

THE POWER OF

／
**PIONIER
GEIST**

**Magazine
2021**

Keeping a cool head—p. 14
MAHLE takes a holistic approach to thermal management—and can thus give a boost to the new generation of electric vehicles.

Lighthouse project in Parma—p. 20
The Italian location proves that innovation and climate protection can go hand in hand.

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.



5

business units

Engine Systems and Components, Filtration and Engine Peripherals, Thermal Management, Electronics and Mechatronics, Aftermarket



Around

160

production locations



12

major research & development centers



71,298

**employees
as at December 31, 2021**



EUR 10.9 bn

sales in 2021



Dear readers,

even in these eventful and challenging times, MAHLE remains a company with solid technological substance, far-reaching expertise, and an imperative to innovate. These strengths shine out from the following magazine pages.

“Every gram matters” talks about the goal of providing the generation being born today a climate-neutral future. We are contributing by developing technologies that reduce CO₂ emissions as much as possible, ranging from hydrogen engines to e-compressors. MAHLE has set a course for climate-neutral mobility. We have a wealth of ideas and can build on 100 years of experience. At the same time, we will continue refining our MAHLE 2030 strategy. “Lighthouse project in Parma” captures a vivid snapshot of what that future may look like.

In 2021, our development teams also made key advancements in the most dynamic, trend-setting field of the automotive industry: e-mobility. The first highlight that comes to mind is the magnet-free electric motor. With this “Declaration of independence,” we’re proving that climate-friendly drives don’t require critical raw materials. This is an important finding given the continued volatility of the markets. Having in-depth understanding of integrated systems is also vital—or rather, forward-looking: we don’t just think in terms of individual components. As One MAHLE, we focus on the big picture. To find out what this could mean for the breakthrough of e-mobility, turn to “Keeping a cool head.” In that article, our experts explain why an overarching approach to cooling and heating is essential in the electric era.

Any business wanting to take on all these challenges so as to play an active part in the transformation of mobility needs a flexible team. Our MAHLE teams worldwide are putting their heart and soul into this company, especially in these economically and geopolitically difficult times. “You never stop learning” showcases employees who are actively engaged in the transformation—not just professionally, but personally too. And they’re clearly enjoying it.

Based on these insights, I can say for 2022 that we want to continue to be a pace-setter and pioneer in our industry. We want our employees to contribute their talents and expertise to MAHLE with pleasure and enthusiasm. After all, the power of Pioniergeist is in our genes—and evident throughout the next 40 pages.

I hope you enjoy reading about MAHLE’s pioneering work.

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

Michael Frick

Deputy Chairman of the Management Board and CFO

Contents



4 / Every gram matters

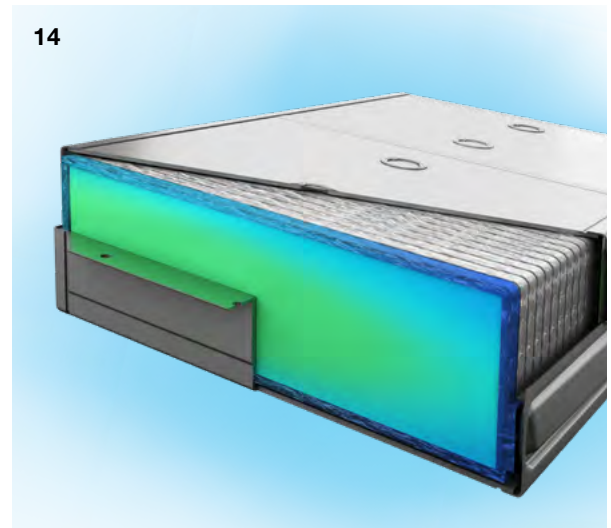
The EU aims to be climate-neutral by 2050. Technologies from the mobility industry are therefore in demand. Besides its e-mobility portfolio, MAHLE also offers other solutions with direct benefits.

12 / #StrongerTogether

In the second year of the pandemic, the people at MAHLE have again demonstrated their extraordinary commitment to “ONE MAHLE.”

14 / Keeping a cool head

Appropriate thermal management will play a decisive role in the breakthrough of e-mobility. MAHLE addresses the topic by means of complete systems.





20 / Lighthouse project in Parma

Innovative thinking and climate protection can go hand in hand. This is illustrated by a visit to the new Service Solutions center in Parma (northern Italy).

26 / “Sustainability is all-encompassing”

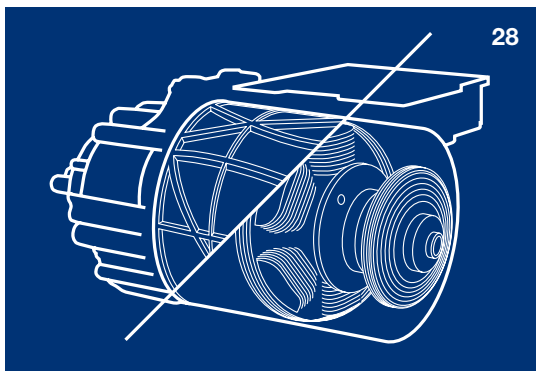
Since the beginning of 2021, Kathrin Apel has been responsible for sustainability management at MAHLE. In the interview, she elaborates on the benchmarks the company wants to set.

28 / Declaration of independence

One step toward more sustainable mobility: MAHLE is developing an electric motor with maximum efficiency that does not require rare earth elements.

32 / You never stop learning

The automotive industry is not only undergoing a rapid transformation in terms of technology. With global training programs, MAHLE offers its employees the opportunity to play an active role in the transformation.



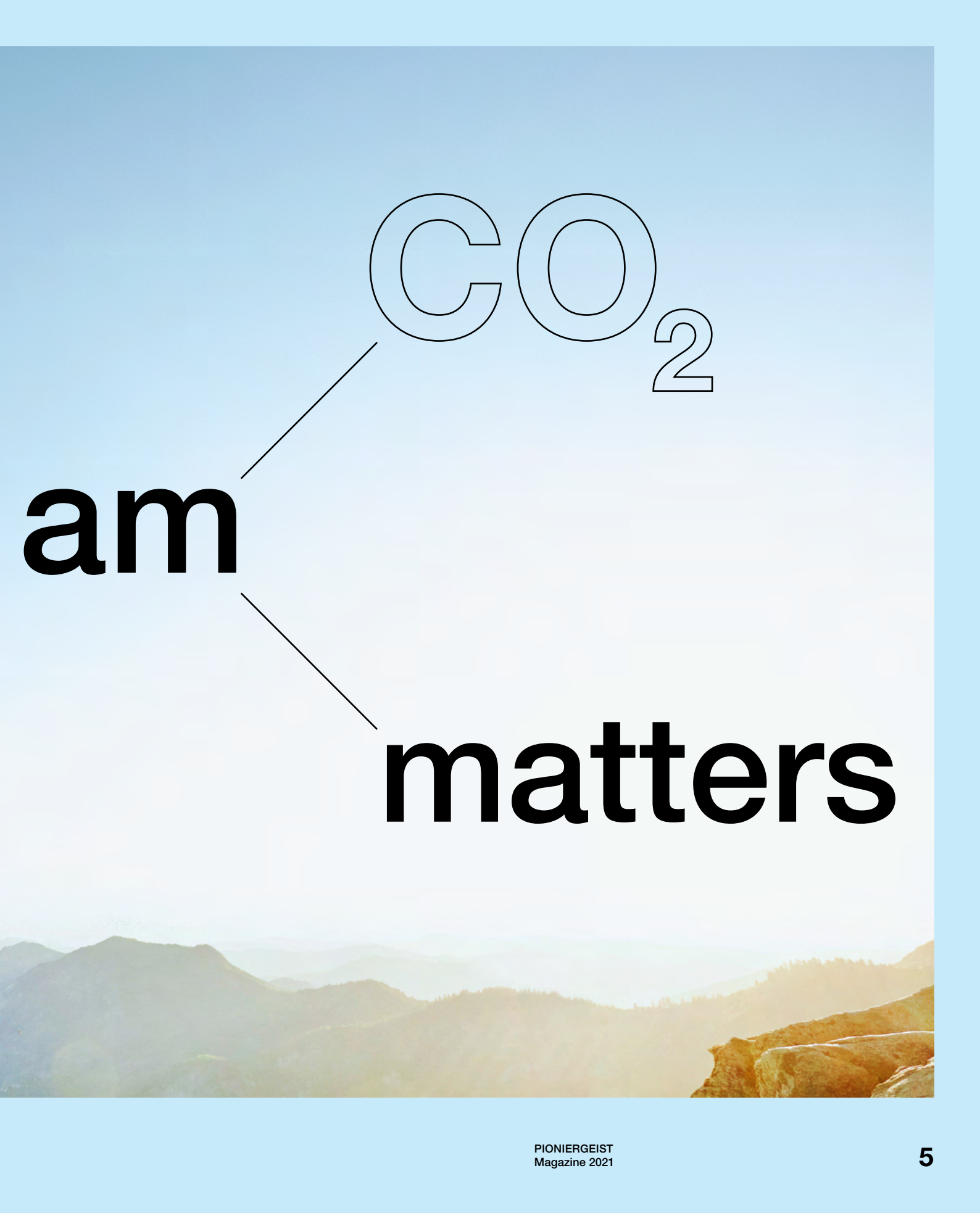
38 / Highlights 2021

42 / Imprint & contact

43 / MAHLE worldwide

Every gr

The EU aims to be climate-neutral in all areas of life and the economy by 2050. A child born today will be able to judge whether this goal has been reached by their 28th birthday at the latest. If every gram of CO₂ saved between now and then matters, every opportunity and every climate-friendly technology should be embraced. In addition to MAHLE's portfolio for e-mobility, three innovative solutions have the potential to make a major contribution to climate-neutral transportation.



am

CO₂

matters

Is 28 years a short time or a long time? In view of the inter-generational challenges, the European Union's goal to achieve climate neutrality by 2050 is certainly highly ambitious. According to German news magazine DER SPIEGEL's climate ticker, we have 7.42 years left at the time of writing. At that point, on the basis of the climate gases emitted today, humankind will have used up the allowance that would have limited the anthropogenic temperature rise to 1.5 degrees Celsius, as was agreed at the Paris Climate Change Conference in 2015.

