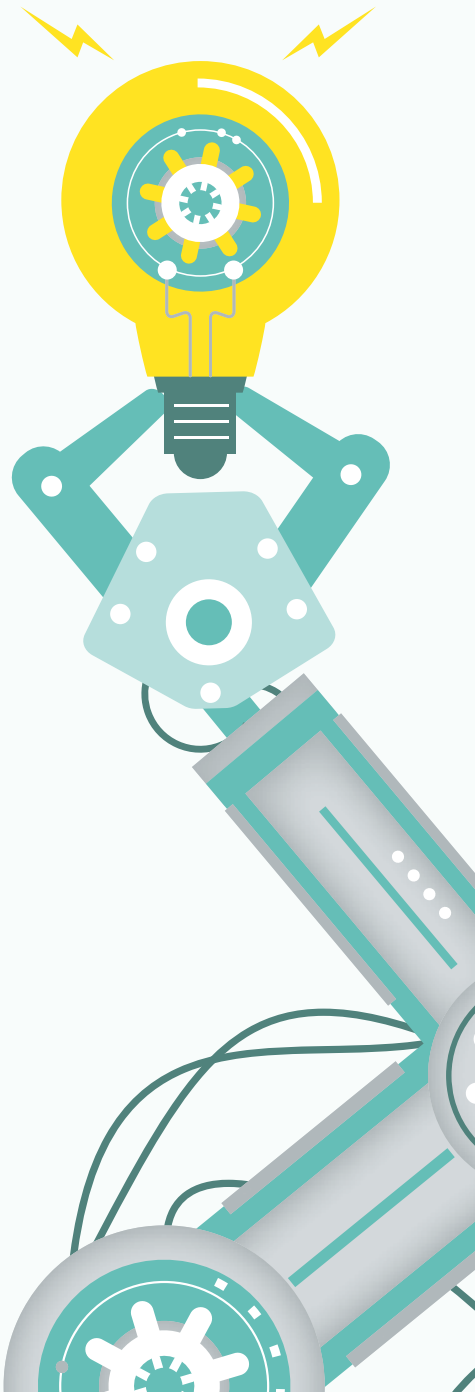
The same applies to the iCub although its emotional states are hardly predictable because they depend on both sensor signals and the respective situation. This robot is growing up in a research center near Genoa. It can walk, grab things, talk and listen, sense when it's being touched, blush and produce charming laughter – and above all: it learns like a child by imitating humans. Several instructors are teaching it to use its toys, clear the table, play piano or hit a target with a bow and arrow. Developmental Robotics is the name of this young AI research field in which robots in the course of their "life" continuously acquire more skills and knowledge.

Even so, they're far from truly understanding the world. No robot and no chatbot has so far had any chance of passing the Turing test. In 1950 – nearly 70 years ago – the mathematician Alan Turing kicked off the AI age. "Can machines think?" he asked and proposed a test: if a human has a conversation with a machine he or she can't see and is subsequently unable to reliably tell whether the conversation was with another human or a machine, the machine has passed the test.

In 1990, the sociologist Hugh Gene Loebner pledged a monetary prize and a gold medal for the first computer program that would successfully complete the Turing test in a 25-minute exchange. To date, the 100,000 dollars of prize money have not had to be paid. Although programs are becoming better and better, they sometimes awkwardly evade questions, make multiple use of text modules or can't come up with sensible answers to everyday questions. Currently in the top spot on the list of the digital entrants in the annual Loebner Prize competition that have at least won bronze medals is the chatbot lady Mitsuku (www.pandorabots.com/mitsuku).

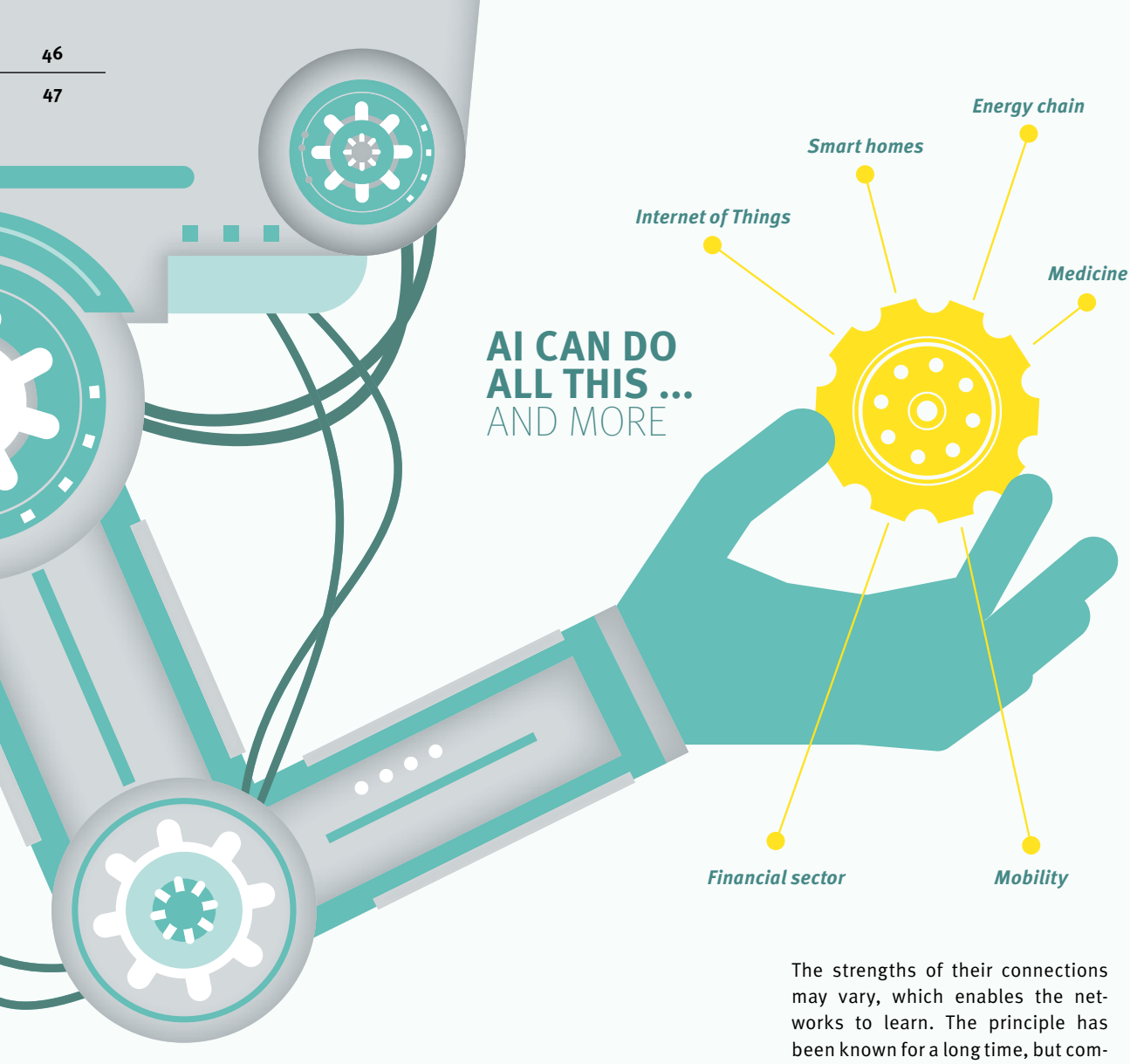
More progress in six years than in six decades before

However, all this does not mean that voice-controlled AI assistants are useless – the opposite is true. In May 2018, a call to a hair salon caused a sensation. The



SCHAEFFLER GOES AI

Smartphones and social media have changed communication around the world. Now, the Internet of Things will interlink vehicles, machines and people. Schaeffler has embarked on the journey of digital transformation.



caller was a machine that precisely responded to what the person on the other end was saying and asking. It would use half-sentences and pause with mm-hmm – providing an impression as if it were thinking about what was being said. Now this software called Google Duplex is being tested in everyday life by smartphone users in the United States. For clearly defined tasks, such as making a reservation in a restaurant, this already works pretty well. Other AI assistants for tedious routine tasks are about to be launched. In 2019, for instance, "Duplex for the Web" was presented: here the assistant takes care of filling out forms typically used on the internet.

The areas in which AI is currently burgeoning are clear: they involve recognition of speech, images and contents of texts, and the analysis of huge data volumes. More progress has been made here in the last six years than in the sixty years before due to three mutually reinforcing trends. First, higher performance of hardware: any smartphone today is able to match the world's biggest supercomputer in the mid-1990s in terms of processing speed and data storage capacity. Second, better software: in artificial neural networks – just like in the human brain – many layers of artificial nerve cells (neurons) are interlinked for the purpose of processing data. The strengths of their connections may vary, which enables the networks to learn. The principle has been known for a long time, but compared to the networks of the 90s, the ones today are millions of times larger and stacked in much deeper layers – which is why they're called deep-learning networks. The third factor is the internet with billions of texts, images, audio and video files that can be used to train AI systems. Their learning expands with every search query, every voice input and every translation request.

Searching 200 million pages of text within seconds

In many areas, we've already become accustomed to using AI: facial recognition to unlock our smartphones, voice assistants like Siri and Alexa, automatic text corrections,

personalized advertising, translation programs or health apps. The first fully automated vehicles are traveling on freeways and robots are working hand in hand with humans in factories. AI analyzes data from trains or turbines for predictive maintenance, computers provide advice to doctors in hospitals and financial experts in banks, and every day, new applications are added.

Increasingly often, machines defeat human champions thanks to AI. In 2011, the IBM system Watson won against the world champions in the Jeopardy quiz show: within a matter of seconds, it combined 200 million pointers to text pages into appropriate solutions. This feat was followed by others in rapid succession: Various types of AI software made only half as many mistakes in recognizing traffic signs as humans, identified all house numbers in millions of photos within 100 minutes and diagnosed cases of pneumonia and types of skin cancer with greater precision than experienced doctors. Most recently, the robot lady Xiaoyi in China passed the country's medical licensing exam because, better than many students, she knew which symptoms were indicative of which diseases and which therapies made sense.

In 2016, AlphaGo software won against the world's best Go players. A year later, AlphaGo Zero beat the previous program 100-0. It had simply learned by playing against itself millions of times. New AI systems call bluffs in poker and have mastered StarCraft II – which is very difficult because, in this game, many players are acting at the same time and no-one has a complete picture of the whole playing field. Even so, the truth is that AI machines are specialists. A computer that wins in chess or Go has only mastered the art of playing these games. It cannot drive a car or mow the lawn. In addition, it's a lot more difficult for machines to move the pieces in chess than to win the game. For instance, it took research scientists ten years to teach robots how to open the door to a house with a key.

New jobs due to AI

What's more, machines have no "common sense." Once a computer has learned how to recognize cats it'll find cats everywhere, even in clouds or in picture noise on screens. Although machines are able to read emotions from faces and voices and act as if they had feelings, these are merely simulations.

In the future, we'll no doubt be using smart machines like we're using smartphones today: self-driving cars, as well as digital assistants and robots in offices, factories and at home. We need smart grids for the energy transition and smart cities to make our cities cleaner, safer and more livable. AI will change all professions and occupations – from farmers scouting their fields by means of drones, to truck drivers switching to autopilot mode, to surgeons operating with the help of robots.

> ***» The lesson here is that by combining the abilities of the human and machine, it created a partnership that had super-human performance. And that is humanistic AI***
>
> AI pioneer Tom Gruber with reference to the use of AI in medical diagnostics

Even so, when doctors tell computers to scan thousands of pictures for the presence of tumors they'll be using the machine as an assistant, but that doesn't mean the doctor is no longer needed. There's no reason to fear mass unemployment because there will also be many new jobs, for instance in training machines, in AI forensics or in neural art design. In education and continuing training, teaching the skills that no machine possesses will be of paramount importance: flexibility and ingenuity, unconventional, holistic thinking and social skills like managing, motovating or solving conflicts – plus ensuring that AI works safely and reliably. Protecting people and infrastructures must be top priorities. Machines are only allowed to provide advice, whereas important decisions – whether in hospitals, in courts of law or in granting bank loans – will have to be made by humans in the future, too.

THE AUTHOR

*Artificial intelligence is one of author **Dr. Ulrich Eberl's** key topics. In the 90s, he was responsible for communication of future trends at Daimler, and up until 2015 at Siemens. He published "Smarte Maschinen" ("Smart Machines"), a book about AI and robotics for which he conducted extensive research in Japan, the United States and Europe. His home robot, Nao Bluestar, often accompanies him to speaking engagements.*

IN THE HEART OF HERTZ

In his thriller “Blackout,” Marc Elsberg describes the collapse of civilization within just a few days due to catastrophic failure of the power grids. How vulnerable are modern societies really when blackouts occur?

by Dr. Lorenz Steinke

SPECTACULAR BLACKOUTS

USA/Canada
NOVEMBER 9, 1965

A programming fault in a protection relay disables a main power line in Ontario/Canada. 30 million people in the northeast of America are without power. Many assume that it’s due to a nuclear war.

USA
JULY 13, 1977

Lightning bolts at night knock out New York City’s power supply, resulting in looting and vandalism. The police arrest 3,800 people.

Italy
SEPTEMBER 28, 2003

In Switzerland, a 380-kilovolt line fails that supplies Italy with electricity. The Italian power grid subsequently collapses, leaving 57 million people sitting in the dark.

