tomorrow

EXPERIENCING TECHNOLOGY WITH SCHAEFFLER

Sustainable living

How technologies assist in using resources efficiently

Sustainable mobility

Innovations for conventional and alternative drive concepts

Issue 2 · 2016

SCHAEFFLER

Sus|tain|abil|i|ty - [səsteɪnə'bɪlɪtɪ]

a) In ecology, sustainability is the capacity to endure; it is how biological systems remain diverse and productive indefinitely. Long-lived and healthy wetlands and forests are examples of sustainable biological systems. In more general terms, sustainability is the endurance of systems and processes. The organizing principle for sustainability is sustainable development, which includes the four interconnected domains: ecology, economics, politics and culture.

b) Sustainability can also be defined as a socio-ecological process characterized by the pursuit of a common ideal. An ideal is by definition unattainable in a given time/space but endlessly approachable and it is this endless pursuit what builds in sustainability in the process (ibid). Healthy ecosystems and environments are necessary to the survival of humans and other organisms. Ways of reducing negative human impact are environmentally-friendly chemical engineering, environmental resources management and environmental protection. Information is gained from green chemistry, earth science, environmental science and conservation biology.

c) Moving towards sustainability is also a social challenge that entails international and national law, urban planning and transport, local and individual lifestyles and ethical consumerism. Ways of living more sustainably can take many forms from reorganizing living conditions (e.g., ecovillages, eco-municipalities and sustainable cities), reappraising economic sectors (permaculture, green building, sustainable agriculture), or work practices (sustainable architecture), using science to develop new technologies (green technologies, renewable energy and sustainable fission and fusion power), or designing systems in a flexible and reversible manner, and adjusting individual lifestyles that conserve natural resources.

Source: Wikipedia

DEAR **READER,**

I recently came across a quote by Albert Camus that perfectly fits 'sustainability,' our focal topic in this issue of our technology magazine 'tomorrow.' It says: "Real generosity towards the future lies in giving all to the present." In other words, by acting with determination today we can decisively influence what the world of tomorrow will look like.

It's not always easy to put words into action when it comes to sustainability, whether it's on a large or a small scale. Honestly, on a rainy Sunday morning, wouldn't you be more likely to reach for your car keys than jump on your bicycle to get your breakfast rolls from the local bakery? This simple example illustrates the point that always giving our all in the spirit of Albert Camus' words is no mean feat.

But even though it requires a strong commitment, we mustn't tire in our efforts of giving our all for a livable future. The Schaeffler Group has clearly defined its position: Sustainability means helping new technologies make their breakthrough – especially those that contribute to a cost-effective, reliable and eco-conscious energy footprint and assist our customers in meeting their growing challenges such as reducing CO_2 emissions or countering increasing fuel costs. Schaeffler anticipates the requirements this entails by developing new product technologies for 'mobility for tomorrow' and extensively investing in research and development.

Four mega trends play a decisive part in this context. With respect to the environment it's climate change, in the economic context it's globalization, in the realm of society it's increasing urbanization and in technology it's digitization. In all four areas, Schaeffler is looking for and finding solutions to help shape 'mobility for tomorrow.'

We're shedding some light on what sustainability means in terms of personal mobility by taking a close look at Europe, the United States and China, starting on page 16. Let's keep our international focus. On page 30, we'll begin to take you on a tour of the eight 'European Green Capitals.' Every one of them is unique and has its very own ideas of how to sustainably combine quality of life, industry and the challenges of transportation especially in the city centers.

Starting on page 72, employees from our locations around the globe will talk about how sustainability is specifically being realized in our company based on examples from their day-to-day work – be it in production, purchasing, logistics or marketing: a report with many exciting aspects.

At this juncture, it's becoming increasingly clear that with respect to 'mobility for tomorrow' there's no way around growing electrification. With its commitment in Formula E, the world's first fully electric racing series, the Schaeffler Group is successfully driving the developments for 'mobility for tomorrow' forward as well – as race driver and technology enthusiast Lucas di Grassi reports in an interview starting on page 88.

I wish you an enjoyable read and interesting insight into the world of sustainability.

Klaus Rosenfeld
Chief Executive Officer

global

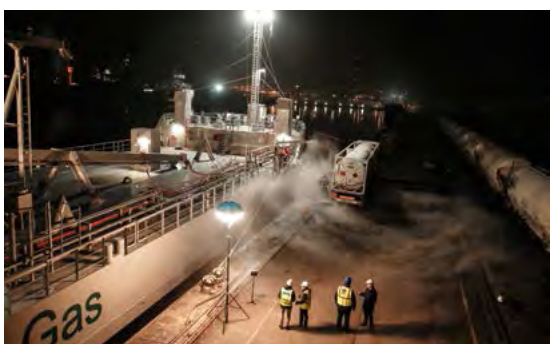
A glimpse of the world

in motion

Innovations in the course of time

here and now

Living with progress



outlook

Technology for tomorrow

CLEAR AND **CLEAN**

Has a UFO just landed in a Paris pedestrian zone? No. The unusual object at the bottom right of the picture is called Watly and actually doesn't belong in perfectly developed urban areas. Watly has been created in order to supply regions with poor, destroyed or non-existing infrastructure with clean water, electricity and means of communication. Watly makes all this available thanks to solar power, is completely self-sufficient and has a neutral energy footprint. In a steam compression distillation process, water – up to three million liters per year – is purified or desalinized using solar energy. The electricity from the sunbeams makes it possible to connect the device directly to households even if there's no power grid in the vicinity. In addition, the system opens up many avenues of digital communication. Health, education, nutrition – Watly addresses many issues in remote and poverty-stricken regions. So, let's hope that many of these UFOs will land there.

» A single sunbeam is enough to drive away many shadows St. Francis of Assisi

global

A glimpse of the world

GLOBAL WATER CONSUMPTION

- *Irrigation*
- *Domestic use*
- *Animal husbandry*
- *Manufacturing*
- *Electricity*

BRIICS (Brazil, Russia, India, Indonesia, China, South Africa), OECD (Organisation for Economic Co-operation and Development), ROW (Rest of World). The statistics only consider the consumption of 'blue water' but not the quantity of rain for agriculture.

Source: OECD

NATURE'S **FORCES**

What a wonderful world this would be: no soot particles, no CO_2 or NO_x emissions, no smog. 'Renewable energies' are one key to clean air. Energy that Mother Earth gives us every day. We just have to put her gifts to good use. In many places, that's already happening – with technologies and civil engineering projects that are impressive but not always beyond dispute. Superlative examples from the field of renewable energies.

by Carsten Paulun

THE LONGEST HYDROELECTRIC DAM

Before the 7,760 meter long Itaipú Dam on the Paraná River located on the border between Paraguay and Brazil was built *40,000 people, most of them Guarani Indians, had to be resettled. Afterward, more than 34,000 workers poured 12.57 million cubic meters of concrete and carved this mammoth project out of the jungle's soil. 145 people lost their lives in accidents during the construction period (1972–1982). The last turbine was commissioned only in 2005. Costs amounted to 3.6 billion U.S. dollars, which caused Brazil's foreign debt to rise dramatically. However, following their commissioning, the 18 (subsequently 20) turbines have been generating over 25 percent of the electricity required in Brazil.*

THE MOST EXPENSIVE CONSTRUCTION PROJECT

The man-made lake created by the Three Gorges Dam on the Chinese Yangtze River is more than 600 kilometers long. *The huge water barrier was erected by 18,000 workers between 1993 and 2006. Although with a length of 2,335 meters it is clearly shorter than the Itaipú Dam (see box at left), its construction cost about 75 billion U.S. dollars due to technical difficulties. Thus, the Three Gorges Dam is the world's most expensive construction project. 26.71 million cubic meters of concrete were used. Its 32 turbines combined have a rated power output equating to 15 modern nuclear reactors: 22.5 gigawatts (Itaipú: 14.5 GW). Still, the highest ever annual amount of electricity (2014) of 98,800 gigawatt hours (GWh) produced only surpassed Itaipú's top output in 2008 by 200 GWh. One of the dam's problems: due to the lack of sanitary landfills in the area of the river's headwaters, people simply dump their trash into the Yangtze, which clogs the dam's inlets and damages the turbine systems.*

INTERESTING FACTS ABOUT ENERGY

Facts and figures help provide orientation in the field of energy production and energy use.

— *The amount of energy consumed per unit of time is called 'power.' It is measured in watts (W).*

— *1,000 W are 1 kilowatt (kW)*
1,000 kW are 1 megawatt (MW)
1,000 MW are 1 gigawatt (GW)
1,000 GW are 1 terawatt (TW)

— *If a blow-drier for instance runs with power of 1,000 watt (i.e. 1 kW) for one hour it consumes one kilowatt hour (kWh) of energy.*

— *3,000 kWh of electricity are consumed per person per year on average, according to the International Energy Agency (IEA, as of 2012).*

— *The worldwide total per capita energy requirement is 7 times as high: approx. 22,000 kWh. In Europe, the average is twice as high.*

— *The total worldwide energy requirement for households, industry and transportation is 153,000 TWh (BP Statistical Review of World Energy 2016). This equates to the energy production of about 1,550 Three Gorges Dams (see above) with a dam wall length that would nearly extend from New York to Los Angeles.*

— *Merely half a billionth of the total solar radiation energy reaches the Earth's surface. Still, this fraction would suffice to cover the world's energy consumption 2,850 times (wind energy: 200 times, biomass: 20 times: geothermal energy: 5 times, ocean current: 2 times; hydropower: 1 time), according to the Renewable Energy Research Association (FVEE).*

THE OLDEST SOLAR COLLECTOR

It just keeps on running. The oldest solar collector system *that's still functional is located on the roof of the Energy Laboratory of Oldenburg University. Originally, a maximum useful life of 25 years had been assumed for solar panels. The cells in Oldenburg have been in operation since 1976 and were installed at the time for research into how the electricity they generate can be used, how the various semiconductor materials age and how weather influences the 336 installed modules. The rated power of the individual modules at the time of their initial installation in 1976 was 10.3 W. 35 years later, 9.9 W were still measured! Today, the entire system still delivers 3.4 kW – enough to operate two vacuum cleaners. The level of efficiency during this period dropped only from 8.55 percent to 8.2 percent. And the system is still busy producing electricity, totaling about 146,000 kWh since 1976!*

THE MOST POWERFUL PUMPED-STORAGE POWER PLANT

The idea is simple but really clever. *Using surplus electricity – for instance at night or on weekends – water is pumped from a lower to a higher elevation and stored in a lake. During the day, when electricity is needed again, this water is simply released to power generators. The result is a huge accumulator with efficiency between 75 and 80 percent. The largest one was commissioned in the U.S. state of Virginia in 1985. The Bath County Pumped Storage Station cost 1.6 billion dollars and initially delivered 2.77 GW. In 2004, power was increased to 3 GW. Each of the six pumps is as powerful as 3,000 VW Golf GTI cars and pumps 800,000 liters of water per second from the lower reservoir into the second one, located 384 meters higher. However, pumped-storage power plants only serve to reduce emissions if the electricity required for the pumps is produced either by nuclear reactors or renewable sources. Most of these reservoirs, though, are still being used for load balancing of coal- or gas-fired power plants.*

THE REMOTEST SOLAR CELL

Probes travel through outer space for years or often decades. *Their energy management is vital to ensuring permanent electricity supply to the scientific equipment, radio communications and the control computers. In the case of missions close to the Sun, solar cells are used for this purpose. Should the probes advance into interstellar space, such as 'Jupiter 1' and 'Jupiter 2,' or explore the planets farther away from the Sun in our solar system, radionuclide batteries have almost exclusively been used so far because solar cell collectors progressively lose efficiency as the distance from the Sun increases. 'Rosetta' (launched in 2004), which orbits the comet 67P behind Jupiter and is scheduled to land there in September 2016, is currently the probe with solar cells operating at the greatest distance from Earth: 600 million kilometers. At a distance of about 750 million kilometers from the Sun, the solar panels still deliver 395 watts.*

THE LARGEST OFFSHORE WIND FARM

People on the coast like to call the wind blowing around their ears a 'stiff breeze.' *This stiff breeze contains plenty of power that can effectively be used to solve our energy problems. Wind turbines are used to 'harvest' the stiff breeze. However, the towers of those in the North Sea are clearly higher than those of their onshore 'sisters.' When several of these giants are packed together, they're called a wind farm or, if at sea, an offshore wind farm. The world's largest one is located in the North Sea in front of the Thames Estuary. The 'London Array' is made up of 175 wind turbines, each 147 meters high. Combined, they delivered about 2,500 GWh of electricity in 2015 – reducing CO_2 emissions by 925,000 metric tons in the process. But even larger arrays are being planned, such as on Dogger Bank 165 kilometers off the east coast of England. This wind farm is to supply 1.8 million households with electricity. By 2020, capacity is planned to be extended from 4.8 to 9 GW.*

THE DEEPEST ENERGY SOURCE

Not only the Sun is a huge energy supplier. *We're also sitting on one right here. The Earth's core is 6,000 degrees centigrade hot and just a few hundred meters under the Earth's surface it is still 300 degrees. Sometimes the Earth's protective crust shrinks to just a few meters, such as in Iceland. The volcanic island in the North Atlantic covers 60 percent of its primary energy requirement with heat from the depth of our planet, even heating streets in Reykjavík and Akureyri with it. Theoretically, the energy reservoir in the upper 3,000 meters of Earth's crust suffices to supply mankind with the required energy for a period of 100,000 years. We just need to manage to tap it. So-called geothermal power plants do just that. They use geothermal energy to produce electricity by means of steam. The first such plant was commissioned in Larderello, Tuscany, in 1904 (top picture). Its output was just enough to supply electricity for five light bulbs. Today's power plant at the same site delivers 0.769 GW and is the third-largest of its kind in the world. 'The Geysers' with 1.8 GW in the United States is the largest one.*

THE LARGEST SOLAR POWER STATION

The Noor solar power station in Morocco is planned to become the world's largest one, *targeting power of 0.58 gigawatts – enough electricity for 1.3 million people. Phase 1 on the edge of the Sahara Desert opened in February 2016 and delivers 0.16 GW, which initially suffices to supply 350,000 people with electricity. As a result of the station, even at this point, CO_2 emissions are cut by 240,000 metric tons, equating to the emissions of 50,000 automobiles per year. In four phases, it is planned to cover an area of 30 square kilometers with movable parabolic mirrors collecting the sunlight. For comparison: Europe's largest solar plant is in France, covering an area of 2.5 square kilometers. The Noor convectors heat a special type of oil that causes water to evaporate in a power station to drive a turbine. The planned total costs amount to about 2.2 billion euros.*

THE LARGEST BIOMASS POWER PLANT

The idea is ingenious: *simply extracting energy-containing substances from nature that would have released CO_2 in the natural decomposition process anyway in order to generate electricity and/or heat from them. Materials that are suitable for this purpose include all types of wood, cereals, straw, reed, textile fibers, sewage sludge, bamboo and waste paper. However, the efficiency of biomass power plants that exclusively produce electricity is a maximum of 40 percent. The rest of the bioenergy is lost as heat. Efficiency increases to near-90 percent when this heat is used for district heating for example. Biomass power plants have been in existence in Germany since 1994. The world's largest one, which uses 100 percent biomass, is in Polaniec, Poland. For 290 million euros one of the eight existing generator systems was converted for biomass operation in 2012. It has a rated power of 0.2 GW.*

THE LARGEST WAVE POWER PLANT

They make buoys dance, push air through tight shafts, move artificial snakes on or huge hinges in water *– waves on the world's oceans are as inexhaustible as geothermal energy. In Mutriku in the north of Spain, the world's first commercial wave power plant was launched in 2011. 16 turbines, driven by air compressed by wave power, generate electricity. Output, however, is still low. The 300 kW are just enough to supply 250 households. If the construction costs of 2.3 million euros had been invested in a photovoltaic station, clearly more households could have been supplied with electricity. Still, wave power plants are being built all over the world at the moment. The largest one is currently being completed in Australia. Operating with 45 buoys, it is planned to produce 19,000 KW of electricity for 10,000 households. Costs: about 57 million euros.* *(More on hydropower on page 68)*

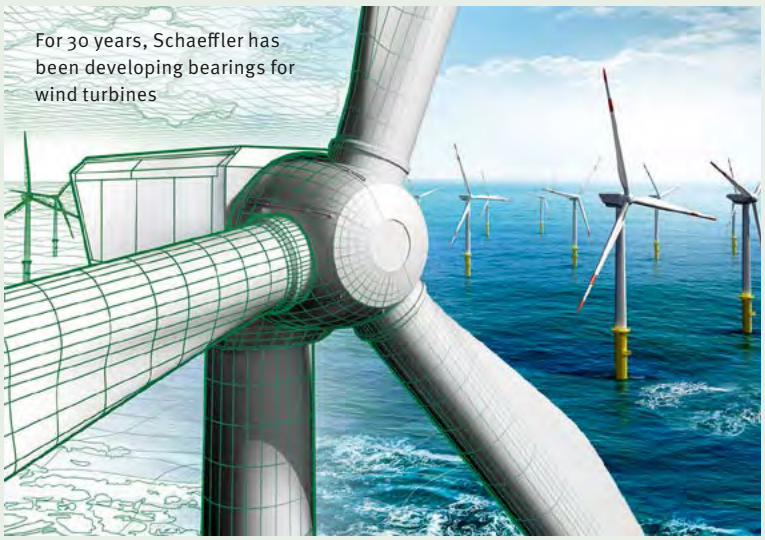
THE MOST UNUSUAL WIND TURBINE

Now if that's not a spectacular neighborhood: *Three wind turbines are suspended between the two 240 meter high skyscrapers of the Bahrain World Trade Center (construction costs: 150 million dollars). As the turbines are not sitting in movable nacelles as usual and can assume an optimum position vis-á-vis the wind, the two skyscrapers are oriented in a specific way. At the front, they're 126 meters apart and in the back only 33 meters. This arrangement acts like a funnel and thus optimally directs the wind toward the rotors, each measuring 29 meters in height. The maximum speed of the rotors is 38 revolutions per minute. In a storm – the system is designed for wind speeds of up to 250 km/h, which equates to the highest category of 5 on the hurricane wind scale – the rotor tips can be turned so that they offer minimal resistance to the wind. Combined, the rotation of the three wind turbines generates 1.3 GWh of electricity per year which corresponds to about 15 percent of the total energy requirement of the Bahrain World Trade Center that was completed in 2008.*

THE WEIRDEST WAY OF GENERATING ELECTRICITY

"Hey, let's dance and create a little current!" *A flexible electromechanical dance floor generates electricity with every moment. A number of discotheques are already using this technology. The dance floor is divided into several floor panels that can be pushed down by the dancers' movements. Piezo crystals in the floor deform under pressure, creating electric charges in the process. These mini charges can be made usable by a generator. A single dancer can generate up to 20 watts this way. As a result, the movements of the party guests can suffice to operate the facility's entire lighting system. Research is also targeting streets that generate electricity when cars drive over them. But – unlike the electricity-generating dance floor – mass production for use in transportation is still strictly a vision for the future.*

USING **NATURE'S FORCES**



For 30 years, Schaeffler has been developing bearings for wind turbines

Bearing solutions from Schaeffler are used in many systems for generating renewable energies. These are a few examples.

Together with two other dams, the two reservoir dams, Macagua and Caruachi, in the northeast of Venezuela form one of the world's largest hydropower complexes. In roll-up gates of the Macagua Dam, chrome-plated pendulum roller bearings from the Schaeffler product portfolio are used. The chrome plating improves running properties and reduces the risk of corrosion. Due to the 40 INA plain bearings, the nine segment gates of the Caruachi Dam can be opened and closed. The water pressure the technology has to withstand is enormous.*

The horizontally movable gates of the Philipps Dam in the Netherlands weigh 400 metric tons. They can be opened and closed by means of FAG pendulum roller bearings.*

In several reservoir dams along the Waitaki River in New Zealand, INA plain bearings are used. They have maximum load ratings. This is particularly important in New Zealand due to the frequent earthquakes which result in a short-term increase of the loads – breaking of the bearings would have catastrophic consequences.

The closed radial gate of the Shui Bu Ya dam project in China has to withstand a water pressure of 150 meters of water. This results in a load of 5,000 metric tons for each of the two bearing locations. The massive steel construction is supported by two axially aligned shafts, each having an ELGES spherical bearing with a bore diameter of 1 m and 2 FAG pendulum roller bearings with a bearing bore of 0.85 m.

More info:

The Andasol solar power station in Spain is a good example of Schaeffler technology applications in the solar sector. Using plain bearings, the 150 meter long collector strands there are guided with an accuracy of tenths of a millimeter to follow the daily east-west path of the Sun. Schaeffler services for Andasol are completed by 7,488 environmentally friendly strips from the range of metal-polymer composite plain bearings. In the supports between the individual collector segments, they ensure low-friction tilting when the segments are guided to follow the sun.

More info:

For the drive trains of wind turbines, Schaeffler offers practically unrivaled know-how. For over 30 years, under its INA and FAG brands, the corporation has been developing and producing bearings for wind turbine systems. For realistic testing of rotor bearings, Schaeffler uses 'Astraios,' the world's largest and most powerful test rig for large bearings.

More info:

For the increasingly important current and wave energy, Schaeffler offers special solutions as well – for instance for turbines, floats, buoys or oscillating airfoils.

In solar or hydropower stations, Schaeffler bearings are exposed to forces that may amount to thousands of metric tons

* INA and FAG are product brands of Schaeffler

MISSION: FEWER EMISSIONS

What does sustainability actually mean in the context of personal mobility? At first glance, the responses around the world look different. It's also clear, though, that some car manufacturers' average fleet consumption in North America, China and Europe has to be reduced by four to five percent per year. Without major technology leaps with internal combustion engines and more extensive use of electric and electrified drives the potential has been exhausted. But sustainability goes beyond the automobile: the energy infrastructure issue might be the crucial one for the powertrain technology of the future.

by Dr. Joachim Becker

CHINA

DIRTY ELECTRIC MOBILITY BOOM

As the saying goes, necessity is the mother of invention. Accordingly, expectations pinned on China are high. There's no other country in the world in which as many cars are currently sold as in the one that's emerging as a superpower. At the same time, the growing number of vehicles aggravates the problem of air pollution. Only a minority among China's big cities complies with the government's clean air standards. Conurbations such as Beijing and Shanghai – both with populations above 20 million – are among the front runners in terms of worldwide smog. Last winter, the highest warning level was in effect in Beijing for several days. It was the worst case of smog in the Chinese capital's history. Restrictions were also imposed on automobile traffic although the government in recent years has been pulling millions of old polluters off the streets.

Growing wealth whets the appetite for state-of-the-art technology. China's no different from the rest of the world in that respect. Luxury four-wheel-drive vehicles are particularly popular as roads away from the big cities soon morph into pothole tracks. But city governments issue only a few thousand license plates for such gas guzzlers per month. On average, Beijing citizens have to wait six years for a new vehicle registration – the chance of getting your hands on one of the coveted licenses is below five percent. By the way, obtaining a license plate in a neighboring city is futile as many of the urban freeways are blocked to cars from other cities. An electric vehicle is the only chance to get a quick registration.

Discrepancies with e-car registrations

Because the air for breathing is becoming scarce China's government has adopted a policy of promoting 'New Energy Vehicles' (NEVs). Electric and plug-in-hybrid vehicles are exempt from the license plate lottery and can be directly registered. Even those Chinese that love big cars accept this argument. In 2015, 177,000 electric and plug-in hybrids were sold in China, according to the consulting firm PwC – as a result, the emerging world power has surpassed the United States as the number one market in this segment. The Chinese Automotive Industry Association CAAM even states sales figures for electric vehicles that are twice as high. But experts are warning of large-scale subsidy fraud. The 'Economic Observer,' one of China's most respected business magazines, reported cases in which electric vehicle manufacturers would sell the same vehicle several times.

Energy from coal-fired power plants

Electric vehicles fit neither with Chinese lifestyles in the city nor in rural regions because the charging infrastructure has only been sparsely developed. Still, the government plans to put five million electric vehicles on the road by 2020. Whether this target will be achieved is completely uncertain because now so-called real-time monitoring is being introduced first. By means of real-time vehicle data transmission, owners of plug-in-hybrids have to prove that they're actually driving in electric mode and regularly charging their vehicles at their sockets at home. "Most owners would simply pocket the cash incentive and then go on to use the internal combustion engine," says Jochen Siebert from JSC Automotive Consulting who watches the Chinese market from his office in Shanghai.

In Shanghai alone, some 5,000 of the 43,000 plug-in-hybrids in all of China were registered in 2015. Since the new policy has come into effect, new registrations of these vehicles have been trending toward zero. That's no wonder because hardly any Chinese can find a charging station near the block they live in. The fact that the electricity for the vehicles is being produced all but sustainably has not sparked a lot of interest so far. Two thirds of the energy consumed in this huge country is supplied by about 2,500 coal-fired power plants. More than 1,000 new ones are currently under construction or in the planning stage. This energy is frequently produced close to the major conurbations, which significantly contributes to their fine dust pollution.

E-cars only locally with zero emissions

At least, fully electric vehicles produce zero emissions locally – albeit not in a particularly climate-friendly way thanks to the energy mix that emphasizes the use of coal. In a well-to-wheel analysis, an electric vehicle emits about 190 grams of CO_2 per kilometer. This equates to an average consumption of eight liters per

A common site: Smog clouds major Chinese cities, such as Shanghai in this case. However, it's questionable whether electric vehicles with merely local zero emissions are a viable antidote

NITROGEN OXIDES NO_x

The chemical compound *of nitrogen and oxygen is produced in the combustion of fossil fuels. Nitrogen oxides irritate and are harmful to the respiratory system. In addition, they're partially responsible for the formation of ozone close to the ground ('summer smog') and acid rain. When nitrogen oxides enter the atmosphere they start nibbling on the ozone layer which filters the UV B content of solar radiation that causes skin cancer. Conversely, nitrogen oxides prevent sunbeams from being reflected by the Earth. This may result in global warming. Experts, however, do not agree on whether sufficient proof is available to support this theory. Nitrogen oxides can be primarily prevented by clean combustion and reduced energy consumption.*

EU limits (Euro 6) for NO_x
Diesel passenger cars *0.08 g/km*
Gasoline passenger cars *0.06 g/km*

100 kilometers. So, the battery-powered cars are not in the least more environmentally friendly than mid-size passenger cars with gasoline engines. Efficient diesel engines are no alternative in China. Currently, the country only represents one percent of the worldwide diesel passenger car market. Due to limited refinery capacities, this fuel is reserved almost exclusively for trucks.

This spring, China's parliament approved a new five-year plan. In it, Beijing outlines the country's future. And for the first time, the government clearly articulates all the things that are going wrong. By the end of 2020, the country plans to modernize coal-fired power plants and develop renewable energies further. Electricity and natural gas are to replace coal as soon as possible. The energy efficiency of new vehicles is to be increased, millions of dirty cars are to be banned from the streets and the purchase of electric vehicles is to be promoted. Starting in 2020, cars may only consume five liters of gasoline per 100 kilometers. In Beijing, this limit will already take effect in 2018, equating to a CO_2 limit of a little less than 120 grams per kilometer. Without increased electrification and hybridization of the powertrain the future requirements cannot be met.

GERMANY/ EUROPE

DIESEL QUO VADIS?

Smog is not only a Chinese problem. In many European metropolises, it transforms the sky into a grayish brown as well. After the Eiffel Tower disappeared once more in a sauce of smog in spring of 2015, the Mayor of Paris, Anne Hidalgo, had enough of this. Temporary access restrictions for dirty diesels might be followed in the metropolis on the Seine River by a general diesel ban in 2020. London, as well, is planning to deter stinking diesels built before 2006 by doubling the city toll in the near future while Stuttgart has plans for introducing the fifth level of its environmental zone that would make it off limits to older diesels. From 2019 on, access might only be permissible with a blue decal for Euro 6 vehicles. This would affect half a million diesel vehicles in the region's five counties and in the city of Stuttgart.

No way around alternative powertrains

Everyone wants to get away from oil. The climate summit held in Paris at the end of 2015 could be summarized as simply as that. Road transportation accounts for about one fifth of CO_2 emissions in Europe. Thus, it trails energy production in second place in the ranking of man-made sources of greenhouse gas emissions. Anyone intent on at least limiting global warming and air pollution will not get around alternative powertrains. Especially since 32 percent of the electricity consumed in Germany already came from renewable energy sources last year. By 2025, Germany plans to produce 40 to 45 percent of its electricity from renewable sources. The target for 2050 is 80 percent. But electric vehicle sales are sluggish and the targeted one million of them on German roads by 2020 are a long way away.

In May, the German federal government decided to provide purchasing incentives of up to 4,000 euros for electric vehicles. In addition, they'll be exempt from road tax for ten years. Development of a country-wide charging infrastructure will be subsidized by the government with a total of 100 million euros. But the question remains as to when the climate-friendly powertrains will prove viable in the automotive mass market even without such help. Another issue is no less critical: In the light of the fluctuating nature of alternative energy supply, who is going to buy the electricity at times of surplus? There is no public discussion about this. Instead, Germany is engaged in an ongoing debate about the diesel's falling into sin.