A child born today would therefore have to be driven in a climate-neutral vehicle by the time they start school; learn in a climate-neutral school; live, eat, and play with no negative impact on the climate. In short: there is not much time left, or as Martin Berger, Vice President Corporate Research and Advanced Engineering at MAHLE, puts it: "We all need to step up our efforts. We have to get better every year or we won't succeed."

Effective and open to all technologies

If we want to achieve ambitious goals, we need to act now. The time for declarations of intent is over, if only because legal requirements have now come into play, as Nils Dressel notes: "Throughout the EU, a 55 percent reduction in CO₂ emissions compared with 1990 levels has already been agreed for 2030." Dressel heads the MAHLE office in Brussels, where he keeps a close eye on EU legislation. "Since 2020, we've seen a lot of activity, for example through the EU hydrogen strategy, with extensive moves toward the widespread use of hydrogen as one of the energy carriers for the carbon-neutral future."

A challenge is always an opportunity. At MAHLE, effectiveness is the guiding principle. "We only do what really has an effect," says Martin Berger. That's why MAHLE continues to develop all manner of technology that helps to cut emissions: first and foremost, of course, systems solutions for battery electric mobility. Then there's the internal combustion engine, which will be powered by both renewable fuels and hydrogen—as will fuel cells. It's a little like sports: sprinters have different strengths and needs than weightlifters. The situation is similar for powertrain technologies, which are optimized for energy efficiency, performance, or endurance, depending on the application.

MAHLE's development work ensures that sustainable alternatives that have reached the necessary level of technological maturity can be brought to the mass market. As well as maintaining the greatest possible breadth and openness to all the available technologies, the company is especially keen to foster cross-border cooperation between its various business units. It's important to seize every opportunity, because every gram of emissions saved matters.

“We all need to step up our efforts. We have to get better every year or we won't succeed.”

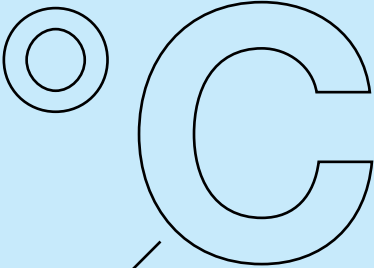
Dr. Martin Berger,
Vice President Corporate Research
and Advanced Engineering at MAHLE

MAHLE supports the development of climate-neutral mobility with innovative solutions

The e-compressor: comfort for the climate. And for the cruising range.

Balassagyarmat/Hungary—The MAHLE plant in Hungary is located in the northeast of the country, an hour’s drive from the capital, Budapest. The production location manager, Gyoergy Szalay, has been working there for more than twenty years. He and his team are currently preparing to start producing the next generation of MAHLE’s electric air conditioning compressor. This global endeavor also involves teams in China, Germany, Slovenia, Spain, and the USA. The market success of MAHLE’s e-compressor shows what can be achieved when interdisciplinary teams work together on the products of the future.

The e-compressor is the key component in an electrified vehicle’s air conditioning system. It compresses the refrigerant, thereby ensuring that the vehicle cabin, the battery, and other components are kept cool. “With this component, it’s clear that we’re making a significant contribution to the acceptance of e-mobility. Our new, high-performance product keeps batteries cool enough to allow for fast charging in a matter of minutes,” says Szalay, adding: “Our e-compressor opens up new possibilities, such as preconditioning when the vehicle is stationary and operation of the heat pump, which will increase both ride comfort and cruising range.”



“With this component, it’s clear that we’re making a significant contribution to the acceptance of e-mobility.”

Gyoergy Szalay,
production location manager, Balassagyarmat/Hungary

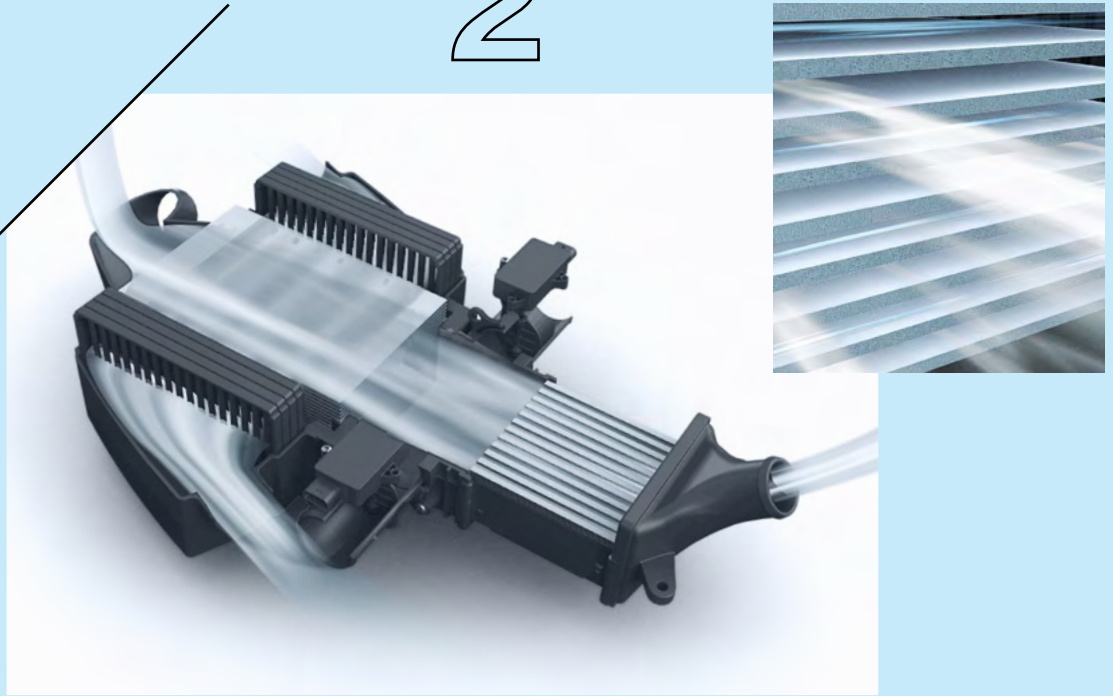
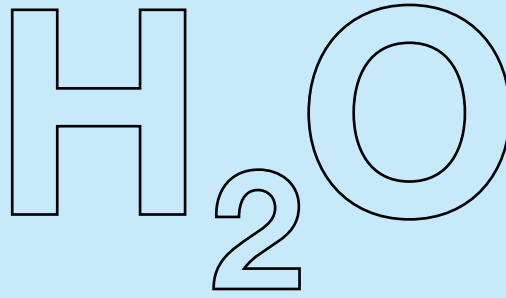
In a vehicle powered solely by a combustion engine, the engine drives the air conditioning compressor directly via a belt. It works less at low speeds, and more at high speeds—no matter how much cooling is really needed. E-compressors, on the other hand, can be controlled independently and only operate when they are actually required—thereby saving energy. In an electric vehicle, the compressor also has another important task: cooling the battery. As charging power increases, more heat is generated in the battery. To help reduce charging times for future electric vehicles, MAHLE was one of the first manufacturers to focus on developing compressors that provide more power and can function at higher operating voltages than the products currently available on the market.

Growing number of customers

The e-compressor project began several years ago; initially within the scope of Thermal Management, it is now handled by the Electronics and Mechatronics business unit. Today, MAHLE already supplies its e-compressor to several customers, and start of production is imminent for others. Series supply to two German OEMs will begin later this year, among other projects. MAHLE also recorded order growth in China last year, and the technology group plans to open a new production line there in 2023 to meet the increasing demand in one of MAHLE’s key markets. In order to keep pace with growth as regards research and development, MAHLE is expanding its capacities in Valencia/Spain, in addition to its established primary development location in Amherst/USA. The new research and development center will enable MAHLE to develop its solutions for customers throughout Europe even more quickly and directly.

The e-compressor also combines several of MAHLE’s areas of expertise. “The electric motor and the appropriate control system, the compressor’s mechanics—we can do it all,” says José Carvalho Gonçalves, Director Operations for the Compressors profit center. According to Gonçalves, one of the biggest challenges is acoustics. “An electric vehicle is virtually silent when it’s driven. That means that every sound inside the car is suddenly much more noticeable, including those made by the compressor.” To set new standards with the latest generation of the product, the developers therefore put all the details of the compressor to the test.

“Powerful, efficient, lightweight, quiet, and low-cost—that’s what our customers expect, and they trust us to get it right, just as we’ve consistently done for decades where compressors are concerned.”



Spaghetti vs. lasagna —the flat membrane humidifier

Stuttgart/Germany—The new test and research center, where MAHLE has been researching new systems solutions for hydrogen applications since March 2021, extends over 1,400 square meters. Components for fuel cells and engines are developed on the test benches. Shiny silver-colored pipework runs through the futuristic-looking, laboratory-like workshops, and there are monitors and measuring stations all around. At MAHLE's Stuttgart headquarters, more than 100 experts are working on future technologies involving hydrogen.

The focus is on developing drive solutions for heavy-duty commercial vehicles. This segment is where the strengths of hydrogen technology come into their own; batteries, on the other hand, are too heavy and too large to be used in long-distance transportation by truck, even in the long term. "However, in order to power heavy-duty commercial vehicles

with hydrogen and without creating emissions, innovative solutions are still required, especially for reducing the weight of the components and increasing efficiency," says Dr. Peter Geskes, MAHLE's global head of development for filtration and engine and fuel cell peripherals. At MAHLE, several teams are collaborating on this across business units and locations. One of the projects is a new membrane design for fuel cells: the flat membrane humidifier.

