



FOCUS

**Magazine
2020**

Cell culture

Having pooled its technological expertise, MAHLE is making the fuel cell drive ready for the market.

–p. 4

Hands on

In the early days of the pandemic, employees at MAHLE locations around the world showed what it means to act decisively.

–p. 12

At a glance

MAHLE is a leading international development partner and supplier to the automotive industry as well as a pioneer and technology driver for the mobility of the future.

Around **160**
production locations

12
major research &
development centers

72,184
employees
as at December 31, 2020

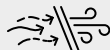
EUR **9.8** billion
sales in 2020

5

business units



Engine Systems and Components



Filtration and Engine Peripherals



Thermal Management



Electronics and Mechatronics



Aftermarket



_____ Michael Frick,
Chairman of the Management Board
(ad interim)/Member of the
Management Board Finance

Ladies and gentlemen,

The year 2020 was like no other. On the one hand, almost all markets and national economies felt the full force of the unpredictable coronavirus pandemic—and the international automotive industry, our company included, was no exception. On the other hand, we at MAHLE surpassed ourselves in many respects as a consequence of this unprecedented crisis. Our magazine article “Hands on” tells this story. It talks about the international teamwork by our locations around the world and how the teams responded decisively to keep our business processes running smoothly. I’m delighted that we also performed a service for society through our production of protective masks and numerous local initiatives.

From a technology perspective, our focus in 2020 was on our strategic future priorities. With our project house and technical cooperation with a fuel cell specialist, we’re helping fuel cell drives achieve their technological breakthrough—read more about this in “Cell culture.” MAHLE’s another future priority concerns electronics and mechatronics. By concentrating these activities in a new business unit, we want to take our expertise in these fields to the next level. With the new test center for electric motors in Fellbach and the new electronics and mechatronics R&D centers in Suzhou and Kornwestheim, we’re ready for the “Next-generation electric.” But for MAHLE, focusing on the drives of the future still means keeping an open mind toward all technologies. After all, there’s still a huge need for the ongoing development of the combustion engine from a global point of view. Why? Our Vice President Corporate Research and Advanced Engineering, Dr. Martin Berger, and Professor Michael Bargende from the University of Stuttgart discuss this topic in a joint interview, “Fuel for thought.”

If we’re to become more efficient and sustainable in the future, it’s crucial that MAHLE is and remains digital. We made a major step forward on this journey in 2020. Two of our digitalization experts explain what we’ve already achieved and how, together, we’re all increasingly using software and intelligent data applications to develop products and processes.

The commitment, flexibility, and resilience that brought us through the exceptional year that was 2020 and are conveyed via this magazine can still be felt throughout MAHLE in 2021. We remain focused and will thus continue to direct all our energies into shaping the future of mobility.

I hope you enjoy reading about developments at MAHLE.

A handwritten signature in blue ink that reads "Michael Frick". The signature is fluid and cursive, written in a professional style.

Michael Frick

Contents



p. 12

p. 4

Cell culture

_____ Commercial vehicles with fuel cell drives are a climate-friendly solution for the future. MAHLE is paving the way with new technology and a strong technical cooperation partner.



Hands on

_____ Spring 2020. The new coronavirus changes everything. No more business as usual—instead, we have lockdown and isolation, quarantine, and stoppages. But things are moving at MAHLE.



p. 20

Next-generation electric

_____ From pedelecs through vans, the market for electric vehicles is booming. MAHLE is ready and waiting for the next generation of drives and continuing to expand its worldwide development network.



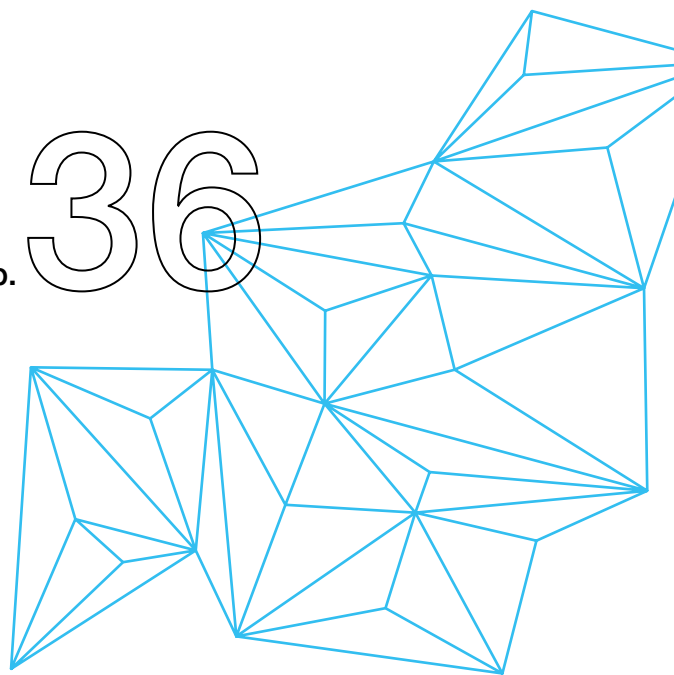
p. 28



Fuel for thought

_____ Is a purely battery-powered mobility landscape the lowest-emission solution for the future? Two experts see other technology pathways as an opportunity to achieve the climate targets.

p. 36



A digital journey

_____ Where is digitalization at MAHLE already part of the daily routine? What other opportunities are there? Two MAHLE experts discuss the status quo and the role of employees.

p. 40 Highlights 2020
p. 44 Imprint/contact
p. 45 MAHLE worldwide

Cell — culture

Fuel cell drives will be a vital technology on the road to zero-emissions mobility. MAHLE has pooled its activities in this field since 2020 and believes it has great potential, particularly for commercial vehicles. By working with an innovative fuel cell developer, MAHLE wants to help the drive of the future make a breakthrough.

Philipp Sommer is a passionate car fanatic with a weakness for complex systems developments and “gasoline in his blood,” as he puts it, smiling. However, he is currently working on ways of using hydrogen to power large commercial vehicles. The young mechanical engineer heads the fuel cell project house at MAHLE. This is where the company brought together all its activities relating to this future technology in 2020 with the aim of boosting its ability to penetrate the market. “We want to think outside our own system boundaries and pursue ambitious targets, particularly in terms of the costs and performance of our components,” explains Sommer.

To turn this pooled knowledge into technical reality, Sommer and his team are able to take advantage of the brand-new test bench at the plant in Stuttgart/Germany. This is where they carry out intensive testing on new developments in the periphery of the fuel cell within a complete drive system. In a nut shell: They improve air management, thermal management (i.e. heating and cooling) and power electronics. As a result: Fuel cells should be significantly cheaper while also durable and thus suitable for mass production. After all, fuel cell technology is regarded as a promising means of achieving the global goal of zero-emissions mobility. As Sommer adds:

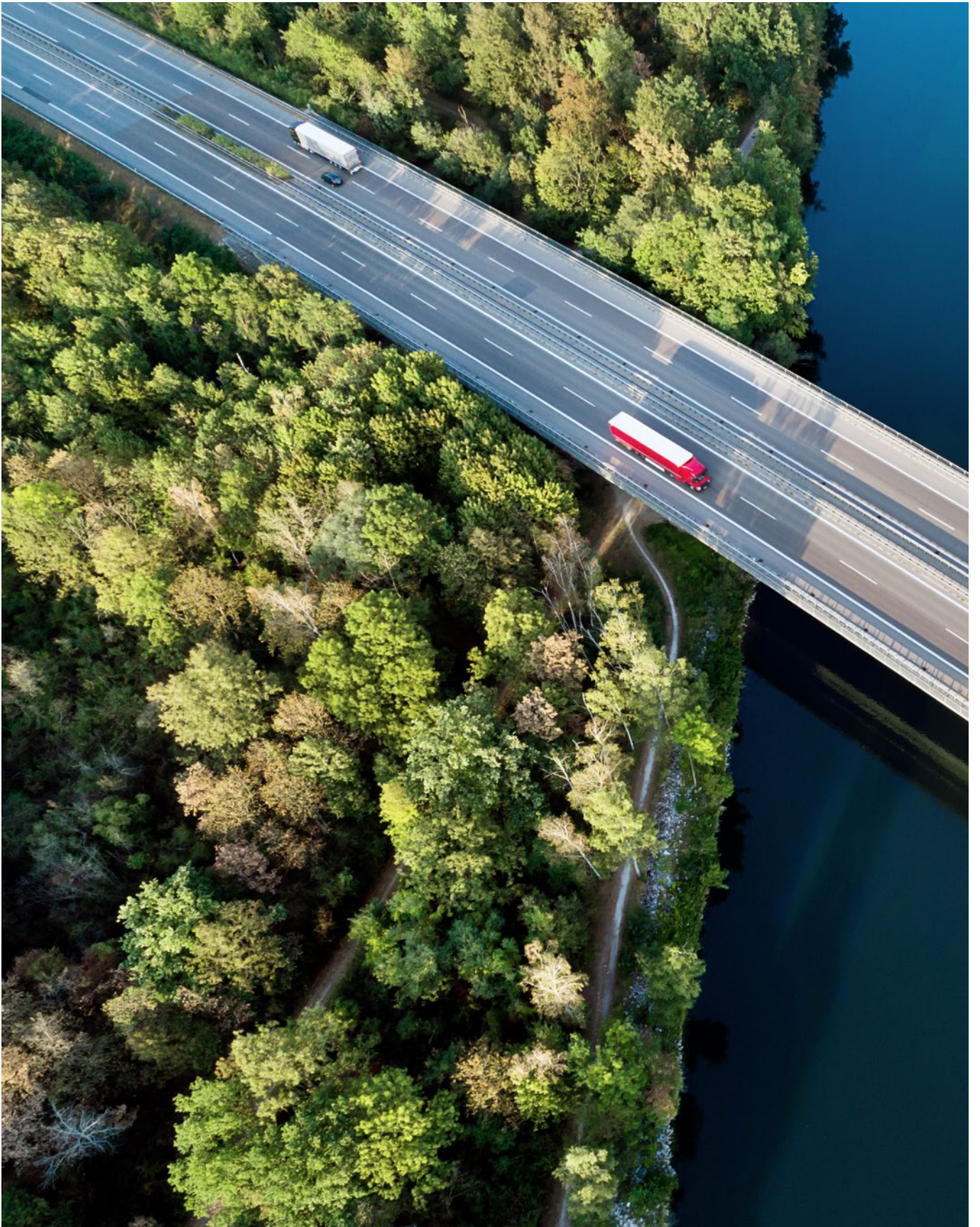
“Through our work, we’re securing MAHLE a share of a market that’s experiencing sustained growth.” MAHLE is already active in this highly promising market with components for both passenger cars and commercial vehicles. For example, it has been a supplier for series production applications in fuel cells on behalf of many well-known international manufacturers for over a decade. Even now, the fuel cell experts are working on customer projects for future generations of fuel cell-driven passenger cars and commercial vehicles.

Technology with a tailwind

With these efforts, MAHLE has moved into the fast lane with respect to a development for which, in Dr. Marco Warth’s opinion, it is worth picking up the pace: “The big difference from the situation maybe five years ago is that public institutions around the world are now putting a tremendous amount of funding into fuel cell technology.” Warth has a degree in mechanical engineering and a doctorate in technical sciences. At MAHLE, he is responsible for development activities in the field of mechatronics under the umbrella of Corporate Research and Advanced Engineering. In his words, that means “everything that we don’t have in the MAHLE product portfolio yet.” And his job? “To turn good ideas into a product within five years.”