Fine dust from tires and brakes

Would our planet be a better place without diesel? Let's briefly remember: Shortly before the turn of the millennium, they were subject to massive criticism as well. At that time, Peugeot was the first automaker to use particulate filters in production cars – at least in Germany. In 2007, the German federal government made the filter a statutory requirement for new diesel cars. Fears that large numbers of diesel passenger cars would break down due to clogged filters were unfounded. Thanks to the particulate filter, now only one percent of the soot particles are caused by diesel passenger cars

HYDROCARBONS HC

Diesel and gasoline fuels *largely consist of a mixture of hydrocarbons. They're released if combustion is incomplete. Some of them are carcinogenic, produce an unpleasant odor when emitted and contribute to smog formation. The HC emissions of gasoline engines are four times as high as those of diesel units. HC emissions are reduced by near-perfect combustion and emission control technologies in catalytic converters and particulate filters. Major HC emitters are the waste disposal and energy sectors, and agriculture (methane/CH_4 etc.).*

EU limits (Euro 6) for HC
Diesel pass. cars *0.17 g/km incl. NO_x*
Gasoline pass. cars *0.1 g/km*

FINE DUST

Fine dust *can enter the bloodstream via the lungs and cause various diseases. The main sources of fine dust are:*

- *Rock erosion (mainly due to water and wind)*
- *Microorganisms, e.g. fungal spores*
- *Pollen*
- *Volcanic eruptions (estimated to amount to 85 million metric tons of ash and dust per year with particle sizes as small as 5 µm)*
- *Wildfires*
- *Agriculture (10 % of European fine dust emissions)*
- *Domestic sources (primarily wood-fired heaters and fireplaces)*
- *Combustion power plants and engines*

EU limit (Euro 6) for fine dust
Diesel and gasoline passenger cars
0.0045 g/km

in Germany. Abrasion from tires and brake pads contributes three times as much to air pollution by fine dust. However, in places (like Paris) where a large number of older diesels are in the streets the new emission control technologies are not effective yet.

This particularly applies to the nitrogen oxide (NO_x) emissions which are primarily caused by diesels. On the test rig, the NO_x emissions of new diesel cars, thanks to Euro 6, are 84 percent lower than they were 15 years ago. The only problem is that city centers continue to be troubled by dirty air. Measurements performed by the German Federal Motor Transport Authority (KBA) recently revealed that in the field many of the 50 vehicle models tested significantly exceeded the statutory standardized nitrogen oxide levels. Outside the test laboratory, even new engines in some cases emit 20 times the legally permissible levels. The KBA results suggest that with many diesel models optimum emission control works only in a narrowly defined temperature window. So, in normal road traffic, the emissions of many diesels are still on the same level they were on at the turn of the millennium.

Diesels need a chemical factory in the exhaust system

In the future, a new emissions test is to prevent optimum emission control from working only in a narrowly defined temperature window. Starting next fall, the so-called Real Driving Emissions (RDE) will replace the roller dynamometer test by on-board measurements in real-world traffic. To satisfy the higher requirements, diesel engines need a precisely controlled chemical factory in the exhaust system because emission control

Due to diesel fuel's high efficiency, the diesel engine remains the one of choice particularly for drivers clocking up high mileage

SOOT PARTICLES

SOOT

80 to 99 % of the black, powder-like solid *is unburned carbon. It has been proven that these polycyclic aromatic hydrocarbons (PAHs) may cause cancer. Especially old diesel engines, as well as power plants, emit plenty of soot if combustion is incomplete and no emission control technology (e.g. filters and oxidation catalysts) is used. Fuel quality is an additional factor.*

has to work with equal reliability on the freeway as on short-distance trips to the local bakery in winter.

Higher efficiency speaks for diesel

This has no bearing on the tangible benefits of diesels. Due to the higher energy density of diesel fuel, the engine can save about 20 percent fuel compared with a gasoline unit in the field. Even though gasoline engines are being massively upgraded at the moment, they won't be able to match the diesel's higher efficiency. Therefore, the diesel will remain the engine of choice for drivers who clock high mileage. A combination of the advantages of the diesel combustion process with energy from renewable raw materials or synthetic fuels would be ideal. Just a few years ago, biodiesel and biogas were regarded as the wonder energy par excellence. But the transformation process toward renewable energies has been sluggish. The EU is a long way away from achieving its targeted ten-percent share of renewable energies by 2020. However, in Germany, diesel fuel already contains seven percent biodiesel which is primarily produced from rapeseed oil. The environmental footprint of this viable standard fuel could easily be further improved with CO_2 based synthetic fuels. However, in light of low oil prices, all alternative energies are having a hard time at the moment. Even in Europe, environmentally friendly powertrains need help from politicians. The tax benefit for low-emission fuels such as natural or auto gas will be extended beyond 2018. But starting in 2019, this subsidy is to be progressively cut back. The gas powertrain is in the same situation as all subsidized alternatives to oil: the wells of the subsidies either run dry at some point in time or the political priorities shift.

USA

BACK TO SQUARE ONE IN THE LAND OF **PETROLHEADS**

Low oil prices have the effect of dope on the U.S. auto market. Sales of large pickups and SUVs are booming. Americans love traveling through their vast country in their living rooms on wheels, possibly even towing a large trailer. As successful as Tesla may be with its electric luxury sedans, the battery-driven powertrain is hardly suitable for many uses within the foreseeable future. Even a brief comparison with other powertrain alternatives illustrates this. Luxury electric vehicles can by now haul an energy supply of nearly 100 kWh but hardly any driver achieves the stated standardized range of more than 400 kilometers. Even with the electric drive's good efficiency of a little over 85 percent hardly more than 300 kilometers of range can realistically be extracted from the 600-kg battery.

Hydrogen as an alternative

So, anything beyond the daily commute to work requires more energy in the fuel tank. Hydrogen might soon become an alternative to the long charging periods and low energy density of battery drive. Hardly noticed by the general public, the eternal candidate for the powertrain of tomorrow has been making further progress. In 2015, the first Toyota Mirai models were delivered in the United States and Europe. The 4.89-meter sedan has been named after the Japanese word for future. It generates its electricity from hydrogen itself and emits nothing but a little steam in the process. Instead of hooking up a battery to a socket for hours on end, hydrogen cars replenish their energy supply in a little less than five minutes, just like other gas-powered vehicles. The hydrogen tanks underneath the seats are said to have an energy storage capacity between 600 and 700 kWh by the end of the decade. With that, the range even of larger vehicles could increase to more than 500 kilometers, provided the driver finds a hydrogen filling station.

Exactly this is where smog-ridden California is planning to take the lead. Within the past three years, more than 60 hydrogen pumps have been set up in Los Angeles County alone. Even today, there are more hydrogen pumps on the United States West Coast than the number planned for Germany by the end of the decade. While the infrastructure is still a far cry from being sufficient the sustainable restructuring of the energy sector might change this in the next decade. When wind farms produce excess capacities the electricity can be transformed into hydrogen by electrolysis and stored with relative ease. In Germany alone, renewable surplus capacity might amount to 120 gigawatts by 2050. If about 15 percent of that were used for generating green hydrogen this would equate to 40 TWh of energy or 730,000 metric tons of hydrogen, enough to operate some three million fuel cell vehicles for one year – as an affordable by-product of restructuring the energy sector.

Growing need for transportation

In 2050, nearly ten billion people are expected to be living on Earth. The demand for transportation keeps rising and cannot be covered by fossil fuels indefinitely. "It's time for an oil change," Daimler CEO Dieter Zetsche already announced years ago. "With the fuel cell, hydrogen could be assuming a role of similarly central importance as the one of oil so far."

In the extremely thin fuel cells, hydrogen is not burned as the name might erroneously suggest. Instead,

CARBON MONOXIDE CO

Like hydrocarbons, ***the colorless, odorless and tasteless but toxic gas*** *is produced for instance in incomplete combustion processes of substances containing carbon. It's ingested via the lungs and inhibits oxygen transport in the blood. CO also contributes to the destruction of the ozone layer that reduces UV B radiation. CO levels can be lowered by reducing energy consumption, switching to renewable energies, achieving more homogenous combustion of fossil fuels and using catalytic converters for emission control.*

EU limits (Euro 6) for CO
Diesel passenger cars *0.5 g/km*
Gasoline passenger cars *1.0 g/km*

the gas from the on-board pressurized tanks reacts with the oxygen in the air. Only a little heat and steam is generated in the process – plus, the electricity that powers the electric motors.

Hydrogen or battery drive?

However, this 'cold combustion' only works if the membranes are injected with sufficient platinum. This makes the stack of hundreds of fuel cells costly jewels of technological progress. "I see hydrogen in competition with further evolutions of battery drive systems that are expected to deliver a range of 600 kilometers by the beginning of the next decade," says Siegfried Pint, "and I'm afraid of us having to concurrently develop both drive systems with a lot of money," says Audi's chief developer for the electrification of the powertrain. However, nobody is expecting a final breakthrough by either of these alternative drive technologies before 2025.

CONCLUSION

Sustainability in transportation continues to be an equation with many unknowns. The final contest between alternative drive technologies has only just begun. That's why many automakers, also in China and the United States, have started to work on an intermediate technology: Vehicles with a 48-volt electrical subsystem can achieve up to 70 percent of the efficiency of a high-voltage hybrid. Without using such partial electrification hardly any manufacturer will be likely to meet the CO_2 emission limits in America, Asia or Europe after 2020. The optimized internal combustion engine will continue to be indispensable for satisfying the growing demand for personal mobility in the next ten to 15 years.

THE AUTHOR

Technological change is everyday business: Dr. Joachim Becker (born 1963) is the technology editor of the 'Süddeutsche Zeitung' German newspaper. The car as a networked robot intrigues the humanities scholar just as much as car drivers who still run the system software 101.

CARBON DIOXIDE CO_2

The non-combustible, acidic, colorless and odorless gas *is a natural component of the air we breathe. It is generated in the combustion of fuels containing carbon such as wood, coal or gasoline (35 metric gigatons from energetic usage worldwide per year) as well as in nature, for instance by cellular respiration or decomposition of organisms (a total of 550 metric gigatons). Even though the ('anthropogenous') share caused by humans appears very small it suffices to cause imbalances between natural production and natural consumption. Part of the excess CO_2 is absorbed by the oceans which become increasingly acidic as a result. Another part enters the atmosphere as greenhouse gas and settles there for at least 120 years. The current CO_2 concentration is considered to be the highest in 15 to 20 million years. However, it's assumed that 500 million years ago, the atmosphere contained 20 times more CO_2, which is an argument frequently used by critics of the greenhouse theory.*

EU limits for CO_2 for passenger cars
until 2015 *120 g/km*
from 2020 *95 g/km*

Low fuel prices tempt U.S. drivers to buy gas-guzzling vehicles with correspondingly high emissions

THE BLISS OF SIMPLICITY

Less is more! A growing number of people commit themselves to minimalism, seeking salvation through sacrifice. From the perspective of sustainability, this is a noble approach. After all, anything that doesn't have to be acquired, produced and disposed of can't harm the environment in any way. But is a feeling of having nothing to lose anymore truly a source of happiness?

by Wiebke Brauer

Things. Wherever you look. Stacked, folded, squeezed and stashed away. The average German calls nearly 10,000 items his or her own, from potholders to cars, from security blankets to sneakers. We collect them in our homes and store tons of them in our attics, basements or garages. Do we really need all this stuff? Maybe not at the moment, but surely, some day we will! Caught in the wheel of consumption that keeps our economies running and defines our society, consumer spending continually goes up, while we, more or less desperately, try to manage all the stuff we accumulate – in Germany as well as in the rest of the western world.

This bit about 'To Have or to Be' is a tricky one. As children in Germany we would chant "It takes little to be happy" and as teenagers we may have shouted "Property is theft!" Today, chances are that we've turned into couch potatoes, munching on chips while leafing through studies on human happiness.

Is there a correlation between happiness and wealth? According to the latest World Happiness Report published by the Earth Institute of New York's Columbia University, the Danes are the happiest, followed by the Swiss, Icelanders and Norwegians. This indicates that prosperity is a source of happiness. Although … Germany ranks in 16th place while Puerto Rico – a state with an economy that has been ailing for years is in 15th. The Kingdom of Bhutan on the other hand, which has had happiness written into its constitution since 2008, is only ranked in position 84: so much for Buddhist contentment.

So what has inspired this ongoing trend toward minimalism in industrial nations? Are we fed up with having too much? Years ago, social scientist Ronald F. Inglehart developed the theory of changing values according to which priorities shift in times of plenty. Fittingly, guides such as 'Simplify Your Life' emerged in Germany at the beginning of the millennium, followed by American Kelly Sutton with his blog 'The Cult of Less' or his compatriots Joshua Fields Millburn and Ryan Nicodemus and their website theminimalists.com. People engaging in this dialog were enthusiastic about the esthetics of paring down and the resulting freedom and agility. And the concepts of a Sharing Economy and so-called NOwnership were formed within this reduction movement as well. Calling anything your own? Heaven forbid! The magic word in the hyper-complex digital age is – access. Who needs racks stacked with DVDs when any movie you'd like to watch is streaming on Netflix? A collection of albums? Providers like Spotify will take care of supplying your music. Owning a car? You can rent one from a car sharing service or Uber, plus a clean eco-conscience for living your personal sustainability commitment as part of the package.

If it doesn't spark joy it should go

So should we just get rid of everything? Yes and no. The success of 'sorting celebrity' Marie Kondo is the most recent manifestation of the effects produced by post-materialism. Her books with titles such as 'The Life-Changing Magic of Tidying Up' have been translated into 27 languages and are selling by the millions. In the United States, the verb 'to condo' has even been coined. The Japanese organizing expert's tenets consist of taking every object into your hands and asking yourself if it sparks joy. If not, it has to go. Whether this also works with a vacuum cleaner or vehicle registration is anyone's guess. At least, you have to admit that it's a pretty simple method to fill your life with joy – albeit not the joy sparked by want of but by having things. Here they are again, 'things.' Simple happiness, after all, is a complex matter.

THE AUTHOR

*Although Hamburg journalist **Wiebke Brauer** is not constantly dreaming of the simple things in life she does have a penchant for throwing things away. She found the idea of the famous organizer Marie Kondo to keep only the things that spark joy so compelling that she immediately went through her home with a garbage bag.*

72 %

of Western Europeans (D, F, GB, I, E) have an **interest in car sharing** but only 55 % would share their own car with others.

Source: Ford Survey, 2016

69 %

of the respondents in a worldwide survey among higher earners (›€80,000) **if given some money** to treat themselves to one thing would choose a trip or activity, 19 % a new technology product and 11 % a fashion item such as apparel or jewelry etc.

Source: The Economist Group Luxury Goods Survey, 2014

474 kg

of **'residential waste'** on average is produced by an EU citizen per year. 1st place: Denmark with 758 kg. The lowest amount of waste – 254 kilos – is generated in Romania.

Source: Eurostat, 2014

5.2 bn

pieces of clothing are stored in German closets and about 2 billion items or 40 % of them are rarely or never worn by their owners.

Source: Greenpeace Survey, 2015

70 %

of Germans admire people who **do not value possessions.**

Source: diffferent's Status Study, 2013

A NOSE FOR ELECTRICAL ISSUES

Walking the dog and checking the condition of a machine in the process? Sounds crazy, but isn't. The Dutch industry services provider SPIT Electrical Mechanics in Almelo that is known for its creative and flexible ideas and approaches actually uses the sensitive nose of man's best friend. By employing furry 'E-Sniffers' SPIT's customers can save a lot of maintenance costs and extend the service life of their machines – a valuable contribution also from a sustainability perspective.

by Wilma Schreiber

Nicole Ent-Schipper directs the three-year old Australian Shepherd Dice to a machine in the hall, one of three waste energy lines on the premises of Twence, a biomass utilization company in Hengelo, the Netherlands. The dog runs around the machine, eagerly sniffing each of its components. From time to time, it climbs on top of the machine to make optimum use of all of its 225 million olfactory cells (humans 'only' have five million of them). Ent-Schipper and Dice walk along the entire line, with the dog attentively responding to every instruction of its handler. After about five minutes, Dice sits, indicating to Nicole that he's tracked down machine trouble.

The demonstration with the E-Sniffer underscores the practical value of this unusual offer by SPIT to avoid premature failure of high-voltage machines. The company serves sectors such as Energy, Industry, Chemical Engineering, Oil & Gas, Agriculture & Food and Water. Its main activity is to assist customers in keeping their machines running. For this purpose SPIT normally uses state-of-the-art instruments for measuring all kinds of possible electrical variables of critical static and rotating machines or components. Based on these measurements, a cloud-based model determines the expected remaining service life of the equipment.

With the larger machines (more than 2 MW) problems are usually found in the electrical systems. About 60 percent of all machine failures are caused by a short-circuited winding. Partial discharges in the coils are an important indicator of this type of trouble. To track down machine trouble, the dog has been trained to distinguish between three signals: "ultrasonic noise as a sign of leaking current, the smell of ozone resulting from partial discharges and the smell of nitric acid when oxygen is deposited in the form of a white powder," explains Leen Keesmaat, Manager Condition Monitoring at SPIT. "The major advantage is that the dog tracks down the problem at an early stage. This leakage typically starts with a small hole in the insulation which gets bigger and bigger and ultimately leads to a very expensive repair. A lot of costs can be saved if the hole can be sealed."

How dogs became E-Sniffers

Customers respond with surprise when Keesmaat tells them about Dice and his half-brother and E-Sniffer colleague, two-and-a-half year-old Gary. "They're amazed about the fact that anyone could even come up with such an idea," Leen Keesmaat says with a laugh. "A few years ago, we ran a joint project with Twente University in order to capture the knowledge of experienced colleagues – our company's heroes – in writing. They were always called in the event of machine failures and would also sniff the machines in order to determine the cause. The wife of a colleague was working with dogs, so one thing led to another."

There's another question he's frequently asked: Why does a company whose core business is maintenance try to find solutions to prevent repairs? "We'd like to guarantee to our customers maximum productivity at minimal costs. That's why we're constantly looking for possibilities to do so even more efficiently," explains the avid engineer.

The major advantage

63 percent of all measurements performed by SPIT confirm that the machine is intact and requires no repairs, which is actually good news. "But during these checks the machine is out of service because cables have to be disconnected. In some cases, it's necessary to remove hundreds of screws and to reinsert them with utmost precision," says Leen Keesmaat. "The cost of downtimes can run up to a few thousand euros or even more than a million euros per day, depending on the machine. This is another advantage of using dogs. They do their work while the machine is in service."

Tracking down trouble with dogs also tasks the handler quite a bit, according to Nicole Ent-Schipper. "It takes a minimum of three years to train the dog." Plus, its handler has to learn to correctly interpret the dog's signals. "I'm a dog trainer and behavioral therapist but in spite of these skills I occasionally miss a signal." SPIT is currently consulting with TÜV about the possibilities of obtaining certification. "There's already a certificate for dogs that detect rust on oil rigs resulting from the structures' constant exposure to saltwater. A major Dutch grid operator, for instance, is working with dogs that track down faults in high-voltage lines installed in the ground at depths of up to 1.5 meters and which would otherwise be hard to measure."

When Dice or Gary detect a defect the extent of it is determined by means of regular measuring methods. "The dogs indicate the problem but obviously can't tell us how many pico or nano coulombs are involved," says Leen Keesmaat. "But they show us when a check is not required. And that's the major advantage."

1 MILL

times better than that of humans is the olfactory sense of dogs. A dog can hear much better as well, being able to perceive frequencies of up to 100,000 hertz while humans can hear only up to 20,000 hertz.

1.5 M

is the length of an elephant's trunk, which makes it the biggest nose in the animal kingdom. But that's not all, as scientists from Tokyo University have discovered that these thick-skinned animals have twice as many genes for odor receptors as dogs.

EELS

have the most sensitive olfactory organ of all. If a sugar lump were thrown into a large lake, an eel on the other side of the shore could smell it.

EXCHANGE OF KNOW-HOW

This is how SPIT and Schaeffler work together.

SPIT draws on a variety of models to determine the condition of machines using big data and machine learning. In the event of impending failure, vibration measurements are used, among other things.

Schaeffler has sensors that monitor the performance of bearings. At the beginning of the year, both companies decided to make their databases accessible to each other and to thus bundle their know-how.

The resulting new findings are implemented in even better products which the customers of both companies benefit from.

Dog handler Nicole Ent-Schipper with her two 'good noses,' Gary and Dice. E-Sniffer training takes a minimum of three years

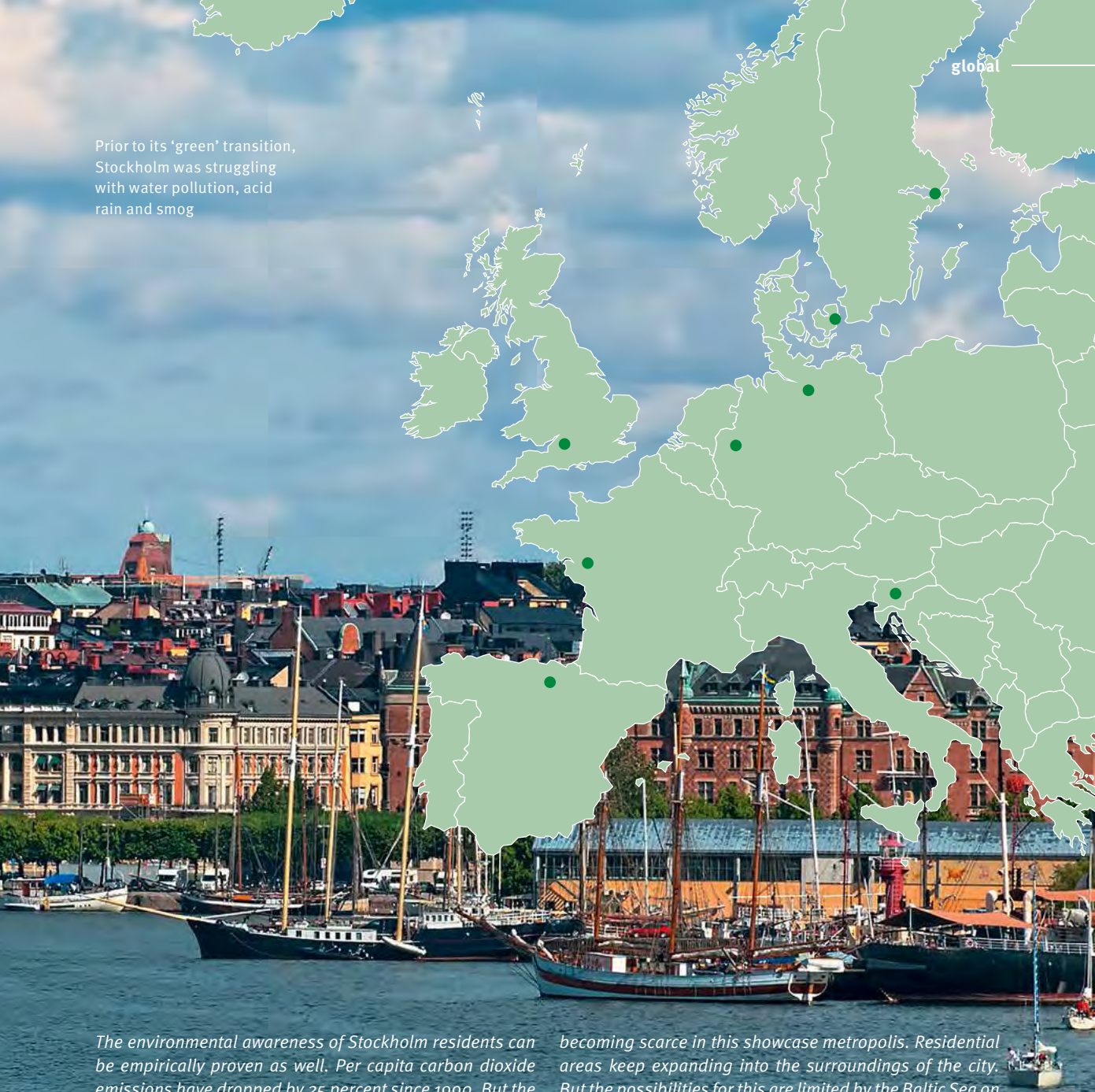
PLACES WE LIKE TO LIVE IN

A tour of the eight 'European Green Capitals.' How did they earn and what have they made of their titles?

by Carsten Paulun

STOCKHOLM
PRIZE GIVER AND PRIZE WINNER

The city that awards the Nobel Prize in five different categories in solemn ceremonies every year received an award itself in 2010 when it won recognition as Europe's first environmental capital. An aerial view of Stockholm immediately confirms that this is justified! After all, Sweden's capital is ***built on 14 islands connected to each other by 57 bridges.*** *In front of them is a conglomeration of 24,000 additional smaller rock islands – the Stockholm archepelago. Water, as far as the eye can see. But this idyll has not always been this perfect. A change in environmental awareness only took hold in Sweden in the late 1980s. The country and its capital* ***were suffering from water and air pollution.*** *Acid rain was plaguing the city which when the sea level rose threatened to be submerged in the brackish water of the Baltic Sea. The people of Stockholm countered this trend and evolved into 'eco-citzens.' Concern for the environment began to play a central role in the city's entire urban planning and promotion of trade and industry. As a result, Stockholm, in 2010, became the first 'European Green Capital.' The people of Stockholm are proud of this accolade. Former Mayor Sten Nordin commented, "More than half of the world's population lives in cities, and in Europe the figure is no less than 80 percent. Cities therefore play an important role in improving the living environment for citizens. This award represents an excellent opportunity to inform and inspire others about the good environmental work being undertaken by the City, the residents of Stockholm and companies."*



Prior to its 'green' transition, Stockholm was struggling with water pollution, acid rain and smog

The environmental awareness of Stockholm residents can be empirically proven as well. Per capita carbon dioxide emissions have dropped by 25 percent since 1990. But the aim set for the future is an ambitious one as well. ***By 2040, the city is to do completely without fossil fuels.*** *The entire energy required for heating, cooling, for electrical appliances and for all public and privately owned vehicles is to be supplied by renewable sources. The Magistrate has set out its objectives in 'Vision 2040.' Examples include continued funding of public transportation usage. The network of cycleways, which is already impressive, is to be continually extended and additional ferry connections can clearly ease the burden on urban traffic. As far back as in 2006, more than one in two of the city-owned vehicles were equipped with alternative powertrains. The rate is intended to rise to 100 percent by 2040!*

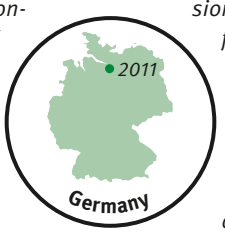
However, the increasing quality of life in Sweden's capital creates some problems as well. *Affordable housing is becoming scarce in this showcase metropolis. Residential areas keep expanding into the surroundings of the city. But the possibilities for this are limited by the Baltic Sea on the east, the airport in the north, the lakes in the west and the Tyresta national park in the south.*

2010

Population *910,000*
Area *187 km²*
Inh./km² *4,900*
Founded *1252*
Industries *Telecommunications, IT, pharmaceuticals*
Special feature *Largest and most populated city in Scandinavia*

HAMBURG GREEN PEARL

'Hamburg, my pearl ...,' Lotto King Karl's Hamburg anthem resounds at each HSV home match at Volkspark Stadium. And the pearl is green. ***Only few metropolises have an equal number of green areas*** *as this Hanseatic city. There's hardly a street without trees, hedges, lawns or shrubs. Hamburg – at least visually – was a green city even before becoming a 'European Green Capital' in 2011. The jury's justification: "Hamburg has made major strides and achieved high environmental standards on the whole in recent years. The city has very ambitious plans for the future that promise additional improvements." Annual energy savings of 46,000 MWh have reduced CO_2 emissions by 15 percent since 1990. By 2020, CO_2 reductions compared with 1990 are to amount to 40 percent and even to 80 percent by 2050. In addition, the city has established binding climate protection goals.*



But these goals are not easy to achieve as the metropolis with a population of 1.8 million is an important industrial location. The Hanseatic city is not only one of Europe's most active hubs but its port is one of the world's largest for containers, plus the city is home to Europe's largest copper mill. In addition, there are some 60,000 companies of all sectors and sizes. ***Environmental protection therefore poses a particular challenge to policy makers and the business community*** *as the city has to keep pace with economic developments. Controversial issues such as the planned deepening of the Elbe riverbed and the permanent traffic jams on autobahns A1 and A7 call for equally swift and environmentally friendly solutions. Plus, there's Germany's Energy Transition policy which the recently launched coal-fired power plant Moorburg with its oversized capacity doesn't seem to really fit with anymore. Consequently, the challenges and solutions are as varied as the city itself. In the port, the huge container ships as well as the growing number of cruise ships are to be supplied with eco-friendly electricity in order to mitigate at least part of the* ***massive pollutant emissions of these oceangoing giants.*** *Other projects such as energetic upgrades of older buildings, the use of low-emission environmental taxis and improvement of wind farms are to help Hamburg achieve further CO_2 reductions.*

But effective environmental protection alone is not enough to earn the privilege of bearing the title of a 'European Green Capital.' In addition to its progress made in terms of air quality and water consumption, the jury praised Hamburg for its efforts made in effective space utilization. The new 'HafenCity' no doubt contributed to the latter as well. In addition, Hamburg scored points for its commitment to cyclists and local public transportation. However, the jury emphasized that ***there was room for improvement in all areas.*** *So, Hamburg has no reason to rest on its laurels and, in fact, doesn't. Still, programs for cyclists or the acceleration of bus transportation that have been initiated aren't popular with everyone. Drivers in particular feel disadvantaged while ignoring the fact that Hamburg is one of the few major cities in Western Europe that has no low-emission zones. Well, it's hard to please everyone.*