Behind this complicated name is an innovation that will extend the service life of fuel cells and allow them to be manufactured at a competitive price. Several prominent carmakers from China, South Korea, Japan, the United States, and Germany are currently focusing on this technology. Peter Geskes begins by using a culinary image to describe MAHLE's innovation: "We've changed the fuel cell design from spaghetti

to lasagna.” So, what does that mean? A fuel cell needs an adequate supply of high-humidity fresh air at all times. If the humidity level in the fuel cells is too low, this reduces performance and service life. The high moisture content of the exhaust air from the fuel cell is used to increase the humidity of the fresh air being drawn in. After all, a lot of water is produced during the “cold combustion” of oxygen and hydrogen. Moisture is carried from the exhaust air side to the fresh air side via many tiny membrane tubes. In Geskes’ image, these are the spaghetti.

Instead, MAHLE uses ultrathin membranes, which are stacked in the humidifier to form a block—the lasagna. Exhaust air with a high vapor content passes through half of the lasagna layers. Fresh air that’s drawn in flows through the other half of the layers toward the fuel cell. The membranes are permeable to water vapor, but not to liquid water and not to gases. As a result, the dry outside air becomes moist after passing through the membrane—which is exactly to the fuel cell’s taste, and it thanks the cook by being efficient and durable. Or in less culinary terms: the more humid the air, the higher the efficiency. But the most important thing is that the service life of the components is extended. The flat membrane technology increases the efficiency of the humidifier, boosting its performance. Size and weight can thus be reduced by up to 70 percent: the lasagna effect.

From idea to research project

Work on the highly effective flat membrane humidifier began in 2017. In September 2018, MAHLE and its partners embarked on a research project funded by the German Federal Ministry for Economic Affairs and Climate Action. Michael Baumann, project manager at MAHLE, says: “I think it would be hard to find another company that has approached the issue of hydrogen propulsion as thoroughly as MAHLE.” He points out that several different areas of MAHLE expertise have come into play in the development process, ranging from thermal, air, and liquid management to filtration and electronics. Michael Baumann also praises the international cooperation between the various MAHLE locations: “We use the feedback from our colleagues in Japan and Korea. The teams there are fully involved in the work here, which is really fun and combines a wide variety of perspectives and requirements.” For example, the seal design was developed in Japan and the manufacturing process in Europe. Series production of the flat membrane humidifiers is scheduled to begin next year, and market demand is high.

“We use the feedback from our colleagues in Japan and Korea. The teams there are fully involved in the work here, which combines a wide variety of perspectives and requirements.”

Michael Baumann,
project manager at MAHLE



The alternative: the hydrogen engine

H₂



There's another way hydrogen can help to reduce emissions—one that, until now, has received less attention outside specialized circles. MAHLE is one of the pioneers working on hydrogen-powered engines. Because hydrogen doesn't contain carbon, it doesn't release CO₂ when combusted, in contrast to traditional diesel and gasoline.

That would constitute a major step toward climate neutrality. Moreover—and this is what's so appealing about using hydrogen—the technology can be based on existing drive systems. That is to say, drives already used in vehicles that are on our roads today, as Christian Trabold explains: “We can reuse components and systems from the engine through the cooling module and on to the vehicle architecture.” The hydrogen engine project manager at MAHLE and his team are engaged in the further development of engine technology for hydrogen combustion. “In hydrogen combustion, the engine parts are exposed to very different boundary conditions than when running on diesel,” says Trabold. He continues: “One completely new issue, for example, is hydrogen embrittlement, which can lead to fatigue when hydrogen is introduced into materials.” Another important consideration is the potential for premature ignition, where the fuel mixture ignites spontaneously rather than being ignited by the spark plug. This leads to momentary high peak pressures and, in particular, can damage pistons and rings. More water is produced in the hydrogen reaction than in the case of conventional fuels, which in turn can lead to corrosion and oil dilution.”

Option for more power and greater cruising range

Hannes Marlok, another project manager in the hydrogen engine team, is convinced of the potential of this technology: “For very heavy trucks that need to be particularly powerful or have a long cruising range, as well as off-highway vehicles, the hydrogen engine is the solution. That's because it requires less cooling in comparison with the fuel cell and is more resistant to dust and contaminants.”

There have been initial expressions of intent among some truck and engine manufacturers to include hydrogen engines in their portfolios. Hannes Marlok sees MAHLE as a leader in hydrogen engine technology. According to Christian Trabold, there are also synergies for fuel cell development: “For example, we can use the same tank design for both applications.”

The hydrogen engine should be ready to enter series production in 2026. It could therefore be a rapidly deployable option for reducing CO₂ that can quickly make a tangible contribution to achieving the shared goal of a carbon-neutral economy.

#StrongerTogether

Take action, don't wait and see. Tackle problems and don't give up. Find solutions, not barriers. In the second year of the pandemic, the people at MAHLE showed what "ONE MAHLE" is all about: they took on social responsibility, stabilized supply chains, ensured smooth production processes, and actively promoted their colleagues' health. These are small stories that represent the big picture.

No standstill

In 2021, the coronavirus pandemic with its regional lockdowns put global supply chains under extreme strain. In addition, the scarcity of semiconductors aggravated the situation. Against all odds, the approximately 900 MAHLE purchasing experts from all over the world went all out: To procure semiconductors in time, the purchasing, sales, and logistics teams completed business planning almost six months earlier than usual. They transparently traced back the supply chains for production and found direct solutions with our partners. As a result, all customer contracts were fulfilled in 2021. Or as Stefan Maier, Vice President Corporate Purchasing of the MAHLE Group, put it:

"The fact that there were no significant interruptions due to missing MAHLE components at customer plants in such a year is a phenomenal achievement by the purchasing and logistic teams around the world."



100%

convinced

Brazil is one of the world's countries hardest hit by the coronavirus pandemic. It is therefore important to convince people of the vaccine's effectiveness. The accompanying campaign was particularly successful in Brazil, thanks to Dr. Ana Paula Egrejas Esper. What was her key to success? "Inform, inquire, and inform again. No question should remain unanswered." The doctor and health manager of the locations in Brazil and Argentina was the face of the local vaccination campaign, and she and her team of over 50 employees achieved enormous results. The health experts provided education via video, telephone, letter, a reminder app, and in many personal conversations. And within a few months, they could convince almost every one of the approximately 8,000 employees at the Brazilian and Argentinian locations to roll up their sleeves and protect themselves by getting vaccinated.

Don't look away

During the coronavirus pandemic, thousands of people in India struggled with hunger. Sanam Harkare from the MAHLE location in Pune was not willing to accept this. She, along with support from her husband Suyash, launched the Replacing Hunger with Smiles initiative. Sanam Harkare remembers the exact moment when she realized she had to do something: "It was a hot day in April 2021, with India experiencing yet another strict lockdown. As we were driving through the streets near our house, my husband and I saw a woman lying dead in the street. She had starved to death!" Sanam Harkare, who works in the Human Resources team at MAHLE in Pune, was deeply shaken by this incident. She wanted to take action and "give something back to society," as she says.

Her idea: a distribution campaign for cooked meals to provide for those who have been in need because of the pandemic. Initially, she and her husband financed the project out of their own pocket. Later, friends, family members, a non-governmental organization known as YOUNG Foundation and numerous MAHLE colleagues offered support. The group grew rapidly to 25 volunteers. An Indian delivery service also joined in. "In the beginning, we distributed 100 meals a day. But within a few days, the number rose to over 1,200 meals per day," says Sanam Harkare. Additionally, the helpers began distributing food packages to needy families and widows who live in Pune's slums, so that they could be self-sufficient. From April to mid-October, Sanam Harkare and her team were able to offer more than 50,300 cooked meals. Grocery kits were delivered to 19,000 families sufficing for three months each.

50,300



cooked meals



3,042,074

FFP1 and FFP2 masks have been manufactured by our colleagues in St. Michael, Austria as of January 2022. The production in the plants ran in addition to regular operations during the past year, which proves once again the Carinthian team's go-getter qualities and can-do attitude.



Remote? For sure!

This could happen: an update for a machine in Stuttgart does not load and the expert from the manufacturer is located in South Korea. Since the pandemic, remote service via online access or smart glasses has been in even more demand. In view of the record number of cyberattacks worldwide, which also targeted industry, MAHLE tested the next level of software in 2021. Its name: Direct Remote Maintenance Access. A highly secure connection to the machine can be established from anywhere.

This is made possible by multilevel security infrastructure and access that is limited to the duration of maintenance, a defined machine, and the assigned technician. This principle works in a similar way to VR glasses. A pilot project proved so successful that the maintenance of machines with VR glasses is to become the standard for all MAHLE plants worldwide.

Keeping a cool head

What has been established for decades in the case of combustion engines has the potential to give the next generation of electric vehicles an enormous boost in acceptance: thermal management designed for optimum performance. MAHLE engineers are using systems solutions to extend cruising range. And to make sure that the passengers and all drive components feel equally comfortable.