50 or 60 hertz – that's the magical frequency at which alternating current pulsates through the power grids all over the world. Even a one-percent drop in frequency by insufficient feed-in leads to problems and large-scale consumers are "forced out." Frequency levels that are too high due to excessive availability of electricity are dangerous, too: Synchronous motors and grid-cycled clocks run too fast, power stations, wind turbines and solar systems are disconnected from the grid, and pumped storage stations push massive amounts of water uphill into dams for intermediate storage of the surplus energy. Power grids require constant regulation in order to work smoothly.

007-style cyber attacks

In the 2012 novel "Blackout," hackers upset this sensitive equilibrium. They tamper with smart meters, which are being installed in more and more countries in the real world as well, and cause power supply to break down in the process. Pure fiction? Far from it, say experts such as Linus Neumann from the famous Chaos Computer Club. The smart meters can only be protected against attacks with difficulty, if at all.

Neither fiction nor speculation, but reality: In December 2016, hackers invade the systems of Ukrainian energy suppliers and knock out the power grid for hours. Their malware, however, not just shuts off the electricity, but causes machines to overheat, lines to melt, and deactivates 27 substations across the country. It takes months to repair the damage. That such attacks are also directed by foreign countries is no longer a secret: cyberattacks as a government service. The mere threat of being able to cause grids to collapse is a highly effective form of rattling someone else's cage. "It's 21st-century gunboat diplomacy," says Robert M. Chesney, a law professor at the University of Texas, who has written extensively about the shifting legal basis for digital operations, in the New York Times. Attackers not only focus on the superpowers China, Russia and the United States, but also on transit countries for electric power like Germany.

The decentralization of the power grids due to the energy transition process plays into the hands of hackers. The more players are sitting at the table the more vulnerabilities exist in IT systems that can be used as gateways for attacks. And since everything is connected with everything else, the weakest link in the chain can cause everything to collapse.

Integrated system is the Achilles heel

However, it doesn't necessarily take criminal energy to paralyze power grids. In 1989, a solar storm caused an overload on power lines in the Canadian province of Québec. Power outages in California in 2003 and in Greece in 2004 can possibly be attributed to reactive loads of air conditioning systems that shift unused electricity back and forth between the producer and the consumer several times per second. In that case, local problems will soon spread. The most recent example in South America illustrates the point. In June 2019, Uruguay, Argentina and parts of Brazil and Chile – nearly 50 million people – were without electric power, presumably as the result of a storm. The big picture, the global interaction of power stations, grids and consumers, is the Achilles heel of any energy supply system.

An additional problem in both fiction and the real world: Lines that have failed must not be reactivated too quickly, because the resulting overload might cause a cascading destruction of parts of the infrastructure. All of this has happened before. The growing proportion of renewable energies does not make reactivation any easier. The natural energy sources are too volatile and dependent

Greece
JULY 12, 2004

Just a few weeks before the Olympic Games, seven million people living around Athens have no electric power. The reason for the blackout: too many air conditioning systems running at the same time.

Switzerland
JUNE 22, 2005

An overload circuit breaker paralyzes the entire railroad system in Switzerland. 200,000 commuters are stuck in 1,500 trains for three hours at high summer temperatures.

Europe
NOVEMBER 4, 2006

Due to a disconnection fault in a high-voltage line above the Ems River, some 15 million people in Central, Western and Southern Europe have no electricity for 1.5 hours.

THREE QUESTIONS FOR ...

... Marc Elsberg, author of the bestseller "Blackout – Morgen ist es zu spät" ("Blackout – Tomorrow Will Be Too Late") published in 2012.

How realistic do you feel is your novel?
That the novel is very realistic has since been asserted to me by many parties. A study by the German Federal Parliament came to the same conclusions. Accordingly, after about two days, a situation will emerge that's no longer controllable. So the degree of reality is relatively high, but the probability is not assessable due to a lack of data.

How did grid operators and energy utilities respond to the research you started in 2008?
Very positively. They were happy that, for the first time, someone emphasized how important they are for our everyday lives – that electricity is the lifeblood of our civilization.

Do you also see your work as a warning to the people in authority?

Up to a certain point, I do. But my main goal is to deliver entertainment, intelligent entertainment.

on external factors such as wind and sun. Smaller photovoltaic systems permanently synchronize their frequencies with the power grid. If no feedback is received from the utility they shut themselves off so that there's no electric load applied to the power transmission lines that might jeopardize technicians performing repair work.

Hospitals, rescue control centers or civil defense organizations have stand-alone solutions in the form of emergency generators. Even so, they hardly suffice to compensate for prolonged power outages – not least because diesel fuel would be in scarce supply after just a few days. Only a very small number of filling stations have backup generators for their electric fuel pumps.

After the grid, transportation collapses

Transportation would soon grind to a halt. Air traffic would cease first, because practically everything at an airport depends on electric power supply. Trains, including those powered by diesel engines, would soon stop running, too because modern switches and signals are electrically controlled. The situation in the streets would hardly look any better. Traffic lights, traffic control systems or barriers in parking garages all need electricity, just like the growing number of electric cars. But drivers of vehicles with IC engines would not be able to refill their tanks either because none of the fuel pumps would work anymore. Ships would continue to run for a while because large ocean-going vessels are floating power stations producing their own electricity. However, without radio communications and Radar, berthing them in narrow ports would be like walking on a tightrope. Plus, when it comes to wireless systems, the cellphone networks would fail as well because only few antennas are backed up by costly emergency standby systems and landline telephone systems and exchanges are also connected to the power grid.

No power, no food, no internet

Supermarkets would have to dispose of spoiled food just a few hours following the failure of their refrigeration

SPECTACULAR BLACKOUTS

China
JAN/FEB 2008

Four million people in the Chinese city of Xhenzhou have to live without electricity for nearly two weeks. Winter storms have paralyzed the grid.

Brazil
NOVEMBER 10–20, 2009

A defect at the Itaipú Dam in the south of Brazil disconnects 87 million people from the power grid – including in the Rio de Janeiro and São Paulo metropolitan areas.

India
JULY 31, 2012

Due to an overload, the grid in 20 of 28 Indian provinces collapses. 600 million people have no electricity – the biggest blackout in history.

+/– 0

The rumor of the Great Blackout in the northeast of the United States in 1965 having led to a **baby boom in New York City** still hasn't been totally dispelled, although research (by J. Richard Udry and others) proved that it was a myth. The birth rate nine months after the blackout was within the normal range of variations.

systems. Merchandise management and digital payment systems at cash register terminals would be dead. The police would have to protect shopping centers against looters. That's why civil defense officials recommend that people store a 14-day supply of non-perishable food and drinking water as a minimum. So-called preppers even store provisions to last them for a year or more.

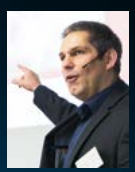
In our own four walls, we would soon feel uncomfortable, too. Not only would our stoves, ovens, fridges, phones, computers, internet and TVs be dead, but so would increasingly popular domestic engineering systems such as electric blinds, air conditioners and heat pumps. Even the owners of conventional heating systems would soon be sitting in the cold because oil or gas burners ignite their flames about six times per hour using household electricity.

The internet was originally supposed to be robust enough to survive a nuclear war, but a global blackout would deactivate most data centers, except in Iceland, where computer parks operate with geothermal energy and hydropower. Problems would also be encountered in many areas of industrial operations. A PC according to the ATX standard can run for a mere 17 milliseconds without power before starting to lose data.

So, what can be done?

In a nutshell: Without electricity, the lights would literally go out on our planet – and not only the lights. The prevention of blackouts requires sufficient production and distribution capacities, reliable control mechanisms that intervene when power supply and demand diverge and IT systems that are protected against third-party interventions. The fact that experts detect considerable deficits especially regarding the latter is anything but reassuring: "It's scary to see that it [IT] is in such desolate condition," IT consultant Tim Philipp Schäfers for instance recently warned on "planet e," a program on German television channel ZDF. Linus Neumann from the Chaos Computer Club suggests that energy suppliers be made liable for damages caused by tampering. The looming threat of claims amounting to billions of dollars or euros should motivate them to take the best possible precautions.

Higher security – be it in data networks or power grids – is technically feasible. However, consumers have to understand that additional security comes at a price, but a stab into the "heart of hertz" resulting in a massive blackout is likely to cost a lot more.



THE AUTHOR

Dr. Lorenz Steinke *has often had to deal with the reliability of grids in his professional life. That's why he trusts redundant systems – and generates his own electricity. He's just had a photovoltaic system installed on his roof: for the sake of the environment – and the future of his children.*

Bangladesh
NOVEMBER 10, 2014

At noon, following a defect, the main power line from India breaks down in Bangladesh. 156 million people are without electricity for ten hours.

Pakistan
JANUARY 26, 2015

Pakistani rebels blow up the mast of a high-voltage line. 80 percent of the country comes to a halt, 140 million people are affected.

Turkey
MARCH 31, 2015

Several power stations fail, the Turkish grid is disconnected from the European grid as a precaution and collapses. 76 million people have no electricity for nine hours.

THE SUSTAINABILITY CHALLENGE

Earth is not doing well. We exploit it, literally cutting off the branch we're sitting on. Considering how humanity is ransacking the Earth's resources we'd actually need 1.75 planets – at this juncture.

by Carsten Paulun

PAGE FOLDS OUT ►

Actually, July 29, 2019 was just a fictitious date, but nearly all news channels worldwide picked up the message: by July 29, 2019, humanity had consumed as many of the Earth's resources as our planet can renew within a whole year. Particularly worrisome is the increasingly earlier date of this day. In 1987, the so-called Earth Overshoot Day was still December 19.

Earth, the vulnerable entity

The vulnerable entity of the Earth threatens to break apart all over the map: The ice of the polar caps is melting, the sea level is rising, hurricanes and other natural disasters are increasing while their intensity keeps growing. The results are poverty and famine which, in turn, cause conflicts to spread especially in the poorer parts of the world. Millions of people suffer from infectious diseases such as ebola, tuberculosis, malaria and AIDS. In 17 countries, including India and Israel, water is becoming scarce. The causes: human exploitation of the planet, plus climate change that's caused by humans – as 97 percent of all scientists agree – as well.

That's why we need to change our behavior and conserve the resources of our planet with innovative technologies, from sustainable energy generation to responsible production methods. All this is part of a comprehensive 17-goal program with which the United Nations intend to get on top of humanity's challenges – and to thereby save the world – because only if the Earth is doing well we humans are doing well, too.

"ASSUMING ENVIRONMENTAL AND **SOCIAL RESPONSIBILITY**"

Three questions for Thomas Fußhöller, Head of Sustainability, Environment and Health & Safety at Schaeffler

How important is sustainability to Schaeffler?
Sustainability is anchored in Schaeffler's DNA. We've clustered sustainability in the four focus fields of "Sustainable Management," "Customers and Products," "Environment and Energy" and "Employees and Society." This represents an active contribution on our part to the United Nations' 17 Sustainable Development Goals.

Why does sustainability have such a high priority at Schaeffler?
Sustainable business success means assuming environmental and social responsibility, in manufacturing, on the product level and within one's own supply chain. Sustainability has truly evolved into a competitive factor. Schaeffler's products support our customers in achieving their own sustainability goals. Sustainability is also important for our employees because who would like to work for a company that neglects social responsibility and environmental protection on its own doorstep?

Where does Schaeffler have to intensify its efforts now?
Climate neutrality is something we can actually achieve relatively fast by buying green electricity and CO_2 certificates while continuing to reduce our consumption by means of energy efficiency actions. In addition, we need to integrate our suppliers more intensively in our sustainable strategy. That's why we're planning to conduct sustainability audits in their operations starting next year. In addition, we have to show how large the environmental footprint of our products is in the utilization stage.

HOLISTIC **SOLUTIONS**

To solve the challenges of the global community, the General Assembly of the United Nations in 2015 formulated "17 Sustainable Development Goals" in the "Agenda 2030."

The overarching goal is to create decent living conditions worldwide. A closer look soon reveals that an isolated solution addressing a single challenge is not possible. Instead, individual aspects have direct or indirect effects on other fields. Everything is interlinked – if one solution fails the big picture threatens to break apart.

The 17 UN goals are only achievable if these economic, environmental and social development aspects are jointly resolved.