Elbe, Alster and plenty of green, as well as a lot of industry and one of the world's biggest ports – Hamburg has to strike a balance between ecology and economy

Population *1,800,000*
Area *755 km²*
Inh./km² *2,400*
Founded *AD 500*
Industries *Hamburg Port, aircraft manufacturing*
Special feature *Hamburg has more bridges than Venice, Amsterdam and London combined*

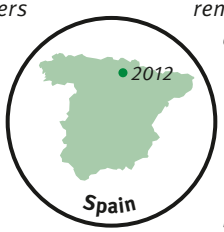
2011

The monument on Plaza de la Virgen Blanca is a reminder of the Napoleonic Wars. Currently, Vitoria-Gasteiz is battling to cut emissions which are harmful to the climate in half by 2050

VITORIA-GASTEIZ
EVERY INHABITANT HAS A 45 M² GARDEN

Population *244,000*
Area *280 km²*
Inh./km² *880*
Founded *1181*
Industries *Automotive engineering, mechanical engineering, aeronautics*
Special feature *Capital of the Autonomous Communities of the Basque Country since 1980*

Vitoria what? Never heard of the place? Vitoria-Gasteiz is located in the middle of the Alava Plateau, about an hour's drive south of Bilbao and the Bay of Biscay. Due to its cool temperatures, the city at an elevation of 500 meters is frequently called 'Sibiria-Gasteiz' and became a 'European Green Capital' in 2012. Vitoria-Gasteiz has been making strong commitments in the fields of ***sustainable mobility, recycling, water consumption, green spaces and urban planning.*** *In selecting Vitoria-Gasteiz, the jury was particularly impressed by the 'Green Belt' project. It accounts for a third of the urban area and forms a ring around the city center so that every resident within a maximum radius of 300 meters can reach a green area within short time. Converted to the population size, every inhabitant has 45 square meters of 'green' to enjoy. Aside from functioning as a local recreational area, the green spaces serve an educational purpose – providing the citizens with practical examples for use in urban gardening projects. Vitoria-Gasteiz has been extremely successful in optimizing its water management as well. Activities have been focused on eliminating leaks in the water mains system, upgrades of the infrastructure and educational campaigns to inform the population about the* ***importance of saving water.*** *The result: per capita consumption of water between 2001 and 2009 alone dropped by a remarkable 20 percent. The city's target is to cut per capita water consumption to a level below 100 liters per day – which is half of the global average.*



Other successful educational campaigns of the city administration were focused on avoiding waste and noise, and the reduction of negative environmental impacts caused by light emissions from buildings and public lighting at nighttime. For local public transportation the city, ***in addition to numerous buses and two street car lines, offers a network of cycleways*** *covering a total distance of 90 kilometers.*

In response to global climate change, the city supports renewable energies such as wind power, solar energy and geothermal energy. In addition, bio gas is produced from municipal waste. ***The city's long-term goal is carbon neutrality.*** *Through various activities such as optimized use of solar energy the city's emissions that are harmful to the climate are to be cut in half by 2050. While leaks in the fresh water mains have largely been sealed, Vitoria-Gasteiz now has to address the waste water system. Pollution of the Zadorra river is to be further reduced by more effective sewage plants which also enable increased recycling of water (not for use as drinking water).*

Another one of the city's forward-thinking focal topics is to integrate ***local industry into its green urban development concept.*** *In Vitoria-Gasteiz, Mercedes-Benz for instance operates the brand's second-largest plant for vans. However, that active environmental protection can also translate into jobs is demonstrated by another industrial partner: Gamesa Corporación Tecnológica – a manufacturer of wind turbines.*

2013

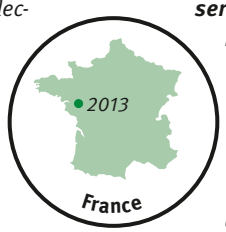
Population *293,000*
Area *65 km²*
Inh./km² *4,500*
Founded *1st century*
Industries *Steel, glass, textile, sugar*
Special feature *'La Villa Hamster' offers overnight accommodation in the rodent's style incl. a running wheel for €100*

NANTES
ONCE LIVABLE, ALWAYS LIVABLE

In addition to three street car lines, 70 bus lines are part of Nantes' public transportation system

Titles entail a commitment. In 2004, 'Time Magazine' named Nantes the 'most livable city in Europe.' This motivated the 293,000 inhabitants of the former shipyard metropolis to up the ante. They'd gotten the message that ***quality of life is inseparably linked with sustainability and environmental protection.*** *The title 'European Green Capital' followed as a reward for this commitment in 2013.*

The jury was particularly impressed by the city's concept for sustainable transportation. In 1985, Nantes was the first city in France to successfully revive a line system for electric street cars. Bus line 4 from Foch Cathédrale to Porte de Vertou has won supra-regional acclaim. It runs completely in its own dedicated lanes and has ***priority at all intersections.*** *Other bus lines are to be improved as well and the same applies to the infrastructure for pedestrians and cyclists. Drivers of automobiles on the other hand are increasingly losing out. Their share in daily mobility is to be reduced to less than 50 percent. As early as in 2013, a per capita reduction of CO_2 emissions to 4.77 tons was achieved this way. For comparison: the level in Germany was twice as high.*

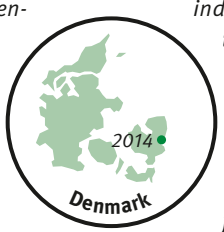


'Compagnie la Machine,' an artist group from Nantes created 'Aéroflorale,' a behemoth machine that could have come right out of a novel by Jules Verne, one of the city's sons. The airship fantasy operates with gas produced by vegetables that compost inside the machine. From Nantes, the project embarked on a tour of Europe with a mission of sharpening environmental awareness. In 2013, it thrilled visitors at the international gardening exhibition in Hamburg-Wilhelmsburg.

In addition to a well-developed public transportation system, Nantes offers its residents plenty of green spaces. The Nantes metropolitan area has ***four nature conservation areas and 33 natural spaces*** *of botanical, zoological or environmental interest. So far so green, but the city keeps tightening the CO_2 screw. Savings are to be achieved in transportation, with buildings and in industrial operations, in spite of the large-scale plants located there. For instance, on the city's southern periphery,* ***Airbus, with a workforce of 10,000,*** *produces fuselage segments and carbon fiber components, among other things. Other important employers include the steel, glass, textile and sugar industries which are responsible for a large part of the CO_2 emissions. Like the other Environmental Capitals (and those aspiring to be awarded this status) the city – with respect to jobs – is challenged to come up with solutions for environmental issues together with the business community, as 'livable' also means income security.*

COPENHAGEN CYCLISTS' NUMBER 1

Denmark's capital Copenhagen is not only the country's economic and cultural center. The bustling Baltic Sea metropolis attracts large numbers of tourists from around the world every year. And they can even take a dip in the harbor basin as ***the water is clean enough even there.*** *So it should come as no surprise that in 2014 Copenhagen was the fifth city to be awarded the title of 'European Green Capital.' Copenhagen primarily scored with the extension of its cycleways and an exemplary district heating grid. As a 'European Green Capital,' Copenhagen is even pursuing a much more ambitious target.* ***By 2025, the city plans to have a completely net zero carbon footprint*** *and, incidentally, defend its title as the world's cycling capital. Citizens are to ride bicycles for 50 percent of their daily commutes. Even at this juncture,* ***Copenhagen's cycle network is world-famous*** *and serves as an example for many foreign metropolises. If bicycle traffic in major European cities were to reach the same proportionate share in total traffic as it does in Copenhagen a minimum of 76,600 jobs would be created Europe-wide in the field of environmentally compatible and health-promoting transportation. This is the conclusion drawn by a UNECE and WHO publication.*



Copenhagen's subways, which were put into service in 2002, set another benchmark. In 2008, transportation experts named them the ***'world's best metro.'*** *The district heating grid is exemplary as well. It already supplies heat to 98 percent of households today. Conversion to renewable energies is the next target. As with practically all of the city's environmental plans, this one is driven by tangible business interests as well. The environmental sector has already become an important economic factor for the city. Some 25,000 people are working in the field of environmental technologies in the Copenhagen metropolitan area. Thousands of companies are active there and the productivity of this sector exceeds the Danish industrial average by 40 percent. This shows that* ***the environmental sector has evolved into the key driver of the country's economic power.*** *Even during the financial crisis in 2008, this field recorded eight percent growth while the country's total growth rate was only 1.1 percent at the time. So all this augurs well for the city's future development. However, the regulatory controls imposed on automotive traffic have disadvantages as well. People living in Copenhagen's surroundings have stopped shopping in the center of the city, now preferring to use the shopping centers on the outskirts. There is a* ***risk of the heart of the city becoming deserted.*** *Copenhagen does not ignore these challenges. Quite to the contrary: the city has formed a network including all the cities that have been nominated for the 'Green Capital' award to foster an exchange of experience and to generate crucial impetus for future developments to make cities even greener.*

Population *590,000*
Area *86 km²*
Inh./km² *6,800*
Founded *1167*
Industries *Machinery, porcelain, textile*
Special feature *Copenhagen's Tivoli is the world's most frequently visited amusement park*

The well-developed cycling infrastructure is to help Copenhagen as a whole achieve a carbon-neutral footprint by 2025

2015

BRISTOL A HUB FOR LOW-CARBON INDUSTRIES

The Clifton Suspension Bridge is Bristol's landmark. It spans the Avon and is an environmental showpiece itself: since 2006 it has been illuminated by LEDs

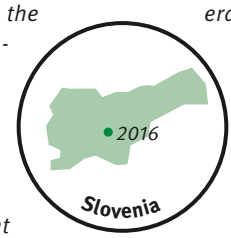
Population 440,000
Area 110 km²
Inh./km² 3,900
Founded 11th century
Industries Aviation, sports cars, hot air balloons
Special feature The 'Brizzle' dialect adds an 'l' to every vowel ending

Is Bristol another case of déjà vu? Back in 2008, the metropolis in the southwest of the United Kingdom with a population of 440,000 was ranked as the UK's most sustainable city. Seven years later, it became the 'European Green Capital 2015.' Is the former top location of the British aerospace industry (home to the Concorde supersonic passenger aircraft and the Harrier Jump Jet) with its white townhouses evolving into a green showcase? Along with the glorious days of the two professional soccer clubs, Bristol Rovers and Bristol City, environmental pollution and poor infrastructural planning were flushed into the sea twelve kilometers away from the city by the Avon river. The many hours of sunshine (1,885 per year) though have remained. Bristol pulled itself together, ***invested in quality of life, sustainability, recycling and biodiversity.*** *Even back in 2008, this endeavor was focused on the citizens and climate change. Today, it's easy to explore the entire city by bicycle. The number of cyclists has doubled in recent years, anticipated to double once more by 2020, according to estimates. From 2005 to 2010, domestic energy consumption has dropped by 16 percent and efficiency in residential construction improved by 25 percent between 2001 and 2011.*

Bristol did not permit itself to take a breather and, by 2015, invested over 500 million euros in the transportation sector alone. ***Efficient utilization of renewable energies is being funded with 300 million euros until 2020.*** *Plus, the local economy was transformed in that Bristol, instead of relying on large-scale industries, opted to promote creative, digital and low-carbon industries, in which more than 17,000 new jobs were created. In the environmental sector alone, Bristol recorded 4.7 percent growth in 2012. The result: In spite of a growing economy Bristol continually reduced CO_2 emissions – by a fifth compared with 2005, which provides strong motivation. By 2050, CO_2 emissions and energy consumption are to be reduced by 80 percent, respectively. On the way toward achieving these targets, Bristol is aiming to become the European hub for low-carbon industries.* ***So it's no wonder that Bristol has adopted the tagline 'Laboratory for Change.'*** *But Bristol's green strategy has not remedied all the downsides of a modern big city. Four of its neighborhoods, for example, are among England's poorest. Although Bristol can take pride in being home to two of the most renowned universities the number of people with completed intermediate-level education is lower than in the rest of the country. Accordingly, there is a* ***significant social divide*** *and alleviating this problem already poses a great challenge to the city at the moment. It's possible that the citizens of Bristol attach even greater value to these solutions than to their title of 'European Green Capital 2015.'*

LJUBLJANA
A CITY WITH A ZERO-WASTE PLAN

As hard as the name of Slovenia's capital may be to pronounce, succumbing to the charm of this small metropolis isn't hard at all. On the one hand, a stroll through the clean streets of this capital city with a population of 280,000 gives you the feeling of being in the Austria of the past – which is no wonder as Slovenia belonged to the Habsburg Monarchy for centuries. On the other hand, the many cafés along the Ljubljanica river undeniably exude a ***Mediterranean flair.*** *A little bit of Laibach, which is the city's historic German name, can also still be detected in the small, carefully restored old buildings lining the banks of the river to which the city owes its name. The abundant vegetation in its surroundings offers numerous opportunities for hiking, cycling and other recreational activities such as fly fishing.* ***Quality of life is high*** *in Ljubljana.*



This hasn't always been the case *though. Less than a decade ago, traffic threatened to suffocate the city center. Crossing the river posed a challenge. Waiting for a bus proved an equation with many unknown quantities. Most of the city's residents remember well that cars used to park along the river banks where cafés are found today.*

The perfect interaction between identifying the problem, working out a strategy and implementing it swiftly and consistently convinced the jury – the name of the 'European Green Capital 2016' is Ljubljana. Within a very short period of time the city fathers managed to convert Slovenia's political, administrative, cultural and economic center into ***an exemplary city of sustainability.*** *This transformation was achieved particularly in the field of local public transportation. Sustainable forms of mobility are promoted and the city center is increasingly transformed into a pedestrian zone. In 2012, the city core was closed to passenger vehicle traffic. Since then, bicycles have been dominating everyday life. The municipal bike renting system, 'BicikeLJ,' has placed 300 bicycles at central locations of the city since 2011. Every bike, on average, is rented out six times a day. The first hour being free provides a special incentive. People with disabilities can use free short-distance transportation by electric vehicles in the downtown pedestrian zones. In addition, methane-powered city buses are increasingly used which additionally contributes to a reduction of CO_2 emissions. 74 percent of the households* ***use district heat and environmentally friendly natural gas*** *which helps improve air quality. Under the 'Sustainable Energies' action plan adopted in 2011, Ljubljana is aiming to achieve a 30-percent reduction of CO_2 emissions by 2020.*

Ljubljana is one of the few cities in Europe that can take pride in using natural drinking water not requiring any pre-treatment by technological processes. In addition, Ljubljana is the first capital city in the European Union with a Zero-Waste Plan. The objective is to adopt a ***lifestyle that generates no non-recyclable waste*** *and doesn't waste any raw materials. Everything is to be recycled.*

Collecting and recycling: Ljubljana aims to become the EU's first capital with no non-recyclable waste

Population *290,000*
Area *275 km²*
Inh./km² *1,000*
Founded *1144*
Industries *Aviation, commodity trade, telecommunications*
Special feature *The university with 65,000 students is one of Europe's largest*

2016

2017

ESSEN PUTS A 400-KM CHANNEL UNDERGROUND

Oops, so green? The Ruhr metropolis Essen keeps surprising visitors with an abundance of nature like here in the 'Stadtgarten' park

Population *574,000*
Area *210 km²*
Inh./km² *2,700*
Founded *845*
Industries *Energy utilities, steel, mining*
Special feature *The main belt asteroid '(133243) Essen' was named after the city*

Essen, the Ruhr district and mining – initially, this doesn't sound exactly like an idyllic place to live. But Essen, a city with a population of 574,000 that has been suffering from the hardships of coal mining crises and major economic changes ever since the 1950s, has evolved into a a real gem – and been named 'European Green Capital 2017.' By selecting Essen, the jury recognized the city's achievements and goals in the fields of environmental innovation, air quality, nature and sustainable environmental policymaking. Sounds simple but in times of bureaucratization and excessive legislation cannot be taken for granted by any means. The city's message: ***"Nothing works without the citizens."*** *It starts with school-age children. 45,000 kids per year receive instruction in environmental subjects at the 'Nature School' Biological Education Center. Plus, the entire Essen population is encouraged to become actively involved in the 'essen-pico-bello' project. Its aim is to heighten people's awareness of cleanliness and increasing the citizens' commitment to it.*

The renaturation of the Emscher that gained notoriety as Germany's dirtiest river is a showcase project for Essen and the Ruhr district. The Emschergenossenschaft public-sector water management association has been working on this mammoth project since 1992. For years the river was dubbed 'Köttelbecke,' which means 'sh... creek' in the Ruhr district's dialect. Ridding the Emscher from this reputation, but above all from its inherited pollution, is worth an investment of 4.5 billion euros to the Ruhr district. Among other things, the money is used to build a waste water canal parallel to the river, part of which runs underground at a depth of up to 200 meters. The ***creation of new river landscapes*** *to be completed by 2020 will benefit many of the district's major cities.*

In 2005, Essen launched its STEP 2015+ urban development plan that is intended to systematically implement the city's transformation and conversion planning process. ***Many of the projects have been completed.*** *Living on the waterfront or in green spaces, leisurely walks along lakeshores and through pastures have already become reality of everyday life. Other projects are to follow, such as the program billed as 'ESSEN. New Ways to Water' that aims to develop and interconnect green spaces and parks.*

The people of Essen have recognized that their goal of turning their city into a green showcase metropolis can best be achieved as a team effort. As a result, as far back as in 1994, a network of various cooperation partners – the 'Essen Consensus' – was formed. The partners work together on specific projects in order to increase the quality of life and the quality of Essen as a place for business through employment and qualification actions based on sensible planning. Local companies, private and public-sector institutions have combined the ***fight against long-term unemployment with sustainable improvement of the residential environment*** *in the city of Essen. Companies that actively participate in the transformation of the city – such as landscape gardeners – have committed to hiring at least one unemployed person under a contract subject to social security contributions for one year. Ideally, this will pave the way for them into the regular labor market. A far-sighted decision by the city fathers as in spite of all the enthusiasm for the transformation process there is one aspect not to be ignored: the* ***current unemployment rate in Essen is twelve percent*** *– which is twice as high as the German average.*

THE AUTHOR

Carsten Paulun *has embraced a sustainable lifestyle ever since his youth, albeit not consciously: his great passions being cycling, wind surfing and sailing. The motor journalist and specialist for crisis communication is now looking for a solar system for his house near Hamburg and thinking about buying an electric vehicle.*

WHEN WILL WE **BE TOO MANY?**

Our numbers keep growing. While about one billion people were living on Earth around 1800, their number had grown to 2.5 billion by 1950. Today – not even 70 years later – there are 7.39 billion of us! And counting. Every 24 hours, the world population grows by another 210,000, equating to about 78 million per year. By 2100, more than 10 billion people may be living on Earth, according to the latest UN projections. Consequently, the question of "how many people can planet Earth support?" is definitely justified. The World Wide Fund for Nature (WWF) warns: We are using 50 percent more resources per year than the Earth can sustainably produce. So, to prevent the branch we all are sitting on from breaking, more efficiency is needed in every part of our lives. Plus, more education, as birth rates tend to decline when educational levels rise. Fair distribution of resources is equally important. While 1.4 billion people today are undernourished an equal number is overweight. This is not an inevitable conflict as there is actually enough to go around: enough water, enough food, enough space and enough energy. Everything exists in sufficient supply for everyone – but up to what level of the Earth's population this will hold true is a question no one can answer at the moment.

» ***Control oil and you control nations; control food and you control the people*** Henry Kissinger

in motion

Innovations in the course of time

Chart: German Foundation for World Population
Source: United Nations, World Population Prospects: The 2010 Revision, 2011

NE PLUS ULTRA!

ANY TIME

A pioneering spirit, innovative drive and entrepreneurial instinct – these are some of the fortes Porsche and Schaeffler share. The products of both companies always mark the optimum, and have been doing so for seven decades. Two sports cars document how fast time has passed. Superstars past and present – a unique meeting of generations. Efficient use of energy is common to both.

by Jörg Walz

A heavy kick in the back, the neck muscles are struggling to keep the head that's jolting backward at lightning speed in an upright position. The car shoots forward as though being launched from a catapult. "Officially, we state 2.5 seconds for the sprint from 0 to 100 km/h," beams Marc Lieb, a practicing Porsche LMP1 driver with a degree in engineering, "but we've even measured 2.3 ..." In less than seven seconds, the speedometer indicates 200 km/h. The power of the total of 887 horses or, expressed correctly in physics terms, 652 kilowatts, is only in balance with the resistances encountered from the road, wind and company at a speed of 345, and is available at all times in an abundance unknown for automobiles. Maximum torque amounts to an awesome 1,280 newton meters: a level that big agricultural machines normally shine with.

Full-throttle out of the shadows of war

The name of this present-day automotive ne plus ultra is Porsche 918 Spyder. In terms of performance, the two-seater belongs to the race car category. But it's street legal and represents an impressive gauge for the ultimate of what's feasible today in terms of automotive engineering. This applies to the powertrain and choice of materials as well as to the finely tuned details. The huge strides that have been made are patently obvious at a family reunion of the youngest Stuttgart offspring with its ancestor, the Porsche 356, which in its day embodied the ultimate of what was feasible as well and forms the foundation of the successful sports car brand.

Seven decades separate the two Porsches. Seven decades of automotive engineering which Schaeffler has accompanied and helped define with its products and technologies. Porsche and Schaeffler have shared many experiences and projects. In 1946, both companies laid the groundwork for their subsequent global activities in the heart of a war-torn Europe. And while in Herzogenaurach in 1948 the launch of the cage guided needle bearing marks the initial innovation of today's technology corporation, the 356 Cabriolet rolls out of the garage in Gmünd, Austria. Today, the well-protected original is on display in Stuttgart-Zuffenhausen.

40 vs. 887 hp

The Porsche Museum located there is also a place for a rendezvous of the two sports cars. Impressive are the differences that can be expressed in numbers: four cylinders versus a V8 with two electric motors, 40 as opposed to 887 hp, top speed of 140 and 345 km/h ... the width of the tires on 16-inch steel rims of the 356 is five inches, i.e. 127 millimeters, the tires of the 918, respectively, are twice and nearly three times (265/35 R20 and 325/30 R21) as wide.

In Porsche's early work, the occupants sit in bucket-shaped seats that are no doubt comfortable. Head restraints and seat belts? No chance! In the 918, belt tensioners, airbags and a range of other safety features such as ABS, ESP and traction control are added – not to mention the carbon fiber architecture that has been optimized for safety as well compared with the sensitive aluminum body shell covering the box-like sheet steel frame of its ancestor.

Its four-cylinder engine is fueled by gasoline using a downdraft carburetor and mobilizes its maximum output at 4,000 revolutions – its cubic capacity by the way is reduced in these very early post-war days for racing reasons, from 1,131 to 1,086 cc. As a result, entries in the popular motorsport class of up to 1.1 liters of displacement are possible. At 2,600 rpm the engine develops its maximum torque of 69 Nm.

Power is transmitted via a manual non-synchronized four-speed transmission (that welcomes double-clutching to carefully match engine and gear speeds). 140 km/h is a remarkable vehicle speed for the empty but narrow roads of the early post-war era. It is made possible thanks to the car's good aerodynamics

» At first, I looked around but couldn't find the car I was dreaming of: a small, light sports car that efficiently uses energy. So I decided to build it myself

Ferry Porsche

The command post of the 918 high-tech sports car appears like an aircraft cockpit compared with the interior of the ancestral 356 with its near-minimalistic look

Stylish LED taillights vs. light bulb lamps: visually, both variants have their own charm but in terms of visibility and safety the modern one is clearly the better solution

Miscellaneous messages and warnings – the Porsche 918 supplies information galore. The 356 indicates only speed and mileage. The driver's five senses are responsible for the rest

The light beam of the LED headlights of the 918 projects by far over half a kilometer into darkness. By comparison, a night-time drive in the 356 resembles a quaint 'lantern procession'

Be it the rearview mirror, the tailpipes or the dashboard controls – much in the Porsche 356 appears downright delicate

with a small frontal area and low weight (600 kilograms). The acoustics of the air-cooled boxer engine are reminiscent of the sound of the VW Beetle. This is no coincidence as both engines have been designed by the same source and show a close kinship.

Purely electric as fast as the 356 and high speed like on rails

Experiencing the performance capability of the 918 Spyder requires a change in venues. So, we head for the test track of the Porsche Development Center located 25 kilometers away in Weissach. Engine sound? Nope! At least the familiar ICE sounds are added with some delay and when needed, because the 918 Spyder is a hybrid, which means its carbon fiber body shell covers both an internal combustion engine and an electric motor. In this case, not just one but two of them. Plus, the lithium-ion battery can be charged on the road or from a socket – which is a characteristic of plug-in hybrids. The battery's storage capacity of 6.8 KWh suffices for the trip to Weissach. The aggregated output of the electric motors is 205 kW, which – in traditional auto parlance – equates to 279 hp. And – if desired – the two tailpipes of the 4.6-liter V8 internal combustion engine remain cold even beyond the top speed of the former 356, in other words the car can be driven strictly in electric mode up to 150 km/h. The four-cylinder oldie consumes 7.2 liters of gasoline per 100 kilometers. The standardized fuel consumption of the hybrid sports car is stated to be 3.0 liters. The car serves itself from the fuel tank and the battery, consuming 12.7 kWh of electricity across the standardized distance.

A mixed double – this applies to the tires of the 918 as well. And this not only refers to the fact that the hybrid sports car is fitted with tires of different dimensions in terms of width and diameter at the front and rear. They've been specifically designed for the special requirements of the 918 Spyder. Grip, cornering force and minimal rolling resistance typically constitute conflicting objectives. The tire engineers resolved this conflict by means of two-component tires. In straight-line driving, the rubber that runs slightly diagonally runs on the inside where resistance is lower. In dynamic cornering, it uses the entire

width and the outside, which offers additional grip, for support. Le Mans winner Marc Lieb demonstrates how well this works on the test track in Weissach on which he seemingly redefines the limits of vehicle physics. The car virtually claws the asphalt and enables incredible cornering speeds. The four-wheel drive system ensures that the truck-like torque is distributed with pinpoint accuracy and that the racer shoots neutrally into the direction desired by the driver.

Other little helpers for the hyper-go-kart feeling are active rear-wheel steering and equally active aerodynamics components at the front and rear with three-way variability.

Nordschleife world record

Speaking about on-board computers: By means of the 'Sport Response Button' integrated in the three-spoke steering wheel four different driving modes can be selected. Among other things, they determine shift times, engine response and the hybrid strategy. There are only two pedals in the footwell – in contrast to the three pedals found in the ancestral car. Instead, the 918 has two paddle shifters in the steering wheel which drivers can use to manually operate the double-clutch transmission with wet linings. Or they can choose to use the convenience of an automatic transmission, for instance when thanks to electric drive they're allowed to enter the center of London which is off limits to cars with internal combustion engines. Like in a volume production car with all the trimmings, drivers can use the phone without ruffle or excitement, have the integrated navigation system point the way and – just as with a smartphone or iPad – swipe across the center console to select various menus. As a result, the 918 allows its drivers to not only achieve best times on the circuit (Marc Lieb lapped the Nürburgring-Nordschleife in it in 6 minutes and 57 seconds! A world record!!), but assists them in everyday life as well.

When it comes to brakes, cooperation and integration are crucial as well. While the 356 was still decelerated via drums, the 918 brakes with pizza-size discs (front 410, rear 390 millimeters) made of a ceramic composite material. Added to them is the braking power of the e-machine that simultaneously feeds energy back into the battery and jolts the heads of the occupants forward with 0.5 *g* if necessary. The electric deceleration power of the Porsche 918 Spyder is two and a half times higher than that of previous systems. In total, the four-wheel drive sports car can thus stop from 300 km/h in less than 250 meters – truly breathtaking.

A clique developed the 356, 400 engineers the 918

Generally, successful cooperation makes the difference nowadays. This is not only evident in the various propulsion and numerous other systems of the 918. The creation process of the 918 Spyder illustrates this as well. While Ferry Porsche still made the ancestor of the 911 and company reality with a small clique of engineers and technicians that were his confidants, the 'inner circle' involved in the creation process of the 918 included more than 400 engineers. The core team in Weissach was joined by armies of engineers in the employ of suppliers whose know-how and technologies contributed to the success of this vehicle. Even components that are unspectacular at first glance, such as wheel bearings, were optimized and tailor-made for this automotive ne plus ultra. The smooth-running high-performance wheel bearings from Schaeffler in which ceramic balls replace the usual steel rolling elements are just one example of fine-tuning work with an obsession for detail. The reward of this effort: minus 640 grams. Even though the total weight of 1,675 kilograms may not suggest it at first glance, for the developers of the 918, every gram matters.

Thus, in the end, it is one idea that energizes many people. Their joint aim is to create a unique automobile and to gather the inspirations and innovations of many players, and to assemble them to create the big picture. And while 70 years ago, a small ensemble of artists jointly created a truly great work, it now takes a whole orchestra. Its work, though, proves a lot more impressive.