New testing infrastructure

With the installation of hydrogen testing infrastructure in Stuttgart, MAHLE has strengthened its position as a development partner for all aspects of the fuel cell and combustion engine. MAHLE’s focus is on the system peripherals surrounding the stack itself. Fuel cell systems can be tested and further developed on several test rigs in the new facility. This also gives MAHLE experts the opportunity to gather key data for fundamental development work on fuel cell technology.





“The big difference from the situation maybe five years ago is that public institutions around the world are now putting a tremendous amount of funding into fuel cell technology.”

——— Dr. Marco Warth,
Director Corporate Advanced Engineering,
MAHLE, Stuttgart/Germany

Warth is confident that this will happen with fuel cells, especially given the political tailwind. In Germany, for example, the Federal Ministry for Economic Affairs and Energy (BMWi) published a National Hydrogen Strategy in June 2020 with plans to invest more than EUR 300 million by 2023. The European Commission has put forward a European Hydrogen Strategy, the primary goal of which is to make investments in hydrogen infrastructure that spans member states, such as in decarbonizing the production of hydrogen by using alternative energy sources. In its Action Plan for an Energy Technology Revolution, China plans to achieve an annual production capacity of 5.5 million fuel cell systems and construct 10,000 hydrogen refueling stations by 2050.

Clear sector focus

Marco Warth calls these “positive signals,” which are stirring ambitions at MAHLE—and raising questions: Which components will we concentrate on? For which sales markets? Where will they be produced? The team in the fuel cell project house quickly agreed on the sector that is best suited to using hydrogen as a means of energy storage. “It’s the commercial vehicle

sector. It accounts for a considerable share of the CO₂ emissions from traffic and, as journeys in this sector are usually long and often international, it would appear to be somewhat less suitable for battery or hybrid solutions,” says Warth. Fuel cell technology offers a long cruising range, rapid refueling, and route flexibility—without impairing the payload capacity.

To see that the team have not come to the wrong conclusion, you only have to take a look at the example of the port of Hamburg in northern Germany. One of the world’s largest facilities for the climate-neutral production of so-called green hydrogen is scheduled to go into operation here by 2025. Compared with gray hydrogen, which is obtained from fossil-based natural gas, green hydrogen is made by splitting water into hydrogen and oxygen. When this is done using renewable electricity—generated by offshore wind farms, for example—the result is an almost emission-free energy carrier. And in Hamburg, the aim is that this will be used to fuel as many as possible of the around 15,000 trucks that call at the port every day.

MAHLE believes that the greatest potential currently lies in the European market. “We want to produce in Europe for Europe,” says Warth. China, which intends to have a climate-neutral economy by 2060, is another exciting market—as is North America. The new US administration under Joe Biden has identified hydrogen as one of

The peripherals are key

It takes more than just a fuel cell to turn ordinary external air and hydrogen into the electricity that drives a commercial vehicle. Many things in a drive system need to be managed, from temperatures, pressures, and voltages to undesirable suspended particles. MAHLE has solutions to deal with all of this. The illustration shows what is needed to ensure a functioning drive.

1 Thermal management

The large front-end cooling modules are just the start. The cooling system—composed of heat exchangers, electric pumps, valves, and fans from MAHLE—runs through the entire vehicle, much like the human circulatory system.

2 Filtration

Filters like those from MAHLE block harmful gases and particles, which could damage the cell or shorten its service life.

3 Electric compressor

This is where the supplied air is compressed. Because even small quantities of oil can cause irreversible damage to fuel cells, MAHLE is developing oil-free bearings.

4 Charge air cooler

Compression heats the air, which must then be cooled efficiently ahead of cold combustion in the cells.

5 Humidification

Fuel cells must be kept reliably moist. Humidifiers from MAHLE transfer humidity from the exhaust air to the dry supply air.

6 MAHLE fuel cell monitor

The module monitors the signals from the fuel cell stack and provides feedback to the central control unit.

7 DC/DC converter

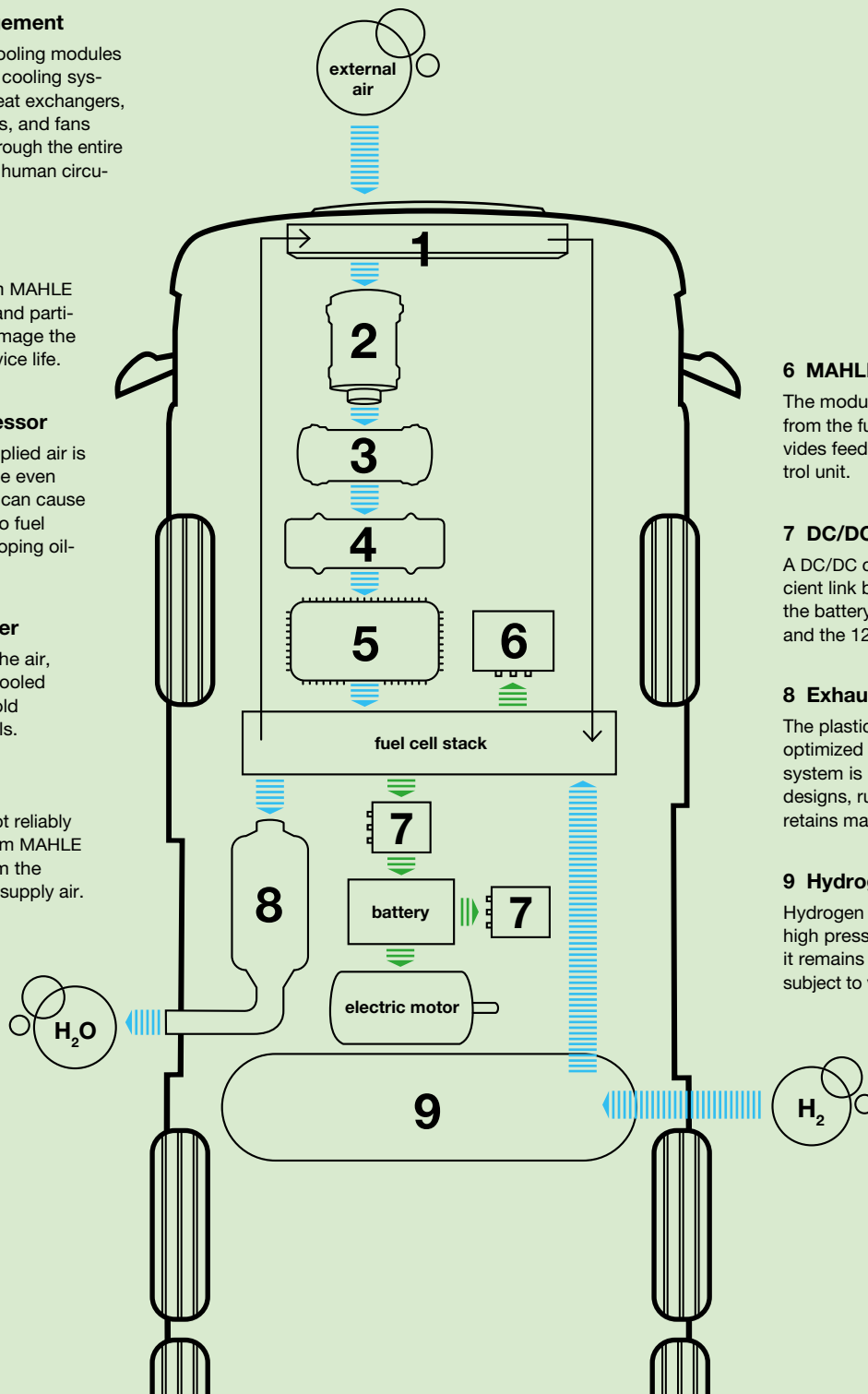
A DC/DC converter is a highly efficient link between the stack and the battery or between the battery and the 12-volt low-voltage grid.

8 Exhaust air system

The plastic exhaust air pathway optimized by MAHLE for the entire system is much lighter than metal designs, runs more quietly, and retains maximum design freedom.

9 Hydrogen storage tanks

Hydrogen is stored at an extremely high pressure of 700 bar. Because it remains gaseous, the tanks are subject to very strict safety standards.



“We’re not interested in ideology. Instead, we want the optimal power-train solution for each sector.”

_____ Dr. Marco Warth,
Director Corporate Advanced Engineering, MAHLE, Stuttgart/Germany

five priorities in its innovation strategy. By 2050, the country aims to be climate-neutral and to become the world's number one producer of the energy carrier.

Intercontinental teamwork

In view of these multinational efforts, Marco Warth believes that fuel cell systems will become global products that will, at most, differ at a local level in terms of the corresponding infrastructure. As for customers, he thinks MAHLE will focus on the OEMs. But Warth also stresses that the company continues to stand by its open attitude toward all technologies: "We're not interested in ideology. Instead, we want the optimal powertrain solution for each sector."

In 2020, MAHLE made a major leap forward in terms of the ongoing development of its expertise and portfolio relating to fuel cells when the technology group agreed to collaborate with the Canadian fuel cell manufacturer Ballard Power Systems Inc. The North American company is regarded as a high-end fuel cell company. Ballard's products stand out when it comes to parameters like durability and are primarily developed for use in trucks, buses, ships, and railroad applications, where they offer great potential.

Through this technical cooperation, MAHLE is accelerating the broadening of its competences in the priority areas of air management (particularly filtration and humidification), thermal management, and power electronics as well as gaining access to expertise in what is known as the stack. This is where the actual cells in which hydrogen and oxygen react to form water and thereby generate electricity are literally stacked together. This knowledge will also help MAHLE to further expand its portfolio of products in the periphery of the stack in order to develop even more cost-effective and robust products for new and existing MAHLE customers in the future.

"The cooperation is both a huge opportunity and a genuine challenge. After all, a Canadian technology specialist and a German automotive supplier have two very different mentalities. These cultures and the 8,000-kilometer distance have to be bridged, and sometimes there's a need to intentionally introduce new approaches as well. Development then progresses somewhat faster than we would have thought possible," says Sommer.

"Through our work, we're securing MAHLE a share of a market that's experiencing sustained growth."

_____ Philipp Sommer,
head of the fuel cell project house at MAHLE



One thing is certain: no one develops a new technology alone, especially one as complex as a fuel cell drive. “Both companies need to collaborate to make advances quickly,” says Marco Warth. After all, the fact that the technology works was proven long ago. It is now a matter of establishing how it can be produced at an industrial scale and at reasonable cost. This is where MAHLE’s many decades of experience in the automotive industry come in. “We understand the sectors, can handle all the specifications, and are well positioned in all the sales channels,” emphasizes Warth. As for Ballard, the engineer is impressed by the typical North American drive to put ideas into practice: “Their experts take an extremely pragmatic approach to their research, whereas we work in a very goal-oriented and systematic way, with development time frames of several years.”



24%

Globally, 24 percent of global energy-related CO₂ emissions are attributable to the transportation sector, which also includes passenger car traffic. Road freight is responsible for one third of this amount. Fuel cell technology is seen as a solution for the emission reduction.