With 1.1 °C above the level of the preindustrial age, 2017 was one of the three warmest years ever recorded

A temperature rise of 1 °C **means 5 % less grain yield**

The **sea level** rose **by 19 cm** (7.5 in) between 1901 and 2010

Worldwide CO_2 emissions have increased by nearly 50 % since 1990

Decent work means fair income, job security and social protection for families, good prospects for personal development and social integration

Sustainable economic development aligns social, environmental and economic development goals with each other

In 2016, **61 %** of the worldwide labor force worked in the **shadow economy**

The unemployment rate among juveniles is three times as high as among adults

Dilapidated infrastructure inhibits industrialization and innovation and promotes poverty

3.8 billion people have no internet access – in the least developed countries, up to 80 % of the population

Environmentally friendly and **sustainable industries create new jobs.** One of the prerequisites is education

The energy sector is the main cause of climate change and **accounts for about 60 % of all greenhouse gas emissions**

1 billion people (13 % of the world population) are living **without electricity;** 87 % of them in rural regions

3 billion people (41 % of the world population) use **dirty fuels** and/or utensils for cooking – as a result of which **4 million people die** per year

Inequality jeopardizes long-term social and economic development, is detrimental to fighting poverty and **destroys people's self-esteem.** This leads to crime, disease and environmental damage

Less inequality means better participation and sharing. It's the prerequisite for using **human economic, scientific and social potential**

In poor countries, **the income gap prevents** the conquest of poverty. In industrialized countries, growing inequality poses a threat to social cohesion and has a **negative impact on economic development**


Mastering the great challenges of sustainable development takes a **joint effort by everyone – governments, civil societies, scientists, the business community and the private sector**
In 2017, the total public net development aid amounted to **146.6 billion dollars – 0.6 % less than in 2016**
Agricultural aid for developing countries dropped from nearly 20 % of the sectorally allocable aid by all donors in the mid-1980s to 6 % in 2016
We're living beyond our ecological means. **By July 29, 2019, humanity had already used up the Earth's annual resources.** In 1990, this day was still dated December 7
When the world population has grown to **9.6 billion** by 2050 it will take three planets Earth to sustain our current lifestyle
An estimated one third of all **food produced – 1.3 billion metric tons** (1.4 billion short tons) worth about 1 trillion dollars – **rot away** every year
RESPONSIBLE CONSUMPTION & PRODUCTION
LIFE BELOW WATER
Oceans absorb about 30 % of the CO_2 produced by humans and mitigate the effects of global warming
The livelihoods of **more than 3 billion people** depend on the diversity of the species in the oceans and on the coasts
The **marine fishing sector** directly or indirectly employs **more than 200 million people**
The **acid content of the oceans** has increased by 26 % since the industrial revolution
LIFE ON LAND
80 % of all animal and plant species live in forests and 1.6 billion humans, incl. 70 million indigenous people, live off them
12 million hectares (30 million acres) of farmland are lost per year due to droughts and desertification (57 acres per minute)
8 % **of the known animal races** have died out and 22 % are threatened with extinction
More than **80 % of human nutrition** is supplied by plants
GENDER EQUALITY
Women are still disadvantaged and deprived of their rights almost everywhere. The majority of the poor and the largest proportion of illiterates are females
More than a third of all women are **victims of physical or sexual violence**
One in three girls aged 15 to 19 still undergo **genital mutilation** in 30 countries in Africa and the Middle East
Worldwide, **women account for only 13 % of the land owners,** the proportion of women in parliaments is 23 %

Corruption, bribery, theft and tax evasion cost developing countries about 1.26 trillion U.S. dollars per year

The judiciary and the police are among the institutions most severely affected by corruption

Every 5 minutes **a child dies** somewhere in the world **as a result of violence**

18 countries are experiencing conflicts, 74 million people there are in urgent need of humanitarian aid

A HOLISTIC EXAMPLE OF HOW EVERYTHING IS INTERLINKED

An example in Guatemala shows how interlinked the UN goals are. 75 percent of the young people in the Middle American country have no chance of further education after elementary school. The results are unemployment, poverty, crime and violence. To break up this spiral, ***international development aid is now investing in 15 model schools*** *where the mostly indigenous juveniles learn to develop small income-generating projects of their own. They include breeding chickens or tilapia fish, for example, as well as moped and bicycle repairs.* ***The young people apply what they've learned in their villages, have prospects for the future – and are supposed to escape from the poverty spiral in this way.***

PEACE & JUSTICE

SUSTAINABLE CITIES

Cities only account for 3 % of the Earth's surface **but cause 60–80 % of the energy consumption** and 75 % of the carbon emissions

In 2030, some 5 billion people will be living in cities – today 3.5 million are urban dwellers

883 million people are living in urban slums

25 % of urban waste is not collected and properly disposed of

NOBODY HERE WINS
ALONE

Everything – humans and technology – has to perfectly interact. This impeccable combination is the prerequisite for successful motorsport. It's also the basis for all the race victories and title wins of the Audi Sport ABT Schaeffler Formula E team, while the racing spirit that the three partners share is the lubricant of this success story.

by Leopold Wieland

"Everyone here is a professor," says Allan McNish (49), Team Principal of Audi Sport ABT Schaeffler, jokingly and precisely putting things in a nutshell because, more than anywhere else in motorsport, the following applies to Formula E teams: they're highly qualified elite units operating with extreme concentration.

Innovative powertrains from Schaeffler and Audi

At Audi Sport ABT Schaeffler, it all starts with the development of the powertrain, which begins at Schaeffler in close collaboration with Audi about two years before the first start of the two race cars. Consequently, Schaeffler and Audi, as early as in fall of 2017, began working on the powertrain they'll compete with in the 2019/2020 season starting in November. "Initially, Audi and we tested various concepts for the motor and transmission, and evaluated the results by means of simulation," says Daniel Kohl (33), Head of Technical Development Motorsport at Schaeffler. Once the technical direction to be pursued had been decided, design and production began.

The motor and power electronics came from Schaeffler's subsidiary Compact Dynamics in Starnberg and with its in-house departments for innovative materials, ball bearing production and electrified drive systems at the headquarters in Herzogenaurach, the Group

participated in the development of the transmission concept, calculation and design of the gearing, bearing development and production, and in the area of the drive shafts. “In all of these areas, we constantly coordinated our activities in terms of content and organization with Audi. Whether by video conferencing or personally onsite, it was always non-bureaucratic and efficient,” says Kohl. Plus, the experts in high-voltage storage systems from the Schaeffler research departments at Karlsruhe University were consulted for assistance as needed. Concurrently, Audi Motorsport in close coordination with Audi’s production development created initial software solutions for the new powertrain system.

Meticulous testing in Audi’s laboratory

Short channels, fast-paced progress and a constant focus on the technology transfer between motorsport and production also characterize the continuation of the project in the next stage at Audi. At the premium brand’s competence center in Neuburg an der Donau, the finished powertrains delivered by Schaeffler and the specification chassis provided by the Formula E organization are assembled into complete race cars for the first time – like most recently in summer of 2019 with the new Audi e-tron FE06 model for the coming 2019/2020 season. “Besides the various engine and powertrain dynos and the test track located directly next to our development buildings, our race track simulator is of crucial importance,” says Dieter Gass. The Head of Audi Motorsport is the landlord in Neuburg and has primary responsibility for the Audi Sport ABT Schaeffler Formula E team that has been factory-backed by Audi since the 2017/2018 season.

Ready for charging the batteries: two mechanics at the rear of the Audi e-tron FE05 where the electric motor sits

Especially in the last few months before the new racing season, as well as routinely before the races, the regular drivers, Lucas di Grassi and Daniel Abt, and development driver Nico Müller “drive” countless kilometers without a single wheel turning. The simulation takes place in the cockpit of a Formula E Audi of the respective current version installed on computer-controlled hydraulic “legs”: driving, track and weather conditions, plus various race scenarios – and all of it totally realistic. Consequently, a major portion of the setup work has already been completed in the virtual world when racing starts in earnest – when the two race cars of Audi Sport ABT Schaeffler compete in the one-day events with their extremely tight schedules that are held in major cities of the world like Hong Kong, Berlin, Paris and New York on city street circuits specifically set up for Formula E.

Sparked by Abt’s pioneering spirit

Preparations for transportation and the races as well as the actual fielding of the cars are in the proven hands of the third team pillar of Audi Sport ABT Schaeffler: ABT Sportsline. As the world market leader in tuning automobiles of the Volkswagen Group and a successful touring car racing team for more than twenty years, the family-owned company from Kempten

ALL FOR TWO

Depicted here are eight important people that help Lucas di Grassi and Daniel Abt achieve victory – in total, more than 100 experts at Audi Sport in Neuburg, ABT Sportsline in Kempten, Schaeffler in Herzogenaurach and Schaefflers E-powertrain subsidiary Compact Dynamics in Starnberg work on the successful Formula E mobility mission

in Bavaria's Allgäu region is a familiar and trusted Audi partner. Plus, the company's CEO, Hans-Jürgen Abt, is the "father" of the ABT, Schaeffler and Audi Sport triumvirate. Right at the beginning of Formula E that was incepted in 2014, Abt, imbued with a pioneering spirit, had entered the first international series for fully electric race cars. At that time, it fit him like a plug fits into an outlet because, just shortly before, he had made electric mobility the third pillar of ABT Sportsline.

"We're a totally well-gelled and extremely experienced squad of experts," says ABT Sport Director Thomas Biermaier. Together with Team Principal Allan McNish, an ex-Formula One driver and former World Sports Car Champion, Project Leader Tristan Summerscale and Team Manager Roger Köhler, he organizes the technical crew that's limited trackside to a maximum of 20 people by the regulations. Each of the engineers and mechanics has several roles. Nearly around the

SCHAEFFLER: **SIGHTS NOW SET ON 2020/21**

How does racing spirit manifest itself at Schaeffler?
Daniel Kohl: In addition to relevant professional experience in motorsport or as part of a university education involving Formula Student, an international engineering design competition for students of technical fields that has existed for more than ten years, all of us have a special penchant for motorsport. This is reflected in a high level of team cohesion and the constant willingness of the department to go the proverbial extra mile for this exciting topic.

How did you get into e-racing as a mechanical engineer?
Daniel Kohl: I got into this field in 2012 via Formula Student in the form of an internship and a final paper at Audi in the area of endurance racing. That was the time at which hybrid vehicles began to also be admitted to the Le Mans 24 Hours.

Daniel Kohl (left), Head of Technical Development Motorsport Schaeffler, with his colleague Benedikt Locker and Formula E driver Daniel Abt (right) at the Schaeffler 4ePerformance concept vehicle

They took everything to an all-new technological level. That was my gateway to this technology and provided me with a basic appreciation of the enthusiasm that can be felt in motorsport and that can also be created by motorsport.

What are Schaeffler's next tasks in the Audi Sport ABT Schaeffler Formula E project?
Daniel Kohl: For us as developers, work for the upcoming 2019/2020 season has practically been completed since August 2019. Our newly developed components have by and large been handed over to Audi Motorsport. From there, they'll be sent to ABT for preparing the cars for the races. Since then, we've been focusing on the development for the season after next, which means we're already setting our sights on 2020/2021. However, if any unplanned damage occurs in the current testing and racing operations, for instance due to accidents, and special spare parts have to be produced, we're immediately involved and, if necessary, trackside, too.

> ***» Just like the technology, you have to keep improving as a driver, constantly challenge and optimize yourself in every respect***
>
> Lucas di Grassi

clock, they're supported by their colleagues at the Audi test rigs in Neuburg because making the 200 to 250 kW (272 to 340 hp) Formula E cars that reach speeds of up to 240 km/h (149 mph) ready to race and able to win is a high-tech job of the most complex kind. This particularly applies to optimally setting up the interaction of the electric powertrain and to managing the energy supplied by the battery and recovered from braking with pinpoint accuracy down to the last centimeter of the race distance. Naturally, the pursuit of perfection never stops at Audi Sport ABT Schaeffler on the mechanical side either. This extends all the way to the last stone being plucked from the tire tread of a car that has come in for pitting.

Even a recipe against stress and anger

The rest of this collective high-precision work is achieving the fastest possible laps and optimum positions, for which Lucas di Grassi and Daniel Abt are

Around the Audi Sport ABT Schaeffler garage: Mechanics practice a nose change that may be necessary in the race after a crash (above left). Control center of the team's directors and technology managers (below left). Multifunctional steering wheel of the Audi e-tron FE05 Formula E car (above right)

responsible at the steering wheel. The Brazilian from São Paulo and the German from Kempten are the most consistent and successful Formula E pairing. They've been teammates since 2014/2015, the electric racing series' inaugural season. Their track record after five seasons and 58 races: one drivers' title (di Grassi 2016/2017), one teams' title (2017/2018), twelve race victories, 40 podium finishes, 14 fastest race laps, 1,101 championship points and, in the end, always in the top three of the teams' classification. "Just like the technology, you have to keep improving as a driver, constantly challenge and optimize yourself in every respect," emphasizes Lucas di Grassi. An important helper in doing so, for him as well as for Daniel Abt, is Audi Sport ABT Schaeffler's team doctor: Dr. Vincenzo Tota. The Italian sports physician, who also supports Audi Sport in DTM racing, not only carefully attends to every fiber in the drivers' bodies. Dr. Tota also imparts to them a mental self-therapy that's particularly helpful for drivers in the frequently red-hot action on the race track: stress and anger management.

Racing spirit is something that nobody at Audi Sport ABT Schaeffler has to be inculcated with. The passion for motorsport has been and will continue to be their common lubricant. Everyone in the team is deeply imbued with it – and living it to the fullest.

THE AUTHOR

Leopold Wieland, *now working as an editor for the communications agency Speedpool, personally "lived" motorsport teamwork: 30 years ago, just having earned a master's degree, the rookie joined Zakspeed where he was tasked to reorganize the press department of the then German Formula One and DTM racing team. The passion of every individual for race cars and racing that even in critical phases kept Erich Zakowski's operation together and drove it forward left a particularly strong impression on him.*

WHAT BRAIN-COMPUTER INTERFACES (BCI) MAY MAKE POSSIBLE

Telerobotics
Robots execute human thoughts in order to perform tasks that are difficult, dangerous or impossible for us (e.g. in surgical procedures and rescue missions or in space travel).