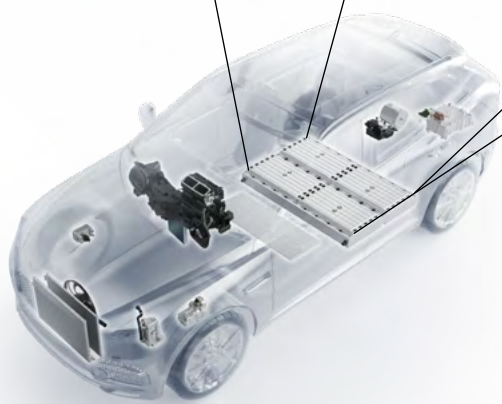
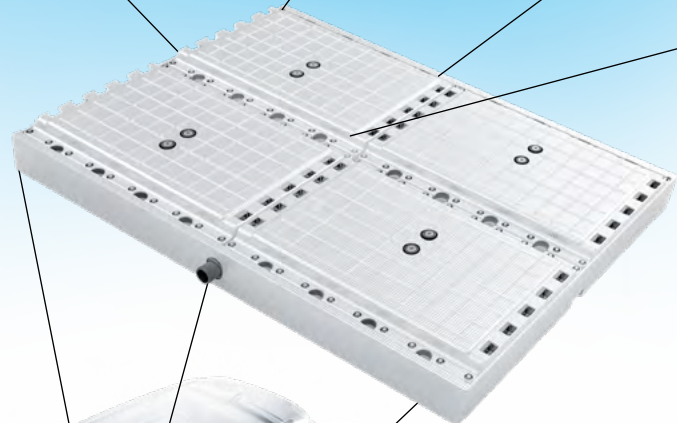
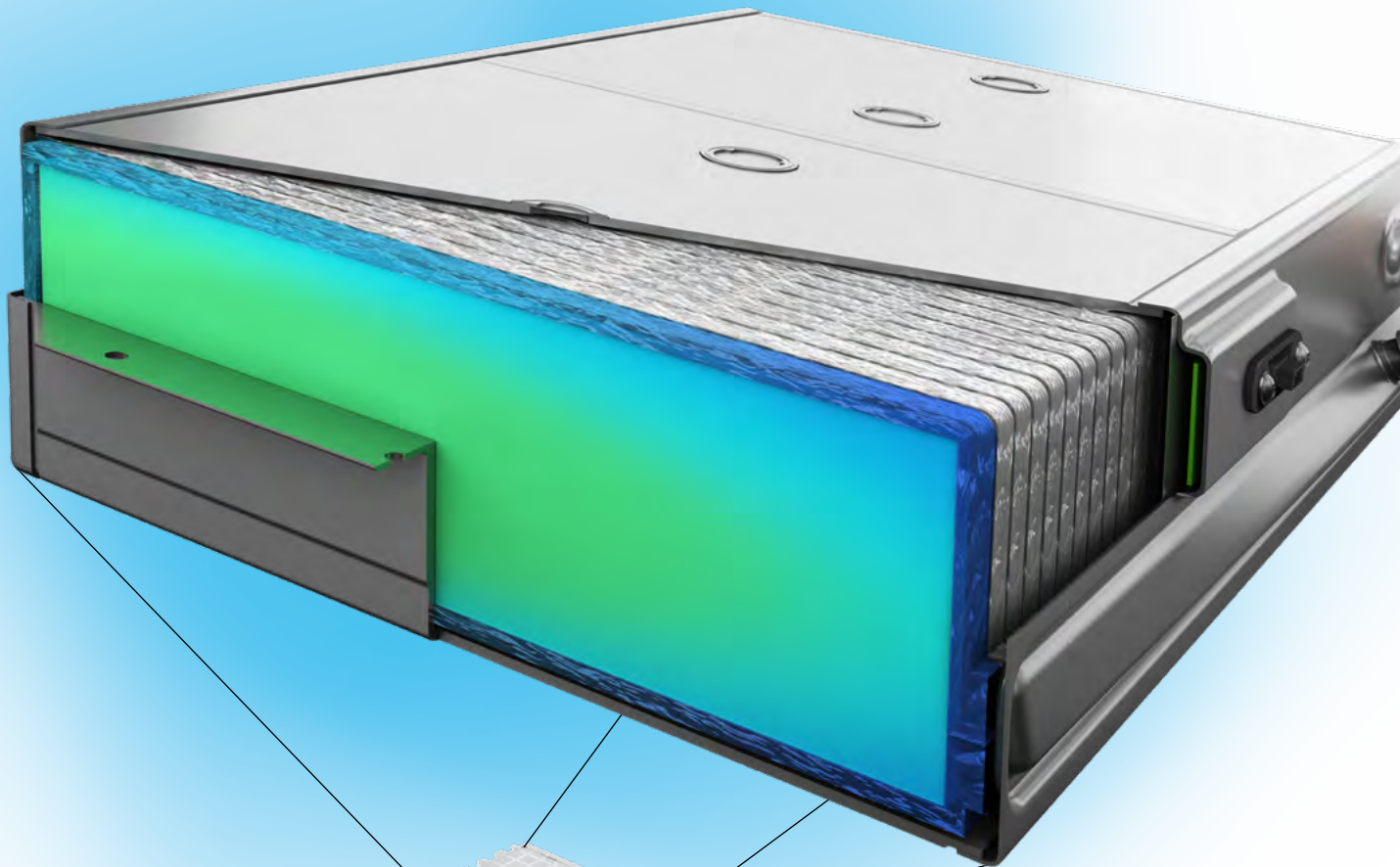
Vehicle manufacturers and their development partners face a constant paradox: the temperature inside the vehicle always runs counter to the outside temperature. When it's cold outside, people like it to be warm inside, and vice versa. Up to now, engineers have used waste heat from the combustion engine to heat the cabin. To handle warmer times of year, air conditioning systems became standard in almost every vehicle class. But with the paradigm shift to battery electric drives, the overall system for regulating heat and cold takes on a new significance.

Dawning of a new age

"An electric motor generates virtually no waste heat," explains Dr. Roger Busch, Vice President Engineering Thermal Management at MAHLE. But anyone sitting in an electrically powered vehicle will also expect to enjoy comfortable temperatures—whatever the season. Without efficient thermal management, it will be difficult for e-mobility to become established on the mass market, as heating and cooling

consume energy, and that's detrimental to the vehicle's cruising range. MAHLE engineers from various disciplines therefore look at the issue holistically—from the smallest electronic component through the complete heating circuit.

This systems approach is particularly important because the demands on modern electric vehicles are constantly increasing: they are expected to charge in minutes, have a range of at least 500 kilometers, and offer the customary level of comfort. It's clear from the various challenges that pioneering spirit is essential for MAHLE developers. The most fundamental challenge involves the thermal management of the powertrain battery. "It's very similar to us humans in terms of its comfort factor," says Roger Busch, putting the concept in a nutshell. A lithium-ion battery works best in a temperature window between 20 and 40 degrees Celsius. This means that a battery must be heated in winter and cooled in summer—if necessary, at high charging power.



20–40°C

is the temperature window in which
a lithium-ion battery works best.

“The powertrain battery is very similar to us humans in terms of its comfort factor. A battery must be heated in winter and cooled in summer—if necessary, at high charging power.”



Dr. Roger Busch,
Vice President Engineering Thermal Management at MAHLE

Faster charging

Many drivers are concerned about how long they have to spend at the charging station. Nobody wants to wait unnecessarily, especially on longer trips on the freeway. “We are seeing today’s charging power levels of between 100 and 150 increasing to 250 to 350 kilowatts,” explains Laurent Art, Director Predevelopment Thermal Systems and Components. This means that a charging stop at a service station takes no longer than it does to buy a snack and visit the restroom. Battery preconditioning is a vital prerequisite for a short “pit stop.” That is to say, the minutes before the car reaches the fast-charging post. The heating/cooling system ensures that the battery cells are at the optimal temperature, allowing them to take up the maximum charging power.

“However, charging shouldn’t be thought of as a linear process, where charging takes place consistently at constant power,” explains Roger Busch. “We talk about a charging curve.” Depending on how full the battery is, the charging output begins at a power level that slowly increases to the maximum during the process. Once 80 percent charging

capacity is reached—if not sooner—the battery system reduces the charging power to protect the cells. It can sometimes take just as long to put the final 20 percent of energy into the battery as it did to charge it up to 80 percent.

This phenomenon can be observed by anyone going to the movies. In a cinema with a capacity of 600, the first 200 guests will find their allocated seats in just a few minutes. It takes the next 200 much longer. Guests seated at the ends of rows have to stand up to let others past. It takes the longest time to seat the last 200 moviegoers. The same applies to charged electrons, which have to find a place on the anode of the battery cells.

The heat pump is key

Heating the cabin and the all-important process of conditioning the battery cells both require energy. Because this energy comes from the powertrain battery, it's no longer available for driving performance. And so the cruising range reduces, especially in winter. This is where MAHLE makes use of the heat pump as an integral thermal management component. In simple terms, it operates in a similar way to a refrigerator. It uses a refrigerant to extract energy from the interior, thereby lowering the temperature. The extracted heat is released to the environment via the back of the refrigerator. The heat pump in an electric car works the other way around. It takes energy from the outside air and uses it to heat the cabin. The bottom line is that less energy is taken from the battery to run the heating system. The electric car travels about 20 percent further at an outside temperature of 0°C than it would without a heat pump, while maintaining the same level of comfort.

Another challenge for developers arises as a side effect of electric mobility: noises that were previously drowned out can suddenly be heard. That's because the rotor rotates almost silently in the stator in the drive. Passengers may find it annoying if thermal management components now become audible. MAHLE engineers therefore have their sights set on a heating and cooling circuit that's as quiet as possible.

Modularization of thermal management

Heat pump, cooling and heating circuit for the battery, air conditioning for the cabin: it's clear from the list of tasks that we're dealing with a complex system with many parts. "There are a large number of components in the vehicle needed for thermal management, as well as lines, connectors, and valves," says Roger Busch. But installation space is a precious commodity. Also, the fewer components that need to be installed during production, the greater the reduction in costs and complexity for the manufacturer. "Our approach is based on modularization," explains Laurent Art. The different thermal management components are combined in modules that are as compact as possible. Instead of working with individual wiring harnesses, the fitters working for MAHLE customers only need to install one assembly. This saves time—in part, because the leakage test on the module is carried out by MAHLE.

How heat pumps work

Ambient air flows into an evaporator in the front end of the vehicle where it meets the refrigerant, which can absorb energy from the air. This causes the liquid refrigerant to heat up and change from a liquid into a gaseous state. In the next step, a compressor (e-compressor) increases the pressure. As the pressure rises, so does the temperature of the gas. It releases its energy to the heating system by liquefaction. The refrigerant circuit is closed via an expansion valve.

Supposing that the outside temperature is 5 degrees Celsius, the electric heating would have to heat the interior from 5 up to a comfortable 21 degrees. The heat pump extracts enough energy from the ambient air to heat the air directly to 21 degrees in order to warm up the vehicle cabin. This saves energy, which means that the system reduces the loss of range experienced in the winter by around 20 percent.

Rethinking the design of heating and cooling systems goes hand in hand with a change in thinking in the company itself. "ONE MAHLE" describes this development best. Business units such as Thermal Management, Filtration, and Electronics and Mechatronics are bringing their competencies into closer alignment. After all, modular systems require a different approach. As Roger Busch describes it: "A holistic mindset has been adopted, with all departments considering the whole vehicle."