THE AUTHOR

Jörg Walz *has tested a large number of automobiles, sports and race cars for 'auto, motor und sport,' for 'Volante' and for 'AUTO ZEITUNG.' But so far none of them have impressed him as much as the Porsche 918 Spyder whose maximum performance capabilities were demonstrated to him by racing pro and Le Mans winner Marc Lieb.*

PORSCHE 356		PORSCHE 918
4-cylinder boxer	**ENGINE**	*V8 gasoline engine, 2 E-motors*
1,086 cc	**CUBIC CAPACITY**	*4,593 cc*
40 hp (29.4 kW)	**POWER OUTPUT**	*System: 887 hp (652 kW); V8: 608 hp (447 kW); E front: 129 hp (95 kW); E rear: 156 hp (115 kW)*
69 Nm	**TORQUE**	*1,280 Nm*
140 km/h	**VMAX**	*345 km/h (electric 150 km/h)*
23.5 seconds	**0–100 KM/H**	*2.5 seconds*
Manual 4-speed transmission	**GEARSHIFT**	*7-speed double-clutch transmission*
830 kilograms	**WEIGHT**	*1,675 kilograms*
Approx. 10,000 DM	**PRICE**	*768,000 euros*

With its weight of 135 kilograms, the internal combustion engine is the lightest one in the V8 league

The huge 21-inch rear wheel with magnesium rims and two-component tires tips the scales at 9.8 kilograms

The V8 gets its fuel on the left, while charging of the electric units takes place on the right

SKIN-DEEP **PERSPECTIVES**

One kilogram of weight saved – doesn't sound like much but in motorsport it can make a world of difference: improved efficiency in detail. Audi's engineers gain exactly this one kilo to play with, thanks to an innovative wrap for the Audi RS 5 DTM car. Paint, however, will keep the upper hand on normal road-going cars: not least because it's becoming more and more environmentally friendly.

by Roland Löwisch

When, according to legend, the Mercedes squad scratches the paint off its new race cars before the Eifel race at the Nürburgring in 1934, it does so in an attempt to comply with the weight limit of 750 kilograms per car prescribed by the regulations. The stripping proves successful – Manfred von Brauchitsch wins in the W 25 that is now called 'Silver Arrow' – and goes down in a particularly intriguing chapter of motorsport history. Today, teams are still struggling for every gram of weight in order to improve speed and agility on the race track, so a kilo saved is a real plus. Audi now enjoys this advantage with the new RS 5 DTM. Thanks to an innovative film with integrated sponsorship logos, among other things, the wrap now weighs about 1,000 grams less.

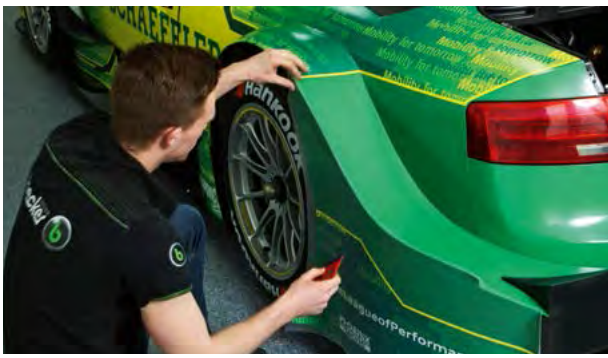
"Film-based wrap offers numerous advantages in racing," says Bianca Becker, CEO of becker design based in Nieder-Olm, who is responsible for the new film-based technology, "but it's the detail that makes the crucial difference. As early as at the stage of creating the production data for digital printing of the films not only the whole vehicle but every single component with its individual shape has to be captured. In addition, the choice of material, printing technique and precise positioning of the film shapes is decisive."

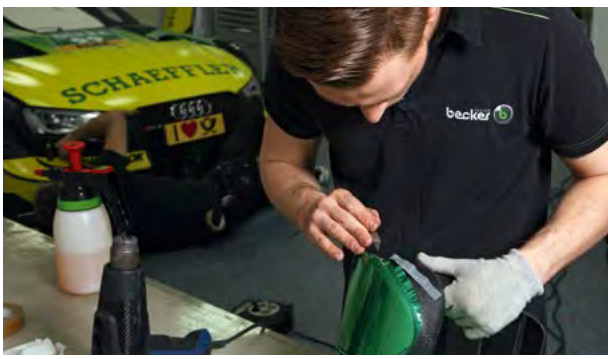
The basic advantages compared with paint are obvious. The application of the initial wrap and subsequent repairs can be accomplished quickly (about a day and a half for installing wrap on a race car) and with a little practice even a mechanic in the pits can install spare wrap. In the past, the scars sustained by race cars in on-track battles would be covered with paint, over and over – and with each coat the weight which the driver had to wield around the corners would increase.

Wrap requires paint as well

Both paint and wrap add weight. Let's take a road-going VW Golf for example. Such a mass-compatible compact car is normally provided with four coats of paint – anti-corrosion electrophoretic dip paint, primer-surfacer (e-coating) to even out irregularities and as protection against stone chips and UV radiation, the basecoat for color and the clearcoat for gloss. In wet condition, these coatings tip the scales at about 14 kilograms and still weigh 4.2 kilos after drying, according to information from DLI (German Institute for Paint and Varnish), although all layers combined are only about one tenth of a millimeter thick, which equates to the diameter of a human hair.

It takes becker design a day and a half to install wrap on the intricate bodywork of a race car like the Schaeffler Audi RS 5 DTM. Applying the complex graphics using paint – if possible at all – would take far longer and result in higher weight





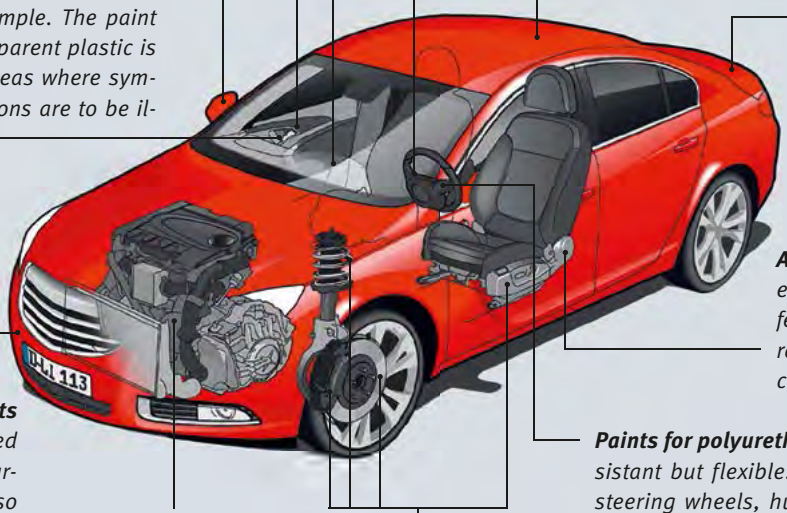
PAINTS **IN AND ON CARS**

UV curing paint systems *harden in a matter of seconds by means of UV light and are extremely resistant. They're used for protective strips and exterior mirrors, etc.*

Soft paints *are used to refine plastic surfaces with a leather-like look and feel*

Automotive production paints *typically consist of four layers (see graphics below)*

Laserable paints *are used for controls for example. The paint applied to transparent plastic is lasered off in areas where symbols or inscriptions are to be illuminated*



Special-effect paints *such as metallic or pearlescent paints are popular with many car buyers due to their visual impact*

Anti-friction coatings *enhance the look and feel of plastics, and reduce creaking and cracking noise*

Synthetic paints *are not only used for coloring purposes but also protect the respective parts against mechanical influences, UV rays and weather*

Alkyd resin paints/epoxy powder coatings *are particularly resistant against heat, cold and chemicals*

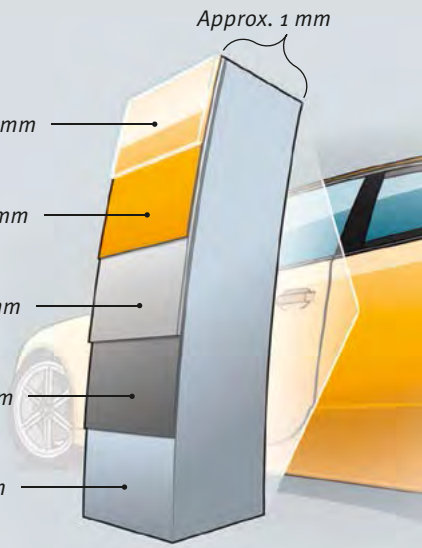
Paints for polyurethane foam *are resistant but flexible. They're used in steering wheels, hub caps and trim parts, etc.*

Powder coatings *contain no solvents, generate little waste and are therefore regarded as environmentally friendly. They're used for dampers, springs, wheels and seat rails, etc.*

INNOVATIONS ELEGANTLY WRAPPED

Films designed for a striking effect *in the case of Schaeffler concept cars like the CO_2ncept-10% point to the innovative technology underneath the production sheet-metal body shell*

COMPOSITION OF **CAR PAINT**



Graphics: Deutsches Lackinstitut (DLI)

Dipped or sprayed: the coats are applied in various process steps

The wrap for a road car like the Golf still weighs more than 160 grams per square meter (race car wrap: 106.8 grams), according to Bianca Becker. About 25 square meters of it are required. However, to prevent corrosion underneath the wrap, the car has to have a coat of paint anyhow or, as a minimum, a coat of primer, at least if its body is made of sheet metal.

Paints are more resistant

The surface quality of film-based wrap, which does not (yet) meet the level of paint, is another disadvantage. "Therefore," explains Dr. Wolfgang Reckordt, Head of Marketing for Automotive Coating Solutions EMEA at BASF, "film-based wraps are typically used only in addition to the painting process. They cannot replace functional properties such as corrosion protection. Furthermore, special effects and colors are not possible, and durability is a lot lower."

The latter carries less weight with race cars, but is certainly important for road cars. "On automotive exteriors, the durability of film-based wrap is determined particularly by the climate and angle of sunlight," says Becker. In Central Europe, for example, the durability of vertical wrap (for instance on doors) is three years in the case of digital printing, four years for solid and metallic colors and five years for black-and-white. The life of horizontal wrap (for instance on the roof) is shorter: three years for black-and-white, solid and metallic, and only two for digitally printed wrap. Reckordt: "By contrast, the life of paint today corresponds to the life of a car."

Still, wrap makes sense on road cars as well, for instance on taxis which are intended only for part-time use and, underneath a wrap featuring RAL 1015, the standard German taxi color, are painted in a color that differs from 'bright ivory.' Becker adds: "Films are superbly suited for personalization jobs in order to stand out from the crowd, for instance by sporting trendy colors or matte gray or matte black. Company cars can externally show their corporate identity and police or other municipal service vehicles have been wearing wrap for a long time. In the case of leasing and promotional vehicles, wrap can serve to protect the paint."

As both methods are justified, both are continually being developed further. "The coats of paint have become thinner and thinner, the application techniques more efficient and waste has been reduced," says Reckordt, "plus, the processes are being optimized as well. For example, using a modern technology, the functionality of the primer-surfacer is integrated into that of the basecoat. This eliminates the need for oven drying of the primer-surfacer which, in turn, saves material and energy." In wrap technology, efforts are underway to replace PVC, which is difficult to dispose of, as the main material.

Smart, for instance, has been pursuing a third approach. A large number of the body parts of this micro vehicle are made of completely dyed plastics that only require a thin clearcoat for protection. Low weight and high resistance are the major advantages of this variant.

By the way, the phrase 'exchanged paint' that has traditionally been used in TV commentator parlance to describe on-track contact between two DTM race cars should have been changed to 'exchanged wrap' a long time ago. The reason is that underneath the wrap there's unpainted carbon fiber practically everywhere.

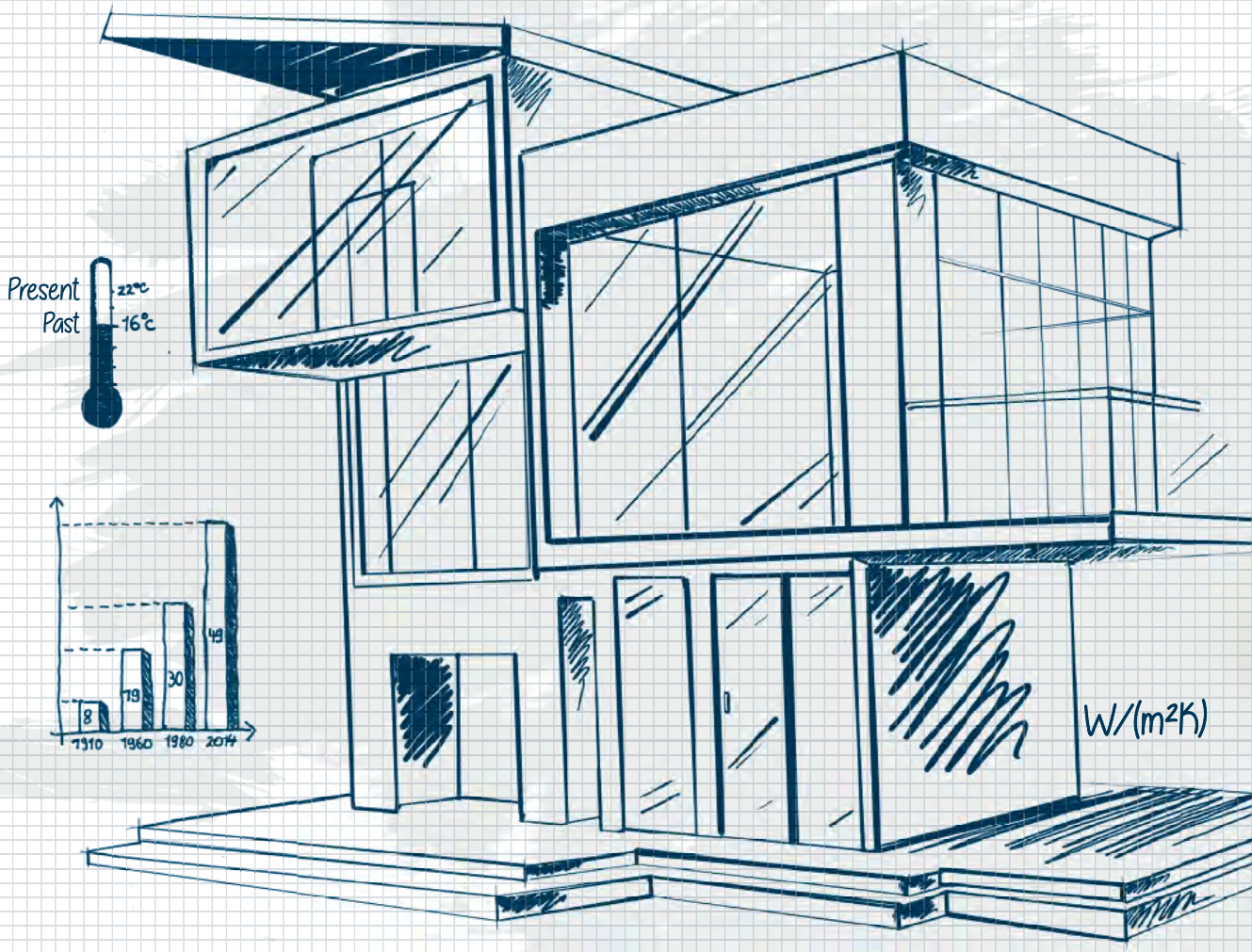
THE AUTHOR

Roland Löwisch *learned in school that black and white are not colors. To protect him from a fate of painting things in black and white, he chose a career as a (car) journalist. Following stints with 'stern' and 'Auto Bild,' he became a freelancer and has been experiencing how colorful the (car) world really is ever since. And as long as his way of painting this world hasn't completely lost its luster, he intends to write about anything that makes up (automotive) life – classic cars, sports cars, off-road adventures. His car for everyday use, by the way, is black. But, okay, you can't have it all …*

ENERGY DEMAND THROUGH THE AGES

According to calculations by anthropologist Marshall Sahlins worldwide annual per capita energy consumption was near-constant up to the beginning of the industrial revolution. Subsequently, increasing wealth and energy-consuming machines have steadily been driving up consumption. But we keep learning, save energy more effectively every day and use advanced technologies that can do more and more with less and less of it.

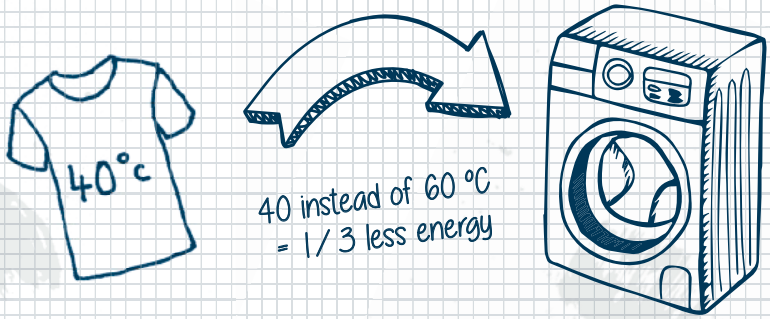
by Carsten Paulun



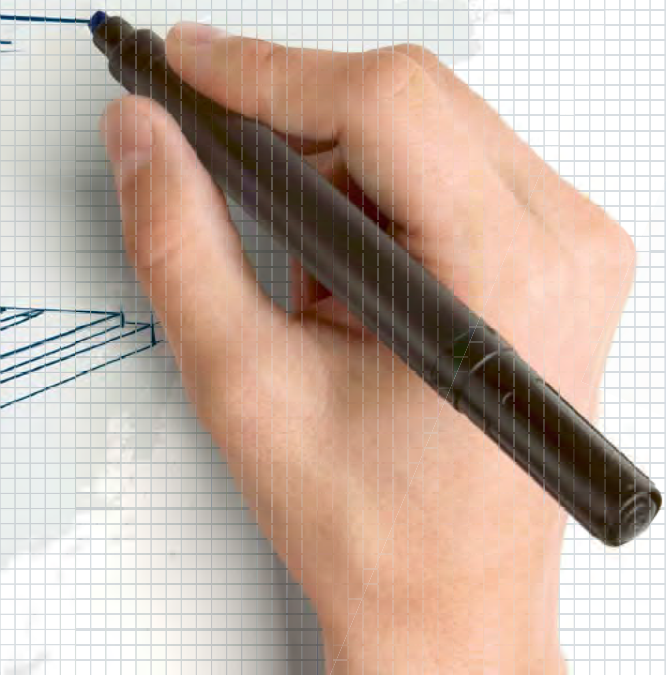
5–7 % energy can be saved by a household by insulating the ceiling of its unheated basement

MODERN HOUSES GENERATE THEIR OWN ENERGY

As recently as in the middle of the past century, central heating was regarded as a luxury. Up to that time, rooms – if at all – were heated by stand-alone stoves, furnaces and the like, fired by coal, wood or anything that was within reach and halfway combustible. People were happy about ***16 degrees centigrade in the living room*** *in winter. The warmest place in the house was the kitchen where a coal- or wood-fired stove was also used for cooking. Emissions of pollutants were on nobody's mind and neither was thermal insulation. Today, this is the subject of several European regulations and in Germany additionally set out in a 1,000-page Energy Savings Ordinance. As a result, energy demand has continually been decreasing* ***in spite of the continual increase in living space*** *(average per person in 1910: 8 m²; in 1960: 19 m²; in 1980: 30 m²; in 2014: 49 m²). Primarily responsible for this trend is state-of-the-art heating technology, which may even include the use of geothermal energy, plus ample insulation. The target is for all new buildings in the EU to become* ***'zero-liter' houses,*** *in other words buildings that generate as much energy as they consume, for instance using solar collectors or heat pumps. So far, so green, but manufacturing the* ***insulation materials for buildings consumes a lot of energy*** *and raw materials. In addition, the issue of subsequent disposal has not been resolved yet.*

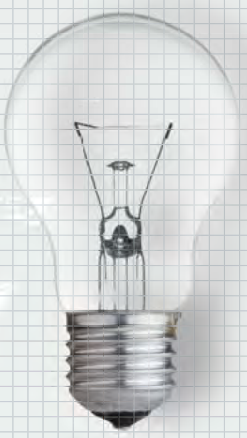


WASHING MACHINES ARE NOT BECOMING MORE ENERGY-EFFICIENT



In Europe, private households consume a third of the total energy used. Heating accounts for a little ***more than half of consumption,*** *while lighting, cooking and electrical appliances are responsible for another third. The consumption by household appliances has* ***dropped by an average of 50 percent in the past 30 years.*** *Examples: A fridge freezer built in 1992 on average uses electricity for 145 euros per year and a more modern unit less than 50. In a comparison of conventional with induction cooktops the result is 83 euros versus 65. But consumers should bear in mind that, in view of environmental considerations, replacing older electrical appliances that are still functional doesn't always make sense (see page 60). Plus,* ***progress in terms of energy efficiency has its limits.*** *Washing machines, for instance, are not going to become more energy-efficient within the foreseeable future. The reason is that for clean results a minimum of water is needed which has to be heated. The only alternative is to lower the washing temperature: a laundry load run at 40 degrees centigrade consumes about a third less energy than one at 60.*

50 watts =
one candela



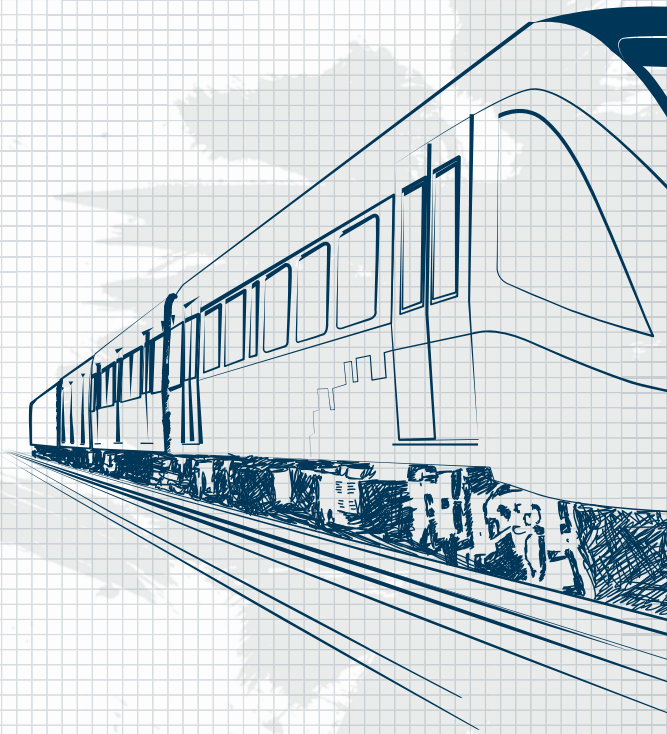
60 watts =
730 candelas

112 watts =
730 candelas

9 watts =
730 candelas

CANDLES
WASTE ENERGY

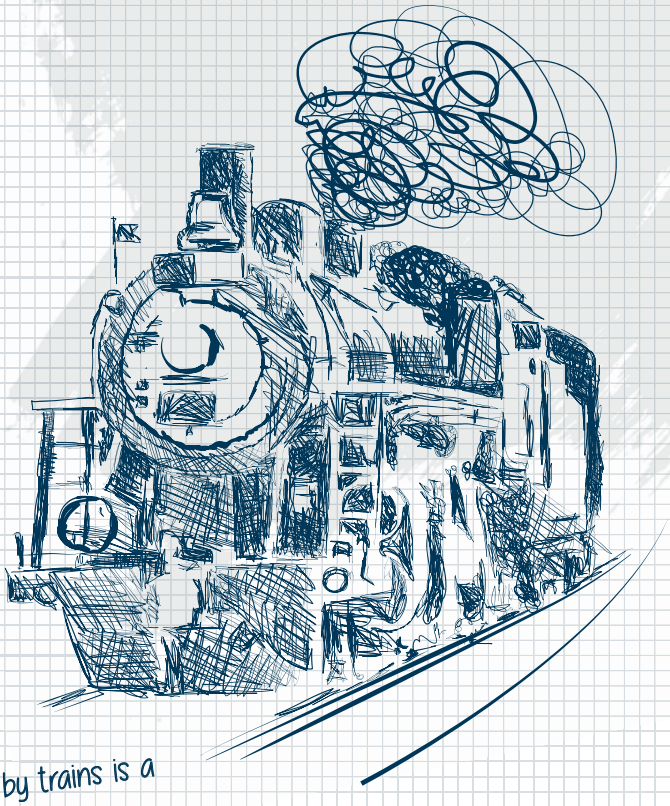
Generating light is one of electricity's key uses. Electric light easily makes our days longer and thus ***increases productivity.*** *Today, light accounts for about four percent of our energy consumption. Too much? Certainly not when looking back on the good old candle. While its light may be cozy the relationship between the amount of energy spent and the brightness it produces is pretty poor. The flame on the wick transforms energy of* ***50 watts into the luminous intensity of 1 candela.*** *For comparison: A 5-watt bicycle lamp without a reflector delivers 2.5 candelas, and even 250 candelas with a reflector. The candle gives off most of its energy in the form of heat. Incandescent* ***light bulbs – albeit to a lesser extent – struggle*** *with the same problem and are therefore under threat of extinction. LEDs are currently the most efficient lamps. An* ***LED with equal light output uses up to 90 percent less energy than an incandescent light bulb.*** *The higher purchasing costs of LEDs are offset by roughly ten times longer life. The disadvantage of LEDs is that when they're broken the entire lamp or bulb sometimes has to be disposed of because the LED itself can't always be replaced. In that respect at least, a candle holder was more efficient.*



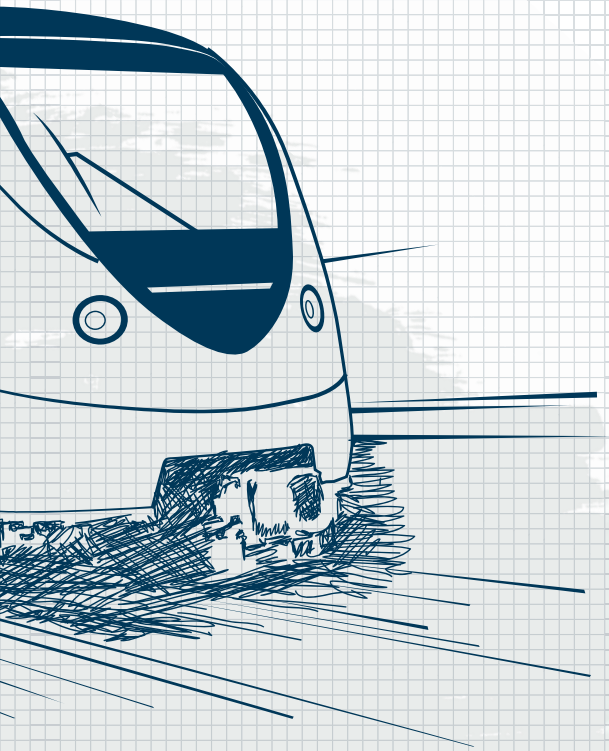
FROM STEAM TO THE HYPERLOOP

133 kilos of CO_2 = a lot of smoke for 90 km/h

The conquest of the American Frontier was marked by smoking guns and smoking steam locomotives. Those days are long gone. Today, the coal-fired iron monsters only smoke on selected railroad tracks, mostly in tourist regions. The last Deutsche Bahn iron horse retired in 1977. The ***most powerful steam locomotive ever used in Germany,*** *the Henschel 45 003-Series from 1940, delivered an output of 2.2 MW (3,000 hp) and achieved a speed of 90 km/h. In addition to plenty of harmful substances and soot particles, it would blow 133 kilograms of CO_2 per kilometer into the air. For comparison:* ***A modern compact-class car exhales not even one thousandth of that.*** *And even a Deutsche Bahn ICE 3 – with power of 18 MW (24,480 hp) and a speed of more than 300 km/h – settles for 1.2 kg/km CO_2 emissions based on the* ***annual average consumption of all ICE 3 trains of 2 kWh/km*** *and the German energy mix (fossil, renewable and nuclear energy). However, since Deutsche Bahn uses 100 percent 'green' electricity no CO_2 greenhouse gas is emitted at all. Even in comparison with a magnetic levitation train (500 km/h, consumption of 6 kWh/km and CO_2 of approx. 3.6 kg/km) the steam locomotive looks pitiful. However, as the speed*