Telepathy
When thoughts are transformed into data they can be transmitted from one person to another one. This, for instance, simplifies communication with people suffering from hearing or speech impairments.

Cloud memory
"I can't remember" is a sentence that will die out thanks to BCI. BCIs make direct connections to the internet and uploading of thoughts into a cloud possible.

Compensating for physical impairments
BCIs can compensate for disorders in the human nervous system and thereby eliminate impairments of motor functions.

outlook

Technology for tomorrow

HOMO SAPIENS **2.0**

When Hannes Sjöblad goes to work he briefly moves his hand toward the electronic access control system and the door to his office opens. The Swedish IT manager also uses his hand to pay for an occasional snack. Sjöblad has had a chip the size of a grain of rice that can communicate with machines implanted into his hand: a human log-in to the Internet of Things. Sjöblad calls himself a biohacker and sees the dawning of an age of human augmentation. A reason to be alarmed? Not necessarily. Cyborgs are already among us today: deaf people who, thanks to being linked to sensors, are able to hear again or blind people who can connect themselves to a mini camera and are able to see. So-called brain-computer interfaces (BCI), a promising field of research, make it possible to control machines by means of thoughts. As far back as in 2002, AI scientist Kevin Warwick, after some practice, managed to control a robotic arm by means of a "braingate" (a microchip connected to the nerve fibers in the lower arm by 100 delicate electrodes) via a wireless local area network (WLAN) and the Internet. In 2016, a test person was at the controls of a flight simulator via BCI. The pioneering tech billionaire Elon Musk with his Neuralink startup is planning to connect the human brain to machines via an interface, too. During a presentation in summer 2019 he demonstrated how extremely thin wires are implanted into the brain and is currently pursuing government approval of the technology. Drive-by-wire-systems such as "Space Drive" from Schaeffler provide an important bridge for translating BCI impulses into real movements. Humans are also integrating themselves with virtual worlds in ways that literally put the experience at their fingertips: South Korean scientists recently presented a data glove with which imaginary things can be haptically experienced thanks to a host of tiny pneumatic actuators: another harbinger of the Cyborg age.

» *I was born human. But this was an accident of fate [...]. I believe it's something we have the power to change*

AI scientist Kevin Warwick

“THE RIGHT SOLUTION AT THE RIGHT TIME”

Uwe Wagner, Head of Research and Development at Schaeffler, talks about predictions and prospects on the road toward modern mobility.

Interview: Stefan Pajung, Carsten Paulun

The name of the rubric in which this interview appears is “outlook”: What are your thoughts on the prospects for modern mobility in 2030?

In order to be able to shed some light on the prospects for future mobility it’s necessary to first look at the requirements and possibilities that will exist in the future. In 2030, the climate, urbanization, as well as the growing demand for transportation of goods into the cities, for example, will continue to be key topics. In this context, it’s also significant to note that we continue to see a high demand for personal mobility. The most important elements of mastering these challenges are optimized or new propulsion technologies, automation, and new urban development concepts in combination with enhanced interurban connections. This opens up prospects for solutions that will be heavily defined by electrified powertrains and autonomous vehicles that will be offered as shared mobility services. These “movers” will partly complement conventional vehicles and partly replace them.

Do you have any concrete predictions concerning future mobility for us?

For propulsion technology, we’re seeing a very strong move toward electric mobility, in which we include both hybridization and fully electric vehicles. Our “30/40/30” scenario for the year 2030, in other words a split of 30 % fully electric vehicles, 40 % hybrids and 30% ICE vehicles, still met with disbelief just a few years ago. Today, it’s becoming increasingly apparent that this is a realistic scenario – some have even begun to trend more aggressively toward electrified scenarios. However, we still feel that, on a global scale, “30/40/30” strikes a good balance between the challenges of implementing this scenario and its effectiveness concerning CO_2. At least, in our estimates we’re able to show that, with this ratio, we’ll be able to achieve the 2050 climate goals for passenger cars and light trucks under certain overall conditions. The second prediction heads in the direction of automation. Compared to electrification, automation will take a little longer in our view, but automation levels 4 and 5 will come. Achieving this will require “true” drive-by-wire technologies, in other words solutions that will no longer involve a mechanical connection between the steering wheel and the wheels. This is where we see major market opportunities for the “Space Drive” technology we offer and continue to develop with our Schaeffler Paravan Technologie GmbH & Co. KG joint venture.

Let’s take a look around the globe: Schaeffler has locations in 50 countries. Do you see a country anywhere that serves as a viable role model for modern mobility?

I don’t see a real role model because the various economic-environmental conflicts of interest in the regions are still simply too big and have not been resolved yet. On the one hand, the necessary reduction of CO_2 emissions has by now been largely accepted, see the Paris Agreement, but on the other, the massive changes that are necessary to achieve these goals have simply not been accepted yet, including the social consequences. What China, for instance, does really well is creating incentives for electric mobility including the establishment of the required

» We're not just looking into the future, but are already intensively working on modern mobility

Uwe Wagner,
Head of Research and Development Automotive OEM and Industry at Schaeffler

infrastructure or political prerequisites for automated driving. But, in Europe, we're also doing some things that are heading in the right direction, for instance, in terms of setting goals and thereby creating awareness for necessary CO_2 reductions.

Are regulations beneficial?
As long as regulations are oriented to the actual goals, in other words the effective and holistic CO_2 emissions, we don't have a problem with them. But as soon as technological regulations are issued, we definitely do. We need an open, unbiased approach to technology, simply because today it's still impossible to know the "right" technological solutions. Any technological regulation reduces the search for innovative solutions. We need answers to a whole host of questions: How can we reduce the energy for the production of electric cars? How can we reduce the use of critical raw materials? How can we establish the necessary infrastructures? We'll have to do a lot of homework in the next ten years. Infrastructure, availability, price: everything has an impact on this issue.

What would help accelerate this process?
We need a holistic technological discussion, which means we have to include sector coupling – in other words the interlinking of the diverse areas of our energy chain – in the development of mobility solutions. This is indispensable to coordinating energy production, energy provision and infrastructure, and propulsion technology in ideal ways. And to this end, we need a holistic, nonpartisan, goal-oriented and, as I said before, unbiased technology discussion. In addition, a stronger international consensus would be desirable. Otherwise, well-meant unilateral national actions might weaken our competitive position in the medium run. This international consensus must be neutral, technology-based and holistic. We don't have that in this form at the moment.

How do you view Schaeffler's role as a global technology group and automotive supplier in this context?
Of course we try to understand and anticipate the requirements to be met by

» As long as regulations are of a general nature and, for instance, establish CO_2 goals, we don't have a problem with them. As soon as technological regulations are issued, we definitely do. We need an unbiased approach to technology

Uwe Wagner

new forms of mobility and to subsequently develop solutions before the market explicitly demands them. Two examples: We've been developing ideas in the area of electric mobility for a long time and have also built various relevant concept vehicles. Based on this preliminary work, we subsequently managed to have projects awarded to us such as the hybrid module with a torque converter on the American market and high-performance transmissions for electric axles. We've also been working on innovations in the chassis area for a long time to enable automated driving and identified drive-by-wire technology as its central enabler. That's why over a year ago we established the Schaeffler Paravan Technologie GmbH & Co. KG joint venture so that the "Space Drive" technology makes it possible for us to offer a solution in this key area. At Schaeffler, we define ourselves as a strategic partner of the OEMs, who, with solid systems understanding, tries to anticipate future needs and offer the resulting solutions at the right time.

Drive-by-wire technology is a prerequisite for autonomous driving

Electric cars, e-scooters, four-wheeled pedelecs such as the Bio-Hybrid, self-driving movers, drones for vertical mobility: does all this fit together, will it combine into an assortment of modern mobility?
In a nutshell: Yes, it will. Of course, some ideas will be sorted out again, too. But it also takes the courage to just try out certain things – new technology platforms – and to get them started. We need this dynamic momentum, this critical energy, from which the sorting process results, in order to then arrive at exactly the right solution.

Is the Schaeffler Mover vehicle concept an example of the courage you're talking about?
Yes, it's a very good example. We created an all-new vehicle concept and installed all-new technologies in it. We integrated the drive system in the wheels, as well as chassis functions such as steering, the wheel suspension and the brake. Plus, there's the innovative drive-by-wire in the Mover as a base for autonomous driving. To give a face to all this and to showcase the vision, we built a complete vehicle and also demonstrated the use cases for passenger and goods transportation with the various body styles. And we did all this without the intention to build complete vehicles at Schaeffler in the future. It was

2,417
patents were filed by Schaeffler in 2018, which makes the company one of the most innovative ones in Germany.

7,991
people, just in the area of R&D, were employed by Schaeffler at **20 worldwide research centers** at the end of 2018.

847
million euros were invested by Schaeffler in **research and development** in 2018.

a bold move and it could have gone wrong, but it generated extremely positive feedback.

What role will digitization play?

First of all: Digitization is not an end in itself but paves the way toward new, more powerful solutions in many areas. And in the area of product development, for one, this means new possibilities in the development process and, for the other, of course, totally new product ideas. For instance, by linking test data analysis, simulation and rapid prototyping via additive manufacturing we aim to shorten development cycles. Or we use AI, in other words artificial intelligence, to reduce the testing effort in the area of strength testing. With new product ideas, we use AI for real-time models to analyze integrated sensor concepts. We've also developed digital twins for industrial applications in which we combine our domain know-how of bearings in the form of classic models with new data-based models in order to achieve fast analyses and deliver services they're based on such as condition monitoring with predictive maintenance.

Is it difficult to establish digitization in a company that, traditionally, has been known more for excellent mechanical components?

No, because we benefit from what has always been one of our hallmarks: We've always looked beyond our component world and developed our products from an understanding of systems. We want to understand which higher-level system our components, modules and subsystems are installed in. And then we see that combining the new know-how in the areas of data science and data engineering with this classic systems expertise can generate enormous dynamism. The product ideas that are completely within the realm of the digital world are, no doubt, still new for us. Today, as well as in the foreseeable future, you'll still be able to touch our products. But we're also working on data-based services and thus on totally new business models and customer-supplier relationships. This is still a new area for us, but about a year ago, we created a dedicated business unit, Industry 4.0, for it – that's what we're going to develop into.

What aspects are coming up short in the current discussions about future mobility, sustainability and energy chain?

The fuel cell. For various reasons. It starts with energy production. If you produce energy from renewable sources you can only feed it into the grid whenever it's directly needed. However, to efficiently use it, you need to increase the base load capacity of such renewable energy sources. This is why stationary battery systems are being pursued. However, if you think about extended storage periods or even about transporting energy across long distances where no power distribution lines are available, you'll soon arrive at hydrogen or processing it into synthetic fuels. And then the fuel cell plays an important role. Another aspect to be considered in this context is that, due to their high weight, the suitability of batteries in large vehicles, in other words trucks or buses, but also in rail vehicles, reaches its limits. These considerations make hydrogen very attractive. And, at least here in Germany, this is still underestimated. The countries in which this development is currently being pursued with great intensity are Korea, Japan and China. And, surprisingly, these are also the countries that are at the forefront of battery technology.

So, do you see major progress in battery systems, going forward?

Initially, it can be expected that, due to scaling, prices will actually drop. And then an intensive effort will be invested in increasing power density. Technically, about 250 Wh/kg are possible today and current research is targeting levels of up to twice that much, for instance with lithium-sulfur batteries. The utilization of critical raw materials is intensively being worked on as well, for instance by trying to reduce the cobalt content on the cathode. This will probably be possible only up to a certain limit. That's why alternative electrode materials from organic substances are in development, too. Lithium is also to be regarded as a critical raw material, which is why post-lithium technologies are the subject of intensive research as well. However, we shouldn't ignore the fact that it took 20 years to get from the lead-acid battery to the current state of the lithium-ion battery, so fast breakthroughs and quantum leaps are rather unlikely. Consequently, the recycling of batteries will become increasingly important in the future, too.

VR technologies accelerate the engineering design process of components

» We've always looked beyond our component world

Uwe Wagner

Our last question refers to the Paris climate goals: which sector will most likely be able to help achieve them?

The energy sector, quite clearly. If it fails to achieve the Sustainable Scenario of the 2018 World Energy Outlook (summary of global energy trends, editors' note) *the mobility sector will not be able to achieve its goals either. We've performed calculations for various scenarios in this context. Our 30/40/30 scenario, based on a sustainable energy production scenario, will be able to achieve the CO_2 goals in 2050. According to the "current policy" scenario, in other words the current, globally planned energy production, we'll miss this target by more than double. Even scenarios with more aggressive proportions of electric vehicles will only make a marginal difference here by 2050. Until 2030, they may even be counterproductive due to the high energy requirements for producing the batteries. At Schaeffler, we're working on various solutions along the entire energy chain, from highly efficient bearing solutions for diverse propulsion systems to a complete portfolio of powertrain technologies in the area of electric mobility to condition monitoring systems for increasing the availability of wind turbines or stationary storage systems for the base load capacity of power stations for renewable energies. In aviation, our Aerospace division is ready to roll out innovative solutions, too. Only those who understand the correlations along the energy chain are able to develop sustainable and efficient products and thereby help achieve the Paris climate goals. We're in a position to do so with a broad and solid portfolio.*

ABOUT UWE WAGNER

Uwe Wagner *(born in 1964) is currently Head of Research and Development Automotive OEM and Industry. Effective January 1, 2020, he will become a member of the management board of Schaeffler AG. As Chief Technology Officer, Wagner will succeed Prof. Peter Gutzmer, who will retire.*

THE INTERWOVEN WORLD OF DOUGLAS ADAMS

Jimi Hendrix and Charles Darwin, Greenland and PowerBooks: The British author not only wrote "The Hitchhiker's Guide to the Galaxy" but also interlinked what's seemingly incompatible – with an unrivaled knack for playing with the diversity of the big picture.

by Wiebke Brauer

Perhaps the most remarkable aspect of Douglas Adams' books is that while everyone interprets the mental pictures painted in them differently his works also unite people. This is primarily owed to the holistic brace that keeps Adams' worlds in orbit: his sense of humor – a biting British way of poking fun at blind belief in technology and ideologies in general, at very earthly absurdities and fears. Another reason is his uncanny ability to interweave a wide variety of topics: robotics and emotions, evolution and digitization, poetry and extraterrestrials. Douglas Adams – the master weaver of the world riddle.