Achieving peak performance with intercell cooling

The holistic approach is also helping to address a recent development. The e-mobility industry is currently at a technical crossroads. After initially using lithium-ion batteries carrying 400 volts, manufacturers are now introducing 800-volt systems in a growing number of vehicle classes. This has the advantage of reducing the charging time by increasing the charging power. For MAHLE engineers, however, it means that more waste heat is generated in the battery system, which has to be dissipated. That's because the amount of heat generated is equal to the square of the increase in charging power. More effective cooling methods are needed.

Up to now, battery cells have been bundled into modules, which have in turn been grouped together to form a battery pack. Fixed to the bottom of these packs is a cooling plate, through which lines containing coolant wind. The plate thereby conducts the heat away from the battery cells. A crucial point as regards future e-mobility is that, as charging power increases, it would be more efficient for the coolant to flow directly around the battery cells. This is exactly what happens in MAHLE's immersion cooling system. It's based on the principle that the liquid surrounds the individual cells. Special electrically nonconductive oils are used. As a result, immersion cooling significantly reduces the battery temperature, so it could be the solution to various technical challenges, such as faster charging or extending the service life of the components.

The ongoing development of thermal management technology therefore continues to call for MAHLE's pioneering spirit. That's because the use of solid-state batteries in EVs is on the horizon, with liquid electrolytes being replaced by solid materials. This increases the energy density and eliminates the risk of fire in the event of battery damage. However, there will still be a need to control the temperature of the battery so that it delivers optimum performance. Heating and cooling thus remain the key technologies enabling the success of e-mobility.



“Our approach is based on the modularization of components to reduce cost and complexity for manufacturers.”



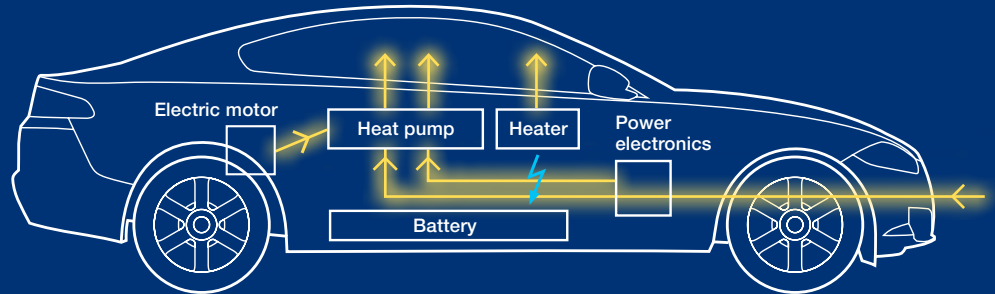
Laurent Art,
Director Predevelopment
Thermal Systems and Components

The future—with no energy loss

Thermal management must learn to save: while the combustion engine's primary target was to dissipate unwanted heat, every joule is used as efficiently as possible in e-mobility.

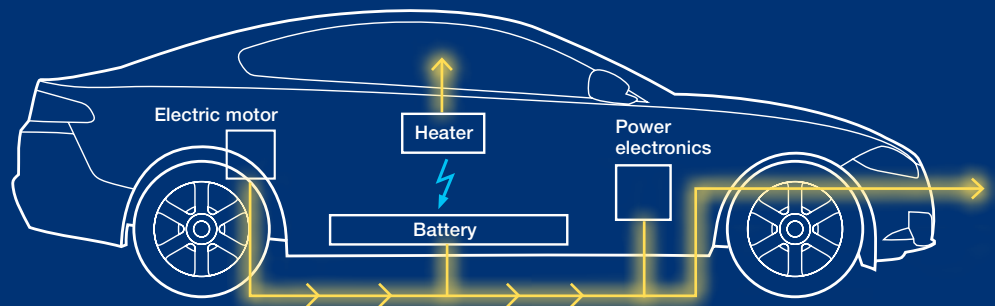
Battery electric drive with heat pump

The powertrain's waste heat and the peripheral energy are used to heat the interior. This reduces the energy requirement of the cabin heating. Essentially, a separate electric auxiliary heater is only required at temperatures significantly below the freezing point (below -10°C).



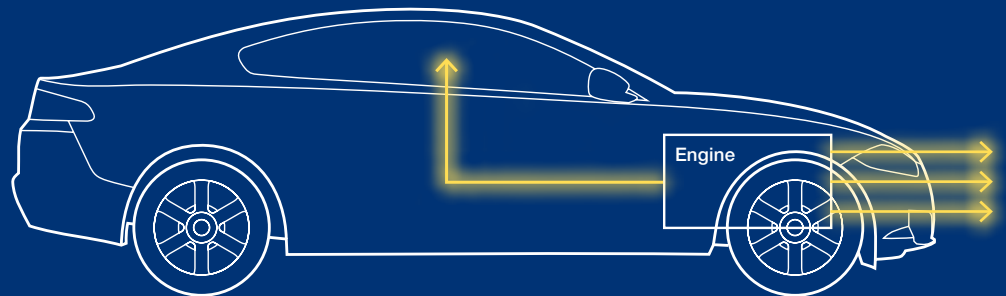
Battery electric drive without heat pump

The waste heat from the motor, the power electronics, and the battery is dissipated to the outside. The energy for the cabin heater is drawn from the battery—this reduces the cruising range.



Combustion engine

Part of the heat generated by the engine is used for the cabin heating, but a large portion is wasted.



Increasing relevance of efficient use of available energy sources

Lighthouse project in Parma

The location is practically emission-free thanks to state-of-the-art technology, and the building generates its own electricity. Then there's the architecture, designed to inspire customers and staff alike. With its new Service Solutions center in Parma/Italy, MAHLE is proving that innovation and climate protection are mutually beneficial.

When the morning sun shines on Parma, the location in the north of the city appears to glow. The snow-white facade reflects the light, while the tinted windows and blue MAHLE lettering provide contrast. The new Service Solutions center is certainly an eye-catching site in the large industrial zone of this economic hub in northern Italy. It's as striking as a lighthouse—a suitable metaphor for a building that aspires to be a beacon project for two of the biggest future topics of all. In setting new standards for MAHLE in terms of climate protection and sustainability, it's hoped that the building will serve as an example for other companies too.

After just over a year of construction, the workforce of around 150 moved into the new headquarters of Group subsidiary MAHLE Aftermarket Italy in spring 2020. This brought the Service Solutions unit's three locations together under one roof, on a site covering 15,000 square meters. The plant develops, produces, and sells diagnostic and driver assistance system calibration devices, equipment for air conditioning as well as emission control and transmission maintenance solutions. Workshop demand for these digital tools is rising—as reflected in the location's dynamic business figures.





“Going green makes an impact –and not only from a climate perspective. When we spend time in natural surroundings, it has an impact on our mood.”

Daniele Colzi,
Managing Director MAHLE Aftermarket Italy



On entering the building’s lobby, you’d be forgiven for thinking you’d stepped into a flagship store. Diagnostic tools developed and assembled here in Parma are displayed on shelves. Alongside them are rows of certificates and a nameplate bearing the logo of workshop service specialist BrainBee, which was acquired by MAHLE in 2017 and has operated successfully in its markets as MAHLE Service Solutions ever since. First-time visitors to the Parma location inevitably find themselves drawn to this exhibition. Which is precisely the intention: “This should be more than just a workplace,” says Daniele Colzi, Managing Director MAHLE Aftermarket Italy. “We want our staff and customers to really enjoy spending time here.”

Working toward zero emissions

More on the feel-good factor later, but first a look at the building’s green credentials. The location’s energy class is A+++, the highest possible rating for a property in Italy. To see how the building has earned such a distinction, we need to start on the roof. The photovoltaic system installed there currently can meet up to 70 percent of the location’s energy requirements on sunny days. By further expanding the PV system in the course of 2022, the site will become independent self-supplier in the medium term even if production is running at full capacity and additional heating or cooling is required. Not only does this make environmental sense, but it’s also good for the balance sheet: by the eighth year of operation, the extended photovoltaic system will have already paid for itself.

Up to **70%**
of the location's energy requirements
can be met by the photovoltaic system
on sunny days.

At times when production at the plant is in full swing, the solar power generated on the roof is needed for manufacturing and in the offices. When the energy demand is lower—at the weekend, during holiday periods, and overnight—the surplus is sold to the local energy supply company. The income generated is reinvested in sustainability, such as optimizing the energy system to achieve further efficiency gains. “Obviously, our goal is to retain our A+++ rating,” says Daniele Colzi. That’s no easy task, however, as demands are increasing every year. In other words, there’s no question of the location resting on its laurels. “But that’s not a problem for us. We’re always looking to improve.”

Moving from the roof back into the plant, the way is illuminated by efficient LED bulbs controlled by a smart sensor-based system. If no motion is detected in a particular area, the lights there are automatically switched off to save electricity. The rooms and halls are cooled and heated with the aid of a heat pump. Natural gas is only needed as a backup when outside temperatures are very low and heat demand for production operations is high. As this is seldom the case in Parma, however, there are practically no CO₂ emissions associated with heating the building either.

Effective cooling, on the other hand, is a must on northern Italy’s hot summer days. The building’s air conditioning system cools the walls and ceilings instead of blowing cold air into rooms. Not only is this technology highly efficient but it also provides a natural coolness, comparable to the pleasant warmth provided by underfloor heating. The data for the location’s smart heating, cooling, and power supply setup is consolidated in a digital control system. A display shows energy managers how high the demand is and how efficiently the system is running—as well as what needs to be tweaked to achieve further optimizations.

A location designed to inspire

But it’s not all about the technology. “Another aspect of sustainability is ensuring people feel at ease in their surroundings,” says Daniele Colzi. Both inside and out, the Parma location looks greener than comparable industrial buildings. It starts on the roof, where staff and customers can attend meetings in unique, plant-filled outdoor lounges on natural timber flooring, protected with sunshades. Some 40 trees grow around the building and green spaces are a key feature, extending over a total area of 1,800 square meters. “Going green makes an impact—and not only from a climate perspective. When we spend time in natural surroundings, it has an impact on our mood,” says Daniele Colzi.