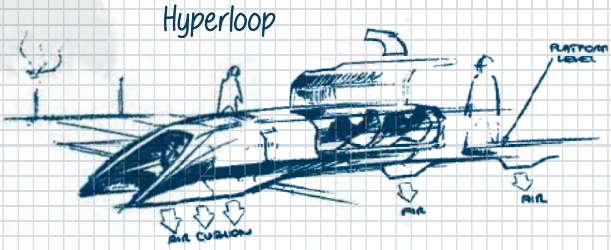


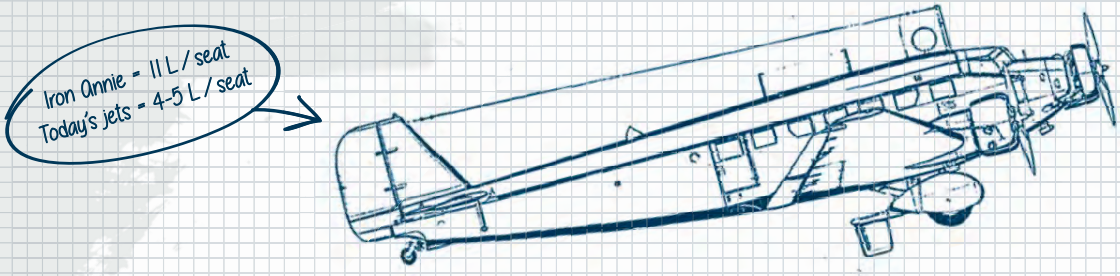
92-95 dB at 80 km/h - noise pollution by trains is a significant environmental issue



of the high-speed trains increases, so does their consumption. The electricity consumption of the Hyperloop planned by Tesla's CEO Elon Musk that is to accelerate to 1,200 (!) km/h in vacuum tubes has been projected to amount to 4.4 GWh (4.4 million kWh), per day (!). However, this electric power, ***which equates to the daily requirement of a city with a population of 360,000,*** *is to be produced by the system itself. Solar panels are planned to be installed on the top tubes of the Hyperloop and wind turbine towers could serve as supporting pillars. In addition, energy is recuperated on braking the encapsulated train. This alone is intended to recover over 60 percent of the energy required for propulsion.*

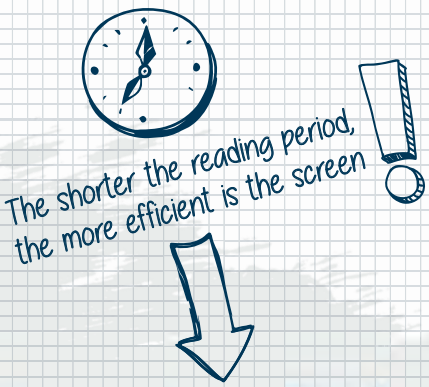
Hyperloop





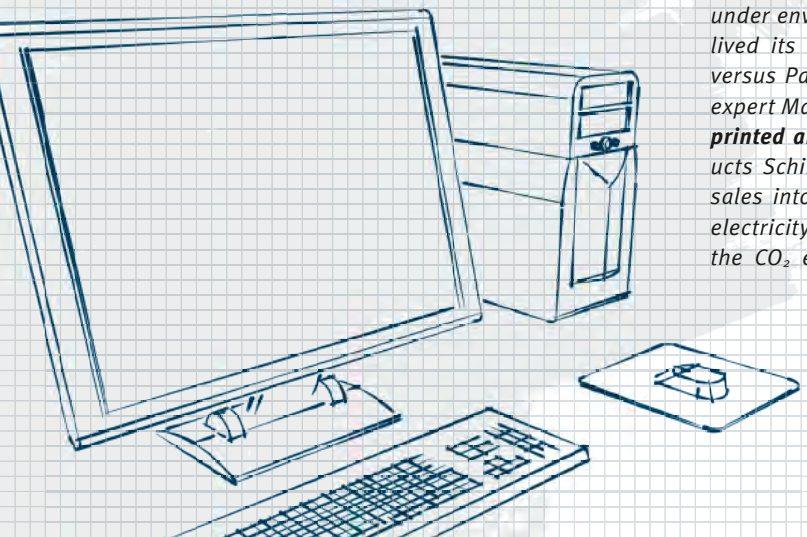
AIRPLANES HAVE BECOME 30 PERCENT MORE ENERGY-EFFICIENT

The Sikorsky Ilja Muromez from 1914 was the world's first passenger aircraft, according to Wikipedia. It had a passenger cabin for 16 people and a saloon with a washroom. Equipped with four 220-hp engines, it achieved a maximum speed of 130 km/h and a range of 500 kilometers. ***The famous Junkers Ju 52 from 1932, nicknamed 'Iron Annie,'*** *with its three propeller engines consumed about 11 liters per seat and 100 kilometers, which is the way consumption is stated for commercial passenger aircraft. Its range was nearly 900 kilometers and its maximum speed 250 km/h, which is just below a third of today's commercial aircraft.* ***Modern airliners consume about four to five liters per person and 100 kilometers.*** *However, this only applies to long-haul flights of about 1,500 kilometers and more. On short hauls of up to 1,000 kilometers, consumption ranges between seven and eight liters. This is due to the start phase consuming a large amount of fuel because the engines have to deliver their full power output. On long-haul flights, the short starting phase in relation to the total distance is not significant. Kerosene, the fuel used by modern jet engines,* ***doesn't emit any more CO_2 than normal diesel fuel.*** *The problem is that due to the altitude of the aircraft the* ***harmful CO_2 is emitted significantly closer to the sensitive upper atmosphere.*** *And due to the rapid growth of air traffic (at twice the rate of the global economy) more and more pollutants get into the atmosphere.*

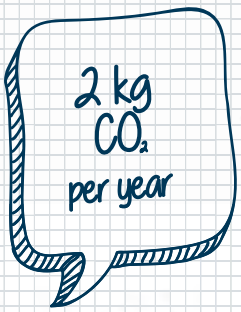


PRINTED PAPER IS OFTEN 'cleaner' than e-paper

The good old paper for news or book printing – at least under environmental aspects, it is far from having outlived its usefulness. In his 'Carbon Footprint Digital versus Paper' report published in 2010, sustainability expert Markus Schinerl ***compared all CO_2 emissions by printed and digital media products.*** *With paper products Schinerl took shipping, production, printing and sales into account. With digital media, in addition to electricity consumption, he based his comparison on the CO_2 emissions generated by the production and*



disposal of the digital devices used to read them. As these levels vary heavily for desktop computers, notebooks and e-readers, they were assessed individually. The utilization of a desktop computer causes the highest CO_2 emissions and of an e-reader the lowest. The results: the longer the reading period, the better the rating achieved by the printed product. In a 20-hour read of a Harry Potter book, ***only the e-reader can keep up with the paper book.*** *All other devices are clearly worse in terms of their carbon footprint. When reading a daily newspaper, says expert Schinerl, the digital variants are generally more favorable when the reading time is less than half an hour. Only with two hours and more the tables turn in favor of the printed product. Research by the Royal Swedish Institute for Technology tends to see the daily paper in front. According to these findings, every individual that buys and reads a daily newspaper for one year is responsible for the related emissions of 28 kg of CO_2 per year. The equivalent of 30 minutes of computer usage per day corresponds to 35 kg of CO_2 per year, according to the Scandinavians. Another finding shows that* ***digital words can harm the environment more than one might suspect.*** *Nearly 70 percent of the worldwide e-mail traffic is email spam, according to Kaspersky's 2013 Spam Report. The resulting worldwide energy consumption amounts to 33 billion kWh. This corresponds to the consumption of 2.4 million U.S. households*



A SMARTPHONE REQUIRES SEVEN TIMES MORE ELECTRICITY THAN AN OLD CELL PHONE

Every evening the same worry: Will the battery of my smartphone last until I get home? While the battery of a 'normal cellphone' like the Nokia 6310 from 2001 easily lasted for a week, the ones in some of our high-tech smartphones won't even last for 12 hours. ***So are these modern devices power hogs?*** *Yes and no. The fact is that the high-powered processors and huge illuminated displays drain the batteries in clearly less time. The reason: even though today's devices obviously have a lot more capabilities their batteries haven't kept pace with these developments. While the battery in the aforementioned Nokia 6310 still had a capacity of 6.7 watt hours, the one in the iPhone 6s merely achieves 6.4 watt hours. So it's no wonder that it has to be charged seven times as often. Ergo, the modern smartphone uses seven times more electricity than the old cell phone. Thus, over the period of one year,* ***smartphone CO_2 emissions amount to a little more than two kilograms per device,*** *compared with the 300 grams of the cell phone from 2001. Even more significant, though, is the manufacturing process of a smartphone. Just the production of a processor that weighs a mere two grams consumes nearly 1.3 kilograms of fossil fuels, which corresponds to over four kilograms of CO_2 emissions.*

SCRAP OR

SAVE?

10 percent off, 25 percent off – can bargain hunting be brought into line with sustainability? Price, in addition to prestige, is often the key selling point. This applies to cars and smartphones as well as to computers or household appliances. If a low-priced product gives up the ghost after the warranty has expired, it's easy to suspect the manufacturer. Is a planned early end of life (experts talk about planned obsolescence) the reason for the failure? Siddharth Prakash, a senior researcher at Freiburg Oeko-Institut (Institute for Applied Ecology), investigated this question together with the Federal Environmental Agency.

by Carsten Paulun

Among other things, the durability study* examined household appliances, printers, notebooks and television sets. The troubling result: Today, devices are replaced earlier than they were twelve years ago. Compared with 2004, a washing machine is replaced 0.9, a dryer 2.8 and a freezer even 3.1 years earlier due to a defect, according to the research. A particularly conspicuous finding: More and more devices that aren't even five years old give up the ghost today. Their share has increased from 3.5 to 8.3 percent. So, is it true that industry systematically plans the end of its products in advance?

That Siddharth Prakash's research doesn't provide any clear proof of this didn't even come as a real surprise to the investigator himself. He even stated the reasons: The lower the price at which the products are offered, the sooner will consumers replace them in the event of a defect. The reason is that the costs incurred for a repair appear particularly high in comparison to a low selling price. So, a low selling price makes a subsequent repair appear to be an unlikely choice. An example: A washing machine purchased for 1,000 euros is more likely to be repaired for 200 euros than one that cost only 300 euros to begin with. Prakash refers to this as 'economic obsolescence.'

Some manufacturers take clever advantage of this in another respect as the U.S. website iFixit.com shows. The provider of repair guides and tools for smartphones and tablets dismantles these devices as soon as they hit the market. iFixit rates their repairability on a scale of one (lowest repairability score) to ten (highest repairability score). The Apple iPhone regularly gets a poor rating because it can only be opened with special tools, which means that users cannot replace the batteries themselves.

Price as a quality indicator

Let's return to the sensitive price issue. If image and prestige of a product don't matter, consumers tend to choose a low-priced one, albeit not the lowest priced

* Study by Oeko-Institut Freiburg and the Federal Environmental Agency, February 2016: 'Influence of the Usage Period of Products on their Environmental Effects: Creation of an Information Base and Development of Strategies against Obsolescence.'

» *As consumers, we don't know how long a product will last*

Siddharth Prakash

one, because word has gotten around that 'nothing is as expensive as a bargain' or 'buying cheap means buying twice.' Consumers desire high quality at low prices. Obviously, every product group has bottom price limits that clearly indicate that at a low price like this, it can be assumed that neither high-grade materials have been used, nor that the product's useful life will be particularly long. Werner Scholz from the Central Association of Electrical Engineering and the Electronics Industry (ZVEI) in an interview with 'Die Welt' said: "Some build washing machines that last for a whole generation. Others build machines that sell for 179 euros."

So, based on price, we can roughly guess the durability of a product but we can't glean any reliable information from it. Researcher Prakash views this as an issue as well: "As consumers, we don't know how long a product will last." Yet detectable durability would influence the purchasing decisions of many consumers. Therefore, the Federal Environmental Agency in Germany demands that manufacturers should have to indicate the expected life of appliances and consumer electronics in the future. Information in terms of operating hours is being discussed as individual usage of the devices by consumers varies so significantly that stating useful life in years appears too vague. Still, reliable information provided by industry as well as testing its truth are a very complex matter.

Many functional products are disposed of

Many consumers aren't even interested in particularly long life when it comes to certain products. Smartphones or TV sets in particular are loaded with innovations and frequently feature new developments. Therefore, as consumers, we tend to buy a new smartphone or TV about every three years irrespective of the product's usable life. So, it comes as no surprise that, according to Oeko-Institut, one in two TV sets is disposed of although it's still functional, only because the consumer would like to buy a new model with more bells and whistles.

The cheaper consumer electronics become, the less attractive it will be to repair them

ZERO-DEFECTS PRINCIPLE

Schaeffler's customers rely on the product expertise and quality consistently delivered by the globally active supplier at very high levels. For nothing is more costly than a machine failure caused by the cheap purchase of a component of inferior quality – be it for a hard-to-access wind turbine, a vessel out on the ocean or even a space car on Mars.

Not least in light of these considerations, the interaction of defect-preventing and defect-detecting actions has been subjected to further development and consolidated at Schaeffler for many years. The 'zero-defects principle' that applies to all locations of the Schaeffler Group and stands for the stabilization of the processes and continuous improvement is the benchmark. It serves to detect and correct weaknesses at an early stage. The careful implementation of the 'zero-defects principle' ensures maximum process reliability and product quality across all stages – from engineering design to manufacturing to support.

Numerous customer awards over the years and certificates according to internationally valid standards prove the high quality standard of the Schaeffler Group. All production sites of the Schaeffler Group have valid certificates according to globally recognized quality standards such as ISO 9001:2008 or ISO TS 16949:2009. Not least due to this commitment to quality the Schaeffler Group received two dozen quality awards in 2015 alone, such as the Volvo Car Quality Excellence Award or the Global Quality Award from Nissan.

In the 'Product Safety Network,' Schaeffler initiated a communication platform that encompasses a large number of companies and is supported by the industry associations VDA, VDMA and ZVEI. The 'Product Safety Network' is under the patronage of the Federal Ministry for Economic Affairs and Energy. The membership is made up of companies with a broad portfolio of engineered and electromechanical products. The network aims to continuously improve product safety in the interest of consumers.

The network puts a special focus on the fields of passenger transportation and machinery and plant engineering. A periodic Product Safety Day serves to foster exchange among the network members. In January 2015, Schaeffler hosted the first Product Safety Day.

Smartphones are replaced for the same reasons. There's no market for a cell phone that lasts for ten years. Who would still like to use a first-generation iPhone from 2007 today? So, the development and production of such devices deliberately target a useful life of about three years. Consequently, the maxim tends to be 'as long as necessary' instead of 'as long as possible.' This either reduces the price of the product accordingly – or increases the manufacturer's margin!

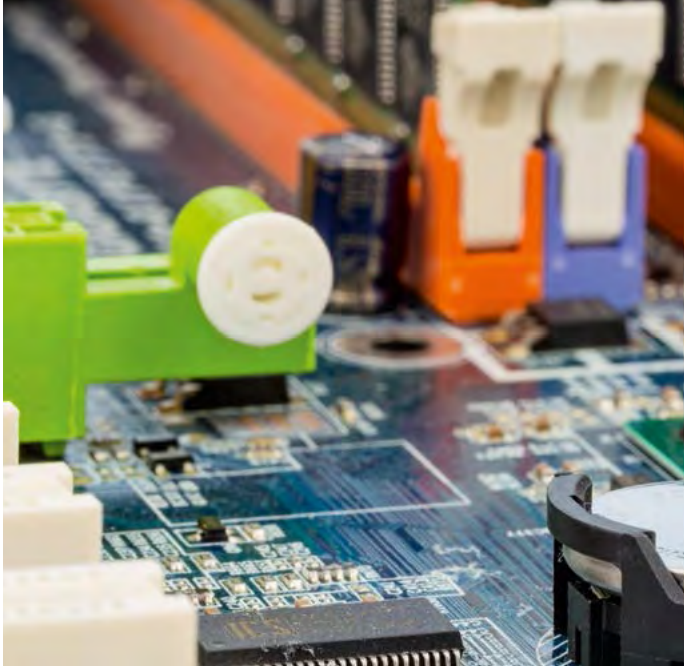
As a result of these strategies, many devices that could certainly be repaired are scrapped. The worldwide pile of electronic waste reached a weight of 41.8 million metric tons in 2014 – and counting, according to a report by the University of the United Nations. So-called 'white goods' such as refrigerators or washing

1/3 of the worldwide **electronic waste** is generated in the United States and China.

Source: University of the United Nations (2014)

300 tons of **gold** were recycled worldwide from electronic waste in 2014, roughly a tenth of the global annual production.

Source: University of the United Nations (2014)



60 MATERIALS

are contained in a cell phone: plastics, glass and ceramics for the housing and display, and 30 metals, predominantly copper, as well as many precious metals like gold, silver and platinum and rare earth metals such as neodymium and cerium in the interior. The quantities in a single device are small (incl. 250 mg silver, 24 mg gold) but about two million of these devices are sold around the world per year. Is there any good reason not to recover the 500 tons of silver and 48 tons of gold processed in the phones?

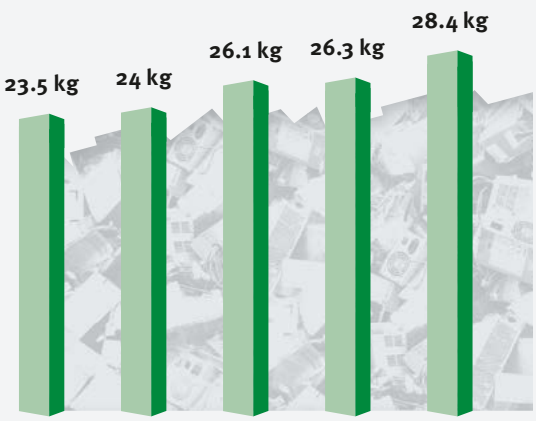
machines accounted for nearly 60 percent of this scrap. Discarded cell phones, printers or laptops accounted for seven percent of the total volume. The pile of waste equates to roughly 1.15 million fully loaded trucks which in a line would result in a length of 23,000 kilometers, the report adds.

Endurance runners score

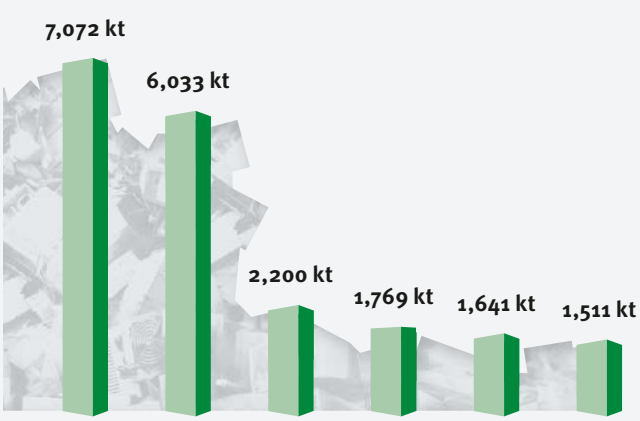
Only a sixth of this enormous amount of waste is being recycled. Most of it, declared as second-hand devices, migrates to developing countries with lax

THE ELECTRONIC WASTE PILE AND ITS MAJOR CREATORS

The top 5 in the per capita ranking (in kilos/year)



The top 5 of the country ranking (in kilotons/year)



Source: University of the United Nations (2014)

environmental regulations. At the same time, this waste represents significant value. The UN University's report estimates the material recycled from it to be worth 48.5 billion euros. However, the recycling heap was also found to contain 2.2 million metric tons of hazardous lead compounds, as well as mercury, cadmium, chromium, plus 4,400 tons of ozone-killing CFC.

So it's no wonder that consumer electronics with a long life pose a clearly less severe burden on the environment than those with a short one. For example, a washing machine with a life of 20 years causes 40 percent (1.1 metric tons) less CO_2 than a machine with a short life. The better energy efficiency of more modern models does not by far offset the environmental burden caused by their production and disposal. For notebooks and TV sets Siddharth Prakash came up with similar findings when he compared the environmental footprint of products with short and long lives. The cumulative energy investment in the production, usage and disposal of a notebook with a useful life of 3 years is about one fourth higher than that of one with a long life (12 years). Its greenhouse potential is about 36 percent higher as well, including an additional 300 kilograms of CO_2.

For television sets the results for 'sprinters' (3-year life) versus 'endurance runners' (12 years) revealed a plus of 28 percent in energy investment, a plus of 25 percent in greenhouse potential and a plus of 600 kilos of CO_2. Or simply put: The greater environmental compatibility of products with a long useful life cannot be denied. Prakash therefore demands that "in addition to mandatory minimum quality requirements, incentives should be created to encourage private and public consumers to use the products longer."

FORMS OF **OBSOLESCENCE**

Obsolescence refers to an item no longer being useful or in use. Product obsolescence is usually caused by changes in the technical or psychological realm. The following distinctions are made:

Planned obsolescence
The useful life or function of a product is deliberately reduced by the manufacturer to motivate the consumer to purchase a new product.

Indirect wear
A component of a device will be prone to faster wear because another component is inferior. This is the case for example when batteries are excessively stressed or overheat.

Functional obsolescence
The product itself remains functional but cannot be fully used due to new requirements imposed by complementary functions. For example, a lack of drivers for a new operating system severely impairs the utilization of a PC.

Economic obsolescence
A defective product may be technically repairable but the costs incurred for the repair are out of proportion to the product's value.

Psychological obsolescence
Frequently induced by trends and fads, a product that's still completely functional is replaced by a new, more popular one.

» You cannot learn a sailor's life by practicing in a puddle Franz Kafka

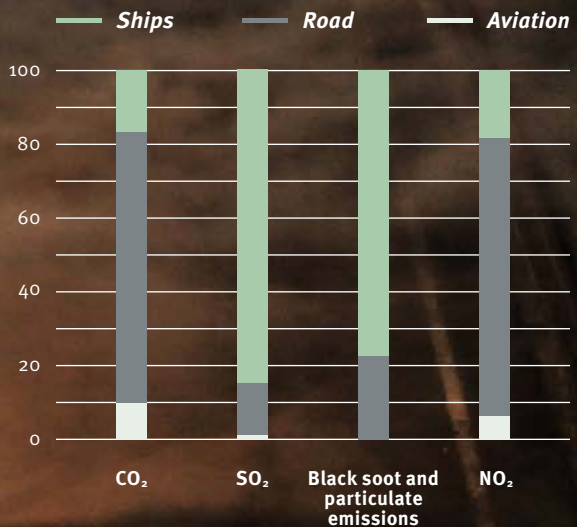
here and now

Living with progress

CLEAN **BUNKERING**

Black trails of smoke, air pollution – seaports in particular suffer from ship smog. The usually older propulsion plants of large vessels predominantly burn cheap, sulfurous fuel oil and blow plenty of fumes and particles into the air. New requirements are intended to motivate ship owners to start looking for alternative fuels. One of them is liquefied natural gas (LNG) which, here at the Rostock harbor, cooled down to 160 degrees centigrade, is being pumped into the belly of a cement carrier. A few ferries have been crossing the Baltic Sea running on LNG as well. Yet the LNG infrastructure is still sparse, its expansion fraught with hurdles. "I wouldn't have thought that using LNG in ships is so complicated," said Monika Griefahn, Environmental Representative of Rostock-based cruise line company AIDA, in an interview with 'Spiegel' magazine. Not the technology, she said, but the approvals involved the greatest complexity. Still, AIDA is planning to increasingly use LNG – initially, in anchorage and, starting in 2018, when sailing the high seas as well. The question is whether captains will actually be making increased use of LNG in their dual-fuel engines or – as feared by environmental organizations – continue to burn cheap oil. Cost pressures are high and offshore inspections difficult …

CONTRIBUTION OF TRANSPORTATION TO GLOBAL EMISSIONS IN PERCENT



Source: zeit.de

TURNING **TIDE**

Electricity generated from the ebb and flow of the tides? Not only are tidal power plants invisible, they supply renewable energy regardless of weather conditions. This technology is being tested in countries such as France and the Netherlands – with help from Schaeffler.

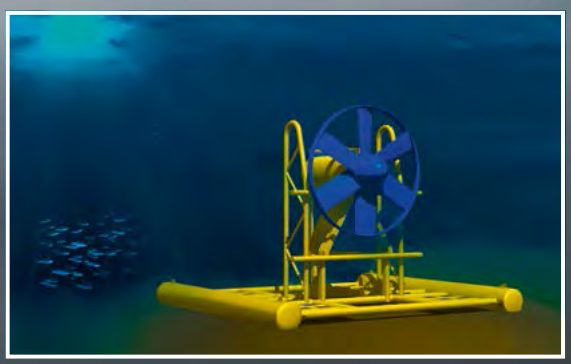
by Laurin Paschek

In 2015, French turbine manufacturer Sabella installed France's first ocean current turbine in a strait between two Breton islands

It is only a few steps from Hans van Breugel's office to the testing facility at the Afsluitdijk causeway. The CEO of Dutch turbine manufacturer Tocardo seems to be well known around here: Truck drivers passing him honk their horns, and van Breugel waves back at them. "Once you get on the dam, you have to keep going all the way to Frisia, the entire 20 miles (32 km)," he says. The long dam is part of the E 22 European road system connecting the Dutch provinces of North Holland and Frisia. It was built in the 1920s to separate the Ijsselmeer from the open sea and protect the shoreline from flooding.

Power from the Ijsselmeer

"For us, this is the ideal place for testing our turbines," says van Breugel. "The sluices are opened twice a day to let the water from the Ijsselmeer flow out." The water runs through four turbines Tocardo has installed right here at the sluice at a speed of 10 to 13 feet (three to four meters) per second. One of them, a prototype, has been endurance tested since 2008. The other three small T1 type turbines are production models with power of 100 kilowatts each. They have been supplying electricity since the beginning of 2015 – and a huge amount of valuable data that the developers at company headquarters



With a total height of 56 feet (17 meters), a rotor diameter of 33 feet (ten meters) and a weight of 450 metric tons, the 'Sabella D10' is a true colossus. The generator operating at a depth of 180 feet (55 meters) achieves an output of 1.1 megawatts

»» *Our turbines operate invisibly under water and have little impact on the environment*

Hans van Breugel, CEO of turbine manufacturer Tocardo

less than 500 feet (150 meters) away in Den Oever can use right away.

Ebb and flow – completely predictable

Their torpedo-shaped bodies and short blades make Tocardo's underwater turbines look like the outboard engines on large boats. They function in a way similar to directly driven wind turbines. Without the use of gearboxes, the rotary motion of the rotors is transmitted to a generator that produces the electricity. Since the density of the water is around 800 times higher than the density of the air – depending on the temperature – the rotor blades are considerably shorter than those of wind turbines. Three things are especially important to the developers of the underwater turbines: the optimal geometry of the rotor blades to catch as much flow energy as possible, the right speed control for all flow conditions and the safe support of the shaft in the aggressive salt water. Schaeffler worked closely with Tocardo engineers to develop maintenance-free tapered roller bearings that are also clearance-free due to the sealing requirements. "We have eight years' experience in the development of this trendsetting technology," van Breugel says proudly. "Our turbines are invisible under water and have little impact on the environment. The greatest advantage of tidal power plants though is that, unlike wind and solar energy, we know exactly how much electricity they'll produce at any given time." Since November 2015, Tocardo has been operating another facility on the 'Eastern Scheldt' barrier in the southwestern part of the country. In the Netherlands' largest tidal power plant, five 250-kilowatt turbines of the new T2 generation are in operation.

On the ocean floor

Engineers are also working on other European coastlines to see how the force of the tides may be used to produce electricity. In June 2015, for instance, French turbine manufacturer Sabella installed France's first ocean current turbine in a strait between two Breton islands. Unlike in the Netherlands, developers here have opted for size. With a total height of 56 feet (17 meters), a rotor diameter of 33 feet (ten meters) and a weight of 450 metric tons, the 'Sabella D10' is a true colossus. The generator achieves power of 1.1 megawatts. "We have found an ideal site at a depth of 180 feet (55 meters)," says Erwann Nicolas, Chief Engineer at Sabella. "Here, due to the topography of the ocean floor the water accelerates to about 13 feet (four meters) per second." The rotor and the shaft follow the rhythm of the ebb and flow: They change their direction of rotation depending on the current. This means high requirements for the bearings that Sabella purchases from Schaeffler. "These direction changes with low current speeds are the critical moments," Nicolas explains. "That is why we stop the machine briefly during the changes to prevent bearing damage." This does not have a negative effect on the generation of clean electricity. After being grid linked in November 2015, in January 2016, Sabella was able to report the production of 50 megawatt hours of tidal electricity by its facility in Brittany. By that time, it had already survived the severe fall and winter storms without any damage. Supported by public funding programs, the manufacturer is currently working on the next generation, 'Sabella D15,' which is expected to achieve a peak output of two megawatts.

Costs as the greatest challenge

At both Tocardo and Sabella, expansion planning is well underway – and with good reason: Both companies see the worldwide potential for tidal power plants at 100 to 120 gigawatts. This corresponds to the output of 70 to 80 nuclear power plants and could someday cover 10 to 20 percent of worldwide energy requirements. The most important requirement for leveraging this potential is reducing costs, for instance by increasing the number of plants produced. "In addition, it is important to design the components with cost in mind," says Erwann Nicolas. "That is why at Sabella we use standard bearings supplied by Schaeffler. To do that, we have even slightly adjusted the dimensions of the shaft to match the available bearings." Hans van Breugel, who plans to launch his third generation of turbines with an output of one megawatt in 2018 to 2019, is especially counting on the

To show what Tocardo's underwater turbines look like, Hans van Breugel hoisted them out of the water by remote control

roller bearing specialist's large product portfolio: "We need a wide range of efficient bearings to be able to scale the turbines," he notes. After all, he wants to install hundreds of new turbines over the next three years, in particular in Great Britain and Canada. In 2019, Sabella intends to place two type D15 turbines on the ocean floor as part of a French government project. In addition, between 2019 and 2020, five D15 turbines off the coast of the Philippines and four identical turbines off the Indonesian coast are expected to start grid operations. The production of clean energy from the ocean is thus entering the commercialization phase.