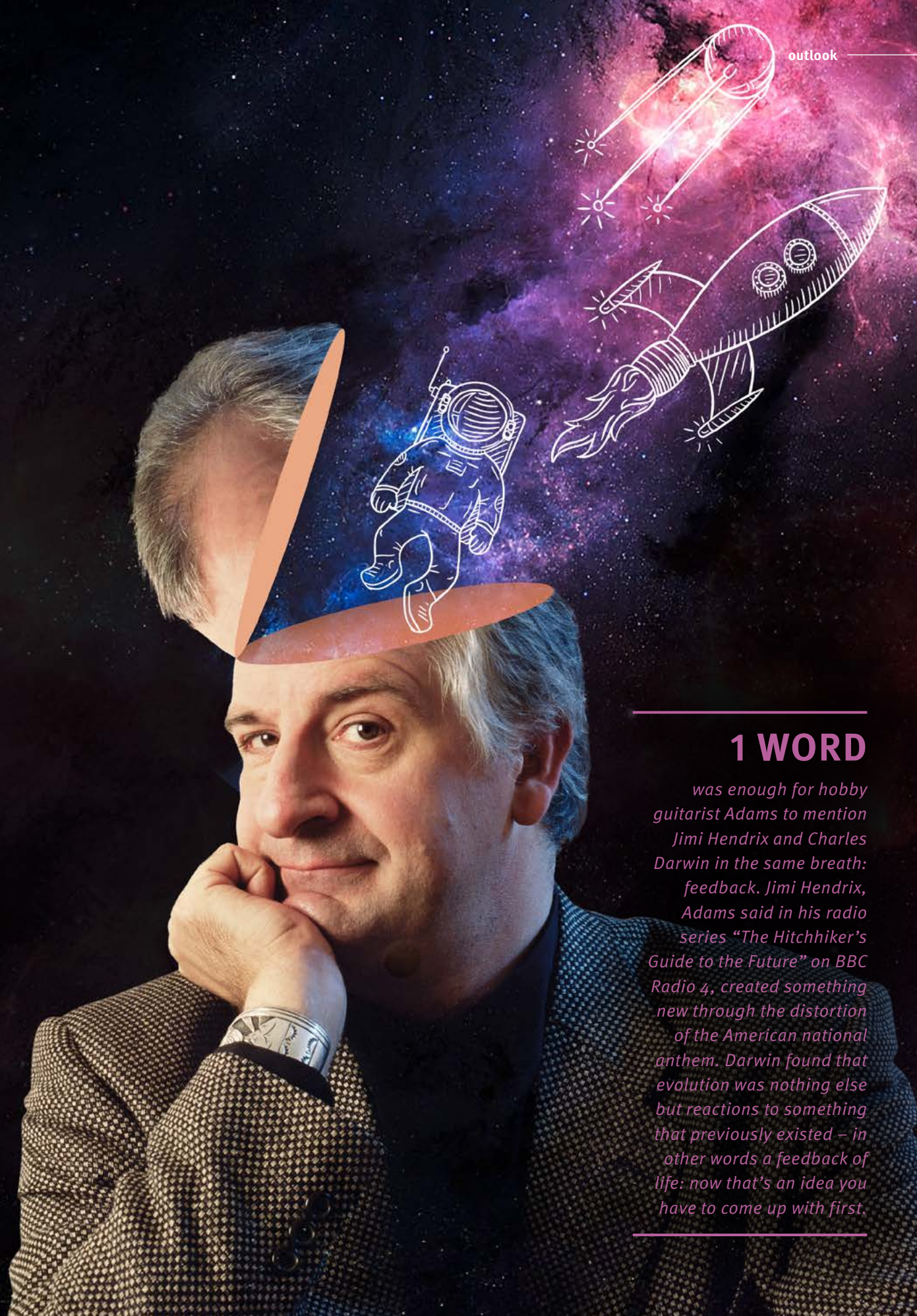
Writer Stephen Fry, who was a friend of Adams', wrote about him: "We never quite knew how conflicting and insane the universe was or how ludicrous and feeble-minded the human race could be until Douglas explained it in the uniquely affable, paradoxical and unforced style that marks him out for greatness."

Another thing that might be mentioned here: Adams' work is not what's commonly regarded as high literature. His jokes are often silly and while his legacy includes a community of devoted fans there's also an equally large number of people who have absolutely no use for his works such as "The Hitchhiker's Guide to the Galaxy," a series of novels about the interstellar adventures of Arthur Dent, an average working-class UK citizen. That said, in order to understand Douglas Adams, one should look at his entire works and his views about "Life, the Universe and Everything."

Zoologist, rock musician, system software designer

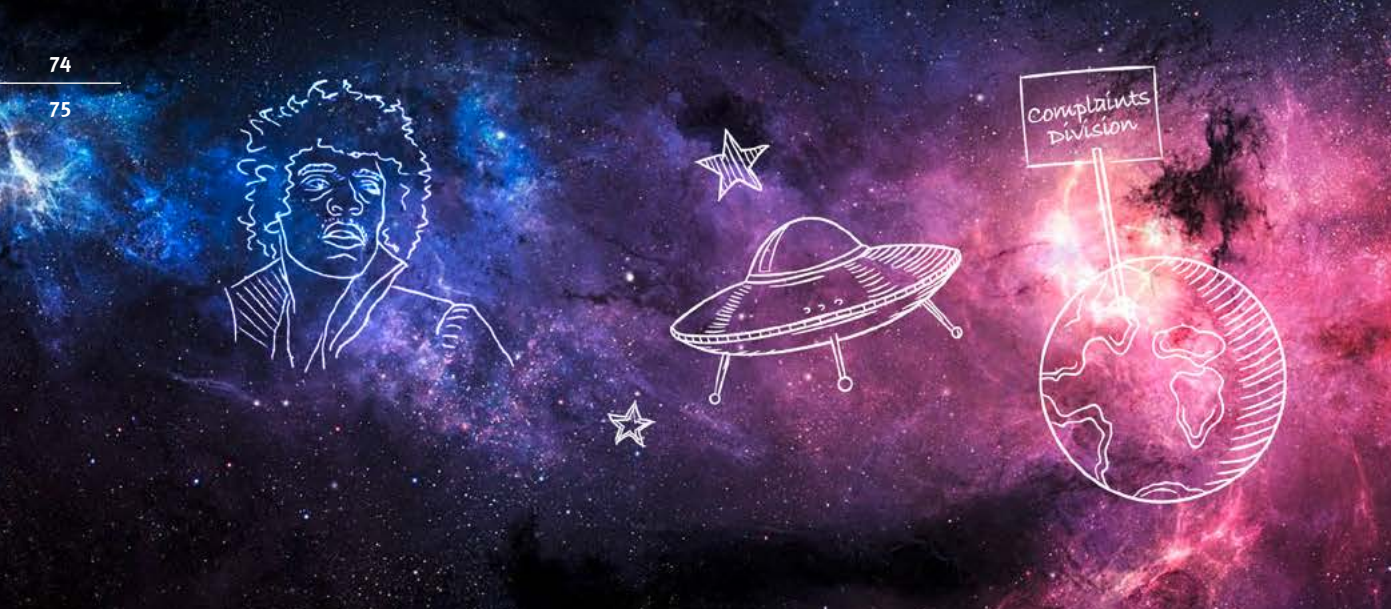
For starters, one could consider the fact that Douglas Noël Adams was anything but an otherworldly sci-fi writer. When asked what other dream career he could imagine for himself he once responded extensively: "Zoologist, rock musician, system software designer." That outlines the colorful cosmos of the author who was born in Cambridge in 1952 pretty well. In school, he had a keen interest in science and later studied English literature at St John's College where he was awarded a scholarship for an essay on the religious poetry in texts of the British poet William Blake and the Beatles. That goes to show that as early as in 1971 his way of thinking was anything but linear.

During his student days, Adams joined various comedy groups, got to meet the founders of Monty Python and went on to work with them after graduating, but wasn't able to make a living that way. In the mid-1970s,



1 WORD

was enough for hobby guitarist Adams to mention Jimi Hendrix and Charles Darwin in the same breath: feedback. Jimi Hendrix, Adams said in his radio series "The Hitchhiker's Guide to the Future" on BBC Radio 4, created something new through the distortion of the American national anthem. Darwin found that evolution was nothing else but reactions to something that previously existed – in other words a feedback of life: now that's an idea you have to come up with first.



he was about to give up on his plans of pursuing a career as a writer and accepted a number of bizarre jobs – including one as a bodyguard for the ruling family of Qatar. He achieved his breakthrough only in 1977, signing an agreement with the BBC about airing a science fiction radio show – it was called "The Hitchhiker's Guide to the Galaxy." The series became a novel, then five novels, and then a cult classic. It was translated into 35 languages and sold in about 20 million copies, plus there were radio drama episodes, television series, a (middling) movie, comics, computer games and stage adaptations.

Thumbs and other visions

Adams made a lot of money, most of which he spent on technology, which included a palmtop: a personal assistant in the form of a portable minicomputer. Older readers may remember that in the late 80s these gadgets were as hip as the newest iPhone today. Although Adams enjoyed the small size of the device he was struggling with how to type on it. Finally, he figured out the best way to do it: "You grip the palmtop between both hands and you type with your thumbs. Seriously. It works." At that time, teenagers typing WhatsApp messages into iPhones using exactly this technique are still a sextillion years away.

» *In the beginning the Universe was created. This has made a lot of people very angry and been widely regarded as a bad move*

From "The Restaurant at the End of the Universe," Chapter 1

However, on a more serious note, there are quite a few people who claim that Adams, due to his ability to interlink things, anticipated technological developments. In the documentary "Hyperland," Adams dreams of technologies that replace linear television. They include a VR helmet – and a hypermedium providing instant access to information that's digitally stored somewhere. Sounds like Google, but that was in 1990. Plus, the travel guide in "The Hitchhiker's Guide to the Galaxy" is described as a device the size of a pocket calculator with hundreds of buttons and a small display that can be used to retrieve any conceivable information. Adams found that his fictitious travel guide was a pretty good model of how the web works and in 1999 decided to put his idea into action with www.h2g2.com, an English-language portal where every user was able to write and view entries. "h2g2," an acronym for "Hitch Hiker's Guide to the Galaxy," did not catch on, but a web-based encyclopedia with a similar structure subsequently did: in 2001, Wikipedia was launched.

The basic uselessness

It's fair to say, though, that fortunately not all of Adams' fantasies became reality. Or would you enjoy a Nutri-Matic Beverage Synthesizer that can produce "a liquid that was almost, but not quite, entirely unlike tea?" The producer of this and countless other nonsensical devices is the Sirius Cybernetics Corporation. Adams keeps bringing up this high-tech company that's responsible for nearly all technical developments in the galaxy in the "Hitchhikers" series – and never does so in a positive light. Adams, for instance, writes this about Sirius' products: "It is very easy to be blinded to the essential uselessness of them by the sense of achievement you get from getting them to work at all. In other words – and this is the rock solid principle on which the whole of the Corporation's Galaxy-wide success is founded – their fundamental design flaws are completely hidden by their superficial design flaws." Adams underpins the Sirius Cybernetics Corporation's incapacity by making its

Complaints Division the largest department in the organization, "which now covers the major land masses of three medium sized planets …"

Obviously, Adams was not uncritical of technology. His frustrations with it went far beyond mischievously poking fun at it in his writings. They actually extended into real life. For instance, he used to get upset about the battery power of his PowerBook: "… funny notion, to name the thing after its only major shortcoming; it's rather like Greenland in that respect." Or he'd rant about "dongly things" – a wide variety of plugs that were flying around his home. In 1996, in the "MacUser" magazine, he asked if it wouldn't be easier to agree on a standard for DC power packs. Yes it would – even today. "Technology is our word for things that do not work yet," he once ironically quoted a friend and in a "Salmon of Doubt," he established three rules describing age-related human reactions to technological innovations:

- **Anything that is in the world when you're born is normal and ordinary and is just a natural part of the way the world works.**
- **Anything that's invented between when you're fifteen and thirty-five is new and exciting and revolutionary and you can probably get a career in it.**
- **Anything invented after you're thirty-five is against the natural order of things.**

Today, we distinguish between "Generation X" that was still familiar with the analogous world, "Generation Y" that grew up with desktop PCs and "Generation Z" that near-exclusively has been exposed to mobile displays. That goes to show that some of the terminology has changed, but Adams' rules have not.