This positive effect continues inside: plants serve as partitions in the office areas, where they noticeably improve the atmosphere. To Daniele Colzi, the open architecture with lots of glass and unimpeded views of manufacturing is a “symbol of the transparency and innovation” that are fundamental to this building: “This concept is all about blurring the divide between offices and production.” Customers who come to Parma for a business meeting get a direct view of the manufacturing process through the glass facades. “This is our way of signaling that we see the two areas as one unit.”

In the pleasantly bright production halls, technicians work at large benches, supported by fully automated systems that are elegance in motion. In training rooms with state-of-the-art equipment, workshop customers are introduced to MAHLE’s innovations from Parma. Currently, much of the training is focused on the TechPRO system, which harnesses artificial intelligence to make maintaining and calibrating driver assistance systems easier and quicker than ever. And in case customers crave a perfect espresso afterward, there is, of course, a café serving the finest coffee here at the Parma location.



“Our industry faces the immense task of rapidly switching over to alternative forms of mobility for the sake of the climate. Innovation and sustainability will be needed at every level.”

Enrico Breggia,
Advisor to MAHLE Aftermarket

Daniele Colzi says customers tend to have an unusual reaction when they visit the headquarters of MAHLE Aftermarket Italy for the first time. Searching briefly for the right term, he laughs and uses an American expression: “Holy cow!” Then he adds, “People are amazed and impressed in equal measure.” How can you tell that people feel at ease in a building? “You can see it in their eyes as they enter and leave,” Daniele Colzi says from experience. “Many employees tell me they’re almost as happy here at work as they are at home.” There simply couldn’t be a bigger compliment for a company based in beautiful Parma. Obviously, the excellent coffee and the outdoor rooftop lounges have something to do with this. “But mainly,” says Daniele Colzi, “it’s because this building shows how worthwhile it feels to put sustainability into practice.”

“See what we can achieve!”

The Parma location is exceptional—but also essential. “As a company, we’re committed to meeting our responsibility to run our business sustainably and do everything we can to reduce our carbon footprint as much as possible—with the aim of making our Parma site climate-neutral,” says Daniele Colzi. Although this target has been all but reached already, he knows it’s just one more step, describing climate protection as an issue with enormous depth. “As soon as we achieve one objective, such as generating all of our own

power, we move on to the next—all the way through to establishing a climate-neutral supply chain.” A Pandora’s box, so to speak? “I think that’s too negative,” says Colzi. “I’d prefer to call it a permanent challenge.”

With regard to the automotive sector as a whole, the MAHLE Aftermarket business unit sees itself as a driver of climate protection. “That’s what we demand of ourselves,” says Enrico Breggia, “also because it allows us to demonstrate to our customers that we’re at the forefront when it comes to leading the automotive and engine industry into the future.” As an advisor to MAHLE Aftermarket, Enrico Breggia was heavily involved in the design and construction of the new Parma location. “The basic concept behind the building is to unite economics and the environment,” he summarizes. “And that can only be done with innovative ideas.”

This is true for the Parma location and the automotive sector as a whole. “Our industry faces the immense task of rapidly switching over to alternative forms of mobility for the sake of the climate,” observes Enrico Breggia. He notes that this not only means vehicles with different drives but also completely new business models and customer relationships. “Innovation and sustainability will be needed at every level,” comments Enrico Breggia, getting to the heart of the matter. By way of example, he refers to a device developed in Parma for analyzing the performance of vehicle air conditioning systems. “This development guarantees efficiency in the car,” says Enrico Breggia. “So it’s only natural that we should demonstrate MAHLE’s air conditioning expertise here in this building as well.” Accordingly, the Service Solution center serves as a brick-and-mortar calling card: “This location sends out a clear message: see what we can achieve!”



Open design, lots of light: the building stands for sustainability in practice, transparency, and innovative thinking. Indoor and outdoor areas are an invitation for employees and visitors alike to exchange ideas.

“Sustainability is all-encompassing”

Kathrin Apel has been Global Head Sustainability & HSE at MAHLE since early 2021. In this role, she is responsible for the company’s sustainability management system, which covers occupational health and safety and environmental management in addition to climate protection. She explains where MAHLE stands in terms of sustainability —and the benchmarks it wants to set.

Ms. Apel, what are your views on the current status of sustainability in the corporate strategy?

As suppliers to the automotive industry, we are setting sustainability benchmarks with our ideas and targets. This is happening on two levels. Firstly, new technical developments target efficiency and sustainability, and are particularly aimed at protecting resources and the climate. Secondly, we operate in a way that supports the measures and our economic stability. We have high ambitions when it comes to climate protection: our global manufacturing will be carbon-neutral from 2040 onward. And we can be proud of ourselves, because we’ve already made our German plants climate-neutral.

How will this be achieved?

We’re motivated and driven by having a specific target—2040 is not far off. And the first milestone is set for 2030, when we aim to have reduced our CO₂ emissions by at least 55 percent compared to our 2018 emissions. We’ve drawn up an ambitious road map comprising three key points.

What are they?

Firstly, we’re increasing the amount of electricity we generate ourselves. We carried out two reference projects with photovoltaics in Parma/Italy and Montblanc/Spain in 2021. We want to build another eight PV systems in 2022. These projects are not only reducing our emissions but also increasing our independence from the volatile energy market as a result of self-generation. Other measures relate to the energy efficiency of our locations, which we aim to improve by at least 2 percent each year. The third topic area includes purchasing carbon-neutral electricity and offsetting remaining emissions.

Who or what is driving the company on this issue?

Most of the momentum comes from within the company itself. But we’re also motivated by the demands and expectations of our stakeholders—especially those of our customers. Our employees also want to work for a company that operates sustainably.

An important point for me in this context is that, on joining MAHLE in January 2021, I quickly realized that the company already had wide-ranging experience in sustainability matters. Aspects such as energy efficiency and environmental protection as well as good working conditions and occupational safety have long been key issues in MAHLE's plants. Our success in these areas, today and in the future, is also a result of the good work already carried out in the past. MAHLE understands sustainability management—even though it might have been called something different a few years ago.

Why is it important to continue to pursue sustainability proactively?

This allows us to build awareness, create momentum in this area, and inspire new ideas. Every system needs a fresh boost from time to time, and we recognize that this has an especially big impact if we don't have to start from scratch. Our employees have a strong intrinsic motivation to think and act effectively and sustainably.

Sustainability goes beyond climate protection—what are your other areas of focus?

Our CO₂ road map is a key element of our sustainability management, but you're right: there's more to it. With regard to our suppliers, we are implementing a system that enables us to track sustainable purchasing and compliance with human rights worldwide. The new Supply Chain Due Diligence Act gives us a legal basis for this. Because our employees are important to us, we want to make further sustainable improvements to occupational safety. We're also committed to increasing the proportion of recycled materials that we use. It's vitally important to me that these sustainability issues are not viewed in isolation from each other. When we think and act sustainably at MAHLE, synergies are created. This means that the initiatives are mutually reinforcing, which benefits us as a company and our employees just as much as it does our customers and the environment. That's why I believe sustainability is all-encompassing.

“Our success in these areas, today and in the future, is also a result of the good work already carried out in the past.”



Declaration of independence

Until now, powerful and efficient electric motors have often employed magnetic materials based on rare earth elements. A new concept from MAHLE for contactless power transmission is making a contribution to sustainable e-mobility by maximizing motor efficiency without any permanent magnets whatsoever.

Zero physical contact, yet always connected: while this may have become a familiar approach for many of us during the coronavirus pandemic, it's actually a well-established principle in power transmission. Known as induction, it involves transferring alternating current from one coil to another via a pulsating magnetic field and is behind the technology that allows batteries in toothbrushes, smartphones, and sometimes even electric cars to be charged wirelessly. MAHLE is now using the principle of inductive power transmission to revolutionize the electric drive. The method makes it possible to selectively energize, and thus magnetize, the rotor of an electric motor. In a stator that's also supplied with an electrical current, this produces the powerful rotational motion that ultimately presses vehicle occupants into their seats right from the off.