THE AUTHOR

Laurin Paschek *is co-owner of delta eta, a provider of editorial services, in Frankfurt am Main. As an avid hobby diver the technology journalist not only writes about hydropower but experiences it first-hand. He sees the current of the ocean as an important energy source of the future.*

800 x

higher than the density of air is the density of water – varying according to temperature. Therefore, the rotors of **underwater turbines** are clearly smaller than those of wind turbines.

10–20 %

of the **world's energy requirements** might be covered by **tidal power plants** one day. This equates to an installed output of up to 120 gigawatts.

4 m/s

is the **optimum speed** of an ocean current to produce electricity. Depending on their locations, tidal power plants have to take the tide changes into account as well.

100 LOCATIONS

in Europe alone are suitable for **tidal power plants,** for instance on the Dutch and French coasts. A particularly large number of them exist in the British Isles.

SUSTAINABILITY FROM A TO Z

Sustainability is more than a concept. The entire value chain of the Schaeffler Group is shaped by responsibility in all interactions.

by Alexander von Wegner

For Raluca Chetrusca, it's clear: no raw materials from regions of conflict. Chetrusca works for Schaeffler in Romania, in the Corporate Material Compliance department. "This way, we ensure that no violations of human rights occur in Schaeffler's supply chain," the specialist explains. Raw materials of dubious origin are not the only ones which are taboo at Schaeffler. The same applies to materials that are prohibited in production or sales countries. Michael Haas works in Herzogenaurach, some 1,500 kilometers away from Raluca Chetrusca, as Head of Product Line Variable Valve Train and Engine Applications. Together with his team he develops and manufactures technologies that help the automotive industry produce fuel-efficient and low-emission vehicles.

Two countries, two colleagues and two completely different lines of work – in addition to the same employer, Schaeffler, they and some 85,000 other employees share the contribution made to the company's sustainable activities along the entire value chain. It consists of the following six segments:

RESEARCH AND DEVELOPMENT
↓
PURCHASING
↓
PRODUCTION
↓
LOGISTICS
↓
MARKETING, SALES AND AFTERSALES
↓
RECYCLING

Sustainable practices, sparing use of resources and social responsibility are essential elements of the Schaeffler Group's corporate culture. That's why Schaeffler connects its economic success with responsibility for the environment, people and society.

Assuming responsibility

With good reason, as long-term profitable growth is not possible without a comprehensive commitment to sustainability. "Our customers increasingly make social and environmental demands in order to successfully market their products in the light of changing general conditions," emphasizes Pia T. Hoffmann, Corporate Responsibility Officer at Schaeffler. "Therefore, the objective is to assume entrepreneurial responsibility along the entire value chain. To assure this, sustainability aspects are consistently considered in the company's business decisions." Employees like Raluca Chetrusca and Michael Haas ensure that they're implemented. She and 17 other colleagues will reveal how on the following pages.

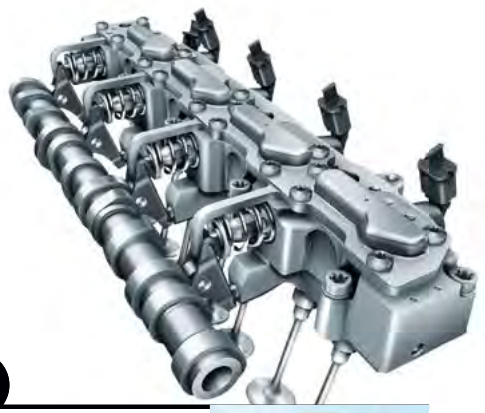
RESEARCH AND DEVELOPMENT

GAIN THROUGH SACRIFICE Schaeffler, for instance, has reinvented the classic torque converter for automatic transmissions. The iTC converter concept eliminates a separate lockup clutch and integrates this function in the converter. With hybridization, the engineers are taking this concept a step further.

» We're now taking the next step by marrying the torque converter with an electric motor. The result is a hybrid module for even lower consumption

Marc McGrath,
CEO Schaeffler Automotive Americas, USA

IN FREE FLOW Schaeffler has come up with an all-new way to control air supply to the internal combustion engine. Instead of a rigid intake camshaft, a UniAir actuator, fully variably, electronically and unthrottled, controls fresh air supply within the entire range of the engine map. In contrast to the previous purely mechanical control elements, a defined oil volume now controls the movements of the intake valve. As a result, throttle losses are a thing of the past.



» We flexibly control valve lift using UniAir valve train technology. Due to this optimization, we help the automotive industry develop fuel-efficient and low-emission automobiles

Michael Haas,
Head of Product Line Variable Valve Train and Engine Applications, Germany

330

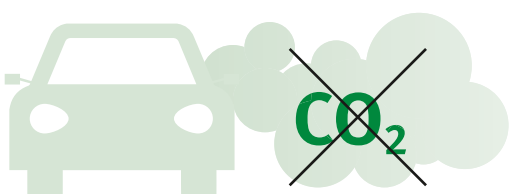
MILLION TIMES A SWITCHING VALVE SWITCHES DURING THE UNIAIR SYSTEM'S LIFECYCLE

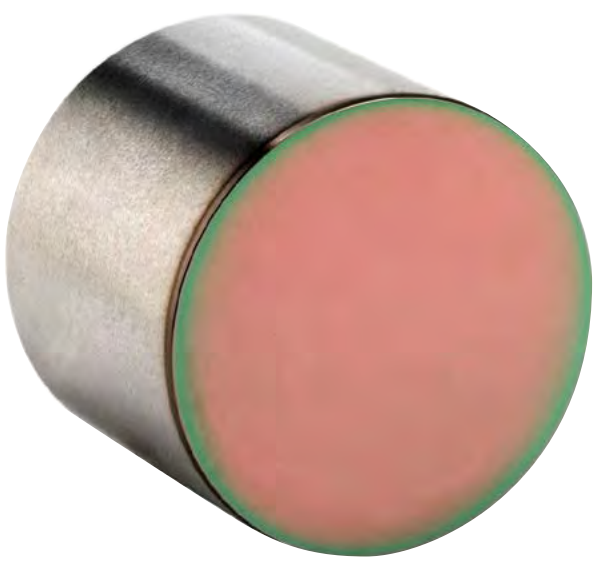
VIRTUAL INSTEAD OF REAL In the development of the roll stabilizer, Schaeffler's expertise in simulation technology pays off. The computer substitutes real-world test kilometers in the model under test. Mechanical components as well as electronics in the vehicle environment are now being simulated. Even the product itself helps save energy. Compared with hydraulic systems, the electromechanical roll stabilizer reduces fuel consumption by up to 0.3 liters.

» Simulation saves time and money when used at the right time. It helps explain physical correlations, understand the product and develop it with greater sustainability in mind

Dr. Tomas Smetana,
Head of Product Line Chassis Actuators, Germany

LAYER BY LAYER Lower fuel consumption starts with the reduction of friction-induced losses. The Schaeffler Competence Center Surface Technology develops coating methods to reduce friction between components. For example, the Triondur CH coating in the automotive valve train can reduce CO_2 emissions by up to two percent. With pendulum roller bearings even 45 percent lower friction can be achieved by using Triondur CX+.





PURCHASING

A WORLDWIDE COMMITMENT In 2015, Schaeffler purchased goods and services from 33,000 suppliers in 80 countries. Suppliers have to meet particularly high demands – such as certificates for environmental management systems. Where possible, Schaeffler opts for local proximity of its suppliers in its sourcing activities in order to reduce shipping requirements and the resulting environmental impact. Schaeffler has been committing its suppliers to the Schaeffler Code of Conduct for several years to ensure adherence to human rights, health & safety as well as environmental protection and regulatory compliance. In the future, a separate Supplier Code of Conduct will ensure this in even greater detail.

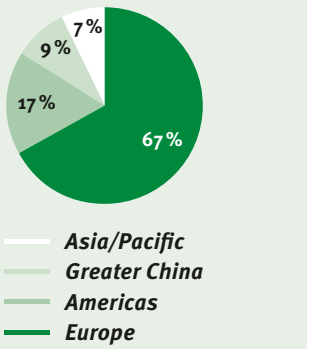
» Since 2015, Environment, Health and Safety have been essential elements of our supplier programs

Thorsten Bünning,
Head of Quality Purchasing, Processes & Methods, Germany

» Aligning the structure of our supplier management with today's needs strengthens quality and logistics, and helps shape the concept of sustainability in the supply chain for our future

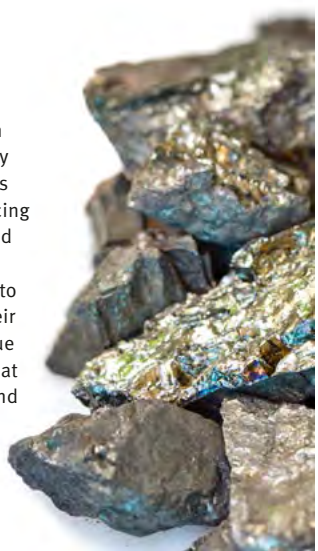
Andreas Knoll,
Head of Purchasing European Region & Corporate Supplier Management

PURCHASING VOLUME OF THE SCHAEFFLER GROUP



IN THE REGION – FOR THE REGION
SCHAEFFLER OPTS FOR LOCAL PROXIMITY OF ITS SUPPLIERS

NO RISK Initially a legal requirement imposed on publicly quoted corporations in the United States, it has long become a global customer requirement to be met by the entire supply chain: the demand not to use certain raw materials from regions of conflict. Tin, tungsten, tantalum or gold, for instance, may contribute to financing armed conflicts in some Central African countries. In 2013, Schaeffler established a monitoring process to trace the origin of these raw materials. Furthermore, the company complies with substance prohibition standards and requires suppliers to implement them as well. A material database contains all materials used and their properties. In addition to Schaeffler products, purchased parts are classified. Due to continual monitoring of the latest legal requirements, the company ensures that substitute processes or substitute substances are developed at an early stage and used in new products.



THE ‘REASONABLE COUNTRY OF ORIGIN INQUIRIES’ CONTAINS INFORMATION ABOUT THE ORIGIN OF CONFLICT MINERALS, IN OTHER WORDS RAW MATERIALS FROM REGIONS OF VIOLENCE

» We consistently observe all substance prohibitions in our manufacturing countries and monitor the developments of material-related legislation in our sales regions. As a result, we are able to respond in time to market changes and develop economical alternatives that simultaneously meet maximum product quality and safety standards

Jens Herrmann,
Corporate Material Compliance, Germany

» In Brasov, strategically relevant suppliers are centrally evaluated in coordination with Purchasing to determine and trace the regions on the globe from which the ores of our raw materials originate. This way, we ensure that no violations of human rights occur in Schaeffler’s supply chains

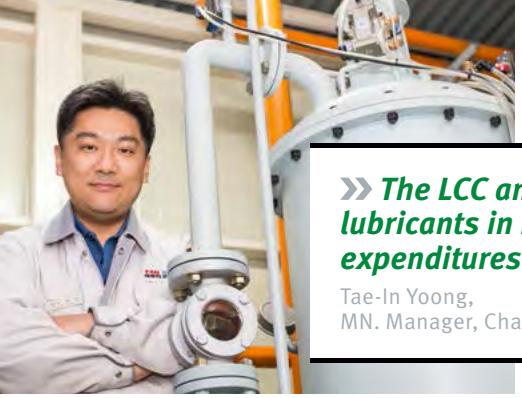
Raluca-Veronica Chetrusca,
Corporate Material Compliance, Romania

PRODUCTION

LONG-TERM COST BENEFITS In a lubricant line in Korea, a compressed air line in the United States and other facilities, Schaeffler demonstrates that lifecycle costs can be cut by purchasing new machines. Although this may result in higher capital expenditures, the lower operating costs of the new machines reduce expenditures across their entire lifecycle.

» Through Life Cycle Costing (LCC) we can make the operating costs of our machines and equipment transparent and reduce them. In addition to energy savings, reductions of CO_2 emissions can be achieved this way

Philipp Münzel,
Corporate Construction, Energy Management & Maintenance, Germany



» The LCC analysis of our new equipment for lubricants in Korea shows that higher capital expenditures can be offset by operating cost savings

Tae-In Yoong,
MN. Manager, Changwon/South Korea

» With an LCC for our compressed air equipment in the United States we were able to demonstrate that additional capital expenditures often result in a fast return on investment due to lower operating costs

Marco Groke,
Plant facilities, maintenance, Joplin/USA

WORLDWIDE VALIDITY Quality and products meet identical standards around the globe – this is Schaeffler's commitment to making mobility of tomorrow possible. Product quality is the prerequisite for low-emission and energy-efficient local and long-distance transportation. A central management handbook prescribes rules and processes for all locations. Audit and review processes ensure compliance with these requirements. In addition, every unit has quality managers or quality representatives. As a result, products from Mexico meet the same standards as those from North America, Europe or other locations.

» In Mexico, we are committed to the zero-defects principle as well and thus ensure maximum process reliability and product quality across all stages – from design to manufacturing to support and service

Eduardo Castilla,
Quality Manager, LuK Puebla, Mexico

BRILLIANT ACHIEVEMENT What's the best way to save resources? Eliminating entire process steps. But that's easier said than done. Still, in the field of metal forming, Schaeffler has achieved a remarkable feat. By now, the tools used for metal forming and subsequent heat treatment operate so precisely that the form and surface of the resulting components is of very high quality. Consequently, the previously customary step of grinding has been eliminated. Numbers illustrate the required precision: dimensions may vary only by a few micrometers although deformations can easily occur for instance in the hardening process step.

0.000001 meters

1 µM (MICROMETER) EQUATES TO A MILLIONTH OF A METER. FOR COMPARISON: A HUMAN HAIR IS 50 MICROMETERS THICK

» In production development, we pay attention to the high quality and value of our products, and to making sparing use of resources

Dr. Peter Bach,
Head of Development Production Technology, Germany

SAVING BY LASER WELDING Laser welding opens up new possibilities of saving electricity. New disc lasers replace old rod lasers and thus reduce power consumption by 88 percent, cooling capacity requirements by 69 percent and circuit water consumption by 92 percent. As a result, Schaeffler saves about 730 megawatt hours of electricity at its Herzogenaurach site – equating to the annual electricity consumption of about 200 four-person households.

88 PERCENT **ENERGY CAN BE SAVED BY WELDING WITH DISC LASER SYSTEMS**

LOGISTICS

KEEPING PACE WITH THE TIMES Logistics in an increasingly integrated globalized economy is not only a matter of time and money. In addition, there's the aspect of sustainability whenever geographic distances as large as those between Europe and China have to be covered. Schaeffler uses an environmentally friendly alternative to ocean and air cargo: rail transportation.

» Our rail transport services in both directions between Europe and China offer an attractive and resource-preserving alternative to air and ocean cargo

Bernhard zur Strassen, Head of Corporate Network Design & Transportation, Germany

» *One of the reasons why our customers in China select us is that we offer a fast and resource-saving logistics solution by rail*

Ludger Tillmann,
Head of Logistics China

MARKETING, SALES AND AFTERSALES

PRODUCT PIRATES LOSE OUT Schaeffler rigorously pursues product pirates around the globe. In doing so, the company not only initiates legal prosecution but takes preventive action as well. The Schaeffler GS1 Data Matrix Code makes every object a unique item and enables its authentication. Counterfeit products lead to property damage and, in the worst case, personal injury. Schaeffler estimates its own business losses incurred as a result of fakes across the entire product portfolio to be in the range of one percent of sales: about 130 million euros.

$1,700,000,000,000

THE INTERNATIONAL CHAMBER OF COMMERCE ESTIMATES ANNUAL ECONOMIC LOSSES INCURRED BY PRODUCT PIRACY TO AMOUNT TO 1.7 TRILLION U.S. DOLLARS. THIS EQUATES TO TWO PERCENT OF THE GLOBAL ECONOMIC OUTPUT

» *In order to ensure effective protection of our brands around the globe, we are complementing legal with preventive actions such as the security code for our original products*

Ingrid Bichelmeir-Böhn,
Industrial Property Attorney, Germany

CONDITION MONITORING Schaeffler has developed systems for condition monitoring which increases the availability of machines and equipment. At the same time, it allows equipment to be operated with greater reliability and efficiency. Companies can thus align maintenance and repairs with the respective condition of a machine. This is a major step ahead compared with conventional methods using preventive or reactive measures. Schaeffler's systems meet high demands made on sensors, acquisition and automatic processing of the measured data. The FAG SmartQB early warning system is new. It detects irregularities in electric motors, pumps, blowers and their rolling bearings. The human-readable text messages on the 7-inch display are truly a novelty in the condition monitoring market.

» By means of the automatically generated human-readable messages in FAG SmartQB Schaeffler offers an easy-to-use and intelligent machine condition monitoring solution. Thus, machine times and availability can be increased for the owner without incurring additional engineering expense. As a result, this solution can be cost-efficiently used even on smaller machines and ancillary components. FAG SmartQB reduces life cycle costs and saves valuable resources at the same time

Volker Erberich,
International Service Management

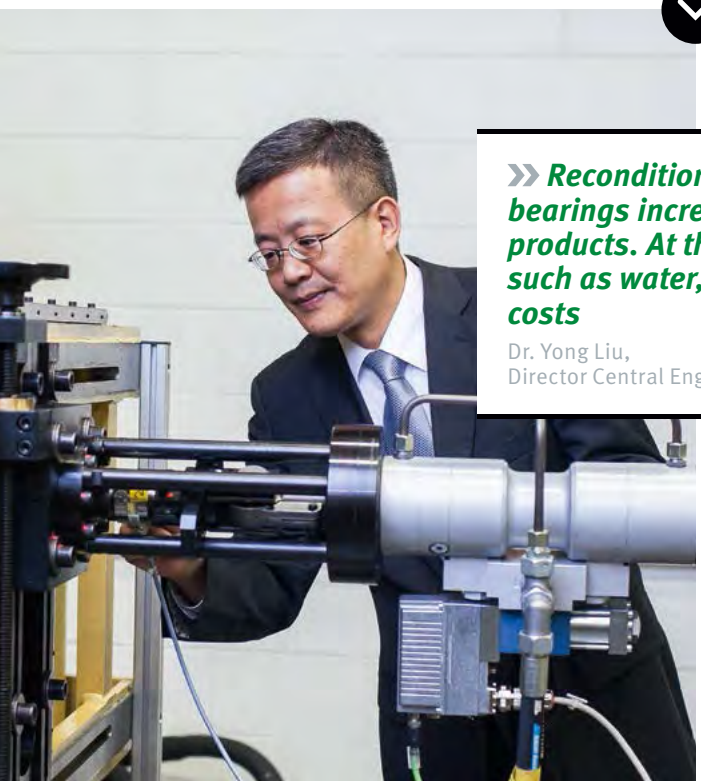
RECYCLING

SORTING AND SEPARATING In the United States as well, Schaeffler has been setting an example. The 'Zero Waste to Landfill' project consists of the strict separation, avoidance and recycling of waste. Companies and municipalities that avoid more than 90 percent of the waste that would otherwise be disposed of are classified as 'zero waste.' At its Fort Mill site in South Carolina, Schaeffler has had a workshop to achieve better sorting and to reduce the amount of waste generated. "Our 'Zero Waste to Landfill' project is focused on continuously improving our campus' environmental responsibility," says Ken Brown, EHS Coordinator at Fort Mill.

LIQUID TURNS INTO SOLID In China, Schaeffler has a site in Taicang. The grinding sludge generated there can be compressed to form briquettes used as fuel to generate heat. At the same time, oil is recovered in this process.

> *Our briquetting plant accomplishes two purposes: it cuts the amount of waste in half and makes the oil available again to manufacturing*
>
> Li You,
> EHS Regional Coordinator, China

SECOND LIFE Schaeffler has developed a process to make the wheel bearings of rail vehicles in China reusable at the end of their normal mileage.



> *Reconditioning of used rail vehicle wheel bearings increases the lifecycle of our products. At the same time, we save resources such as water, reduce CO_2 emissions and cut costs*
>
> Dr. Yong Liu,
> Director Central Engineering, China

WILL VS. DOING

What's stopping us from saving the world? Nothing, if it weren't for juicy steaks, roaring V8 engines and the travel bug. About the dilemma between ideals and reality, temptation and confusion, the automobile and the bicycle.

by Wiebke Brauer

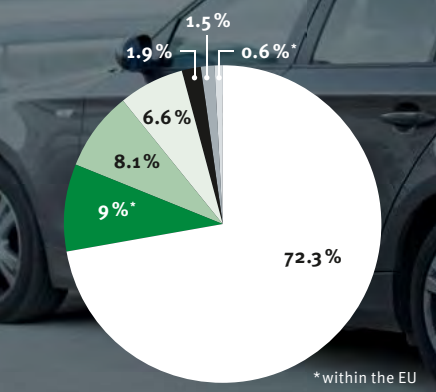
ING

Good intentions have more enemies than a wild boar at the beginning of the hunting season. On the one hand, we have our ideals. Our wish to protect living creatures instead of just devouring them in the form of salami. The noble ideas of adopting a lifestyle that protects the climate and of assuming social responsibility. Living with sustainability in mind and a decent environmental footprint that leaves a clean and livable planet to future generations – that would be the way to go. We could wipe the slate clean and go on living with a clear conscience! An exhilarating thought. If it just weren't for that salami. Flavored with truffles and tickling our tongue with its savory freshness still giving a taste of the muddy forest ground the hog used to wallow in. And, if it weren't for that internal combustion engine exuding a tempting air of freedom and adventure, of power and grandeur. Plus, that incredibly cheap Caribbean vacation! Temptations are lurking around every corner.

However, the question is if sacrifice alone is the answer. How noble are these ideas in reality, how helpful the things we give up, how sensible our aspirations? Couldn't it be that, instead, we get entangled in a ball of modernistic dogmas, hypocritical ethics and a trendy lifestyle? Life was a lot easier in the days when "grub came first, then ethics" and after us, the deluge.

12,700 km

are covered by an EU citizen on average per year using **powered transportation,** broken down as follows:



- *passenger cars*
- *bus*
- *motorcycle, moped, etc.*
- *airplanes*
- *train*
- *subway, street car*
- *ship*

Source: Federal Statistical Office of Germany, 2013

European champions

in using automobiles are the Cypriots. 89 % state that **cars** or **motorcycles/mopeds** are their primary means of transportation. The Czechs head the list in public transportation, with 37 % using mainly **buses or trains.** The Romanians are a front runner in terms of **walking** (29 %) and the Dutch when it comes to **cycling** (31 %).

Source: Eurobarometer

At least, that's the way it seems when taking a closer look at the difference between eco-mania and reality. Unless we happen to be one of those warriors of the green religion hopping around the countryside toting jute bags, eating algae tofu and cleaning their teeth with a birch wood toothpick at night, we get up in the morning, grab some coffee-to-go in a disposable cup, get into our SUV for a 12-minute drive to the office. Riding our bicycle to work? Not today, because there's a light drizzle. At lunch, we may have a steak and for dinner, a glass of wine with our pasta, maybe followed by a cigarette while we look forward to our next long-haul journey. Here's some data to slightly temper these little everyday delights: We eat 60 kilograms of meat per year, every German, according to Greenpeace, causes six times the carbon dioxide emissions the Earth can tolerate and – to really put a damper on things – we should face the fact that we produce 221.5 kilograms of packaging waste per year. So, what are the alternatives? Sure, we could join the zero waste movement and stop leaving any trash behind. We could shop in stores that offer their wares without plastic packaging or even with no packaging at all: a great idea but one that's hardly feasible unless you happen to live in Berlin-Kreuzberg where the chance of finding such stores is greater than, say, in Cuxhaven. Plus, this plan becomes even more impossible to carry out if you don't feel like doing your shopping armed with Tupperware boxes – or have an insatiable craving for Nutella sandwiches. Oh well, if it were just the Nutella sandwiches … Only one in three German drivers can imagine buying an electric vehicle, according to a forsa survey commissioned by CosmosDirekt. And what about the others? 37 percent may seem like a lot but all other Germans indulge a different dream. Aside from the majority that doesn't trust the range of an electric vehicle or can't afford to buy one, there's a small group of those that defy reason and worship the internal combustion engine. At night, these fuel heads mutter words like self-ignition, combustion chamber, natural aspirated engine and glow

plugs. That's sexy, combines pyromania, the smell of fuel and the power of cubic capacity!

There's reason to suspect that these nostalgic folks would never dream of letting someone else use their beloved vehicles. "Sharing is caring"? Perhaps it is. But 61 percent of German automobile owners never lend their car to someone else – in spite of the sharing economy being touted as the new promised land of happiness. By the way, there's no research available about the number of people that would rather sell their mother than lend their car to a stranger. Perhaps we're lucky there isn't.

The deceptive footprint of the organic avocado

Anyway – would you be a better person if you sped down the asphalt on electric power? Like that of conventional automobiles, the consumption of electric vehicles is a lot higher than the manufacturers say, according to research by the Department of Transportation of the Technical University of Denmark (DTU). So, here we are with the controversial issue of how to generate electricity as ironically expressed in a slogan coined in the Germany of the eighties in response to the country's anti-nuclear power movement: "My power comes from my household socket." The crux of the problem in a world that is hyper-complex to begin with: For any type of research published, you can find another study or argument that refutes it. It starts with electric mobility and continues with food. The choice not to eat anything with a face is an honorable one. But what about all the single-celled organisms and worms being killed by grain and soy bean monocultures? And isn't it true that even rain forests are being cut down to satisfy the growing demand by tofu consumers? Whatever we do, it's a catch 22. However, just shrugging our shoulders and heading for the next burger drive-through in our Chevrolet Camaro isn't the way to go either. Well, not always.

Obviously, we need to address our personal responsibility for this planet. But why not poke a little fun at veganism apparently being the new promise of salvation for the consumer society? Rational people will go out and buy vegan sausages or burgers produced by well-known meat brands in order to stand out from the crowd of normal omnivores. Others spend incredible amounts of money on organically grown avocados from Chile whose carbon footprint is probably larger than that of any European foreign minister. The high prices for organic products work a little like buying indulgences from capitalism. Those who can afford it buy absolution, feel healthier, physically optimized and morally superior. We can either respond by criticizing or ridiculing such trends. But we don't have to. There's nothing wrong with a desire to ease one's conscience. Revamping your karma and polishing your halo? Some may find that silly, but it's only human. When trendy excesses and sanctimonious self-delusion make us ride our bicycle to work and feeding our face with a vegan burger just on a single day while, miles away, an old wild hog wallows in mud without having been converted into truffled salami – than we may not have saved the world but at least made it a slightly better place. And dreaming of salami can't possibly be a sin.

> ***» I have a million ideas as to how we get out of this. They all point to certain death***
>
> From 'A Hitchhiker's Guide to the Galaxy'

CARBON FOOTPRINT OF FOOD

CO_2 equivalents in gram per kilo of the product

Product	*Conventional*	*Organic*
Poultry	*3,508*	*3,039*
Beef	*13,311*	*11,374*
Pork	*3,252*	*3,039*
Vegetables, fresh	*153*	*130*
Vegetables, frozen	*415*	*378*
Potatoes, fresh	*199*	*138*
Potatoes, dehyd.	*3,776*	*3,354*
French fries, frozen	*5,728*	*5,568*
Tomatoes, fresh	*339*	*228*
Pasta	*919*	*770*
Butter	*23,794*	*22,089*
Yoghurt	*1,231*	*1,159*
Cheese	*8,512*	*7,951*
Milk	*940*	*883*
Cream	*7,631*	*7,106*
Eggs	*1,931*	*1,542*

Source: GEMIS 4.4

375,000,000

vegetarians make **India the world's stronghold of meatless nutrition.** Veganism on the other hand hardly exists on the sub-continent. In this case, with 6 million vegans, the United States is in the world's top spot.

Source: vegane-bewegung.de

WASTE FOR A **VIABLE FUTURE**

Fibers, bioplastics and CO_2: lateral thinkers are discovering outstanding new materials derived from what has traditionally been regarded and destroyed as waste.

by Kay Dohnke

230 m

metric tons of **petrochemical plastics** are produced worldwide every year (Worldwatch Institute). Nearly 30 % could be replaced by plastics made from the bio 'waste' lignin.

CO_2 and other flue gas emissions from blast furnaces are to be made usable for producing chemicals like ammonia and methanol, according to plans of the **'Carbon2Chem'** project – perhaps in 15 years from now.

Source: carbon2chem.com

CRADLE TO CRADLE

Michael Braungart and William McDonough's concept is based on the idea of producing consumer goods from few materials in a way that at the end of their useful life they can be **easily decomposed** and recycled without any loss in materials.

Whenever Anke Domaske hears words such as 'waste' or 'discarding' they sound to her like expressions from a distant past. Like a way of thinking that has tended to cause rather than solve problems. In other words, like something she has long moved on from. Anke Domaske operates an extremely successful business with – rotten milk. The north German fashion designer from Hanover has developed 'Qmilk,' a high-grade biofiber with outstanding properties. And she gains it from milk that's no longer fit for human consumption. It used to be poured down the drain or farmers would dump it on their fields.

Domaske has discovered a miraculous material in it. In search of an untreated fiber, Domaske, who is a professional microbiologist, experimented with casein, the lactic protein from which curd cheese is made and which she processed into a fiber. This fiber is organic and regional, produced with 90 percent less water consumption than conventional fibers, highly durable, skin-friendly and even compostable. By now, Domaske's machines are running at full speed and international demand is rapidly growing.