In 2001, Douglas Adams died at the age of 49 – of a heart attack at a gym which, in a grim way corresponded to his sense of humor. The fact that in 2016 "Dirk Gently's Holistic Detective Agency" inspired a television series that was also distributed on Netflix would probably have pleased him. Particularly because he once characterized the story on which the series is loosely based as follows: "… it's an enormously complicated plot … Part of the complexity is there to disguise the fact that the plot doesn't really quite work." Because in spite of all the curiosity, creativity and far-sightedness with which Adams interlinked different fields of knowledge he was by and large primarily this: a human being with weaknesses he was able to make fun of.

42

In the "Hitchhiker" novel, this number is the response by the supercomputer "Deep Thought" to the question about "Life, the Universe and Everything" after 75 million years of computing time. Even today, this number is considered, analyzed and discussed again from time to time in IT circles although Adams in 1993 admitted why he chose 42 as the solution: "The answer to this is very simple. It was a joke. It had to be a number, an ordinary, smallish number, and I chose that one. Binary representations, base thirteen, Tibetan monks are all complete nonsense. I sat at my desk, stared into the garden and thought '42 will do'. I typed it out. End of story."

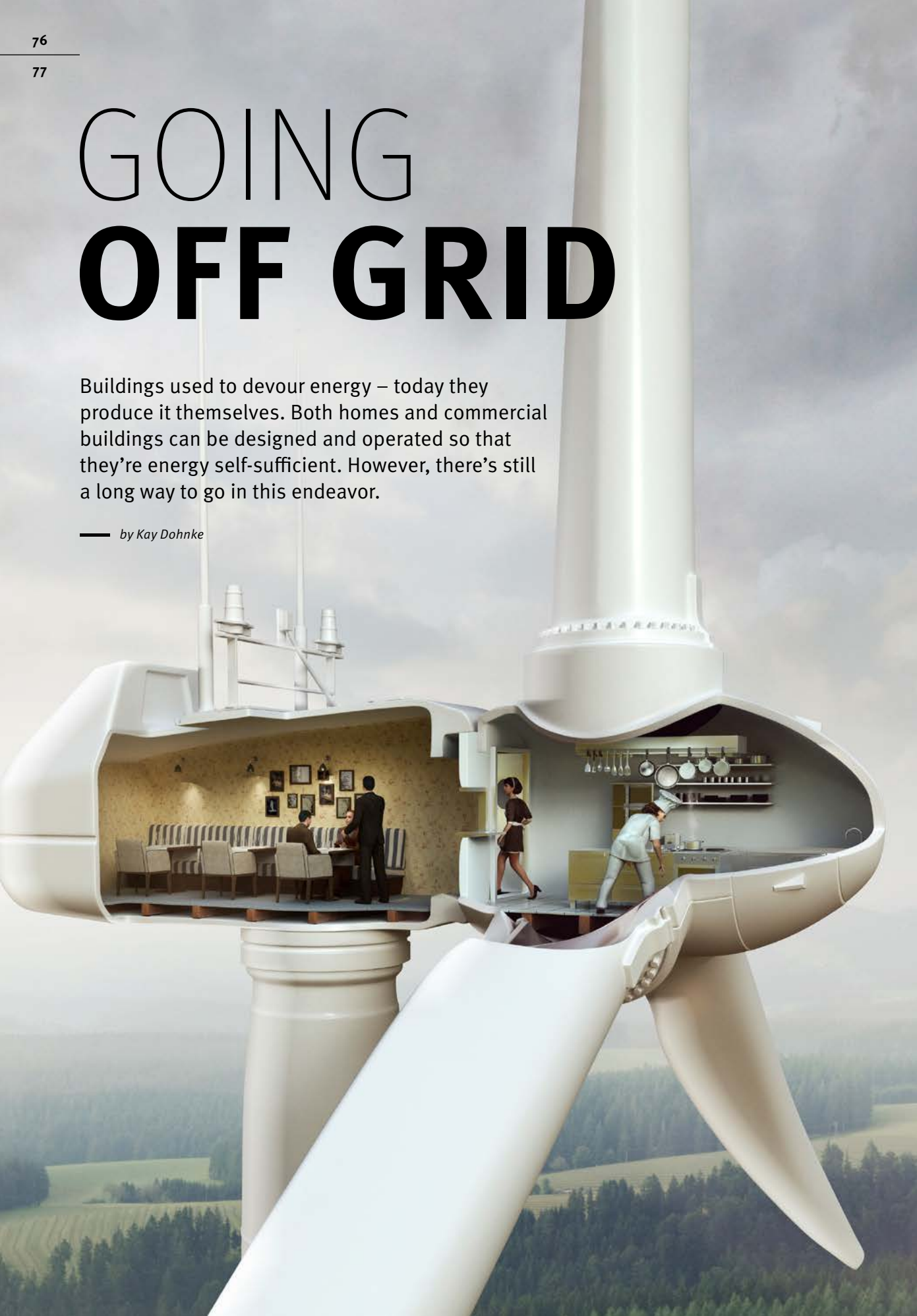
THE AUTHOR

Wiebke Brauer *read most of Adams' books in her teenage years and was tickled pink by them. While refreshing her reading for this text, the Hamburg journalist again became painfully aware of the void his death has left in the world.*

GOING **OFF GRID**

Buildings used to devour energy – today they produce it themselves. Both homes and commercial buildings can be designed and operated so that they're energy self-sufficient. However, there's still a long way to go in this endeavor.

by Kay Dohnke



High-rise buildings with glass façades, more than 240 meters (790 ft.) tall, a corporate headquarters like a stack of cardboard boxes, commercial buildings like dark monoliths or a spaceship from "Star Trek." They're one-of-a-kind – but not just because of their shape: The Torre Reforma in Mexico City, the New Repsol Campus building in Madrid or Samsung's U.S. headquarters in Silicon Valley are low-energy buildings, or largely energy self-sufficient, featuring innovative building technologies – and that makes them rare exceptions among commercial buildings worldwide.

This said, statistics show the urgent need for sustainable construction in the light of climate change. Every week, an area as large as Paris is developed for new building projects, according to a UN report from 2017. The construction sector alone is responsible for eleven percent of global energy-induced CO_2 emissions. Another estimate attributes eight percent of the worldwide CO_2 emissions just to cement production. Even more CO_2 – 28 percent – is blown into the atmosphere during the subsequent utilization of the buildings. For comparison: the transportation sector in 2017 accounted for 22 percent. So when it comes to the big picture of climate change, it's hard to avoid taking a closer look at the building sector.

While more and more architects in industrial nations focus on environmental aspects and their private clients have them design Passive Houses or even Energy-plus Houses, commercially used buildings still have quite a long way to go in terms of comprehensive sustainability. However, in view of the aforementioned statistics, a change in thinking is slowly starting in this area as well. There's a lot that can be done with technology: air conditioning by foundation cooling or integration of heating lines into concrete beams, sustainable electricity generation by solar façades, energy savings by means of thermal energy storage systems using water, or insulations that can be controlled as needed. In other words, solutions already exist and now it's up to architects, civil engineers and – not to forget – their clients to install them in high-rise buildings and factory halls, office buildings and commercial architecture.

Many individual measures result in a holistic concept

In their own four walls, many Davids have already implemented the things that the Goliaths are still experimenting with. A Passive House today only needs about a twentieth of the energy that conventional houses consumed in the 1970s. However, there's a lot more to an energy self-sufficient off-grid house. The Energy-plus House version, in other words a building that produces more energy than it consumes, is the most eco-friendly solution.

A standard office building has a primary energy consumption of 235 kWh per year and square meter (10.8 sq ft). With a range of efficiency measures, the Z3 in Stuttgart consumes 26.1 kWh

The receiving area of Schaeffler's corporate headquarters in Herzogenaurach is intended to become an energy-plus building as well. Some 200,000 kWh of electric power per year are consumed there for inbound and outbound shipments, and for intermediate storage. A planned solar power system on the roof is supposed to deliver 380,000 kWh and surplus electricity is planned to be used for charging electric vehicles or the production of hydrogen for fuel cells, etc. Energy backup with large storage systems for cloudy days has also been included in the project

A building in Stuttgart shows how individual technologies can be combined into a holistic sustainability concept. It is the headquarters of the Züblin construction corporation that has been designed by the architectural firm MHM in Vienna. The cube building named Z3 is heated with waste heat from the in-house data center

SMALL BUT POWERFUL

As an alternative to large wind turbines, ***novel wind roofing tiles with integrated mini turbines*** *generate CO_2-free electricity. With a 100-m² (1,080-sq. ft.) roof area and wind speeds of 5 m/s, (16 ft./s) 50 kWh per day can be achieved. Wind roofing tiles using the light and heat of the sun with solar modules (pictured) can deliver even higher output.*

while triple glazing with slats keeps the heat inside the building and serves as sun protection. The energy system's operation is based on trigeneration (combined cooling, heat and power). The building is passively air conditioned with a wet-cooling system that operates with evaporation chill. Façade-integrated photovoltaic modules generate electricity and daylight is guided into the building's interior via roof mirrors.

However, not only new buildings can be planned and operated in energy self-sufficient ways. In conjunction with renovation projects, for instance when replacing heating systems, major energy savings potential can be realized. Today, even the Passive-House standard can be achieved for many older buildings by means of basic energetic modernization, particularly insulation and optimized heating and air conditioning technology. This applies to residential as well as industrial buildings. In the light of the high energy and resource consumption that new construction entails, such energetic modernizations can make sense in two respects (see "Sustainable construction" info box).

However, technologies for energy self-sufficient buildings are also of interest to the three billion people with no or insufficient access to the power grid or to those who use high-emission and dangerous methods for heating and cooking.

SUSTAINABLE CONSTRUCTION

Concrete, brick, steel, glass – the ***production*** *of all these construction materials* ***entails high energy and resource consumption.*** *The amount of waste generated in this sector is huge, too. There's an urgent need for optimization. Concrete recycling and intensified utilization of wood as a CO_2-neutral construction material offer viable prospects here.* ***The University of Brighton has built a "waste house"*** *from over 85 % household and construction waste (including DvDs, bicycle tubes and discarded clothing) that is used as a classroom building.*

According to a Guide published by the German Federal Construction Ministry, there are five factors to be considered in holistically sustainable construction:

- ***Ecological quality*** *(effects on the global and local environment, resource consumption)*
- ***Economic quality*** *(lifecycle costs, space efficiency, adaptability)*
- ***Sociocultural and functional quality*** *(incl. comfort & safety/ security, mobility infrastructure, design quality)*
- ***Technical quality*** *(incl. sound, heat & condensation protection, protection against the forces of nature, maintenance-friendliness, demolition/renaturation)*
- ***Process quality*** *(incl. planning, invitations to tender, contract awarding & construction execution, consideration of optimal facility management)*

The selection of the site *should satisfy sustainability standards as well. How far are usage-relevant facilities away, what are the transportation connections, what special characteristics does the site have (sunlight, shade, noise, ground water level, risk of flooding)?*

Off-grid can help solve many problems

Especially in rural areas in developing countries, off-grid solutions are a highly viable alternative. The costs of establishing stable grids there amount to about $2,500 per household – let alone the average of nine years it takes to do so. A small solar power system can be installed for $30 and a basic off-grid solution for $500. A stable supply of electric power – also to small businesses – that can be achieved in this way is also an important element in fighting poverty and therefore sustainable not only from an environmental point of view.

Off-grid solutions also appear to be a sustainable and sensible alternative in view of the forecast population growth to as many as ten billion people by 2050. This refers not only to developing countries or individual, detached houses but to entire towns or urban neighborhoods such as Feldheim in Brandenburg, Germany. In 2014, the village went off grid with solar and wind power, a biomass power-plant and a large battery. Since then, developers from all over the world have been visiting the small community on the outskirts of Berlin to learn how this project can be implemented in their particular regions.

So-called ReGen Villages are supposed to become even more self-sufficient than Feldheim. People living in such holistically independent communities not only produce

SUSTAINABLE PRODUCTION – IN THE FACTORY FOR TOMORROW

In order to continually improve the sustainability of its manufacturing locations, Schaeffler is pursuing a holistic approach. To this end, in August 2018, the additional focus activity "Sustainable Factory" was defined for the "Factory for Tomorrow" (F4T) initiative as part of the "Agenda 4 plus One." It encompasses 21 sub-projects in the fields of energy generation and reduction of consumption, resource efficiency, production systems, employee mobility and material transportation:

Energy generation
includes solar and wind power, biomass, geothermal energy, combined heat and power stations, air-heat exchangers, large-battery storage systems, etc.

Energy efficiency
includes waste heat recovery, thermal utilization of waste, optimized lighting, etc.

Resource efficiency
includes construction material selection, eco-friendly packaging, recycling, water treatment, rain water utilization, etc.

Logistics & mobility
includes connection to rail and local public transportation, CO_2-neutral transportation, e-charging stations, e-vehicle leasing for employees, showers & locker rooms for cyclists, etc.

This is automotive and industrial supplier Schaeffler's idea of a factory of the future

their own energy but their own food, too. Also included are autonomous water management and waste-to-resource systems. If everything goes according to plan, the first homes of such a ReGen Village in a neighborhood of the Dutch town of Almere will be ready for occupancy in 2020 – it would be an excellent example of sustainably cutting the cord.