Source: International Energy Agency (IEA), 2018

A system mindset

MAHLE’s clear role in the partnership is to concentrate on developing the individual components of a fuel cell system—but it also needs to consider the bigger picture: “It’s a very complex task,” explains Philipp Sommer. “The design criteria for the components change as soon as I shift my focus from the individual parts to the system.” We can see an example of this in various components, such as humidifiers, that have air and hydrogen flowing through them. “Although a circular cross section at component level theoretically achieves the best results in terms of pressure losses and efficiency, we now tend toward more elongated, rectangular designs, because they can be integrated much more effectively into the overall system and have cost advantages when it comes to manufacturing.” In making these adjustments, MAHLE puts the know-how in the field of filtration and plastics processing that it has built up over decades to good use. “Given the current state of the art, a fuel cell drive is not a stand-alone piece of technology—instead, it’s always engineered together with a battery. The question is: What power output and design will it have?” explains Warth. He also comments that suppliers like MAHLE will need to have an input into these matters at an even earlier stage in the future. “I expect the spectrum of vehicles to broaden still further. The days of one model for all applications are over. This increasing diversification will also have an impact on our components.”

The goal: proud faces

Marco Warth imagines that it will only be a few years until an efficient hydrogen infrastructure and trucks with fuel cell systems that are able to compete on price and performance are available. “Until then, we’re advancing from milestone to milestone. All with the goal of seeing the proud faces of our colleagues when we help the fuel cell drive in which our components are installed to achieve its major breakthrough,” says Marco Warth, adding that this moment is what motivates him every day. And maybe then, Philipp Sommer will declare that he now has hydrogen rather than gasoline in his blood.

3 questions for ...

Randy MacEwen, CEO at Ballard Power Systems Inc., on strategic objectives and the technical collaboration with MAHLE.

“Our objective is to bring to market the best fuel cell engines for medium- and heavy-duty commercial vehicles.”



What made Ballard decide to cooperate with MAHLE?

MacEwen: “There is a growing demand for fuel cell engine solutions for commercial vehicles. Ballard has been developing this technology for the past 40 years. We realized that we needed a reputable partner with strong expertise in developing and producing drive components and systems to succeed in the industrialization stage. As a global Tier 1 supplier to the automotive industry, MAHLE brings unique expertise in developing components for fuel cell systems and in-depth knowledge of truck system requirements.”

What are Ballard’s strategic goals, and how does the partnership with MAHLE contribute to these?

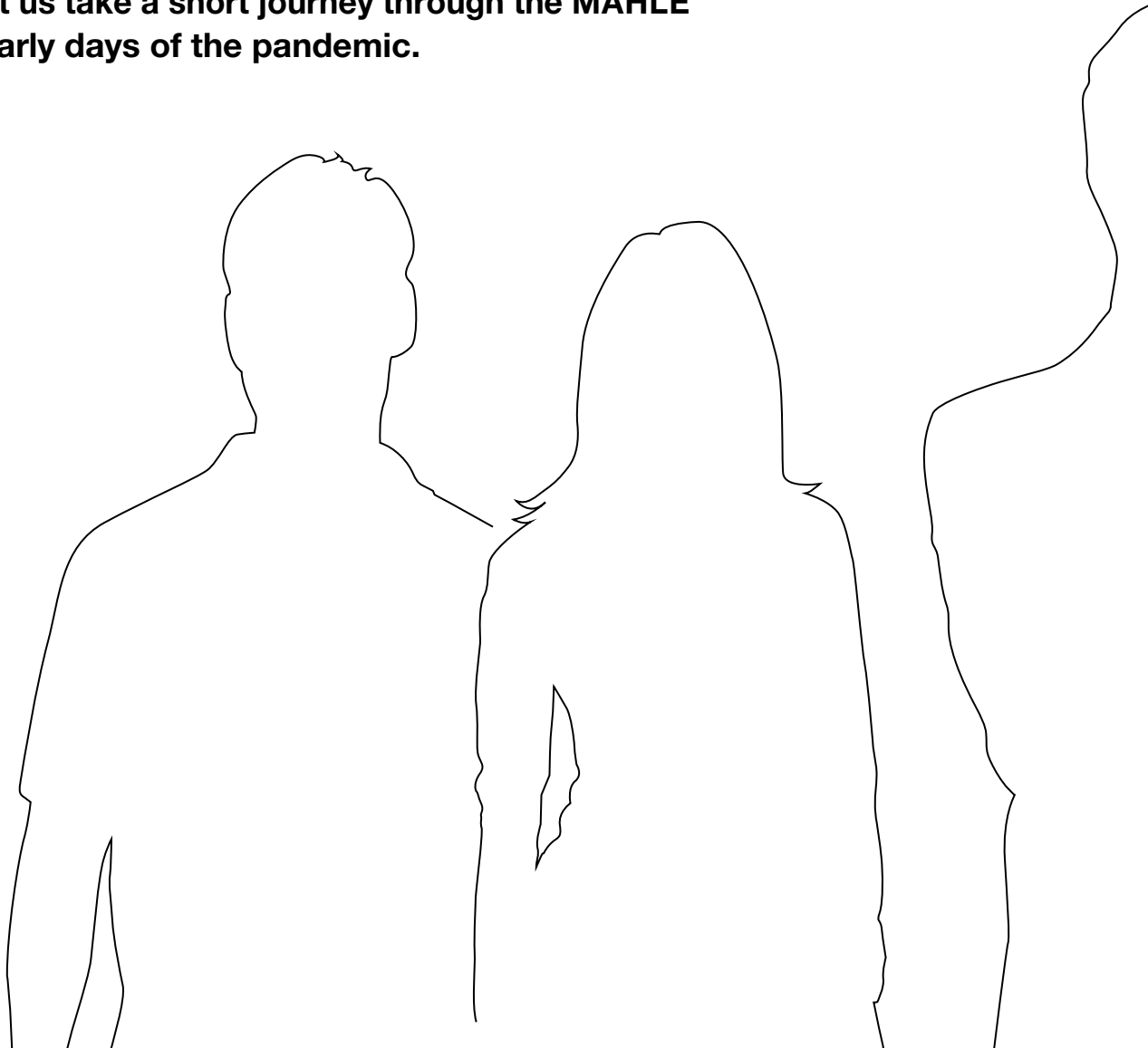
MacEwen: “Our objective is to bring to market the best fuel cell engines for medium and heavy-duty commercial vehicles. MAHLE’s key contributions will include systems integration knowledge—such as in cooling and power electronics—and fuel cell-specific components, like filters and DC/DC converters. Added to this is the company’s expertise in development optimization—from modeling to testing and manufacturing scale-up capabilities on five continents.”

How is the cooperation going in these challenging times with respect to the pandemic?

MacEwen: “Despite COVID-19, our cooperation made significant progress in 2020. Our teams have been able to develop a program plan and define targets and product requirements. Working in these challenging conditions has brought our teams closer together and validates our alignment on shared values, corporate culture, and a vision for sustainable technology.”

Hands

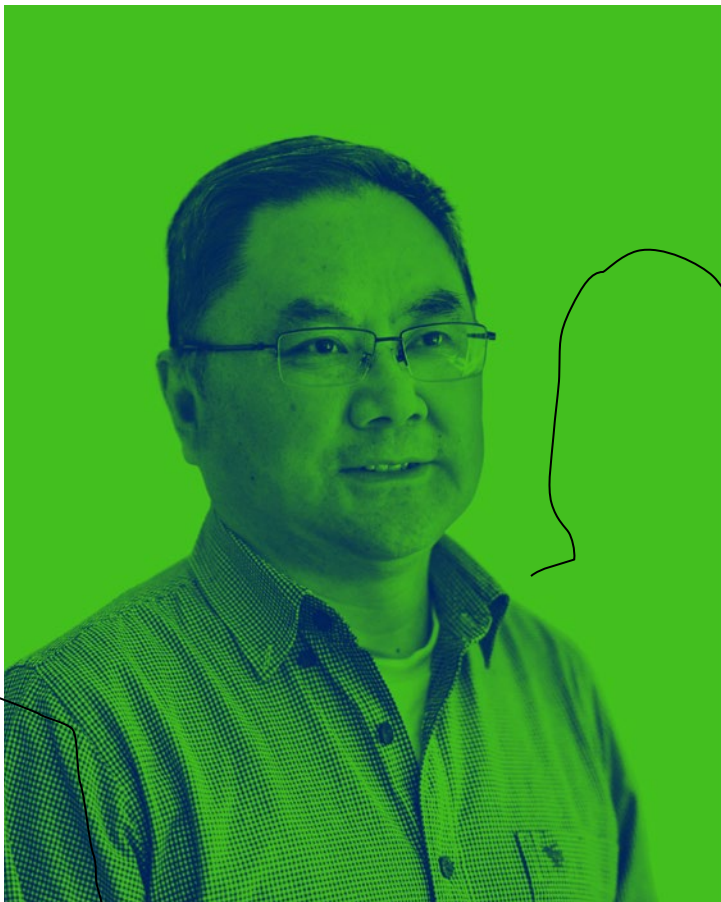
Spring 2020. The new coronavirus changes everything. No more business as usual—instead, we have lockdown and isolation, quarantine, and stoppages. But things are moving at MAHLE. Under the most difficult conditions, remarkable projects start across the globe within a few weeks. Let us take a short journey through the MAHLE world in the early days of the pandemic.



on

“It was a truly unique time.”

—— Jack Huang,
Head of Health Safety Environment for the
Asia/Pacific region at MAHLE in Shanghai/China



+++ January 2020, Shanghai/China +++
While carefree après-ski celebrations are still taking place in Europe, Jack Huang is already racking his brains about how to deal with the new coronavirus. As Head of Health Safety Environment for the Asia/Pacific region, he is responsible for the health and safety of the employees at the more than 25 MAHLE locations in China. A large part of the workforce is on vacation for the Chinese New Year. This makes planning a little easier, but the challenges for Huang are immense: Every day there are new reports about the virus, in addition to ever-stricter guidelines from the government. The Hubei region is completely locked down, other provinces as well. There are countless unanswered questions. How infectious and dangerous is this disease, how does it spread, what needs to be done to resume business quickly? Huang works from morning until late at night these days, cooperating with all members of the Health Safety Environment (HSE) team to develop guidelines for resuming business at all Chinese plants, networking with the Purchasing department to ensure that there are sufficient protective masks available for all employees, and supporting the plants in safely returning employees to work. Huang monitors the situation in the respective Chinese plants and reports back to the China management team on a daily basis. “It was a truly unique time,” he says today.