Of environmental and economic interest

500 kilometers farther south in Germany, at Tecnaro in Ilsfeld near Stuttgart, a similarly wondrous process is taking place. As lateral thinkers, Helmut Nägele and Jürgen Pfitzer discovered a super-substance as well and have paved the way into a great future for it: lignin, a waste material generated in paper production. It used to be incinerated. The two chemists developed 'Arboform' from it, a high-grade bioplastic with all the properties a bioplastic material must have – except, it's not made from oil but from wood fiber waste. Arboform has versatile uses and is non-toxic, produced without harming the environment and can be composted.

Sour milk and wood fibers: Domaske as well as Nägele and Pfitzer represent a new way of thinking. They're not deterred by words like 'trash' or 'waste' but take an analytical look at materials, penetrating the surface in a manner of speaking, and detect new potential in it. Lignin is not wood but a polymer and sour milk has got what it takes to make a fiber. Their developers achieve a structural transfer, opening up perspectives that were necessarily blocked out by conventional thinking.

The take-off points for Qmilk and Arboform are in the pre-consumer phase of global waste production and are characterized by special aspects. Both biosubstances are created without additional land usage. Domaske's fiber production doesn't use any foodstuffs that would still be fit for consumption and for Arboform not a single extra tree has to be cut. They're of interest to industry as they can be permanently produced in reliably large quantities and high quality. Every year, two million tons of spoiled milk are disposed of in Germany and 70 million tons of lignin, the raw material for Arboform, are incinerated annually around the globe.

Waste incineration destroys raw materials

To Armin Reller this is like a red rag to a bull because the expert for waste and recycling, and head of the Fraunhofer Project Group for Materials Recycling and Resource Strategies IWKS, thinks that waste incineration is simply stupid: "We destroy many valuable raw materials and dump them as slag in landfills – losing the diverse potential which these materials actually have and which could be used again if we handled them more effectively."

Domaske, Pfitzer and Nägele on the other hand make use of 'knowledge of substance correlations' which in Reller's view is so important and, based on materials previously ignored, are starting new value chains that ease the burden on resources and the environment. Initial process models show that a wide range of materials can be derived even from the greenhouse gas CO_2. It's almost like in the fairytale of Rumpelstiltskin in which the miller's daughter can spin straw into gold.

THE AUTHOR

After working for many years as head of an editorial team and editor-in-chief, ***Kay Dohnke*** *has been exploring the world of sustainability as a free-lance author in Hamburg for some time now. "It's a field," he says, "in which you can find positive topics and exciting people every day."*


ABT
DHL
Audi Sport
ABT SCHAEFFLER
FORMULA E
WE
WÜRTH ELECTRONIK
LGT
QUALCOMM
MICHELIN
ABT
DHL

“WE AIM TO DRIVE **INNOVATION**”

With ten podium places and three victories Team ABT Schaeffler Audi Sport made its mark on the second Formula E season. Vice champion Lucas di Grassi about the fascination exuded by electric cars, the challenges posed to the engineers and his very personal passions for technology.

by Jörg Walz

You missed the title in a thrilling Formula E finale by just two points. How satisfied are you with the season?

Obviously, I was disappointed at first but just a few days later, the gratifying feeling of having contested a successful season was stronger. We couldn't expect to keep the title race against the Renault factory team open up to the finale. I feel that all the mechanics, engineers, partners, and also we drivers, can be proud of what we achieved this year. We left the season with our heads held high and are going to come back stronger than before.

Formula E finished its second season. How do you judge the development of the series?

Formula E is a very interesting project. Everyone, including myself, was skeptical about how people would respond to the series. The decision to race in the world's biggest metropolises instead of on boring permanent race tracks was a key to success. The fans and the media are enthusiastic about Formula E, and more and more car manufacturers and drivers have an interest in joining the series. In my opinion, Formula E is a success story and its importance will continue to grow.

Schaeffler developed the powertrain for the current car together with the team. How would you describe the way of getting there?

When Formula E was incepted there was no corresponding technology available. So, there were 40 standard cars – equipped by McLaren, the battery was from Williams and the chassis from Dallara. Subsequently, in the second season, development was permitted only for the components that are relevant for road-going technology as well. So, aerodynamics, which plays a really major part in Formula One, is specified in Formula E. The only important area for product development in this case was the powertrain. Everything that's located behind the battery, the ERS, the motor, the transmission, the differential, the rear suspension, was not specified. We developed our own ABT Schaeffler MGU01 powertrain that put us in the position of battling for the title up to the last race.

What challenges are involved in such a development?

For us, the only thing that matters is what the battery delivers: electric power of 200 kW. Now it's important to transfer the major part of this power as efficiently as possible and with the least possible weight to the wheels. The question of the number of gears is important too: the fewer gears you have, the better because acceleration is constant. But, as a result, you need a larger motor. And the smaller the motor, the more gears are required. So, we started out with a small motor with five gears in the first season and then opted for the compromise of a slightly larger motor with only three gears. Other teams have two or five gears or two motors. We selected a good compromise. That provides us with good, constant acceleration on some of the tracks. We hardly need to shift gears – that's very good – and, at the same time, we kept

our weight low. That's why this season we were one of the few teams below the weight limit. So, I feel we did the right thing.

One of the key words in electric mobility is efficiency …
It is in Formula E too. Only in qualifying, efficiency isn't so important because you can use as much energy as you like. In the race, the driving style is somewhat different because you have to drive with energy in mind. Every car can use 28 kWh and you have to make do with that for half of the race. If I have to defend myself or attack I'll use more and will subsequently have to use energy sparingly. The drivers and the team are challenged to come up with a perfect strategy and make spontaneous adjustments.

What kind of technological innovations will the next years bring?
Today, we're at 28 kWh per car and in the fifth season, we're aiming for 56 kWh – with that, it'll be possible to contest the race with only one car, without switching vehicles. Increasing power from 200 to 250 kW will be an intermediate step. So, there's a detailed roadmap – Formula E is making good progress. Most of the limitations of course are battery induced.

What are your views of motorsport of the future? One of the key words in this context is the Roborace, a car race with driverless race cars that is planned to be run as part of Formula E's supporting program.
When I first heard about driverless cars I wasn't particularly happy because they'd put me out of a job (laughs). *But we're going through a very interesting phase in motorsport at the moment. We've reached the point at which many systems in the car are doing a better job than I. But, honestly, is that still a sport? I accept Roborace as a series in which the engineers can put all the technological possibilities into a driverless car. And in the other categories, we're going to continue to battle about who the best driver is – so, I believe that both will have a great future.*

You mentioned various categories. In the FIA World Endurance Championship (WEC) you're competing in a hybrid car – what's the significance of motorsport for hybrid development?
I suppose that in motorsport the 24-hour race at Le Mans will be the last to become fully electric: simply because it's unrealistic to stay on a maximum performance level with a battery for 24 hours. But the transition to hybrids – as we've been seeing on the road – marks a huge step forward. Le Mans has been promoting this transition to hybrids for five years now and during this period fuel consumption for the same lap time has nearly been cut in half. Prior to that, the introduction of hybrids took about 40 to 50 years.

Working together with the engineers contributes to success in a major way. As a race driver, how much of an engineer are you yourself?
Well, I come from a family of engineers. My father and my older brother are engineers. I think the plan was for me to become an engineer too. I love complexity. That helps me because it makes it easier for me to talk to and understand engineers and technicians. It's hard to formulate wishes because our cars are so complex. If I have a problem in a specific corner there are various possibilities to resolve it. It may be due to the suspension, the differential or the tire pressure – if you have a little knowledge of how the car behaves you can act with greater precision and make better decisions.

I heard that you not only have a professional interest in innovations relating to electric mobility …
Even I have some free time now and then, and enjoy assembling things. I'm pursuing a few projects in terms of electric mobility which, in my opinion, has a great future, particularly in urban areas. Living in Monaco, I rarely get into my car. But the region is very hilly so, unless you're exercising, you don't necessarily want to

Driving Formula E development forward: Chief Technology Officer Prof. Peter Gutzmer (right) and Dr. Simon Opel, Head of Special Projects Motorsport, are on site at the races


ump
High
SCHAEFFLER

At the limit: Lucas di Grassi battled for the title up to the last race

Test drive: Lucas di Grassi tested Schaeffler's Bio-Hybrid in London and is fascinated with the concept

sweat a lot. To make a long story short: I wasn't happy with the e-bikes on the market, so I bought the individual components from various manufacturers and built myself a prototype. Now, I'm working on a three-motor bike without a chain and without a mechanical brake. It only uses regenerative braking and electric power. I'm pursuing several projects and enjoy applying the things I learn in my races in everyday life. There are so many opportunities. There are a lot of things that aren't fully developed yet or there's a niche to be served or I'm not happy with a current product. That's why I'm doing this as a hobby. I think that when I retire someday I'm going to get into this line of work.

I assume that you've seen Schaeffler's ideas on micromobility and our Bio-Hybrid. What do you think of ideas like these?

I love them. And I've not only seen them but, before the Formula E finale in London, I also had the opportunity of a test drive and a lot of fun in the process. Everything we're dealing with in Formula E has a direct influence on these technologies. From the softer applications to temperature control to various materials, magnets and the efficiency of drive systems: we can use anything we come into contact with on a small as well as a large scale. This is a world that totally fascinates me. The innovative and forward-thinking ways in which Schaeffler is active in this field are exactly the way to go.

What challenges are our developers going to face from your perspective?

The macroscopic production and storage of energy is a very interesting topic that has to be driven forward. And then it will be necessary to think about how to use this energy and how to efficiently transfer it to the production line. You know, I'm a big fan of micromobility in the cities and of small scales. But we're talking about bio and zero-emission fuels here, new fuels for aircraft, commercial trucks and for all the other things a high-energy internal combustion engine is needed. I believe there's a broad spectrum here. We have to improve technologies, drive them forward and change them. For us in Formula E it's also important to change people's perception and culture in a way that makes them lose their skepticism of electric mobility and innovation in general. We'd like to show that it's not only better for the environment and for them personally but also cheaper to pursue this approach. That's why I'm proud to be among the front runners in Formula E and working with outstanding partners like Schaeffler.

TEAM ABT SCHAEFFLER IN FORMULA E **2015/2016**

4 continents

9 countries

10 races

10 podium places

3 victories

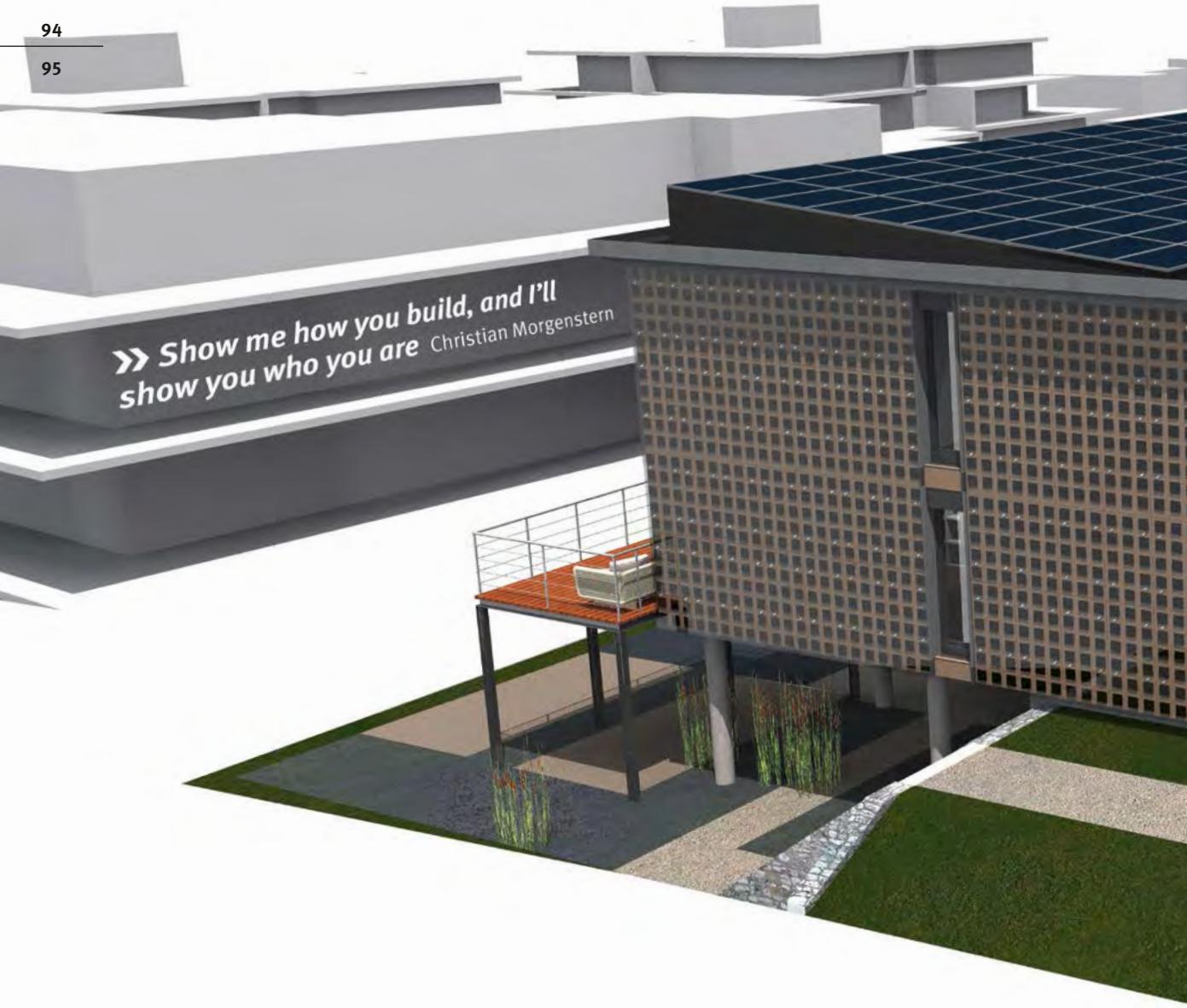
4 2nd places

3 3rd places

221 points

2. place driver

2. place team



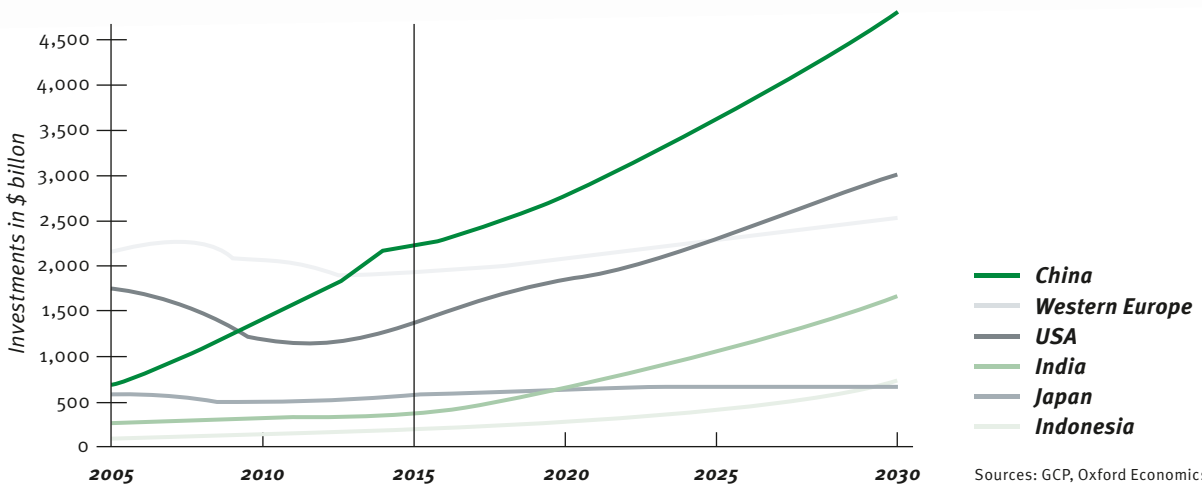
THESE ARE **MATERIALS** YOU CAN **BUILD ON**

Sustainable construction, is that possible? It has to be! After all, the production of concrete and steel, the preferred materials in modern architecture, generates about one tenth of global carbon dioxide emissions. No wonder that scientists have long begun to address this issue. Approach number one: using concrete facades of which some 130 million square meters are installed worldwide per year, to at least generate energy. Heliatek, a company based in Dresden, has developed organic, transparent solar films for this purpose which can be installed in diverse facades. Concrete, glass, sunblinds – anything's possible. The solar films generate about 25 percent more energy than conventional silicon-based solar cells. A different approach is being pursued by Swiss architect Fredy Iseli who has developed a construction material consisting of waste paper, wood and cement as a substitute for concrete. The material has a honeycomb structure and is ten times lighter than concrete. The first buildings, shown here as an illustration, have been erected at Lake Constance. Back to nature in urban construction is the aim pursued by bio engineer Dr. Michelle Oyen from the University of Cambridge. Her plan is to develop new construction materials from natural raw materials such as egg shells and bones that can even be used in the construction of skyscrapers. Research by her academic colleague Paul Dupree is aimed at replacing steel that is massively used there. The professor of biochemistry is in the process of discovering the secrets of cell walls in order to subsequently improve the strength, stiffness and durability of natural materials so that ultimately there'll be no need to use any steel in housebuilding at all.

outlook

Technology for tomorrow

THE WORLD'S LARGEST CONSTRUCTION REGIONS



Sources: GCP, Oxford Economics

SMALL CELLS, MAJOR EFFECT

Microorganisms such as bacteria and fungi are increasingly put to systematic use by humans in a wide range of fields. Further environmentally sustainable applications are now emerging thanks to genetic engineering – potentially changing our society.

by Christian Heinrich

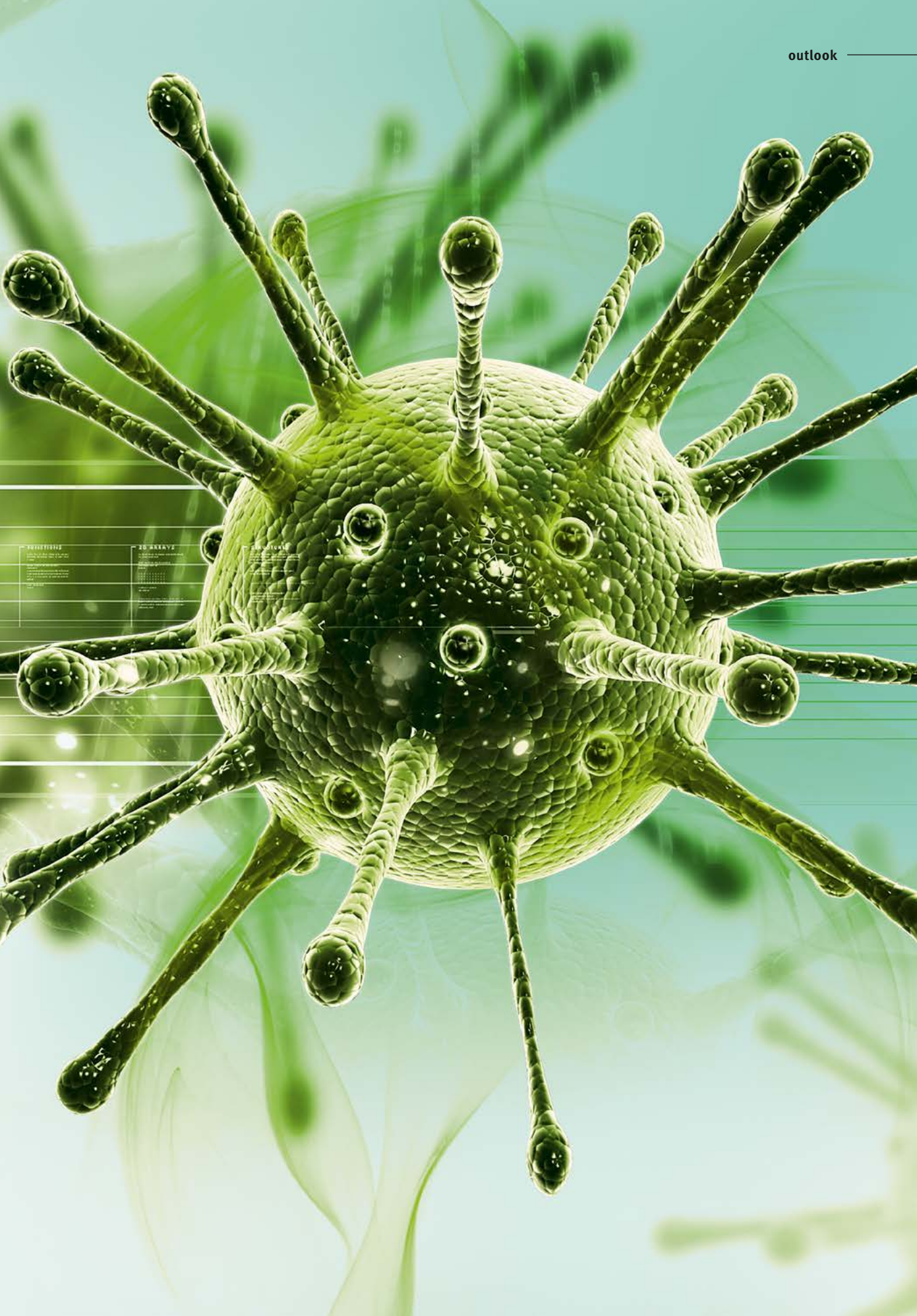
An army of millions of helpers that do their work diligently and without complaining: What sounds incredible has long become reality on a molecular scale. Bacteria! These microbes that are largely known only as pathogens increasingly serve industry, business and research as an untiring workforce. And in some cases they tackle tasks that only they can perform. This is no vision of the future but reality. In fact, to some extent we even depend on their labor to keep a cycle going that's vital for humans: the water cycle.

Every sewage treatment plant today uses microorganisms – particularly bacteria and yeasts – to decompose biological contaminations of waste water under constant aeration. Carbon compounds, nitrogen, ammonia, etc. are removed from wastewater this way. A sewage treatment plant without these so-called biological purification stages is hard to imagine anymore.

In the field of medicine, microorganisms have become indispensable helpers as well. Here, they've long been used as veritable factories. Today, vitamins and antibiotics are produced using fungi and bacteria. In the field of penicillins alone, pharmaceuticals with a market value of 15 billion euros are produced annually by fungi nowadays. These medicines, in turn, are used to eliminate other bacteria that attack the human body. Without antibiotics like penicillin human life expectancy would arguably be a lot lower than it is today.

Bacteria degrade plastics and oil

Let's take a look at a totally different issue. 230 million tons of plastic are being produced per year of which more than 55 million tons are polyethylene terephthalate, abbreviated PET, a particularly common type of plastic. Only a fraction of it – two million tons – is being recycled. For a long time it seemed unrealistic that microbes could actually efficiently degrade the synthetically produced PET or other types of plastic. Until scientists of Kyoto University in Japan found



5,000

of the bacterial species assumed to amount to several **million are known.** And only 200 of them are pathogens.

Source: Robert Koch-Institut

€15 BN

is the **market value of the penicillins** produced annually by bacteria and fungi.

Source: Book 'Industrielle Mikrobiologie'

0.1 – 700

micrometers is the size of bacteria. Unlike viruses which are 50 times smaller, bacteria have a cell and a metabolism of their own. Therefore, they are considered to be **living organisms.**

a bacterium last March that eats PET. With only two enzymes it degrades PET and generates energy from it. The bacterium which the scientists have named 'Ideonella sakaiensis' works slowly. At a temperature of 30 degrees centigrade, it takes the bacteria six weeks to break down a piece of plastic the size of a fingernail. "We have to improve the bacterium to make it more powerful," says agricultural chemist Kohei Oda from Kyoto Institute of Technology who was involved in the development.

Improving or even modifying a bacterium – thanks to biotechnology, the genomes of microbes can in fact be manipulated more systematically and with greater ease to produce specifically desired properties. Aside from understanding which bacteria can do what under which conditions, this is another factor that currently extends the possible uses of microorganisms enormously. "Genetic engineering might be applicable here," Kohei Oda agrees with reference to the bacteria he and his team discovered.

A similar approach is being pursued by a research team headed by marine biologist Brett Baker from the University of Texas in Austin. Following the Deepwater Horizon oil spill, they found a range of bacteria that can degrade oil. "We were surprised to find that many different bacteria fed on aromatic hydrocarbons, even though these are much harder to break down," says Baker. This is another case in point where efforts are now underway to find out how bacteria might be systematically propagated and utilized.

A joint European project called P4SB, in which the Aachen and Leipzig Universities are involved among others, even takes this a step further. That bacteria break down petroleum-based plastics is not enough for this research team. In a further step, the microorganisms are to convert the degraded materials into bioplastics. The aim is for the bacteria to excrete bioplastic modules that can be reused. "We're working on interlinking the individual steps and developing the corresponding tools for this," says project team member Lars Blank from the Department of Applied Microbiology of RWTH Aachen.

A battery of bacteria

Particularly this joint project shows that 'industrial microbiology' as this branch of research is called in which microorganisms are systematically used for production and degradation processes depends on interdisciplinary cooperation. In this consortium, experts from the fields of Synthetic Biology, Metabolic Engineering, Enzymology, Process Engineering, Polymer Science and Environmental Research pool their knowledge. Only such collaboration between professional disciplines delivers the desired results increasingly often: bacteria that produce substances which are needed and those that degrade harmful ones. Even though many of these results are achieved only at a scale of laboratory work at the moment, it's not unlikely that bacteria will soon be used in many fields as routinely as they've been in sewage treatment plants.

And these developments are likely to mark just the beginning. Thanks to progress achieved in manipulating genomes, numerous other possible applications can be expected to emerge in the future. Scientists from the Netherlands have already developed the prototype of a battery that is based on the metabolism of bacteria. The era in which man takes control of some of the microorganisms has only just begun.

THE AUTHOR

Christian Heinrich *has a doctorate in medicine and works as a freelance science journalist in Hamburg. Publications he writes for include 'Süddeutsche Zeitung,' 'Zeit' and 'tageszeitung.' His interest in scientific innovations not only concerns technological developments but their effects on society as well.*

PLEASE **PLUG IN**

Electric vehicles are regarded as an important key to mobility that is less harmful to the environment. To increase their market share and to reach long-distance drivers and curbside parkers, comprehensive availability of charging opportunities seems indispensable. That's easier said than done though ...

by Michael Specht

Norway has 14 times fewer inhabitants than Germany, the motherland of automobiles, but more electric charging columns. The Netherlands have only twelve percent of Germany's area but supply drivers of electric vehicles with power at about four times as many charging columns. In France and the United Kingdom, too, twice as many charging stations as in Germany can be found. So, the home of Audi, BMW, Mercedes, Opel, Porsche and VW has some catching up to do. Most recent statistics reflect that drivers in Germany are able to head for a little less than 5,600 publicly accessible charging stations. Statisticians have figured out that, as a result, a charging column can be found every 111 kilometers on average. For comparison: The Dutch have one every seven kilometers. If progress continued at the same pace, we'd have about 12,000 columns by 2020. That's light years away from the target of 70,000 established by the National Electric Mobility Platform.

But now, thanks to a funding project announced in mid-May, 300 million euros are planned to be invested in developing the public charging infrastructure in Germany. An important investment into mobility of tomorrow as experts agree that an insufficient network of charging stations, in addition to their high purchasing price, additionally inhibits the proliferation of electric vehicles. "Buyers have a deep-seated fear of stranding with an empty battery out in the middle of nowhere," says Stefan Bratzel, Director of the Center of Automotive Management (CAM) in Bergisch Gladbach. But the question is who's responsible for developing the charging network? Politicians that establish the targets? Electric utility companies or electric vehicle manufacturers? Or a totally new player?

A normal charging station today costs some 10,000 euros. From a mid-term perspective, there's no money to be made with it by selling electricity. Possibly, not even for the long term. Jürgen Schenk, Head of E-Mobility at Mercedes even believes that Germany will have a surplus in charging stations in just a few years' time. "Due to the progress made in battery technology, we're going to achieve electric ranges of more than 500 kilometers by 2020. In that case, drivers, at best, will need quick-charging stations along the autobahns."

Everyone's going their own way

So it's no wonder that the current investments in charging stations are only progressing slowly. The car manufacturers are struggling with the issue as well, and don't feel that it should be their responsibility to ensure a further development of the charging infrastructure. Plus, there are no intentions to create isolated solutions like that of Tesla offering its customers exclusive charging stations and free electricity. Mercedes man Jürgen Schenk: "We don't consider this to be conducive to achieving the goal."

Still, a higher-level arrangement is lacking. "Everyone's going their own way," says CAM Director Bratzel. Drivers of electric vehicles wishing to cover longer distances are almost forced to register with various providers to keep from encountering 'locked' stations. There's no such system in the normal diesel and gasoline market. Fuel is available at any filling station, irrespective of the brand, to any driver. In isolated cases, there are possibilities to use charging services for electric vehicles from other than one's standard provider, similar to the roaming principle for smartphone usage rates. Or the customer sends a text message with a code to their electricity provider. In this case, though, users have to be aware of the fact that hefty surcharges may be incurred which may increase the rate charged per kWh by more than 50 percent. This is unacceptable and slows the spreading of electric vehicles. "The time has come to pursue non-discriminatory access to electric charging stations," says automotive expert Ferdinand Dudenhöffer. The Director of the CAR Center for Automotive Research at Essen-Duisburg University is sure that only when all electricity providers are able to deliver their current to their customers at their rates at any public charging station transparency will be enhanced and electric mobility pick up momentum.