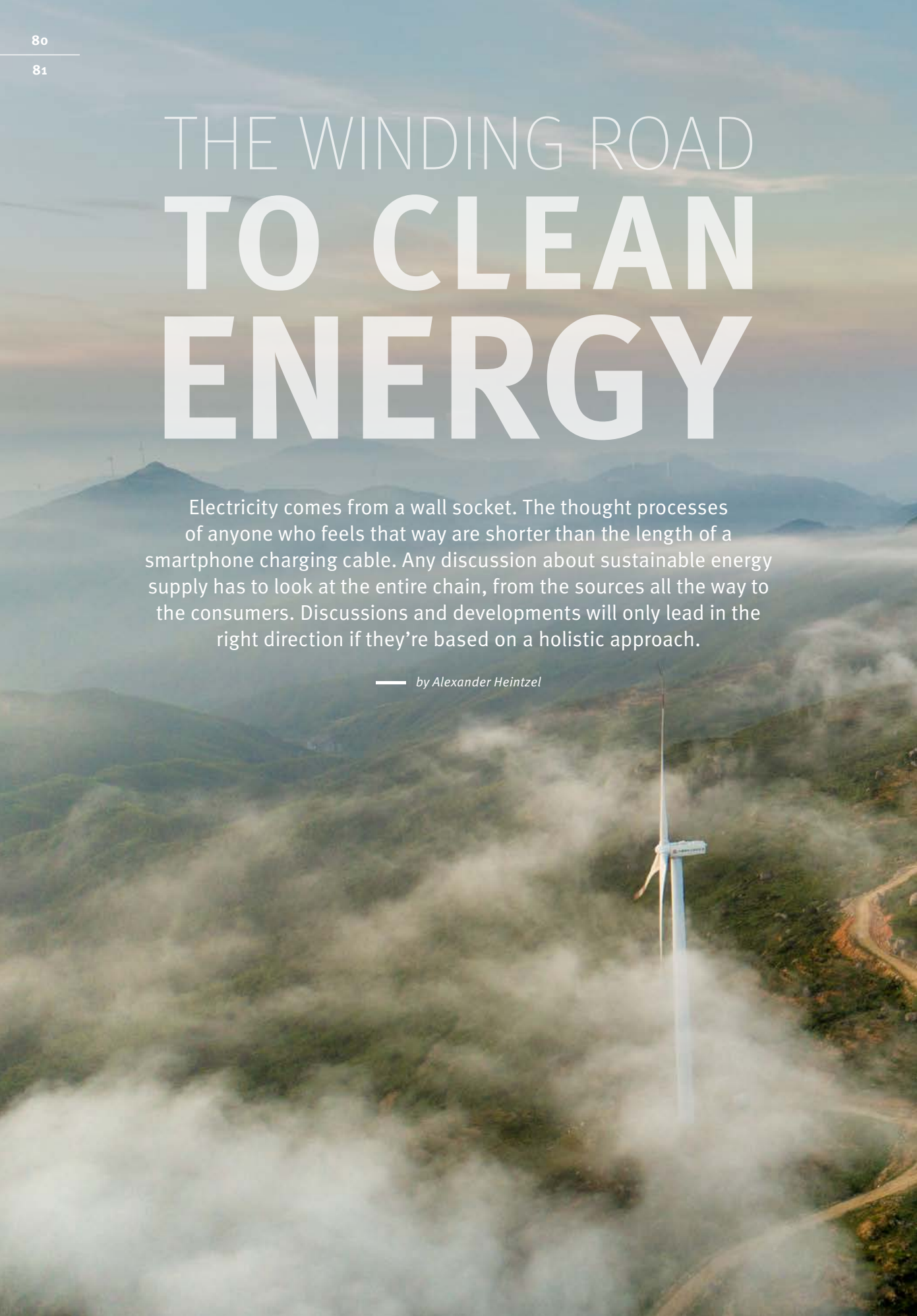
THE AUTHOR

*Sustainability journalist **Kay Dohnke** is convinced that it's already possible today to operate a building without external energy. He fully expects future construction regulations to require this – worldwide.*

THE WINDING ROAD TO CLEAN ENERGY

Electricity comes from a wall socket. The thought processes of anyone who feels that way are shorter than the length of a smartphone charging cable. Any discussion about sustainable energy supply has to look at the entire chain, from the sources all the way to the consumers. Discussions and developments will only lead in the right direction if they're based on a holistic approach.

by Alexander Heintzel



In the lines below, we'll be talking about gas and oil, about wind and sun, about generation and consumption, and about efficiency and waste. We'll be talking about the big picture relating to energy. The reason why we will, and in fact have to, talk about this is clear: the goals established in the Paris Climate Agreement must be achieved – or better yet – exceeded. In other words, the warming of the climate must be limited to a maximum of two degrees centigrade or, if possible, to 1.5 compared to the pre-industrial age. Quite a few scientists consider even this limit to be too lax, especially since it's not binding but merely a declaration of intent. So, the aims are high, but they're achievable. At least that's what a Special Report by the Intergovernmental Panel on Climate Change published in early October 2018 reveals. In the report, experts show that the rise of the average temperature can be limited to a maximum of 1.5 degrees centigrade by fast, decisive action of all the key players. This also means that we no longer have a lot of room for improvement because, at this juncture, we're already at "plus 1." This makes a combined and comprehensive global effort involving all economic and societal groups all the more important. No sector, no country, and not even a continent, alone would be able to bring about the required change because the key to success is of such massive proportions that it could only be inserted into the lock – and turned in it not just once but twice – in a joint effort. The key, according to the IPCC, is the drastic reduction of worldwide greenhouse emissions, first and foremost, CO_2. Consequently, the first turning of the key would have to be the 45-percent reduction of CO_2 emissions by 2030, compared to the level in 2010. Around 2050, in other words the second turning of the key, emissions should be at zero.

€ 50 billion

is the amount of money that **needs to be invested** just in the German **transmission network** by 2030, according to forecasts by the grid operators.

Source: Federal Ministry of Economic Affairs and Energy

Per capita energy consumption to increase just slightly

As said above, this is a more than ambitious goal, especially since there'll be more and more people – ten billion by 2050, according to forecasts – living on Earth. Plus, all of them will be striving for increasingly higher quality of life. Both of these factors tend to increase rather than decrease the demand for energy. By 2040, experts anticipate the global energy requirement to grow by 30 percent. In view of the population growth, this would imply only a minor increase of per capita consumption – that's at least some good news.

The hydropower station at Lac d'Emosson in Switzerland has a capacity of 193 MW – as much as a small coal-fired power station

Besides saving energy, for instance by means of more efficient technologies and sacrifice, we have to make our energy production more sustainable. Consequently, decarbonization of the energy and heat sector, which currently accounts for a fourth of global greenhouse gas emissions, is at the core of the energy transition process, for instance by expanding the use of CO_2-free energy sources. They include electricity generation from wind, solar and hydropower, the use of geothermal energy, as well as so-called sector coupling: electricity generated with carbon dioxide emissions is used, for instance, to produce synthetic fuels and hydrogen to power vehicles and machines.

The power grid bottleneck

Ideally, the electricity required for this is supplied by Northern Europe's huge wind farms and by photovoltaic farms in North Africa. Algeria, Libya and Egypt already rank among Europe's biggest energy suppliers. By 2050, 17 percent of the European electricity demand could be covered by green electricity from the desert, according to research by the German Aerospace Center (DLR). However, the European power grids, which are regarded as being extremely fragile even now, are the bottleneck for this type of energy transition. They have no additional capacities for handling this extra electricity. Experts estimate that Germany alone has a shortage of about 30 transmission lines to transfer wind power from the North Sea to southern Germany.

Close to collapse

The threat of large-scale grid failures, aka blackouts (see article starting on page 48), paralyzing all of Europe looms increasingly often. So far, grid operators and energy utilities have always managed to respond fast and to stabilize the grid by drawing on reserve power stations whenever grid frequency dropped below 49.5 hertz. Reserve power stations are typically gas- or coal-fired plants that, if needed, can be reactivated quickly in order to balance the grid. Countries planning to ensure their power supply near-completely from sustainable energy sources are facing a basic problem: a stable electricity supply by continuously controllable power stations is no longer available. Consequently, if CO_2 emissions in the energy supply sector are to be sustainably reduced by the utilization of solar or wind power stations, the power grids have to be concurrently enabled to handle the additional loads and storage systems for the energy from renewable sources created – across the entire European grid.

45 %

of the worldwide energy consumption is planned to be satisfied by renewable sources by 2040.

Source: World Energy Outlook 2018

Storage and lightning-fast availability of electricity is also necessary in another respect: if only 36 owners of electric cars plugged in their vehicles for recharging near-simultaneously in a local grid supplying 120 households with electricity this would result in a blackout, according to calculations made by worldwide strategy and business consultancy Oliver Wyman.

However, electric energy storage systems are a basic prerequisite not only for reasons of stabilizing the

In 2017, the installed capacity of photovoltaic systems worldwide surpassed that of nuclear power plants for the first time

> ***» Without investing billions in the European grids, there'll be regular blackouts in the next five to ten years – and expected to occur across the board from 2032 onward***
>
> Thomas Fritz,
> energy analyst at Oliver Wyman
> strategy consultants

grids. Only with their help are we able to reliably use electricity from wind and solar energy during the so-called “dark doldrums” when neither the sun shines nor the wind blows.

Energy storage systems are lacking

So, storage systems are urgently required. The problem, though, is that the storage systems existing now are far too small or in the state of pilot projects that are by no means able to help ensure electricity supply. Currently, systems with sufficient capacity are neither being built or planned in Europe although there are many possibilities for storing electricity for subsequent use: from simple pumped storage power stations to large-scale battery-like or compressed-air storage systems.

For domestic use, small storage systems with a capacity of four to twelve kWh have long become established. They’re suitable for absorbing local photovoltaic peaks and are thereby able to assist the local distribution network. However, due to the required safety and high connection costs, they’re hard to integrate as balancing reserves. Covering just the storage demand in Germany – 80.000 GWh according to expert estimates – would require about one billion home storage systems.

10 million

kilometers (6.2 million miles) is the length of the **European power grid,** which supplies 260 million households and small businesses with electricity.

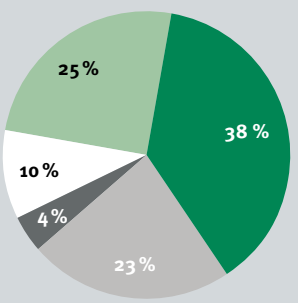
Source: Union of the Electric Industry - Eurelectric

Storage in synthetic fuels

By contrast, storing unused electricity from renewable energy sources in hydrogen or methane seems to be a viable approach. In this process, water is transformed into hydrogen by electrolysis. The energy required for this is provided by surplus green electricity. As needed, the hydrogen can either be transformed into electricity in a fuel cell, for instance to propel electric vehicles, or be transformed into methane by carbonization. Methane is superbly suited for storage and can be reconverted into electricity in gas power stations in the event of power shortages. This has the advantage of creating a closed CO_2 loop, plus the storage capacities for methane in the form of underground underground storage sites as well as the necessary gas power stations already exist.

Based on a similar principle, synthetic fuels (SynFuels) can be produced as well. They would provide CO_2-neutral fuels with low NO_x levels to satisfy mobility needs. This has the advantage of instantly making the internal combustion engines that have been used so far CO_2-neutral. SynFuels, from a technical “as well as a systemic perspective, are the perfect complement,” says Professor Christian Beidl, PhD, from TU Darmstadt, in an interview with the technical magazine “MTZ.” “Without synthetic fuels,” says Dr. David Bothe, an expert from Frontier Economics, “the mobility transition will not be successful.”

WORLDWIDE POWER GENERATION BY ENERGY SOURCES



Coal
Renewable energies
Gas
Nuclear energy
Oil

Coal is still the most important source of energy in power generation. However, renewable energy sources – including hydropower and wind power as well as photovoltaics and biomass – have been catching up fast, now ranking in second place.

Source: International Energy Agency, published in 2016

HOLISTIC KNOW-HOW

Efficient utilization of energy entails the need to take the entire energy chain into account. Just optimizing individual areas is not enough (see interview with Uwe Wagner, starting on page 66).

Sustainable use of energy is only possible if the primary energy is produced from renewable sources in an emission-free process, for instance by wind power, solar power, hydropower or geothermal energy. The technology group Schaeffler supports energy production from renewable sources with technology and know-how (see below).

In order to be able to use CO_2-free energy in system-conformant ways, technologies for storing it must be created. Like in other areas, there's more than a single approach to be pursued.

And for mobility of the future, Schaeffler has already developed components to enhance the efficiency of IC engines, technologies for the fuel cell and electric drive systems.

PRODUCTION

Schaeffler's portfolio for wind turbines extends from low-friction drive bearings to digital diagnostic tools. However, Schaeffler also offers products for hydroelectric and solar power stations

STORAGE

One of the areas in Schaeffler's development focus: power-to-liquid, i.e. the conversion of renewably generated electricity into hydrogen for fuel cells or electricity-based synthetic fuels

CONSUMPTION

Efficient components such as the E-axle were developed by Schaeffler early on and are already used on the road. In addition, the efficiency of IC engines is continuously enhanced

Plus, there's another advantage: hydrogen and SynFuels could be produced directly where the CO_2-free electricity is generated, such as in North Africa, thereby replacing at least some of the required power transmission lines.