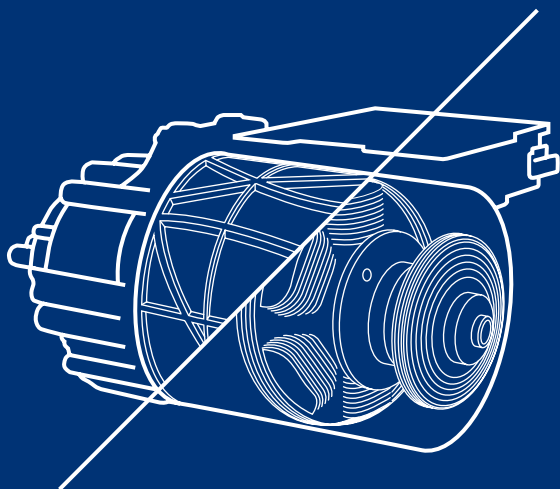
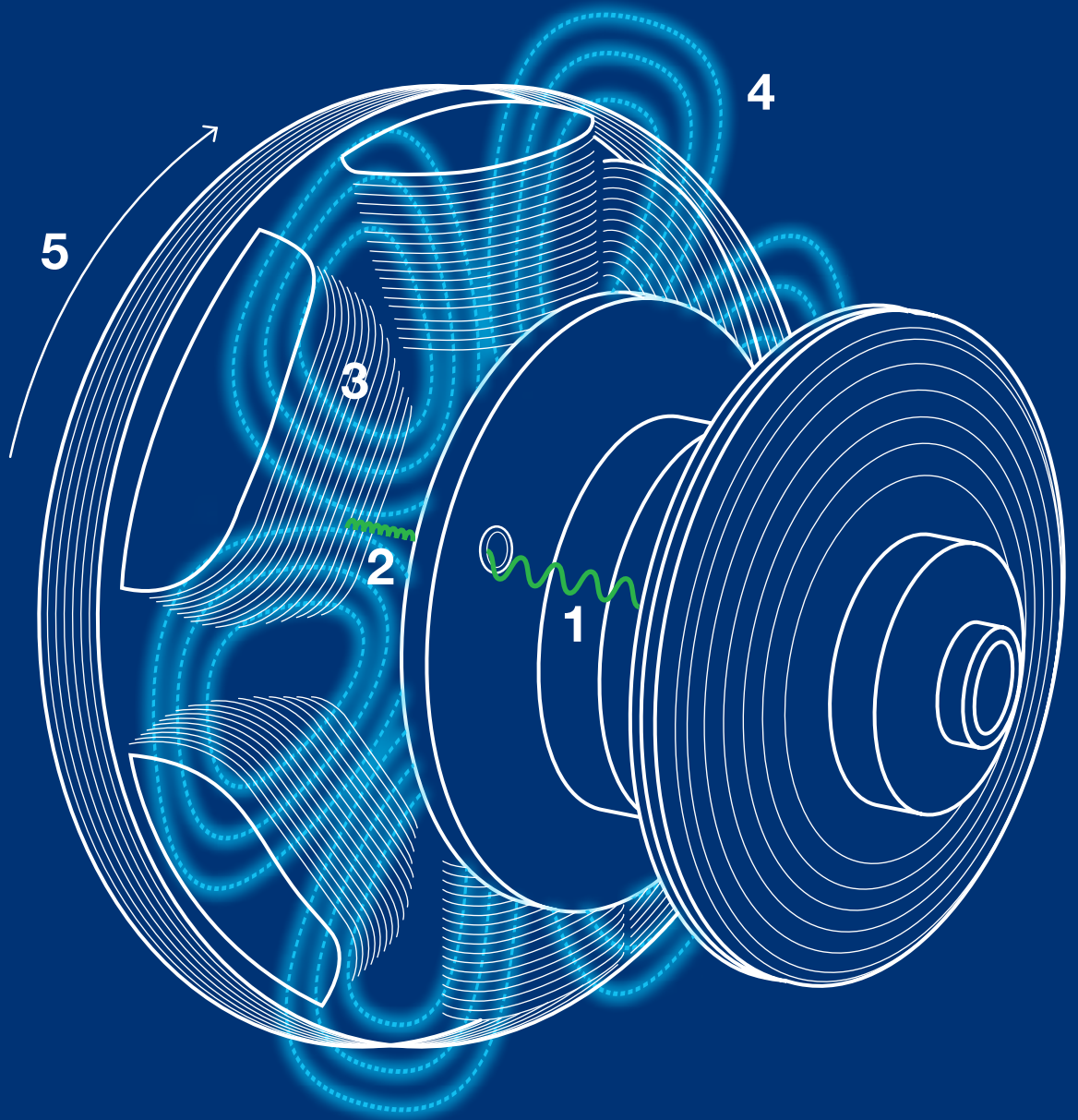
Less dependence in supply chains

To help explain the benefits of the new motor, Martin Berger, Vice President Corporate Research and Advanced Engineering at MAHLE, provides some background: "The greatest power density at a very high level of efficiency is currently

achieved by permanently excited electric motors, which is why you'll find them in many sporty vehicles." The core of the rotor in these machines contains magnetic materials, principally neodymium and dysprosium, which belong to the rare earth group of elements. Although these metals aren't actually rare, their mining and further processing is concentrated in just a few regions. "During the coronavirus crisis, if not before, the automotive industry has learned that one-sided supply chain dependencies are better avoided," reports Berger.

No slip or wear

Although there are already alternatives, these too have disadvantages. Take the asynchronous motor, for example, in which the rotor runs somewhat slower than the magnetic field produced by the stator. This difference, known as slip, leads to lower efficiency, at least at low and medium rotational speeds. Then there are magnet-free synchronous machines—two of the best-selling electric cars in Europe in the last decade use this principle. However, the current in these mass-production motors is transmitted to the rotor through



The heart of the motor is the contactless transmitter: the rotor is **supplied with energy (1)** via an alternating field, which is then converted into **direct current (2)** for the magnet coils.



These **magnet coils (3)** replace the permanent magnets. They induce a **magnetic field (4)** in the air gap and cause the motor to generate **torque (5)**. Depending on the operating point, this field—in contrast to permanent magnets—can be controlled easily in its magnitude.

“We’re convinced that we’re on the right track with our technology for the next generation of electric motor platforms.”

／
Dr. Martin Berger,
Vice President Corporate Research
and Advanced Engineering at MAHLE



sliding contact. Where there's sliding, there's friction, and friction not only decreases efficiency but also almost inevitably leads to wear over time—disadvantages that are avoided with the contactless power transmission technology patent-pending by MAHLE.

Preparing for the e-future

Once the idea was formed, Berger and his team began by spending around two years working on countless computer simulations and then on secret laboratory and bench tests. They had both the expertise and the test equipment, as MAHLE has long been developing and producing electric drives for practically everything that moves—from e-bikes to powerful sports cars. Finally, the results were officially presented in spring 2021. The prototype, a 140-kilowatt unit, has already demonstrated outstanding efficiency. Up to 96 percent of the current supplied is converted into mechanical energy. Even more importantly, an efficiency of at least 95 percent is achieved in large areas of the operating map used for road travel. As might be expected, the feedback from customers has been incredible, with dozens of vehicle manufacturers looking to speak with the MAHLE experts. MAHLE is now in discussions with several customers regarding series production, which may begin in 2025. Berger sees further opportunities: "We're convinced that we're on the right track with our technology for the next generation of electric motor platforms due to go into series production in the second half of this decade."

However, MAHLE is not pursuing an all-or-nothing approach. Although the company is able to develop and produce complete electric drives, European automakers in particular are making use of their own electric motor production facilities to ensure that existing plants can still be utilized to capacity as sales of vehicles with combustion engines decline. "We still consider ourselves a technology supplier," says Berger, explaining the business model. In practical terms, this means that customers can only purchase the core component—the inductive current transformer. A third option may be the most attractive for some manufacturers, with MAHLE supplying the complete rotor together with the mechanically connected current transformer.

Big picture concept

From a technical perspective, there's a crucial advantage to viewing the rotor and current transformer as one unit: a motor's performance also depends on how efficient the resulting heat can be dissipated. "A design that takes account of all of these factors provides optimal cooling at minimum expense," says Berger. The preassembled rotor and current transformer module can also be easily inserted into the stator as a complete unit at the customer's motor production facility, thereby saving on installation and logistics costs.

Although there's still a long way to go before series production, the path is so clearly mapped out that Berger's team is already working on the finer points. Such as how to use a countercurrent pulse to demagnetize the rotor as quickly as possible in the event of an emergency. Or how an 800-volt version of the motor, originally designed for 400 volts, might look. Clearly, the switch to e-mobility in no way marks the end of the story of technological progress. On the contrary, the sustainable magnet- and wear-free synchronous motor from MAHLE heralds the start of a new era of evolution.

You never stop learning

The automotive industry is not only undergoing a rapid transformation in terms of technology. The necessary skills and working methods are also constantly evolving. MAHLE offers its employees worldwide the opportunity to expand their skill set in order to remain an active part in the transformation of the mobile future.

“Shaping MAHLE’s future through goal-oriented and tailor-made training—this is our ambition. That is why we are continuously developing our learning and qualification programs and establishing new formats and tools that make learning more flexible,” says Julia Kuntznawitz, Head of Corporate Personnel Development at MAHLE. Lifelong learning is an essential part of MAHLE’s corporate philosophy. And needs-oriented training to acquire new skills and expertise are a focal point of human resources development. Throughout the world, more than 70,000 employees at 160 locations can participate in a comprehensive range of advanced training courses, in person and digitally, locally and globally, with a choice of more than 200 global topics, which are constantly updated and expanded to help all employees be forward-thinking and meet the demands of the new mobility.

MAHLE needs committed and well-trained employees with the necessary skills and competences within the company in order to successfully deal with the future transformation in the industry. In the future, the company will focus even more on identifying and promoting talent at an early stage, and will thus intensively support the development of new qualifications and skills. That is why MAHLE is investing in selected measures and instruments that support continuous development as well as in vocational training and part-time study courses. Committed and curious—that is the common motivation of MAHLE employees.



“These first few steps within the framework of the Transformation Roadmap made me hungry for more. I want to acquire more technical skills and more knowledge.”



Rafat Sperling, 42,
head of Liquid Cooled and Electric Heat Exchangers in
Ostrów/Poland

When MAHLE acquired the thermal management business from automotive supplier Delphi Automotive PLC in Ostrów in 2015, Rafat Sperling, then a global engineer, was part of the transformation team tasked with combining expertise from both companies to bring the best possible products to market. During a conversation in Stuttgart following the takeover, it quickly became clear that he would lead the new team in Ostrów that would be responsible for the development of liquid heat exchangers. “A job for which my previous work and studies were not sufficient,” comments Rafat Sperling. “I have more of a mechanical background. I started out as a stamping engineer, and electronics and electrics were only touched on in my studies.” During the annual discussion with his supervisor, he spoke about how he could prepare himself for the future.

Last year, he participated in Transformation Roadmap—a global qualification initiative. The purpose of this program is to proactively qualify employees for new or changed roles in our future business areas such as e-mobility. “What was particularly valuable to me during the training, was the lively discussion with a German professor about what can go wrong during production and even during product planning,” says Rafat Sperling. “These first few steps within the framework of the Transformation Roadmap made me hungry for more. I want to acquire more technical skills and more knowledge.” He also took part in the Leadership Training initiative. “There I learned how to deal with myself and be a good moderator for my team,” he says. He is currently one of the regional talents that are being promoted as a potential global executive. What helps him to manage all of this? “I’ve been doing karate for 35 years. This helps me to remain focused on and committed to what I want to do. Karate is important for my personality and my inner strength.”