flexibility

+++ March 21, Stuttgart/Germany +++

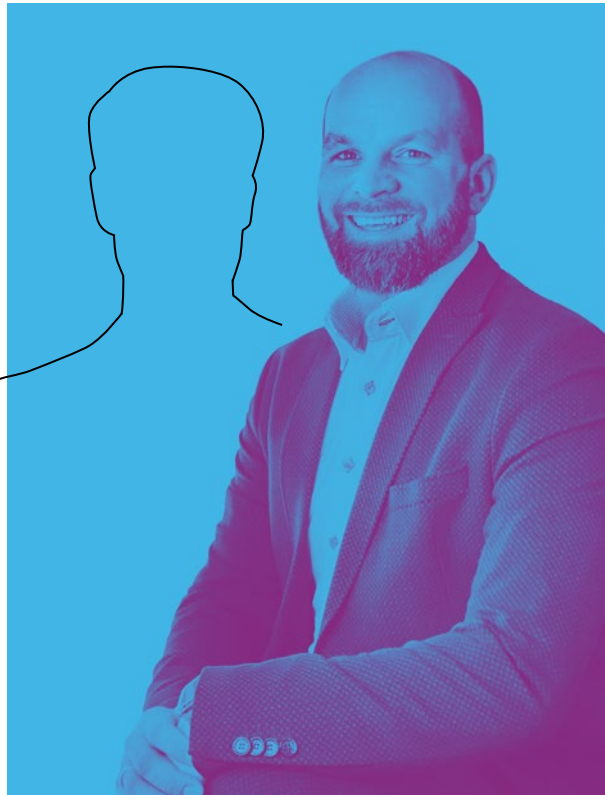
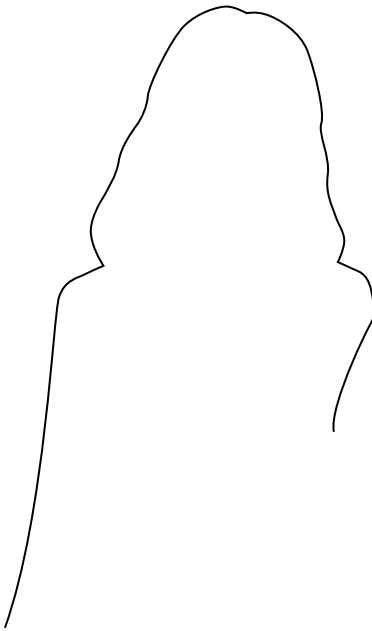
It is a Saturday. Frank Rohde sets off at 04:00 to pick up his daughter from Frankfurt Airport. It will be the last flight from Thailand before flights to Germany are suspended. In the car he hears the news that the coronavirus situation is getting worse: France is shutting down, Spain is declaring a state of emergency, and in Germany the number of people testing positive is rising rapidly. The head of the Filter Elements and Filter Media department has two questions on his mind. First, how will his department cope with the impending shutdown? Second, what can he and his team do to help fight the virus? Together with his supervisor Jörg Rückauf, he develops the idea over the weekend: “We need to make protective masks. It was clear to me that our filter media also protected against the virus,” says Rohde, looking back. But as an automotive supplier, how do you build up mask production from scratch? “With a lot of effort through try and error and with the right partners.” For three weeks, a small, powerful team from Austria and Germany devotes itself completely to this development. The first templates are created using paper and a stapler; the clip of a bread bag also serves as a makeshift tool. “We know how to filter air. But developing a protective mask was real grassroots work,” Rohde recalls. MAHLE gains an additional partner: the underwear manufacturer Triumph, which contributes its expertise in textiles and sews masks made of the MAHLE filter material in its workshops in parallel with the planned in-house production. “Atemmasken statt BHs (face masks instead of bras)” is the headline in the Frankfurter Allgemeine Zeitung. The ambitious goal of producing 1.5 million masks a month is quickly achieved. “The way we pulled it all off was an amazing and unique experience,” Rohde sums up. The enthusiasm is still palpable today: “There was no template for this venture; everything had to be developed as a team. Success like this brings people together and strengthens the internal and external network—and this extends beyond the pandemic.”

“We know how to filter air. But developing a protective mask was real grassroots work.”

_____ Frank Rohde, head of the Filter Elements and Filter Media department, MAHLE in Stuttgart/Germany

creativity





**+++ End of March,
St. Michael/Austria +++**

Frank Rohde is in close contact with his MAHLE colleagues in Carinthia, where a team of five employees is also working flat out to develop protective masks. The families are also involved: “The wife of one colleague is a dressmaker, and so naturally she made her expertise available,” recalls Christopher Opetnik, Head of Production at MAHLE in St. Michael in Austria. As is so often the case, the devil is in the detail: masks for women require a different cut than those for men. And thought must also be given to those who wear glasses. Above all, however, it is important to organize the production of the protective masks in such a way that it does not affect the plants and lines belonging to the core business—the production of filters and engine peripherals. “It was clear that we would need additional capacity, because of course, no customer order could be delayed because of the production of masks.” Having achieved this gives Opetnik satisfaction to this day. “The project has shown how versatile we are—and how quickly we can pick up speed.” The final milestone for Opetnik was the CE certification, which was achieved in April 2021. This means that MAHLE masks can also be sold externally—contributing to value creation in the region and to regional responsibility.

solidarity

**“The wife of one colleague
is a dressmaker, and
so naturally she made her
expertise available.”**

_____ Christopher Opetnik, Head of Production,
MAHLE in St. Michael/Austria

+++ March 23, Parma/Italy +++

Northern Italy is a coronavirus hotspot, and the MAHLE Aftermarket branch in the region has closed. Managing Director Carlo Rocchi, however, has no intention of remaining idle. On the one hand, he recognizes that his employees need something to focus on in these difficult times. On the other hand, he is convinced that his unit must make its know-how available for technical solutions in the fight against the pandemic. His idea: a device that uses ozone to disinfect the air in vehicle cabins. It can be used in cars and buses as well as in hotel rooms or offices. Anywhere that requires hygienically clean air, now and in the future. At the heart of the device are sensors and software that regulate the supply and removal of ozone. The team needs a completely new production line to manufacture the machine. Building it proves to be a difficult undertaking: supply chains are compromised and companies in lockdown. But necessity is the mother of invention. One partner manages to deliver the most important parts. Missing components are ordered online. From isolation, the company begins advance sales of the product, which has so far only been available on paper. "The project felt like a bet I knew we would win," says Rocchi. Production of the OzonePRO air cleaning device starts on May 27. In the second half of the year, MAHLE Aftermarket Italy sells more than 4,000 of these units.



inventive spirit

**“The project felt
like a bet I knew
we would win.”**

_____ Carlo Rocchi, Managing Director,
MAHLE in Parma/Italy



“The project meant taking a big step out of our comfort zone.”

—— David Gurney, Senior Principal Engineer, MAHLE in Northampton/UK

+++ March 24, Northampton/UK +++

With the UK in lockdown, the National Health Service expects to urgently need thousands of new ventilators within a few weeks in order to treat COVID-19 patients. The medical device consultancy Team Consulting is commissioned to look for a solution and rapidly develop a working prototype. The consultants arrange a video call with MAHLE Powertrain UK: Would the analysis team consider contributing their powertrain engineering know-how to develop a simulation of the ventilator? “We accepted immediately,” says David Gurney, Senior Principal Engineer. Under lockdown conditions, the work begins. After three days, the first model is ready, simulating the ventilator, and a bellows device used to replicate the human lung. A week later, the model is accurate and ready to use. It is rapidly put to work investigating how the ventilator performs in the many tests required to gain approval. Pilot production starts on April 20. “The project meant taking a big step out of our comfort zone,” Gurney explains. He had never experienced such a high pace of development: what usually takes months or years was achieved here within a few weeks “without any technical compromises—after all, this is a medical device.”

pace

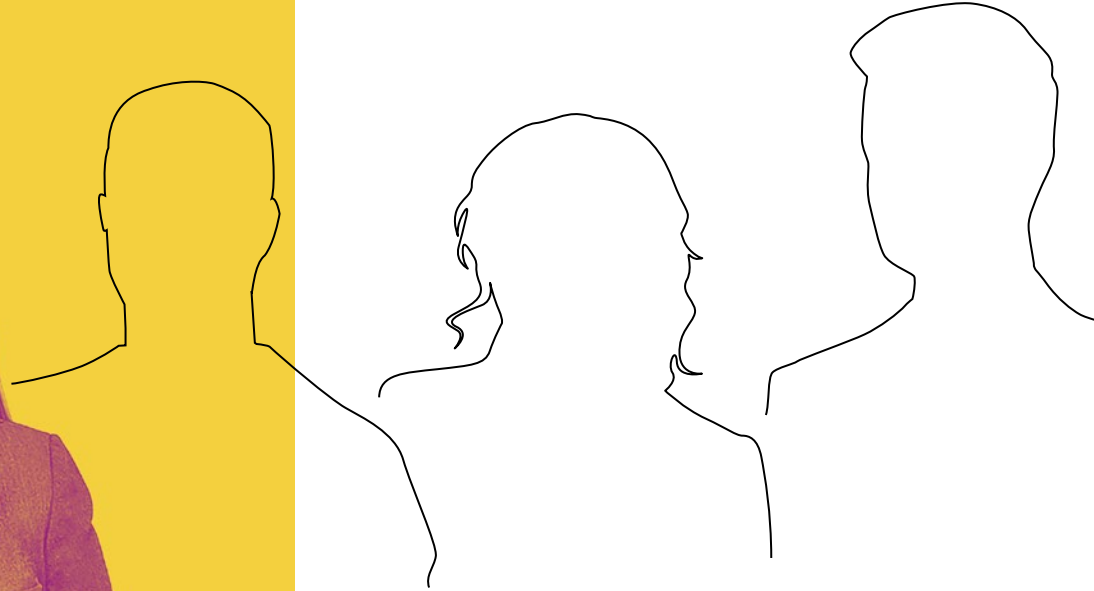


**+++ End of March,
Santa Catarina/Mexico +++**

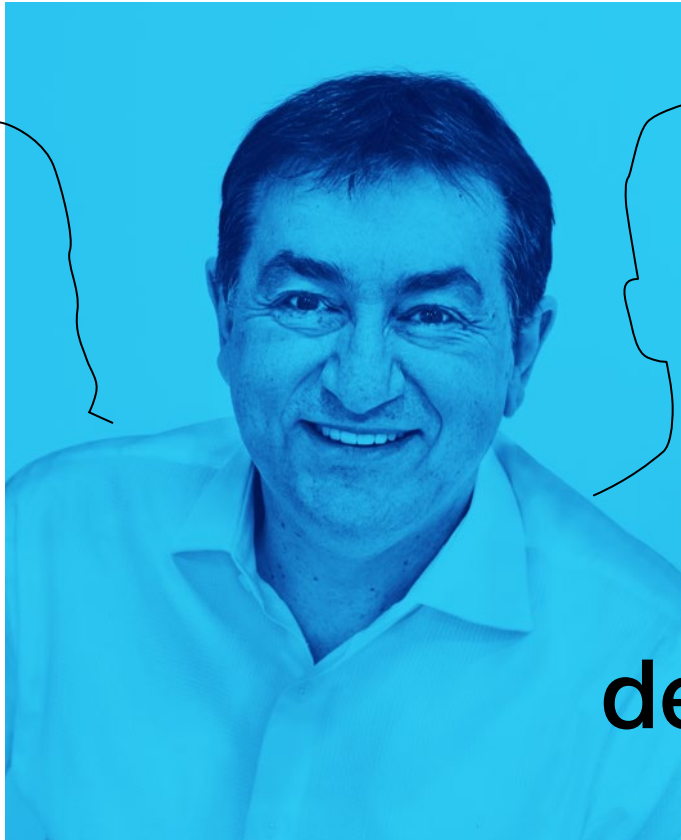
The first wave hits the country hard. Deyanira Hernandez is Head of Human Resources for the Filtration locations. Drawing on the experience of the subsidiaries in Europe and Asia, she develops a hygiene concept: PCR tests and temperature checks, distancing rules even in factory buses, and mandatory mask wearing. Employees feel safer in the plants than anywhere else. Because MAHLE is providing medical advisers and even oxygen equipment for emergencies, the branches become places where help can be provided to everyone without any red tape. "Our actions helped to support the Mexican health system," says Hernandez.

**“Our actions helped
to support the Mexican
health system.”**

_____ Deyanira Hernandez, Head of Human Resources
for the MAHLE Filtration locations, Santa Catarina/Mexico



safety



dedication

“To have achieved so much in so little time and under such difficult conditions? It was an absolutely fantastic experience.”