China's example

Such a strategy is highly sensible for physical, supply-related and, not least, economic reasons. Efforts made in China and the Gulf region, where scientists are already intensively working on SynFuels and hydrogen for energy storage purposes, show the international relevance as well as the potential and necessity of a globally integrated approach.

Only if we make a deliberate effort to use all available options will electricity continue to come from a wall socket – in cleaner and more reliable ways than ever before – plus serving as a viable driver of energy and climate transition.

THE AUTHOR

***Dr. Alexander Heintzel** is editor-in-chief of the renowned technical magazines of the ATZ Group within the Springer Nature publishing house and has a long track record of dealing with topics relating to energy and power grids.*

HIDDEN CHAMPIONS OF BOTANY

In the near future, inconspicuous plants with natural superpowers might help us stop famines, the destructive overexploitation of raw materials or climate change.

by Oliver Jesgulke

Phytomining

NATURAL GOLD DIGGERS

Plants as miners clawing raw materials from the Earth: ***Phytomining is the name of this field of research that's based on the discoveries of British botanist Alan Baker and U.S. research agronomist Rufus Chaney four decades ago.*** *The Texan investment firm Viridian Environmental that had substantially supported the two scientists at the time secured the patent rights to the research results and prohibited any commercial use of them. Why? More than likely that will remain a secret forever. A few years ago, the patents expired and since then phytomining with so-called hyperaccumulator plants has literally been sprouting again.*

One of these floral miners is Alyssum murale *(pictured below). The cultivation of this member of the crucifer family on nickel-rich soil has turned into a lucrative business. The "weed" is grown on fields, harvested and dried, for instance around Lake Ohrid in Albania that's severely contaminated by heavy metals.* ***By burning the residues of the plants, 500 kilos (1,102 imperial pounds) of the ash can yield 100 kilos (220 imperial pounds) of valuable nickel*** *that's needed for rechargeable batteries and paints for example. Although the yield from deep mining is much greater, biomining is a lot more eco-friendly. Plus, the lower the concentrations in the Earth's crust the more economical is phytomining. The herbal nickel harvest starts being economically feasible at a concentration as low as 0.1 percent, whereas in conventional mining it has to be ten times as high. Another nickel digger is Pycnandra acuminata, a tree that grows on New Caledonia's main island.* ***A fourth of its sap consists of nickel.***

The "harvesting of metals" such as cobalt, tellurium, thallium and rare-earth elements includes the systematic breeding of special plant species. ***One of these experts is Phalaris arundinacea (aka reed canary grass) whose roots go down as far as 3.5 meters (11.5 feet) into the ground*** *(pictured above). It specializes in the semimetal germanium, which is required for fiber optic cables, infrared sensors, chips and solar cells. Worldwide, only a few hundred tons of it are extracted per year, primarily in China, and exported at a premium. Phytomining with Phalaris arundinacea might break up this monopoly. Although at the moment only about three milligrams (0.0001 ounces) of germanium can be extracted from one kilogram (2.2 imperial pounds) of the plant grown in European soils, specially bred strains are supposed to multiply the current yield.* ***Another advantage: Phalaris arundinacea is regarded as an energy plant with a high biomass yield*** *and even after the green stuff has ended up in biogas fermenters the mineral resources can be extracted from the fermentation residues. To increase the phytomining yield of Phalaris arundinacea, scientists from TU Bergakademie Freiberg are experimenting with substances that make it possible for the roots to better absorb germanium and rare-earth elements. Citric acid is such a substance and there's a botanical helper for this purpose, too: lupines introduce it into the soil.*

Plants can even be used for gold mining. *The noble metal can be extracted from the mustard plant, albeit in such tiny amounts that it's not profitable.*

Phytoremediation

GREEN **POISON ASPIRATORS**

Cadmium, lead, zinc, nickel, platinum or palladium – around the world, countless areas are contaminated by toxic metals from industrial and military operations or farming. In Germany alone, there are 300,000 such areas. ***Soil cleanups cost enormous amounts of money. A small, inconspicuous plant might change that in the future: Arabidopsis halleri.*** *The species is a hyperaccumulator plant and via its roots can absorb high concentrations of heavy metals that would be highly toxic to humans and animals. In this way, it protects itself against herbivores. Arabidopsis halleri thrives on the perimeters of shut-down mines, old steel mills and abandoned industrial areas. Research scientists from Ruhr-University Bochum are investigating the plant that's hardly ten centimeters (4 inches) tall because its characteristics are highly useful: Arabidopsis halleri might make soil fit for cultivation again –* ***aka phytoremediation.*** *However, this form of decontamination is a slow process that takes years. Therefore, the objective is to breed plants with large leaves that suck larger amounts of contaminants from the soil, store them and, ideally – see phytomining – make the soil usable again.*

Food

HUNGER **FIGHTERS**

The world community is facing a humongous challenge: By 2050, it has to produce nearly twice as much food as today – without additional resources. Quinoa, a pseudocereal plant from the Andes that has been cultivated for thousands of years, might be a serious alternative. ***It grows under extremely adverse conditions, needs only little water and is able to cope with barren soils,*** *which even makes it more resistant than corn. The plant contains plenty of protein and unsaturated fatty acids, as well as vitamins B and E, calcium, magnesium, iron and zinc. Even its oil content is higher than that of wheat. As a trendy food, it has already made its way into health food stores around the world.*

Energy & decontamination

MULTI-**TALENTS**

Microalgae have recently begun to be used for biofuels, bioasphalt and as bioreactors for warm water and heating of buildings. *At the same time, they're suitable for extracting radionuclides such as radioactive silver, cesium, zinc, cobalt and uranium from the Earth. In research investigations by Institut Laue-Langevin in Grenoble, microalgae were introduced into a holding basin for spent nuclear fuel. The single-celled algae reproduced and, so to speak, fed on the radioactive isotopes. The outcome of the experiment marked a breakthrough because* ***the plant cleans up the radioactive cooling water.*** *To do so, the algae absorb radioactive particles and store them, enabling them to survive an absorbed dose of 20,000 Gy. For comparison: a dose of five Gy is enough to kill a human being. The French scientists are now hoping to make use of this capacity.* ***They're planning to clean up contaminated areas such as those in Fukushima and Chernobyl*** *and make them habitable again.*

Filtration

AIR **CLEANERS**

In our own gardens or yards it's typically very unpopular and hard to get rid of. But moss can actively help protect the environment. ***Many components of exhaust emissions serve as nutrients for moss or are decomposed by bacteria living on its small leaves.*** *That's why startup company Green City Solutions came up with the idea of using moss walls against the high levels of particulate air pollution in big cities. The properties of moss are also of interest to the automotive industry: The "Oxygene" concept tire presented in 2018 contains moss on the inside. By means of its tread pattern water is absorbed from the road when it rains and circulates inside the tire. This is meant to start a photosynthesis process that releases fresh oxygen to the environment via the moss.* ***In Sono's Sion electric vehicle, moss is intended to act as an air filter for the interior.*** *The idea: due to the negative charging of the moss, positively charged particulate is filtered out of the air. Microfiber cloths, by the way, work according to a similar principle.*

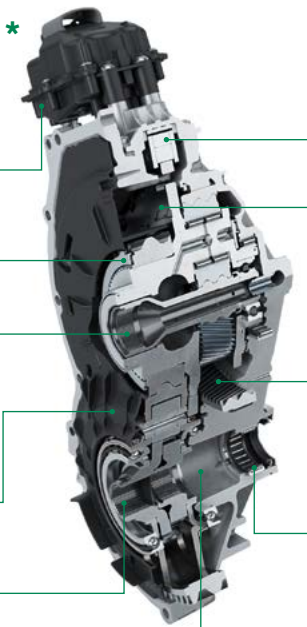
THE AUTHOR

As an urbanite, author ***Oliver Jesgulke*** *is happy about every green spot in Berlin and participates in two small urban gardening projects next-door. He used to think moss was a nuisance and quinoa a vegan hype. His research for this article has changed those views.*

MASTHEAD

Published by
Schaeffler AG
Industriestraße 1–3
D-91074 Herzogenaurach
www.schaeffler.com

Schaeffler Communications
Thorsten Möllmann (Senior Vice President Global Communications & Branding)
Martin Mai (Head of Newsroom, Global Editor-in-Chief Schaeffler Group)



*

Executive Editors
Volker Paulun, Stefan Pajung (Deputy)

Editor-in-Chief
Martin Mai

Coordination
Carina Chowanek, Jana Herbst,
Julia Schneider

Editorial Team and Production
Speedpool GmbH

Pre-press Stage
Julien Gradtke, Mathias Mayer,
Diana Schröder

Copy Editors
David Feist, Volker Hummel,
Christoph Kirchner, Martin Knopp

Printing
Hofmann Druck Nürnberg GmbH & Co. KG

Graphic Design
Manuela Mrohs (AD),
Gökhan Agkurt,
Ivo Christov,
Mariessa Rose,
Julian Schmaljohann,
Thomas Wildelau

Authors
Wiebke Brauer, Björn Carstens, Denis Dilba,
Kay Dohnke, Dr. Ulrich Eberl, Dr. Alexander Heintzel,
Oliver Jesgulke, Wolfgang Karg, Roland Löwisch,
Jan Martin Ogiermann, Carsten Paulun,
Dr. Lorenz Steinke, Leopold Wieland

English Translation
Helga Oberländer

Photo/Illustration Credits
Front page: Hiroshi Watanabe/Getty; p. 3: Schaeffler; pp. 4/5: Gruppe C Photography, Schaeffler, HTC Vive Arts and Emissive, Hadel Productions/Getty; pp. 6/7: Gruppe C Photography; p. 8: Shot by Scott/Getty; p. 9: Schaeffler, Gökhan Agkurt; p. 10: Oktay Ortakcioglu/Getty, pxhere.com; p. 11: Christianto Soning/Getty, GrandinMedia.ca; pp. 12/13: Max Etzold; pp. 14/15: Jürgen Eich, Schaeffler, Max Etzold; pp. 16/17: Max Etzold, C. Boehm, Audi, Fotoatelier Christiane (2); pp. 18–21: Sciepro/Getty (2), Karduelis/Wikipedia, private; pp. 22/23: Schaeffler; p. 24: Yorkfoto/Getty; pp. 25–27: Rainer Weisflog/Imago (2), Manuela Mrohs, Universität Duisburg-Essen, private; S .28/29: Duesenfeld GmbH; pp. 30/31: Vinzo/Getty, Veolia Deutschland, Roth International; pp. 32/33: Bertrand Langlois/Getty (3), private; pp. 34/35: Ruslan Gilmanshin/AdobeStock, Monsitj/Adobe Stock; pp. 36/37: Mongkolchon/Adobe Stock, Monsitj/Adobe Stock, Paper Boat Creative/Getty, private; pp. 38–41: Rusm/Getty, Manuela Mrohs, private; pp. 42/43: HTC Vive Arts and Emissive; pp. 44–47: Alashi/Getty (3), Ertz/Siemens; pp. 48/49: Carlos Casillas/Getty; p. 50: Lukas Ilgner; p. 51: Ramzi Rizk/Getty, private; pp. 52/53: Martin Barraud/Getty, Schaeffler; pp. 54–57: Thomas Wildelau, Ivo Christov; pp. 58–63: Hoch Zwei/Audi (14), Schaeffler, Asja Caspari; pp. 64/65: Hadel Productions/Getty, Lushik/Getty; pp. 66–71: Schaeffler (7), Andrzej Wojcicki/Getty; pp. 72–75: Getty (3), private; p. 76: Miguel Navarro/Getty; p. 77: Logic Swiss, Züblin; p. 79: Schaeffler, private; pp. 80/81: Zhongguo/Getty; pp. 82–85: Getty (4), Schaeffler (2), Uli Regenscheit/ATZ; p. 86: Manuela Mrohs; p. 87: Rasbak/Wikipedia, private; p. 88: Hermann Schachner/Wikipedia, Shanti Hesse/Adobe Stock; p. 89: Chokniti/Adobe Stock, Creativmarc/Adobe Stock, private; p. 90: Schaeffler

** This electric transmission in an arrangement parallel to the axis accelerates the front axle of the Audi e-tron. It is designed for input torque of 400 Nm and can be combined with an optional parking lock.*

tomorrow All previous issues

01/2015
Mobility for tomorrow

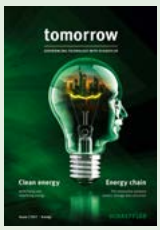
02/2015
Productivity

03/2015
On the move

01/2016
Innovation

02/2016
Sustainability

03/2016
Digitalization



01/2017
Energy

02/2017
Motion

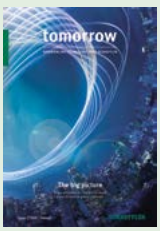
03/2017
Machines

01/2018
Transformation

02/2018
Urbanization

03/2018
Acceleration

01/2019
Challenges



02/2019
Holism

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"

Shortlist
"External Publications"

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

Gold Winner
"General Website, Categories-Magazine"

Silver
Writing: Magazines Overall

WEB WORLDS
Learn more about the megatrends that are changing the world at ***schaeffler.com***