Electric mobility might be experiencing a major boost if the millions of curbside parkers – actually predestined as e-mobility users – could be gained as a target group. But even today, hunting for a parking space in the city is a daily battle for these drivers. Additionally competing for one of the scarce charging stations might produce a horrific scenario. So it comes as no surprise that in Germany 80 percent of all electric vehicle users charge their cars on their own sockets at the moment. Systems like the one launched by Berlin start-up ubitricity could help spark the enthusiasm of the large group of curbside parkers to switch to electric mobility. The idea the company based in Germany's capital has come up with is 'SimpleSockets.' They feature lean technology, replace costly charging stations and can be installed anywhere – for instance at any street light. Billing uses so-called SmartCables which – and that's the crux of the system – cost about 600 euros due to their technical complexity. Thus, a portion of the costs for developing the infrastructure for such a system would shift from the electricity provider to the user. Unless the energy supplier funds the cable purchase when the consumer signs a mobile power supply agreement – a strategy that has been common practice in the smartphone market for years.

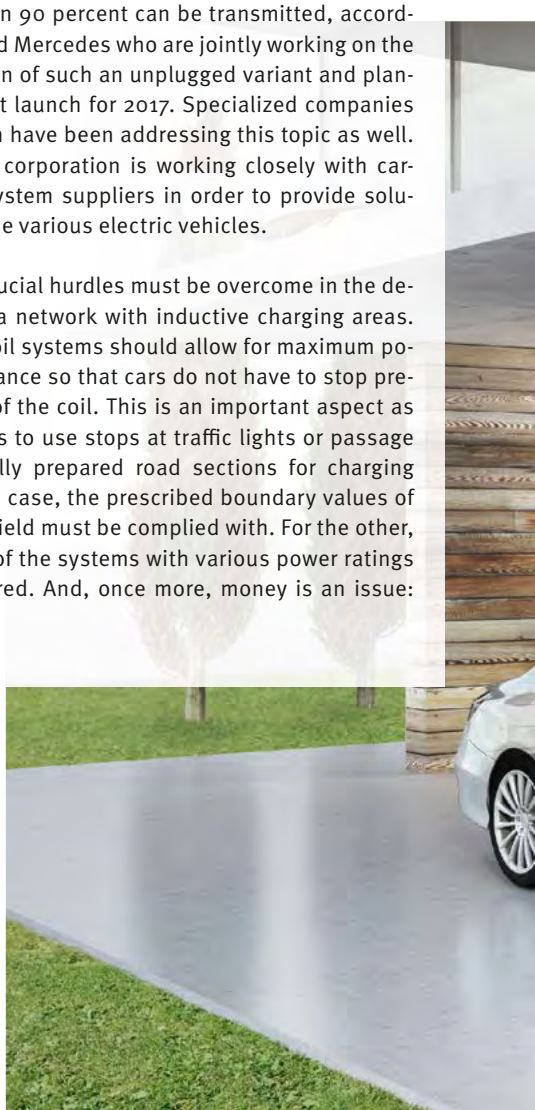
In the Munich region, the project group 'Light & Charge' led by BMW has begun to upgrade lampposts and street furniture with charging stations. In contrast to the Berlin 'SimpleSocket' concept, a large part of the technology here is contained in the charging device itself. Obviously, the yellow brick road to charging has not been found at the lamppost yet either.

The future belongs to inductive charging

However, surveys among electric vehicle owners have revealed that constant fiddling with charging cables is a nuisance, especially in bad weather and winter. This is a particularly significant disadvantage with plug-in hybrids. Due to their short range, the batteries have to be charged almost daily in order to fully exploit the vehicle's fuel economy benefits, so efforts to field inductive charging ('unplugged') are to be accelerated. In the 1997 science fiction movie 'Gattaca,' this technology still seemed to be a distant dream. Today, it has already become reality in field tests. The operating principle using magnetic coils resembles the charging process for electric toothbrushes. The car is parked on top of an induction panel in the ground (primary coil). The corresponding counterpart (secondary coil) sits underneath the vehicle. Now current will flow in a wireless process.

At the moment output of up to 3.6 kW with efficiency of more than 90 percent can be transmitted, according to BMW and Mercedes who are jointly working on the implementation of such an unplugged variant and planning its market launch for 2017. Specialized companies like Qualcomm have been addressing this topic as well. The American corporation is working closely with carmakers and system suppliers in order to provide solutions that fit the various electric vehicles.

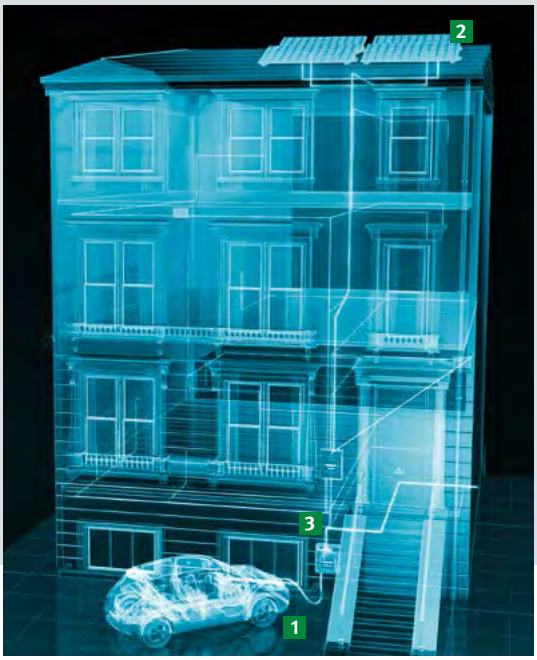
Three crucial hurdles must be overcome in the development of a network with inductive charging areas. For one, the coil systems should allow for maximum positioning tolerance so that cars do not have to stop precisely on top of the coil. This is an important aspect as there are plans to use stops at traffic lights or passage over specifically prepared road sections for charging as well. In this case, the prescribed boundary values of the magnetic field must be complied with. For the other, compatibility of the systems with various power ratings must be ensured. And, once more, money is an issue:



SMART **STREET**

This is Nissan's idea of curbside parking 3.0. *In a 'Smart-Street' devised together with the architectural and design firm Foster & Partners, the electric vehicles are charged at an inductive parking space* ***(1)*** *with renewable current* ***(2).*** *Once the batteries are fully charged, the driverless electric cars automatically move on to allow the next vehicle to be charged. Should voltage deficits occur in the surroundings, the batteries of the bi-directional charging system serve as an energy reserve and feed electricity back into the grid* ***(3).***

YouTube video:
How the 'Smart Street' works



WIRE**LESS**

Inductive charging remedies the issue of cable spaghetti. *We all know it from our electric toothbrushes or smartphones: wireless charging. There's no need to fiddle with cables, plugs and sockets. You simply drive your car on top of the induction panel* ***(1),*** *the secondary coil* ***(2)*** *in the car receives the electromagnetic impulses and conducts the current to the battery* ***(3),*** *with 90 % efficiency. However, the current flow is not as intensive as in the case of a cable connection, resulting in longer charging times. Mercedes and BMW are planning to offer the system in their top-end models in 2017.*

ELECTRICAL PIONEERS

The Coburg 'Flocken Electric Car' *from 1888 is regarded as the world's first four-wheel passenger car powered by electricity. Around 1900, 40 % of the automobiles in the United States were powered by steam, 38 % by electricity and only 22 % by gasoline, according to Wikipedia. The tide slowly began to turn in 1912 as fossil fuels became increasingly affordable and allowed for longer ranges. The battery of the Lohner Porsche (pictured) from 1900 weighed over 400 kilograms and enabled a range of some 50 kilometers. To increase it, the company in 1902 followed up with a hybrid model in which a Daimler gasoline engine recharged the battery – so this is another technology that's not new.*

who will finance this infrastructure and how will power consumption be billed?

Curbside parking 3.0

Recently, Nissan ventured an intriguing advance into mobility of the future. Together with the renowned architectural and design firm Foster & Partners the carmaker designed a mobility vision. In the Nissan world, all driverless electric vehicles look for an inductive parking space at night in a so-called 'Smart Street,' are charged with electricity from renewable sources, autonomously swap parking spaces to make charging available to other electric vehicles and are ready for the user's commute to work the next morning.

In the Nissan proposal, parked cars are used as energy accumulators which can feed unused electricity from their fully charged batteries back into the grid in valley load conditions. This is an idea being pursued – and already tested as well – by other providers such as in the 'Micro-Smart Grid' in Berlin-Schöneberg. For good reason: One of the issues encountered in the wake of the growing proportion of renewable energies (primarily wind power) is the high fluctuations that occur when feeding

THE EASY WAY OUT

Cheap socket, expensive plug. *Charging stations for electric vehicles can easily cost 10,000 euros or more: money that's not easily recovered though. This is another reason for the hesitant extension of the charging infrastructure. But there's another option, says Berlin start-up ubitricity. With 'SimpleSockets'* ***(1)*** *featuring lean technology the company based in Germany's capital is able to convert practically any street light into a charging station for little money. The expensive technology, required for billing among other things, is in the cable* ***(2)*** *with a corresponding price tag: about 600 euros. In the aggregate, the system is still affordable and might help increase the number of charging points quickly.*

ubitricity.com

this power into the grids. In the bi-directional charging process, the batteries of electric vehicles could intervene as intermediate accumulators with a leveling effect.

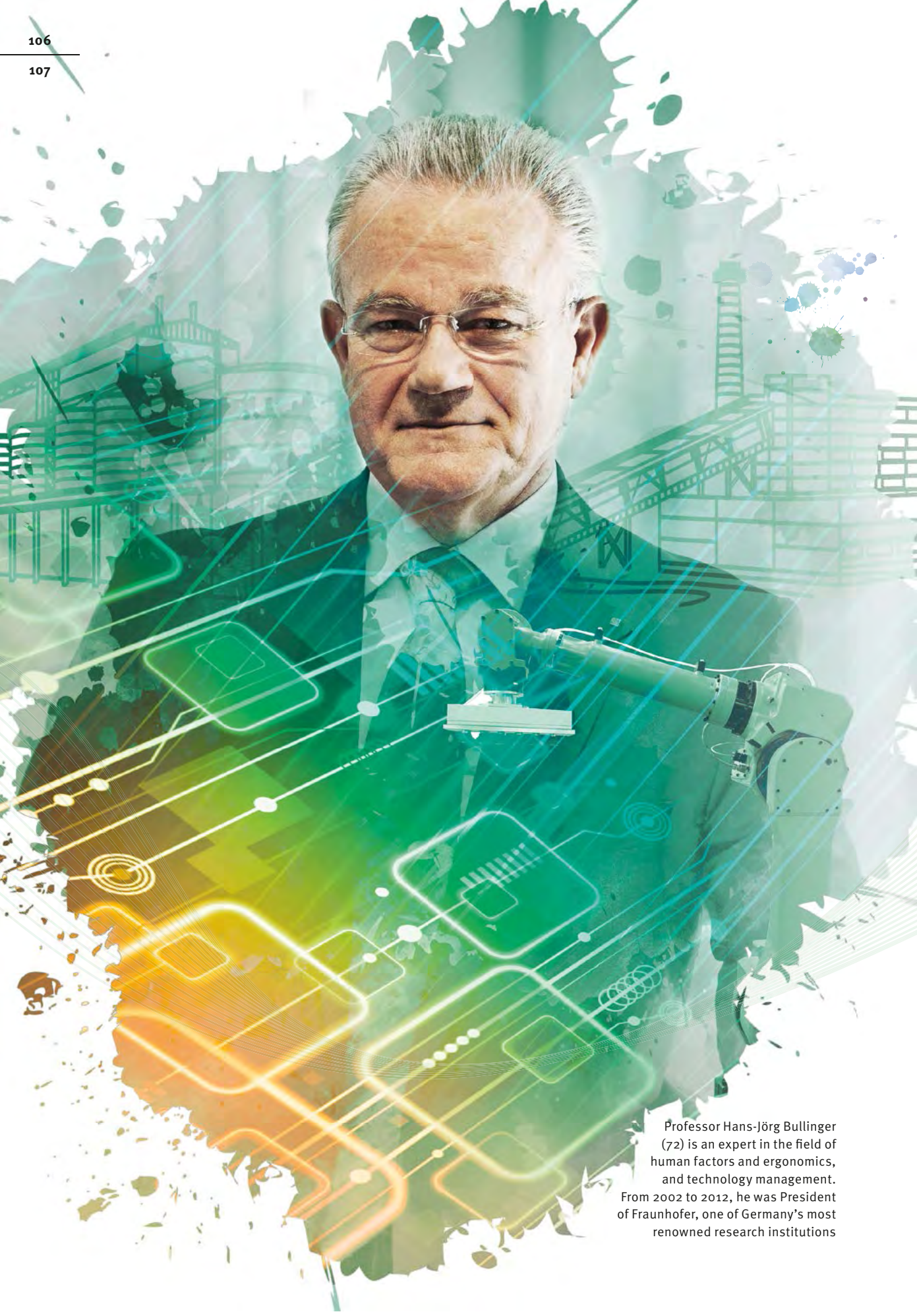
The INEES research project of the cooperation partners Volkswagen, LichtBlick, SMA Solar Technology and the Fraunhofer Institute for Wind Energy and Energy Systems Technology has investigated the possibility of achieving a stabilizing effect on the power grids by the batteries of a pool of electric vehicles as well. The project's conclusion: technically feasible even today, but not profitable under current general conditions.

But what will happen in the future when millions of electric vehicles more or less simultaneously are plugged in for charging after their drivers have returned from work at night? Will the power grid that even now has to cope with maximum loads during the voltage rush hour between 5 and 9 p.m. be able to handle the additional load? Especially as charging currents are becoming increasingly potent? Charging stations with 20 kW of alternating current used to be regarded as the benchmark. At the moment, a consortium with participation of the Fraunhofer Institute is running tests with 150 kW direct current systems that push 300 kilometers of range into the batteries in 30 minutes. Will the grids withstand such loads? A final answer is difficult. To prevent power outages in the first place, so-called smart charging strategies already exist. The charging process in this case doesn't necessarily start when the car is connected to the grid, but when the grid load permits it.

Obviously, many issues are yet to be resolved before charging electric vehicles will be as simple as 'filling up' at the fuel pump. But the beginnings there were bumpy as well: gasoline was initially available only at drug stores and the first fuel pumps were introduced only in the 1920s.

THE AUTHOR

"A car with an internal combustion engine? Never again," said ***Michael Specht*** *when switching to electric mobility more than two years ago. Since then, he has covered over 27,000 kilometers in his BMW i3 (without a range extender of course). The infrastructure that is said to be lacking doesn't bother the Hamburg journalist. He does 99 percent of his 'refueling' at home.*



Professor Hans-Jörg Bullinger (72) is an expert in the field of human factors and ergonomics, and technology management. From 2002 to 2012, he was President of Fraunhofer, one of Germany's most renowned research institutions

ROBOTS CREATE MORE FREEDOM

Healthier jobs, less stress, a clean environment: Technical progress gives many people a better life, says long-standing Fraunhofer President Hans-Jörg Bullinger. However, that doesn't apply to everyone. An interview about the future.

by Claus Gorgs

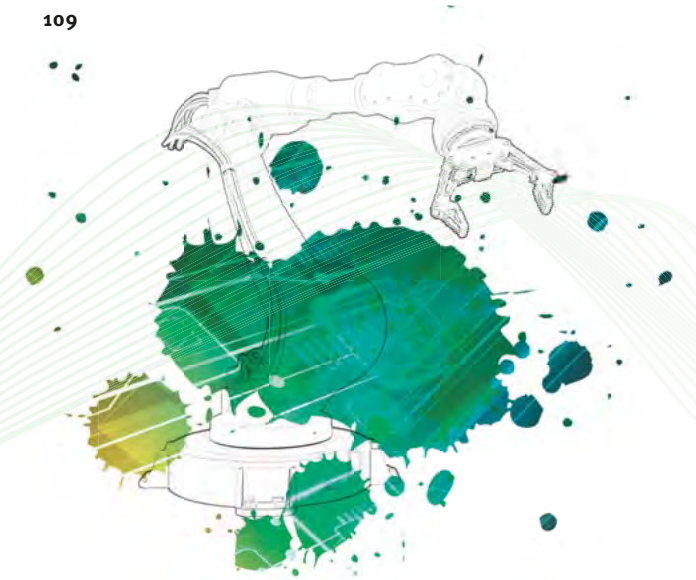
Professor Bullinger, industrial production is becoming increasingly integrated and intelligent robots are moving in. What does this mean for work of the future?
We're going to see a major automation boost, especially on high-volume production lines. With companies that manufacture a great diversity of product variants, the trend is likely to point toward greater specialization. Even at this juncture, it's clear that we're going to need people with higher skills in both areas – and I mean more people than we have at the moment.

At the same time, intelligent machines are increasingly replacing skilled people. Is digitization more of an opportunity or a risk for employees?
Well, it's not like we had a choice in the matter. This development will come. And wherever opportunities exist, there are always risks as well. Obviously, people that used to perform simpler tasks in a factory are going to be in a bind. This type of work will disappear. In specialized activities, robots will tend to be used more for assisting people and making their work easier. On balance, I believe that the opportunities will outweigh the risks.

What could the collaboration between man and machine look like?
It's not primarily about robots replacing people in the production process. Integration is the key topic. Merging production data, planning data and customer data – this is where the enormous efficiency benefits are found. For instance, with knowledge of when what order has to be finished and how the machine capacities are utilized at that time employees can make arrangements among each other about who will do the job and who may be going home earlier on a sunny day. Digitization makes it possible to provide people with greater freedom of scheduling their work.

Will a factory without people be the final stage of this development?
I do see this as a possibility but it's going to take ages before this will happen in industry on a large scale. Naturally, at that stage, a lot of industrial jobs will be lost, no doubt about it. At the same time, new ones will be created in the production of automation technology. Unfortunately, it won't be possible to do this with the same people that will be laid off in the factory. And this, exactly, will be the social dilemma of the coming decades. The next five to ten years, though, will primarily be about specialization of the jobs in which digital technology and integration assist people.

How should companies and employees prepare themselves for this development?
I keep saying that there are three essential tasks: 1. Qualification 2. Qualification, 3. Qualification. Where solid skilled-worker knowledge is required today we're going to need the qualifications of engineers in the future – with a practical orientation. A lot of system knowledge will be required, a mix of electronic, mechanical and IT knowledge. A lot of the curricula at vocational and engineering schools will have to be rewritten in order to properly prepare us for this development. And we're going to need less people for producing the same volumes.



Now the economy doesn't only consist of industrial jobs. How is digitization going to change the other sectors?
The demands made on understanding math and computer science are going to increase in other professional fields as well. However, basically, we can say that wherever abilities such as empathy, emotion or creativity are required people will clearly have an advantage over technology in the future too. Doctors, architects or writers can hardly be replaced by computers. But when it comes to analyzing large amounts of data, merging available information and drawing conclusions from it, the Industrial Internet of Things is clearly superior. It doesn't take a banker to evaluate the credit worthiness of a customer.

What should HR managers be looking for in recruiting new employees in the future?
Creative potential and willingness to embrace change and learn new things are primary considerations. Today, nobody has any detailed knowledge of the types of skills we're going to need 20 years from now. What we do know, however, is that job profiles are going to change much faster and more frequently than they have so far. People who keep pace with these developments, support and drive them are very valuable for a company. In addition, all-new opportunities to market their abilities will open up for highly skilled and specialized people. So, why should they seek permanent employment by companies in the first place?

What should they do instead?
They could become self-employed and work for various clients – where you work is becoming less and less relevant due to digitization and increasing data transmission speeds. This is already quite common in the media sector and among business consultants, and now the trend is picking up momentum with IT specialists and engineers as well.

If work is becoming more and more location-independent, does this mean that work and private life are moving closer together again, perhaps even merging?
Digitization offers the unique opportunity to make work more convenient for people. Modern factories can be integrated into city centers and residential areas because they're no longer noisy or pollute the environment. Noise and dirt were the reasons why factories disappeared from the cities 100 years ago. Now, they can return – for instance thanks to production technologies like 3D printing. This will spare thousands of people from having to make long commutes and relieve the loads on roads and the environment. In addition, we'll be able to make working hours a lot more flexible. Many activities that used to be tied to an employee's workplace can now be performed at supplier's sites or at home. There's a whole host of interesting options.

Does this also apply to people with lower skills whose jobs will be eliminated by digitization?
The development toward the Industrial Internet of Things entails the risk of a social divide. On the one hand, there are those who are sufficiently skilled and have work and on the other, there are those whose jobs are eliminated and who are left with no or only poorly paid work. This risk must not be played down. That's why we need a qualification offensive in all areas of work. This will be the great challenge of the coming years and decades.

1 TRILLION
objects will be **interlinked** via the internet by 2025 and continuously produce data.
Source: McKinsey

390,000
new **jobs** might be created in Germany in the next ten years due to digitization.
Source: BCG

1 BILLON
messages were **written by robots** in 2014. In journalism, the machine is gaining ground as well.
Source: digitur.de

TRENDSETTER SCHAEFFLER

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Schaeffler's further education offering is pooled around the world under the umbrella of the Schaeffler Academy. This offering addresses all employees and provides targeted training and further education opportunities for apprentices, employees, executives and members of management alike. At the end of fiscal year 2015, about three percent of employees within the Schaeffler Group were enrolled in an apprenticeship program. Thus, the number of apprentices increased by about six percent compared to the previous year.

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advanced training activities in Germany in 2015

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» *Innovative prowess and technology leadership start in the minds of creative employees*

Corinna Schittenhelm, Member of the Board of Managing Directors, Human Resources, at Schaeffler AG

LOADED **WITH POTENTIAL**

In the future, batteries are going to play a much more important part in supplying us with energy than they have been so far. Obviously, due to the increase in electric mobility, but also in completely 'normal' power supply. Good reason to look at the question of what batteries are actually capable of – and what happens to these useful electricity accumulators when they run out of juice.

by Thomas Arndt

Germany's north east can take pride in a respectable achievement in the field of energy storage back in 2014. Since then, WEMAG, a utility based in the Mecklenburg region, has been operating Europe's first commercial battery storage power station in Schwerin, which has made the company a pioneer in an increasingly faster growing industry. The facility operates fully automatically and serves to store electricity generated from wind and solar power to balance short-term differences in demand and supply of the power grid. Inside the building which is about the size of a school gym, 25,600 lithium manganese oxide cells can store electricity in a matter of milliseconds. Five medium-voltage transformers, each weighing four metric tons, connect the power station with both the regional distribution grid and the nearby 380-kV maximum-voltage grid. Company spokesman Michael Enigk has no concerns with respect to the sustainability of this investment: "The batteries specifically supplied for this purpose by Samsung have a guaranteed life of 20 years," he says.

Life is the keyword for the growing number of drive energy storage devices for electric vehicles too. It's much longer than commonly assumed. Eight-year warranties for instance are provided by Volkswagen for the batteries of the e-Golf and by Nissan for the Leaf. Mercedes-Benz guarantees up to ten years to its customers, depending on the electric vehicle model. Within this period of time, between 70 and 80 percent of the original capacity must be available to exclude a warranty claim. If storage capacity diminishes, so does range. But a battery that becomes weaker doesn't necessarily require a complete replacement. In the e-Golf, for example, 264 cells are packed in 27 modules, so a repair, for instance by replacing an individual module, is certainly possible.

Long life of such drive batteries is important because their 'energetic backpack' is a heavy one. That is to say that the amount of energy that is required to produce a large lithium ion battery is enormous and so is the amount of carbon dioxide emitted in the process. 125 kilograms of CO_2 are emitted per kilowatt hour (kWh), according to assumptions by the Institute for Energy and Environmental Research (ifeu). The battery of an e-Golf stores 35.8 kWh, thus generating 4.48 metric tons of CO_2 – as much as a Golf

TDI emits by combusting fuel on a distance of some 40,000 kilometers.

The second life of drive batteries

Still, at some point in time, batteries for use in electric vehicles are considered worn – although they still have some power left. That's when the so-called second life of drive batteries begins: for instance in a power station.

Operation of the world's largest second-life battery storage facility in Lünen in Germany's Westphalia region is planned to launch shortly. The joint venture between Daimler, The Mobility House and GETEC Energie uses battery systems that have reached their end of life in electric vehicles. In Lünen, they are bundled in an array to create a stationary storage facility with a total capacity of 13 MWh. Like the ones in Schwerin, the batteries in Lünen are intended to stabilize the power grids.

A similar approach has been pursued since 2013 by BMW and the energy corporation Vattenfall. In

» Low-cost and powerful storage devices are a key technology of the de-centralized energy revolution

Heiko von Tschischwitz, Electricity Manager

Hamburg's 'HafenCity,' the two partners, in addition to a quick-charging station for electric vehicles, operate a battery storage facility as a buffer. A two-megawatt facility using the potential of end-of-life drive batteries is planned to be commissioned at the 'Cruise Center Steinwerder' cruise ship terminal in the Hamburg port before the end of the year to ensure grid stability as well.

50 percent recycling rate demanded

Just these few examples illustrate that electric vehicles are not special waste on wheels. Even when a drive battery has lost all of its 'juice' at some point – the Association for Electrical, Electronic and Information Technologies (VDE) assumes a total usable period of over 20 years in a battery's first and second 'life' – it can still be put to good use. Recycling companies such as Snam in France, where Toyota is having nickel-metal hybrid batteries reconditioned, or Umicore Battery Recycling, the market leader in the field of disposing of the wide-spread lithium-ion batteries, take care of recycling the raw materials. The focus, however, is not on recovering lithium. This alkali metal only accounts for one percent of the weight of a battery. In an electric Golf that's about three kilograms. The purchasing price is not even ten euros – recovering lithium from a used battery would be more expensive. The recovery of installed metals such as cobalt, copper and nickel is more important, easier and, above all, more efficient. Umicore separates the metals using patented UHT (ultra-high temperature) technology. "At the end of this process, less than one percent of residues are left. Thus, we clearly surpass the recovery rate of 50 percent by weight required by the EU," explains Klaus Sparn, Marketing & Sales Manager at Umicore.

Not everything being salvaged in a battery recycling operation – be it from batteries in electric vehicles or domestic uses – necessarily ends up again in a new battery. Zinc or zinc oxide for example are also supplied to the automotive sector for corrosion protection, old steel finds new uses in the construction of buildings. In a third life, so to speak.

THE AUTHOR

Being a live wire all the time is not the way for ***Thomas Arndt*** *(born in 1959) to go. The Hamburg journalist who started his writing career with a daily paper in Kassel in 1980 as a trainee says: "Those who pull the plug from time to time will have more energy in the long run."*

THE BATTERY AND ITS EXCITING ELECTRIC HISTORY

— ***About 200 BC,*** *the so-called Baghdad Battery is created. Freshly pressed grape juice may have served as battery fluid, according to scientists. The achievable voltage was approx. 0.9.*

— ***In 1800****, Italian Alessandro Volta uses copper and zinc plates to create the voltaic pile, the first battery of the modern era. He has been commonly regarded as the inventor of this type of electricity storage.*

— ***In 1854,*** *Wilhelm Josef Sinsteden builds the first lead-acid battery. Five years later, Gaston Planté replaces the lead plates by the spiral arrangement that is still commonly used today.*

— ***In 1882,*** *Henri Owen Tudor from Luxembourg uses a water mill to continuously charge his lead-acid battery and thus creates the first privately used building that constantly has electric light.*

— ***In 1890,*** *W. H. Lawrence invents the first dry battery for domestic use. In 1896, his invention goes into mass production: weighing about 1.5 kg and intended to supply electricity for telephones.*

— ***In 1899,*** *independently of each other, Thomas Edison and the Swede Waldemar Jungner invent the nickel-cadmium cell – the most common end-user battery up until and into the 1990s.*

— ***In 1957,*** *the Canadian Lewis Urry files a patent application for the first alkali battery for the consumer goods market. Its life is much longer than that of zinc carbon models.*

— ***In 1992,*** *AA lithium batteries are introduced. They finally have sufficient capacity even for modern devices with high energy consumption.*

— ***In 2013,*** *an electric car drives 1,600 km with an aluminum-air battery. It is not rechargeable though, and the aluminum has to be replaced when the battery is empty. Work on viable solutions continues.*

MASTHEAD

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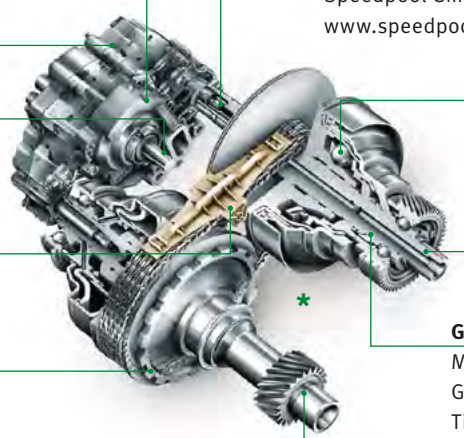

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** The picture shows Schaeffler's LuK variator with pulley sets, chain, guide rail and hydraulic control system developed for Audi's multitronic®. Based on this CVT transmission technology, Schaeffler recently introduced a plug-in hybrid concept.*

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