_____ Edison Bueno, Director and General Manager
Filtration & Engine Peripherals South America,
MAHLE in Mogi Guaçu/Brazil

+++ April 24, Mogi Guaçu/Brazil +++
MAHLE also takes on a consulting role in Brazil. A personal phone consultation hotline is set up for employees and their families at the eight locations. People call to obtain information and assistance. This is invaluable because the Brazilian government initially takes the virus less seriously. Like everywhere else in the country, thousands of protective masks are needed in the region north of São Paulo state. The filtration experts at MAHLE South America do not hesitate: they want to help. In cooperation with the textile company Fibertex, the team develops protective masks. MAHLE donates the first batch to local hospitals and social welfare organizations: 70,000 protective masks that save lives. “Being able to contribute to this has made my team and me proud,” says Edison Bueno, Director and General Manager Filtration & Engine Peripherals South America. What will he take from this experience? “I’ve been with the company now for twenty-five years. To have achieved so much in so little time and under such difficult conditions? It was an absolutely fantastic experience.”



Next-generation electric

The market for electric vehicles is booming—from pedelecs and passenger cars through vans, they are appealing to more and more customers. Now, with MAHLE’s support, the next generation of drives is already in the starting blocks—for electric vehicles that will be even more efficient and even more suitable for everyday use. The company is continuing to expand its international development network for this purpose. We take a look inside three locations that are pioneering the future.

From niche to mainstream: In the pandemic-hit automotive markets, the electric drive has made significant gains almost everywhere around the world. For instance, electric passenger cars have doubled their market share in Europe to around 4 percent. Pedelecs were so popular in 2020 that, for some models, customers were prepared to accept delivery times of several months—something that used to be the case only for exclusive sports cars. At the same time, large logistics companies announced plans to speed up the electrification of their vehicle fleets. In recent years, MAHLE has already helped to usher in generation electric’s leap forward. With motors and the associated power electronics, the company is increasing driving pleasure and propulsion efficiency—not only for battery electric vehicles but also for hybrids of all performance levels. Added to this are electric auxiliaries, actuators, and valves—for steering assistance or controlling air conditioning circuits, for example. And last but not least, thermal management systems keep cabins warm while batteries and powertrains stay cool. These also include electric coolant pumps that provide cooling for drive motors and batteries in both battery electric and fuel cell vehicles.

Nevertheless, there is always room for improvement. That’s why the technology supplier pooled this essential expertise for the future in the Electronics and Mechatronics business unit in 2020. The unit’s development network is already working on a generation to come, which promises to offer an even better fit with people’s lives and with the requirements of logistics

specialists. The most important objective is that using an electric vehicle should be just as flexible as using an equivalent with a combustion engine. For example, instead of simply making batteries larger and larger, MAHLE’s engineers are primarily focused on increasing their charging speed.

In the future, it should be possible to feed enough electricity into the cells of a battery in 15 minutes to cover a cruising range of 500 kilometers. This will be achieved by means of two technological innovations. First, a new-generation battery will prevent heat from accumulating in the battery. The battery cells will no longer only be cooled from below via a plate; instead, they will be embedded in a matrix, which will circulate coolant around the cells from all sides. By using this technique, known as immersion cooling, much more heat can be dissipated in a short time, paving the way for unlimited, ultrafast charging. Second, MAHLE aims to play a role in raising the voltage level of the entire powertrain of future electric cars to 800 volts. Doubling the voltage means that double the electricity can flow into the same conductors in the same amount of time.

So that all customers around the world can benefit from these advantages, MAHLE combines the knowledge of thousands of engineers across all its locations. They pool their expertise in mechatronics and electronics to create a constant stream of new innovations. How? That will be revealed on a visit to three locations.

Precision work in Kornwestheim

“Our proximity to major automotive manufacturers in the region helps us to keep our fingers on the pulse.”

_____ Dr. Armin Messerer,
location manager and head of the
global Mechatronics business,
MAHLE in Kornwestheim/Germany



Kornwestheim on the outskirts of Stuttgart/Germany is the location of MAHLE's new command center for its global mechatronics network. Here, around 100 engineers work in close dialog with colleagues from German, Spanish, Slovenian, Japanese, and Chinese locations, for example, on solutions for various types of drive with a focus on the electric vehicles of the future. “Our proximity to major automotive manufacturers in the region helps us to keep our fingers on the pulse,” says Dr. Armin Messerer, location manager and head of the global Mechatronics business segment. He views the 800-volt technology as a global megatrend in the automotive industry. Customers in Asia have since joined German premium manufacturers in showing a great deal of interest. From a technical perspective, adjusting the voltage level is anything but trivial. “We have to pay attention to every single detail in order to prevent unwanted voltage flashovers and short circuits,” Messerer explains. This is as much about the chemical processes as it is about the materials used. Sometimes, even a coat of paint is decisive in determining dielectric strength. All this has to be tested with state-of-the-art equipment.

Meanwhile, the portfolio for an 800-volt world has come a long way. The highly compact and very effectively cooled 800-volt traction motor developed in-house by MAHLE is ready to be launched. The electric air conditioning compressor for this voltage level will go into series production next year. In recent years, the Mechatronics team has successfully brought other electric auxiliaries such as electric coolant pumps and fan motors in the 12 V, 24 V, and 48 V range into series production at the MAHLE plants in Slovenia, Japan, and China.

The degree to which each cog needs to mesh with the next in order to turn the electric car into a convincing alternative for many people can be seen in the example of an electric fan drive recently developed by MAHLE. Simply transferring this part from a combustion engine into the electric world would not be a good solution. That's because a combustion engine emits a lot of heat, especially when driven hard at full speed. By contrast, the electric drive's high degree of efficiency means it produces much less waste heat. However, if the vehicle is being charged with 400 kilowatts or more, the stationary electric vehicle's fan drive has to work very hard—and that is something you would rather not have to hear. A new, extremely quiet model currently being worked on by MAHLE engineers in Kornwestheim aims to address precisely that.



1 An eye for detail: Roberto Almeida e Silva is Head of R&D Automotive Drive Systems.

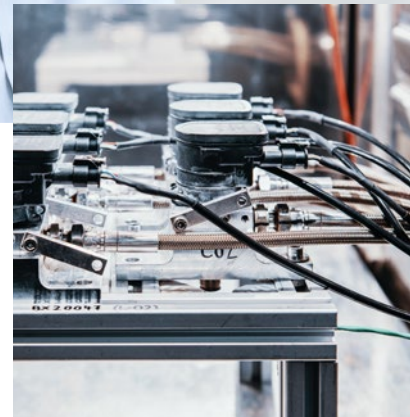
2 Bernd van Eickels is in charge of development in Actuators and Auxiliaries at MAHLE.

3 The three experts work in close dialog with colleagues from German, Spanish, Slovenian, Japanese, and Chinese locations on solutions for various types of drive.

1



2



3



1

1 The new test center in Fellbach near Stuttgart has been in operation since the end of 2020.

2 Jakub Lasica and Neil Fraser oversee every detail from the control room.

3 On the test rig, a lot depends on voltage and current.

4 As the test rig engineer, Jakub Lasica makes sure that every test runs smoothly.

2



3

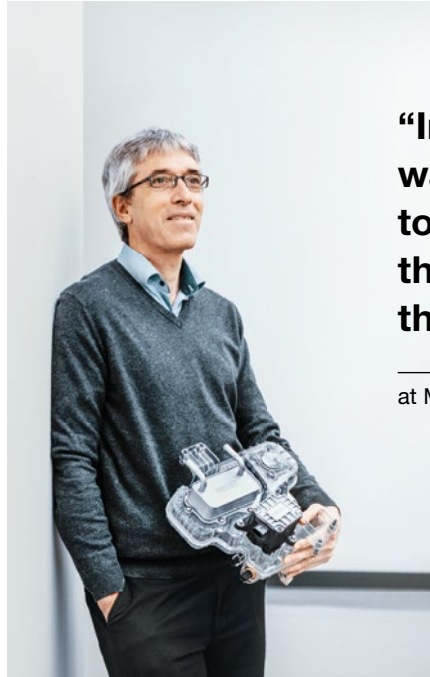


4

Systems testing in Fellbach



When your aim is to make sure that everything that belongs together fits together, it is not enough to develop individual components—however perfect they may be—and then put them through their paces. Neil Fraser, head of development at MAHLE Powertrain in Germany, proudly shows us around the new test center, which was commissioned at the end of 2020 in Fellbach, also near Stuttgart. “We don’t just have the systems expertise for a complete electric axle drive—we can test it too,” says Fraser. For this, the test rig—which looks like an astronautical engineering laboratory—comprises a type of setup that can only be found in a few other places in Europe. The test specimen, that is to say, the electric axle, is tensioned between two electric dynamometers. They stand in for the wheels and thus simulate the entire driving resistance for an electric drive with a power output of up to 840 kilowatts. A small but important detail that results from this setup is that the two dynamometers operate entirely independently of each other, which means that the different rotational speeds and torques resulting from cornering can be recorded. “In the design stage, it was particularly important to us that we replicate the reality of the road on the test rig,” explains Fraser.



“In the design stage, it was particularly important to us that we replicate the reality of the road on the test rig.”

____ Neil Fraser, head of development at MAHLE in Aschheim/Germany

This also includes the power supply to the test specimen, which is ensured via a battery simulator. This battery simulator can be operated like a lithium-ion battery. Algorithms stored in the simulator thus reproduce the actual behavior of a real vehicle battery. The test rig as a whole can simulate temperatures between minus 30 and plus 130 degrees Celsius. The test cycles to which the electric axle is subjected are in turn derived from numerous prototype trials previously carried out by MAHLE with real drivers. These often involved vehicles with combustion engines, but Fraser sees no contradiction here: “On the contrary. After all, we want the switch to an electric car to entail as little adjustment as possible for the driver.” Since MAHLE also sells drive development as a service, vehicle manufacturers can hire the test rig by the day. “When they do so, we’re able to run almost any test cycle they bring with them,” promises Fraser.

Proximity to the market in Suzhou

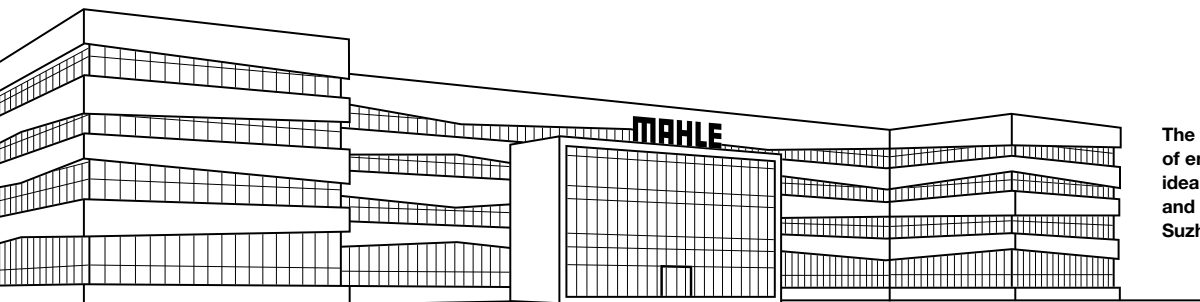
“Many Chinese customers expect more from us than just excellent individual components.”

_____ Kun Hu, General Manager,
MAHLE in Shanghai/China

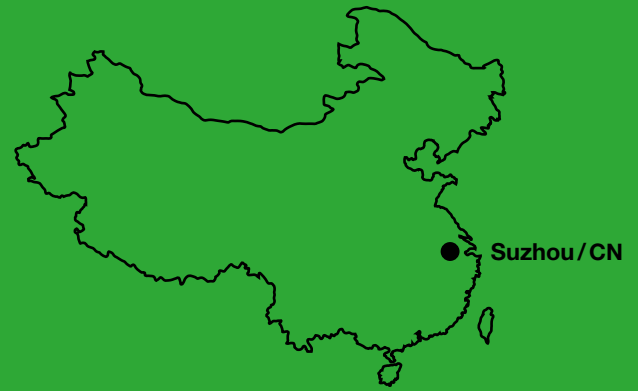
When it comes to sales of purely battery-powered vehicles, China still leads the way. So it is only logical that MAHLE's electronics and mechatronics initiative should also lead to new investments in China and that the country should be a source of momentum for the company's European locations. A new development center in Suzhou—a megacity with a population of some 10 million people around 100 kilometers northwest of Shanghai—will thus be commissioned in 2021. Its construction was already completed at the end of 2020. Up to 500 engineers are expected to work here in the future. “A clear course toward electrification has been set in China,” explains Kun Hu. The responsibilities of the general manager of MAHLE China include the development of MAHLE's new business segments in this important market. “In terms of registration numbers, cars with battery electric or hybrid drives are set to dominate in just a few years.”

Systems development is one of the focal points in Suzhou, as is the establishment of regional development expertise in electronic and mechatronic products. “Many Chinese customers expect more from us than just excellent individual components,” says Hu. “We need to be able to develop and validate complete electric drives—and it should be done on site here, in close dialog with the customers.” According to Hu, these customers—above all, Chinese automobile manufacturers—are just as ambitious when it comes to technology as the long-established European brands. “The subject of 800-volt technology is as important in China as it is elsewhere.” With the difference that a supplier is expected to provide complete solutions, including thermal management. “We have the know-how in the Group, and now we're bringing it here,” says Hu.

Suzhou and Kornwestheim are separated by over 8,800 kilometers as the crow flies. And yet, MAHLE's electronics and mechatronics pioneers around the globe share a common goal: to make the next generation of electric vehicles even more suitable for everyday use.



The future home of hundreds of engineers and new ideas: the MAHLE research and development center in Suzhou/China.



“We need to be able to develop and validate complete electric drives – and it should be done on site here, in close dialog with the customers.”



Fuel for thought

In a world of battery-powered e-mobility, conventional fuels would be rendered obsolete. But can the energy requirements of the entire transport sector really be met by the electricity grid alone? Professor Dr. Michael Bargende from the University of Stuttgart and Dr. Martin Berger, Vice President Corporate Research and Advanced Engineering at MAHLE, see other technology pathways as an opportunity to achieve the climate targets.

There is a lot of talk about battery electric vehicles at the moment. But market research suggests that many newly registered vehicles will still have a combustion engine even several decades into the future. What's going on?

Bargende: A case in point of this misunderstanding is the announcement that, by 2035, General Motors intends to sell only vehicles with powertrains that do not produce direct emissions.* Many people have equated this with a complete switch to electric vehicles, but, for one thing, “aspiration” means a “hope or endeavor” rather than a “resolution.” Moreover, General Motors has by no means said that it no longer intends to sell combustion engines. After all, it is perfectly conceivable that, in the future, cars with internal combustion engines will minimize their local pollutant emissions to such an extent that they will no longer have any environmental relevance (so-called “zero-impact” emissions). And as far as CO₂ emissions are concerned, combustion engines aren't inextricably linked to fossil fuels.

Berger: I agree completely. The challenges posed by local pollutant emissions will be resolved under all conceivable boundary conditions with exhaust emission standard Euro 7, if they haven't already been by Euro 6. But when it comes

to the reduction targets for CO₂ emissions, electric vehicles are currently the be-all and end-all—especially for legislators. However, this way of thinking merely shifts the responsibility for reducing CO₂ to another sector, which doesn't solve the problem. On the contrary, the energy still has to be converted somewhere and then distributed. And before we ban the combustion engine entirely, we should first ask ourselves whether it wouldn't be more advisable to stop using fossil fuels instead. At the very least, we should remain open to different technologies.

What might a climate-friendly drive concept incorporating a combustion engine look like?

Berger: We're already seeing the beginnings of that concept here and now. It's a matter of using existing plug-in hybrid vehicles the right way, for example. To this end, drivers need to have sufficient everyday options for recharging their batteries—designed with a relatively compact form factor—over and over again. On the other hand, renewable electricity must always be available for electric vehicles, otherwise the whole concept makes no sense from an environmental perspective ...

*Source: <https://media.gm.com>,
“An aspiration to eliminate tail-pipe emissions from new light-duty vehicles by 2035.”

Bargende: I'm convinced that the future of private transport will be electric in the first instance. But what does that mean exactly? In urban settings, it's highly probable that we'll drive battery electric vehicles. That's because people in these areas aren't necessarily reliant on public charging stations. Many motorists can simply charge their car at home via a wallbox or in their building's underground garage, for example. Outside metropolitan areas, however, the logistical effort associated with purely battery-powered electric vehicles is too great. In my view, a hybrid drive with an electric motor and a combustion engine is the better solution here—if that combustion engine is run on renewable fuels. And if we look at the commercial vehicle sector, it's difficult to imagine how driving a battery-powered 40-ton electric truck from Munich to Hamburg can be economical and environmentally friendly, even under the most favorable conditions. In this context, we'll still be dependent on chemical energy carriers in the future.

Which climate-friendly fuels do you see as having the advantage?

Berger: The most important thing is to use nonfossil fuels. On the one hand, these include hydrogen and ammonia, both of which are carbon-free. That's good to begin with, in terms of avoiding CO₂. However, these are gaseous fuels whose energy density is rather low in relation to volume. In the case of hydrogen, they need to be compressed at high pressure or liquified at very low temperatures to prepare them for use, which, incidentally, also makes them really difficult to store.

So, is it better to convert the hydrogen into e-fuels in a second step?

Berger: That is the case for some applications at least. In my view, the best energy carriers are carbon-based fuels obtained using renewable electricity—synthetic gasoline or diesel, or even methanol, for example. These fuels are liquid at normal temperatures, and they don't need to be supplied under pressure—just as we're used to with fossil fuels. They have a high energy density and are easily stored in tanks. If the carbon were to be captured from the environment beforehand in order to produce these fuels, we'll also have created a circular economy for CO₂—thus generating hardly any additional CO₂ emissions.

How do you respond to skeptics who argue that the efficiency of e-fuels is substantially lower compared with using electricity directly in battery electric drives?

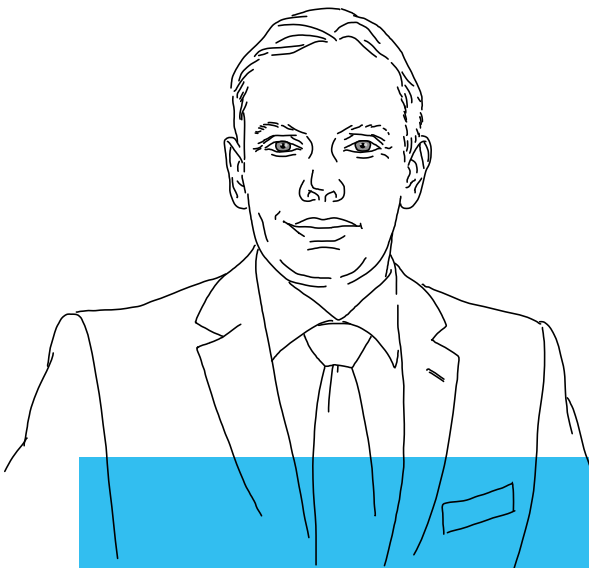
Bargende: Our planet potentially has many more times the solar or wind energy available than we will ever need. So, the question of efficiency is secondary for now. Instead, we should be asking how we can get renewable energy to consumers on a large scale. Just as reserves of fossil fuels lie far away from most advanced economies, the same applies to renewable energy potential. For example, it makes much more sense to locate large solar power plants in North Africa or on the Arabian Peninsula than in Europe.

“The production capacity would have been in place long ago, had policymakers and legislators recognized synthetic fuels as a means of reducing CO₂.”



Prof. Dr. Michael Bargende

Professor Dr. Michael Bargende works at the University of Stuttgart, where he is the Chair of Vehicle Drives in the Institute of Automotive Engineering (IFS). He is also a member of the Board of Management of the Research Institute of Automotive Engineering and Vehicle Engines Stuttgart (FKFS). Before joining the university, he worked in research and development at the Daimler Group for around 17 years.



Dr. Martin Berger

Dr. Martin Berger has been in charge of Corporate Research and Advanced Engineering at the MAHLE Group since January 2020. Before that, he spent five years as Director of Engineering Services at MAHLE Powertrain.

“If we’re serious about meeting the climate targets in the transport sector, there’s no way around using synthetic fuels as a complement to e-mobility.”

The customer paradox

Ultimately, it is the user who decides. But at the moment, expectations and needs in private transport are still strongly influenced by the possibilities of combustion engines.

40 km

100% of those surveyed drive an average of 40 km per day.

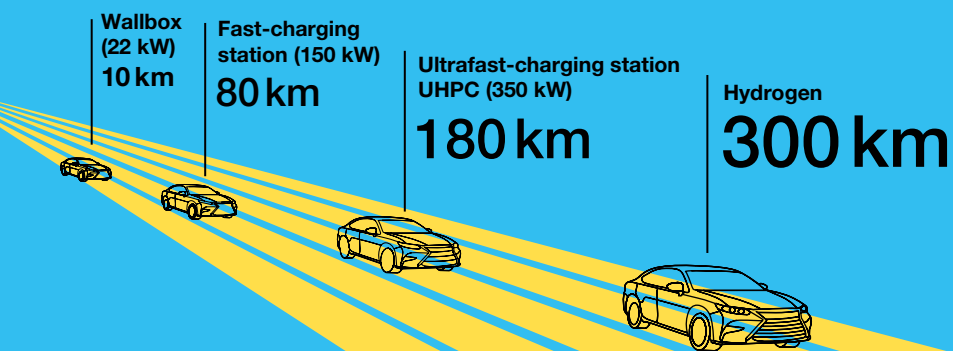
68% of those surveyed expect their vehicles to have a cruising range of around 500 km.

500 km

max EUR 800

67% of those surveyed would only be willing to pay up to EUR 800 more for an electric vehicle (compared with a comparable vehicle with a combustion engine).

Source: Deloitte, 2020 Global Automotive Consumer Study



Cruising ranges

The distances that passenger cars can travel today after five minutes at the pump or charging post.

So, the energy transition in no way involves the advanced economies becoming more self-sufficient ...

Bargende: The opposite is the case. But how will we transport the electricity produced, for example, in North Africa to Europe? An electricity cable—under the Mediterranean, for instance—wouldn't work, because we're talking about gigawatts of power. That means we need to produce a chemical energy carrier on site, be it hydrogen, ammonia, or synthetic gasoline or diesel. Once it has been transported to the consumer, it no longer makes sense to convert the fuel back into electricity. So, in a world based entirely on energy from renewable sources, we'll still have chemical energy carriers too.

Berger: Let's take the example of the European Union. Although it's one of the world's largest economic areas, it imports around two-thirds of its energy requirements—mostly in the form of oil and gas. If EU countries want to avoid the CO₂ emitted as a result, they need to import other forms of energy, because it's patently clear that they cannot cover their requirements themselves. But, for the reasons Professor Bargende has just given, the imported energy cannot be purely electrical. One option would be to store the energy as a gas in the form of hydrogen or a synthetic natural gas and transport it via pipelines. Incidentally, this

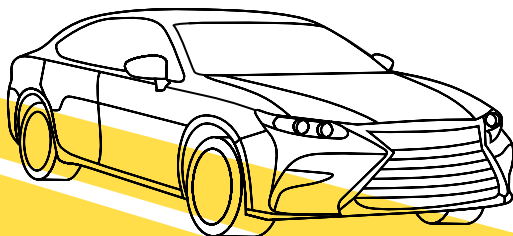
would allow us to use pre-existing infrastructure as storage. In Germany, for example, the largest available energy storage system is currently the gas network. Another option is to liquify the electricity and transport it as an e-fuel in tankers. But if the renewably generated energy is already stored in the form of a chemical, it can then also be used directly in combustion engines.

We touched on efficiency already. Is it even possible to do a scientific well-to-wheel comparison between a vehicle with a combustion engine and a battery electric vehicle?

Bargende: No. The data for this is insufficient and doesn't take full account of the underlying complexity. Certainly, many well-to-wheel efficiency studies have been carried out. Yet they all come to different conclusions because they have all applied different boundary conditions. From my point of view, there are much more important factors when it comes to evaluating technologies.

Gasoline (cruising range dependent on tank size)

800 km



Such as?

Bargende: The benefit to the customer, for example. So, the question would be: What is the cost-benefit for customers? In urban areas, I would expect electric vehicles to offer the greatest benefit from this perspective. On longer journeys and in the heavy-duty commercial vehicle sector, on the other hand, combustion engines using chemical energy carriers provide the greatest benefit. On that basis, developing the right vehicle and fuel concepts is vital.

We've talked a lot about the future. But what advantages can e-fuels already offer today?

Berger: The biggest advantage of synthetically produced gasoline or diesel fuels is that they can be blended directly with fossil fuels. By using admixtures, we can start using climate-friendly fuels in the existing fleet right now. This way, we can reach almost all of the global vehicle population directly—with a corresponding strong leverage effect in terms of carbon footprint.

There are around one billion motor vehicles on the world's roads, most of which have combustion engines.

Berger: There are technology pathways that help the climate both economically and environmentally. That's why we believe that all options should be pursued. We don't have the time to wait until there are only fully electric vehicles on our roads, powered entirely by green electricity. For the reasons we've just discussed, this won't happen in the medium term anyway. If we're serious about meeting the climate targets in the transport sector, there's no way around using synthetic fuels as a complement to e-mobility.

How can we create the necessary production capacity for these fuels?

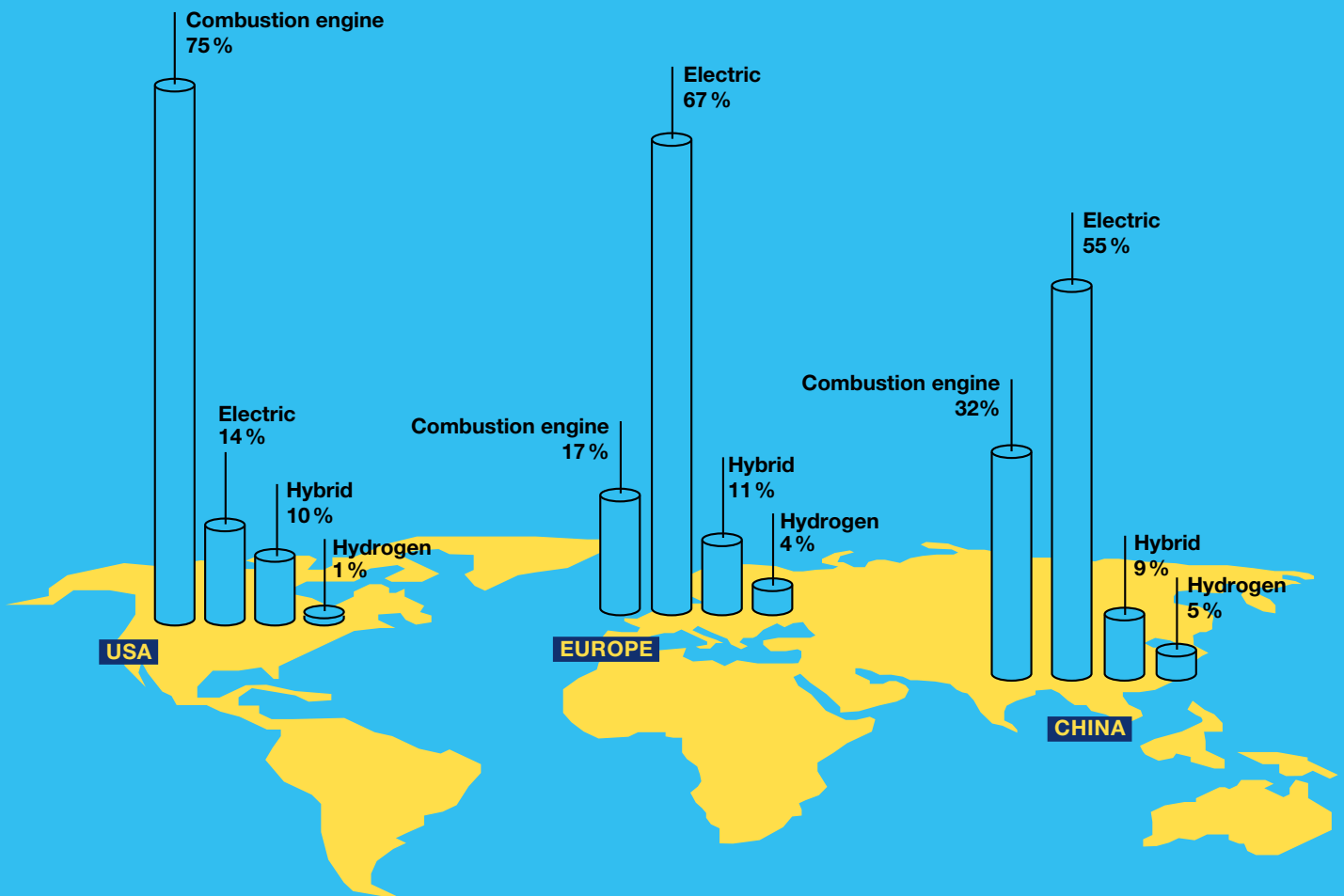
Bargende: That's a political and economic question rather than a technical one. The production capacity would have been in place long ago, had policymakers and legislators recognized synthetic fuels as a means of reducing CO₂. So far, they have not done so. As long as CO₂ is emitted from vehicle tailpipes, it will be taken into account—even if great effort has been made to capture it from the atmosphere in the first place. The CO₂ emissions from the chimney of a power plant using fossil fuels to generate electricity for electric vehicles are, by contrast, overlooked by exhaust gas legislation. It doesn't make sense.

Berger: According to our calculations, e-fuels would be around one euro per liter more expensive to produce than fossil-based gasoline or diesel. If there is the political will, this difference can be covered or at least reduced by adjusting taxes or offsetting it against fleet emission targets. One thing must be very clear here: this is not about demonizing the electric vehicle. Rather, it's a matter of fair competition between technologies.

The mix of the future

A discussion about clean fuels that considers all technologies is still important when it comes to climate protection. This is evidenced by the forecasted distribution of powertrain technologies in new vehicles in the three major markets USA, China, and the European Union in 2035.

Source: PwC, Digital Auto Report 2020





A digital journey

The year 2020 helped to drive forward digitalization at MAHLE—and this extends far beyond the shop floor. Markus Bentele, Vice President Information Technology & Overall Responsibility Digitalization at MAHLE and Alexander Kutsch, Vice President Corporate MAHLE Production System & Factory Digitalization, explain where the focus lies now and how employees at MAHLE already embraced the transformation some time ago.

“Change starts with ourselves”

Mr. Bentele, as one of the decade’s top ten CIOs in Germany, Austria, and Switzerland, what is your vision for a digital MAHLE Group?

Markus Bentele: A “digital MAHLE” combines the strength of a global group with the ability to adapt quickly. As a digital MAHLE Group, we are, on the one hand, not a start-up, but still a strong, global company that operates with maximum efficiency and excellent products in stable supply chains. On the other hand, we’re also a place where—with innovative spirit, a willingness to take risks, and top know-how—new ideas for the powertrain of tomorrow are generated in line with our Vision: “MAHLE—We shape future mobility.” This requires digital, modular processes, data consistency and excellence, and the trickiest thing: a culture of transformation that’s always open.

The possibilities of artificial intelligence or big data extend far beyond the shop floor. Where else can these technologies help us?

Bentele: I see it this way: In principle, modern technologies can be used to create real value for the employee and for the company in any task. Data analysis is already helping us to optimize purchasing

As Vice President Information Technology, Markus Bentele is responsible for the interaction between IT and the relevant departments and, as the global overall coordinator, is in charge of automation and digitalization.



volumes. We have a quality system that tracks down the sources of defects more quickly with the support of AI. Automated, data-driven processes relieve our colleagues in the Finance function of routine tasks. That's why it's not enough just to have a few digital experts on board. Everyone, at all levels of the business, must engage openly and actively with the new possibilities—and they need to do it now. These technologies are not just helpful, they connect and optimize the efficiency of and collaboration between technology, employees, and processes at MAHLE. The future is already here.

What are the priorities of MAHLE's digitalization drive?

Bentele: We've set clear priorities. First, we're investing in technologies and know-how to accelerate our CO₂ reduction and environmental protection efforts. What we're talking about here is IIoT-driven energy management systems and scrap reduction platforms. A second focus is on digital process automation in our plants, but also importantly in our indirect service areas. This encompasses everything from the swarm-based, AI-supported supply of materials on the assembly line through to automated export certificates.

What is the current situation at MAHLE, and what are the next steps?

Bentele: For several years now, we have been using pilot applications to build up the understanding and expertise needed to initiate corresponding efficiency gains through to global rollouts, which are now leading to further initiatives and being implemented in phases. This is done in close cooperation with all relevant departments. Digitalization can never be carried out in isolation, highlighting the importance of our motto One MAHLE—One Team. So, working in different teams, we take on dozens of use cases with positive business cases every year. Small experiments can fail, but not big rollouts—after all, we're talking about major investments. That's why we've incorporated all of this into a step-by-step approach. With each quick little step, we learn what works—or what doesn't—and can thus respond in the right way for MAHLE. We don't just talk about agility, we're also increasingly learning how to be agile and putting this into practice.

Digitalization scares initially a lot of people. How are you getting the entire MAHLE team on board?

Bentele: We're well aware that many of the innovations we're driving forward also have the potential to cause conflict. It's something we take seriously. After all, it's the employees who make the company's success possible. There are many different aspects to "getting people on board." For one person, it's anxiety about losing their job, for the next, it's fear of a new tool, and the third person doesn't understand what added value the digital possibilities can bring to their everyday work. These are just a few examples. We're therefore taking a broad approach with a clear communication strategy, a new program for advanced training, and, for example, by firmly embedding digitalization in management development. But we also see the personal motivation of the employees as a key source of leverage. Change always starts with ourselves. But that's exactly where our strength lies—with a clear message: Let's tackle the digital future together! Let's build the digital MAHLE that will shape at least 100 more years.

Team challenge

How is the digital transformation progressing at MAHLE specifically? One thing is clear: The focus of the transformation is on added value for the customer, the company, and its employees. In exciting projects, teams at MAHLE demonstrate that they are already shaping developments.

If you imagine the digitalization process as a long expedition, then we are about to embark on the critical stages. There are three reasons to continue. First, it is too late to turn back. Second, we are now on a steep ascent. Third, no one is traveling alone. Customers, suppliers, companies, and their employees—everyone is on this journey together. The aim of this expedition is to create a highly efficient and highly flexible company—a “digital” company. MAHLE shows how this works as a global supplier group.

“When we talk about this expedition, we’re referring to a complex task,” explains Alexander Kutsch, Vice President Corporate MAHLE Production System & Factory Digitalization. His objective is to transform MAHLE’s about 160 production locations in such a way that the end result is an overarching, unified system. “We don’t want isolated pockets of digitalization with a few lighthouse projects but rather a transformation along the entire value chain.”

This is not being done at MAHLE simply for the sake of it. “We have our customers and their own specific requirements clearly and firmly in mind,” says Alexander Kutsch. More specifically, “If digital solutions can improve the quality, reliability, or sustainability of our products, we will use them.”

However, the digitalization process will only succeed if the employees also recognize how they stand to benefit from the innovations. “To achieve this, we need to breathe life into the major future technologies like artificial intelligence or the Industrial Internet of Things (IIoT),” says Alexander Kutsch. All the projects aim to design the human-machine interfaces in such a way that employees are relieved of routine work and thus discover new creative freedom. It’s not about replacing people but rather empowering them.

The following projects highlight areas where Markus Bentele and Alexander Kutsch believe this digital transformation has been particularly successful within the company.

Already in motion

Automated invoices

Clearing goods through customs is one of the most time-consuming and monotonous tasks performed by our locations in Mexico. It involves processing numerous invoices for customs agencies. Since 2019, these entries have been taken on by a “bot”—an automated program that carries out standard tasks independently, saving time so that the employees can focus on more meaningful tasks. This is one example of around 50 projects that the Digital Automation Office’s international team has initiated in the MAHLE Group. Whether in our plants, in the Purchasing or Finance functions, or within our IT structures, the goal is always to save time and resources, analyze business activities, and identify new opportunities.

Intelligent guided vehicles

Vehicles that not only drive autonomously in the production halls with the help of AI but also communicate with one another are no longer simply a sci-fi fantasy. The result is an intelligent swarm in our material warehouses. The “coordination” between the machines increases flexibility and productivity in logistics and delivery processes—and saves costs. These vehicles have already been successfully introduced at the Neustadt and Schorndorf locations in Germany. As lighthouse projects, they will drive rollouts in additional plants and warehouses throughout the MAHLE world.

AI hackathons

MAHLE’s digital experts predict that many jobs in the Group will soon be supported by systems incorporating artificial intelligence (AI). These tools are still unfamiliar territory for many employees, which leads to questions: How do these systems benefit us? And, how safe are they? At regular hackathons, real-world challenges are solved using AI by means of rapid prototyping within a defined time. This is how employees are learning how AI solutions can help to create real value from data. By preventing breakdowns, aiding decision-making, or inspiring new business models—to name just a few examples.

Energy management system

If you want to save energy, you need to know how much you are consuming and where efficiencies can be made. The MAHLE plant in Montblanc/Spain uses a system based on the Industrial Internet of Things (IIoT) to analyze this information: Machines communicate their energy and production data to software that then analyzes, compares, and evaluates it. This produces a detailed analysis of the current efficiency status of an entire production line. The team members save time because they don’t need to collect the data themselves. Instead, they can focus their efforts on running simulations to identify where further increases in energy efficiency can be made. Furthermore, they can use it to measure the effectiveness of planned energy measures. This not only saves money, but also conserves resources. Digital technology is thus becoming a key tool in helping MAHLE to achieve its climate target and become carbon-neutral by 2040.

“We don’t want isolated pockets of digitalization with a few lighthouse projects but rather a transformation along the entire value chain.”

—— Alexander Kutsch, Vice President Corporate
MAHLE Production System & Factory Digitalization



Predictive maintenance

When it comes to machinery, serious defects do not appear out of nowhere. In numerous cases, their presence is signaled by anomalies. These can be measured—and a MAHLE team at the location in Hwasung/South Korea is using this information to detect damage before it occurs. The employees use sensors to continuously measure machine vibrations. The data feeds into software that sounds the alarm as soon as irregularities appear. At MAHLE’s plants in Hwasung and Ulsan, 40 machines have been connected to the system since mid-2019. Since then, several sudden machine breakdowns have been prevented.

Preventing waste using machine learning

For many years, MAHLE has been working to produce aluminum tubes as efficiently as possible and with minimal impact on resources at its location in Durban/South Africa. Once a certain point was reached, however, it was almost impossible to make further optimizations—until the teams on site discovered machine learning (ML). Their approach begins with the collection of data by networked machinery. This data helps the interdisciplinary team to spot anomalies in the production process, which can then be gradually eliminated. This has resulted in 30 percent less waste, increased productivity, fewer breakdowns, higher quality, and a closer look at the production processes.

Additive manufacturing

Can you imagine a machine that produces pistons one day and heat exchangers for inductive charging systems the next? It’s possible thanks to additive manufacturing. For this new method of piston production, the development team uses a technology called laser powder bed fusion, which layers metal in powder form and uses a laser to melt it into a solid component. The laser is controlled by a system that has previously been fed with a digital model of the component. This means that it is also possible to manufacture small quantities of components that have been individually designed for customers. The production process itself is automated, the system reports when a physical component has been created from the data and high-tech powder.

Digital sprints

So-called PPI sprints involve around ten team members from all areas of the business meeting in one plant to work with participants from the plant on the optimization of production processes. During the COVID-19 pandemic, the teams have been carrying out digital sprints. The live videos from the production facility not only convey the feeling of being at the heart of the action, but also allow the ideas developed together to be implemented directly on the equipment and the result to be evaluated immediately.

What was MAHLE working on in 2020?

What inspired the Group? And what did it celebrate?

Here is a small selection of MAHLE's highlights of the year.



Printing potential

For the first time, in collaboration with Porsche and Trumpf, MAHLE succeeded in developing and producing high-performance aluminum pistons, which were manufactured using 3D printing technology. The pistons achieved positive results on the engine test bench for Porsche's 911 GT2 RS sports car. What's special about the components is that they have the potential to boost the output of the already powerful 700 hp engine by up to 30 hp.

High



Gaining recognition

The Ford Motor Company gave MAHLE a Ford World Excellence Award for Diversity & Inclusion and Sustainability. The automobile manufacturer has thus acknowledged the extensive efforts made by MAHLE to promote diversity in the company and make continuous advances in sustainability. In 2020, MAHLE received a total of about 80 awards in the fields of innovation, technology, and quality from renowned customers, partners and other stakeholders.



Getting started

By opening its Start-Up Space in Stuttgart/Germany, MAHLE has given new business ideas a home of their own. The two start-ups already established on the market have been based here since September: chargeBIG, which develops intelligent charging infrastructure, and Com4Kids, which ensures children's car seats are kept at an ideal temperature. At the end of 2020, they were joined by the two young teams from COMET and bikeeye. They are starting the incubation phase in the ideas lab with the aim of getting their innovations for the mobility sector market-ready.

lights

Infection control from MAHLE. With its OzonePRO device, MAHLE has made a solution available to car rental businesses, fleet operators, public authorities, and operators of private and commercial real estate that provides effective protection against coronaviruses for vehicle cabins and building interiors. According to certified laboratory Eurofins Biolab Srl, OzonePRO reduces the number of active coronaviruses by around 99.7 percent. Interiors are thus effectively cleaned in around 30 minutes.

Cleaning up





Always moving forward

MAHLE has been keeping the world moving for 100 years. Since 1920, MAHLE has developed from a small workshop to one of the largest automotive suppliers with around 160 locations in 30 countries. December 1, 2020, marked the 100th anniversary of the day that the foundation stone for today's Group was laid in Stuttgart/Germany. The technological pioneering spirit of the brothers Ernst and Hermann Mahle is something the company is still renowned for.

For many decades, motorsports have been important to MAHLE as a real-world laboratory in which to develop ideas and generate new knowledge for series production. In August, MAHLE became the new technology partner for DS TECHEETAH, reigning champion in the pioneering ABB FIA Formula E racing series. MAHLE is using its many years of expertise in e-mobility to support the team and gathering key insights for sustainable mobility in the process.



Electrifying



In the summer, MAHLE launched a new generation of its drive system for e-bikes. Thanks to its extremely compact design, the X35+ system consisting of wheel hub motor, battery, and control units can be integrated almost invisibly into a bicycle frame. Rather than follow the trend toward maximum power output, MAHLE offers ideal user-oriented performance. This makes the system more streamlined and lighter: including the battery, it weighs just 3.5 kilograms.

Integrating

Reliable protection for fuel cells. By taking a modular approach, MAHLE is reducing the time and expense involved in developing air filters for fuel cells, giving developers direct access to a ready-made “off-the-shelf” component. Fuel cells with an output of 25–50 kW or 80–120 kW benefit from reliable protection against harmful gases and particles—and fuel cell technology is taken a significant step closer toward suitability for large-scale production.



Protecting

A smart air conditioning system from MAHLE now offers an ideal atmosphere as well as protection against fine particulates. The fine-particulate sensors are integrated into the air conditioning system and in direct contact with both cabin air and external air. As a result, the air conditioning system’s response to current pollution levels in the vehicle cabin is instant and precise, and the air is cleaned in line with custom requirements.



Customizing

Imprint/contact

Published by

MAHLE GmbH
Pragstraße 26–46
70376 Stuttgart/Germany
Phone + 49 (0)711-501-0
www.mahle.com
info@mahle.com

Contact

MAHLE International GmbH
Corporate Communications/Public Relations
Pragstraße 26–46
70376 Stuttgart/Germany
Phone + 49 (0)711-501-12506

Concept and design

3st kommunikation GmbH
Taunusstraße 59–61
55118 Mainz/Germany
www.3st.de
info@3st.de

Text

Dirk Böttcher
André Boße
Laurin Paschek
Johannes Winterhagen

Photography

Dirk Bruniecki, Andreas Pohlmann, MAHLE Archiv

Translation

Target Languages GmbH
Waldhofer Straße 102
69123 Heidelberg/Germany
www.target-languages.com
info@target-languages.com

Print

ELANDERS GMBH
Anton-Schmidt-Straße 15
71332 Waiblingen/Germany
www.elanders.com/ger
info.GERMANY@elanders.com

© 2021 MAHLE GmbH,
00007853 EN 2.0.4 / 21

MAHLE worldwide



**Around 160
production locations**



**12 major research &
development centers
worldwide**



**More than 72,000
employees***

North America

**27 production locations
14,599 employees***

Canada, Mexico, USA

Europe

**65 production locations
33,009 employees***

Austria, Belarus, Bosnia and Herzegovina, Czech Republic, France, Germany, Great Britain, Hungary, Italy, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Turkey

Asia/Pacific

**59 production locations
15,694 employees***

China, India, Indonesia, Japan, Philippines, Singapore, South Korea, Thailand

South America

**8 production locations
7,955 employees***

Argentina, Brazil

Africa

**2 production locations
927 employees***

South Africa