Patricia Ducatti Miguel Medeiros is the woman who pulls all the strings for mechanical compressors in Brazil. She is responsible for all new projects in Brazil. Her responsibilities: to manage and control the projects from the acquisition to the end of production, and to communicate with the customers. Her daily challenges: “Talking, negotiating, rethinking, and finding solutions that everyone is satisfied with,” she says. “I’m the customer’s eyes in project development.” After studying mechanical engineering in 1994, she started her career in the logistics sector. She later became a project manager for various companies, and since 2005 she has been in the automotive industry. At MAHLE, she took part in a Future Leaders Training course. “The interchange of experience was great,” she notes. For her, however, lifelong learning boils down to daily learning. “I continually have to update my technical know-how, struggle with time management, and deal with different people. When you’re passionate about your job, you also want to tackle the unexpected problems, and later you can rejoice over the solutions found.” She sees herself as a kind of facilitator for her group. “I don’t keep the knowledge I acquire during training to myself. I share it with everyone. I want my team to shine.”

“When you’re passionate about your job, you also want to tackle the unexpected problems, and later you can rejoice over the solutions found.”

Patricia Ducatti Miguel Medeiros, 50,
project manager in Jaguariúna/Brazil






Having his dream job, but still wanting constant change—that could be the headline for MAHLE employee Sven Fleischer’s professional life. Ever since his internship while studying automotive engineering, he has been passionate about the company. He says: “My enthusiasm for the company has never left me.” In 2007, after completing his studies, he started working in the acoustics testing department. Two and a half years ago, he saw an advertisement for a part-time master’s program in mechatronics, for which he successfully applied. “I supervise the electrodynamic vibration test benches, so I work with electronics a lot. As a research engineer, it was clear to me that there will be many new developments in the future, so I wanted and needed to continue my training.”

His application is successful. MAHLE offers him and other co-workers the opportunity to study on a part-time basis. As part of the Transformation Roadmap project, MAHLE assumes 100 percent of the tuition fees. Furthermore, lectures take place within working hours. The Works Council organized rooms for the students to meet in study groups and help support each other learn. “In the beginning, it was a big adjustment to learn permanently again,” says Sven Fleischer. It’s a life in the fast lane with hardly any free time: He will soon become a father for the second time, and wants to complete his studies with the submission of his master’s thesis. Then he intends to continue doing what inspires him every day: “Combining theory and practice at work, learning and growing as new products are developed, and never stop learning.”

“As a research engineer, it was clear to me that there will be many new developments in the future, so I wanted and needed to continue my training.”

Sven Fleischer, 39,
research engineer vibration testing in Stuttgart/Germany



“I want to bring people at MAHLE together and motivate them – irrespective of their gender, identity, nationality, language barriers, ideology, or religion.”

Changzhong Liu, 50,
Director Corporate Purchasing Asia in Shanghai/China

Changzhong Liu was one of the first members of the Global Talent Circle, a worldwide MAHLE initiative for the ongoing development of top executives which includes modules in Brazil, China, and Germany. For two years, the selected talents with different functions and cultural backgrounds met around the world, in order to prepare themselves for the working world of the future and learn about leadership, the different MAHLE locations, and the local markets. “For example, we flew to Brazil to see, among other things, how they work together and what contribution MAHLE makes to the community there,” says Changzhong Liu, who started

his career as a product engineer in 1996 and joined MAHLE in his current position in 2014. He was thrilled by the team building: “We spoke very openly about our roles and the challenges we face, and we formed strong bonds. We are still in contact even though the program has ended. We help one another apply what we have learned, we congratulate one another on our birthday, and we sometimes go out when we meet at one of the locations.” His goal after this global exchange of experience: “I want to bring people at MAHLE together and motivate them—irrespective of their gender, identity, nationality, language barriers, ideology, or religion.”

“I felt that I could improve my negotiation skills. In the training course, I learned how to address my team even better and how to identify problems and solutions.”

／
Ariane Celisca Gonçalves Araújo, 32,
project manager in Mogi Guaçu/Brazil



Her supervisor Bruno De Aguiar describes Ariane Araújo as a perfect example of someone who can handle numerous problems at the same time. She has worked at MAHLE in the field of customer project development for more than 15 years and has been the matrix team leader of the product development process since 2017. As a project manager, she ensures that schedules are adhered to daily, assesses risks and opportunities together with the team, controls the budget, guarantees quality and delivery, and keeps in touch with customers. “But I felt that I could improve my negotiation skills,” says Ariane Araújo. She thus participated in the Mindset Negotiations training course. “There I learned how to address my team even better and how to identify problems and solutions.”

And since she is the mother of a four-year-old son and usually works remotely, she was also nominated as a regional manager for the Female Leadership program in South America. “I learned strategies on how to solve problems even when I’m not able to go to the other person’s desk. I learned how to give constructive feedback digitally. And I learned about the best way to balance work and family as a manager.” She says that her greatest motivation is that MAHLE trusts her to juggle and meet all the different demands on a daily basis. “It’s nice to work in an environment where people believe in you.”

Highlights 2021

Exciting projects, new product solutions, and promising collaborations—despite all the challenges, there were many highlights for MAHLE in 2021. Here's a brief overview of just a few of them.

progressive



MAHLE sets the pace in 3D printing: in June 2021, MAHLE opened a new center for additive manufacturing processes in Stuttgart, where complex components for the production of prototypes can be manufactured in just a few days. This significantly accelerates the development of components for electric vehicles and other climate-neutral drive technologies in the fields of thermal management, mechatronics, and electronics.

preventive



Vaccination for our future: in many parts of the MAHLE world, including Austria, China, Germany, India, Japan, Mexico, and Slovakia, MAHLE employees were vaccinated during company vaccination campaigns. Until summer 2021, more than 13,000 members of staff had taken advantage of this opportunity, sending a clear message in support of the fight against the coronavirus. At some locations, the vaccination offer was extended to family members of MAHLE employees.

effective



Calibration of driver assistance systems in under a minute: this is now possible with the TechPRO® Digital ADAS 2.0 from MAHLE Aftermarket. Innovative keystone technology allows workshops to align vehicles with the calibration frame much more quickly by fully automating the calibration process. Other benefits of the product include cost-effective use and intuitive operation.

productive



Since April 2021, around 70 engineers have been developing solutions for alternative drives at MAHLE's new electronics and mechatronics development center in Changshu/China. The team is also working on charging solutions for electric vehicles as well as thermal management applications for alternative powertrains. Thanks to this new development center, the MAHLE Group is further expanding its systems expertise with the electric powertrain as well as electronics and mechatronics.

alternative



Hydrogen—an important technological building block for the mobility of the future: components for fuel cells and engines are put through their paces at the MAHLE hydrogen test center in Stuttgart/Germany, which opened in March 2021. The goal is to develop economical and robust systems solutions for the automotive industry—with a focus on heavy-duty commercial vehicles. In July 2021, MAHLE strengthened its commitment to the field of hydrogen technology when it joined the New Vehicle and System Technologies funding program, initiated by the German Federal Ministry for Economic Affairs and Climate Action.

In 2021, MAHLE received around 75 awards for innovation, technology, quality, and customer service from renowned customers, partners, and other stakeholders.

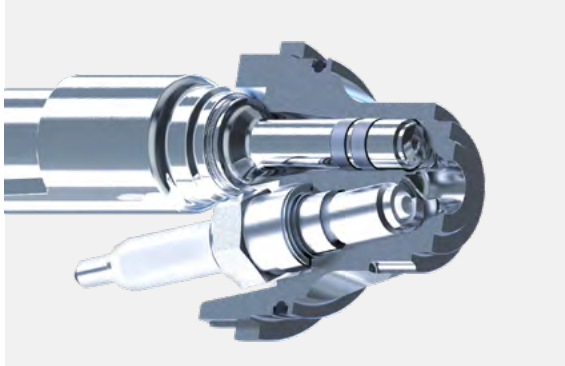
positive

MAHLE adopted a new approach at the IAA Mobility: while the Group presented its promising and sustainable mobility concepts to trade visitors in the halls of Munich's exhibition center, MAHLE's mobility solutions were also on display to the general public in the Open Space in downtown Munich. This allowed many automotive engineering enthusiasts to experience MAHLE technologies for the mobility of the future up close and interactively. Offering exciting insights into the Group's development work, the MAHLE Mobility Talks were a special highlight of the showcase in Munich's city center. The talks were streamed via the MAHLE YouTube channel and achieved good coverage within a short time.



interactive

collaborative



MAHLE Powertrain, the development service provider owned by the MAHLE Group, supports Liebherr Machines Bulle SA in developing hydrogen-fueled internal combustion engines. The MAHLE Jet Ignition (MJI) prechamber ignition system developed by MAHLE Powertrain plays a particularly crucial role here. By using this technology, the mixture of hydrogen and air can be ignited and burned at a high compression ratio, which makes the combustion process very efficient. The collaboration aims to promote the use of hydrogen generated from climate-neutral processes in heavy-duty and off-road applications.

In 2021, MAHLE was externally rated for the first time and was classified by the rating agency Moody's as Ba1 with stable outlook. This assessment confirms the Group's financial standing and corporate strategy. The rating also strengthens MAHLE's position on the international capital markets and makes it more attractive to investors.

competitive

As a partner to the German federal state of Baden-Württemberg, MAHLE is presenting its products at the World Expo, which opened its doors in Dubai on October 1, 2021. The company's exhibit focuses on integrated modular and systems solutions for e-mobility applications. The highlight of MAHLE's presentation is a magnet-free electric motor that does not require rare earth elements and is thus highly sustainable, efficient, and wear-free. Visitors can also find out about MAHLE's activities in the fields of battery cooling, technologies for pedelecs, and electric vehicle charging.



attractive

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
Beatrix Gerstberger
Robert Habi
Dirk Kunde
Johannes Winterhagen

Photography

Dirk Bruniecki, Andreas Pohlmann, Wolfram Scheible,
Manuel Uebler, Kerstin Wille, MAHLE Archive

Illustration

Blagovesta Bakardjieva/carolineseidler.com

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

© 2022 MAHLE GmbH,
00007859 EN 2.0.4/22



MAHLE worldwide



**Around 160
production locations**



**12 major research &
development centers
worldwide**



**More than 71,000
employees***

North America

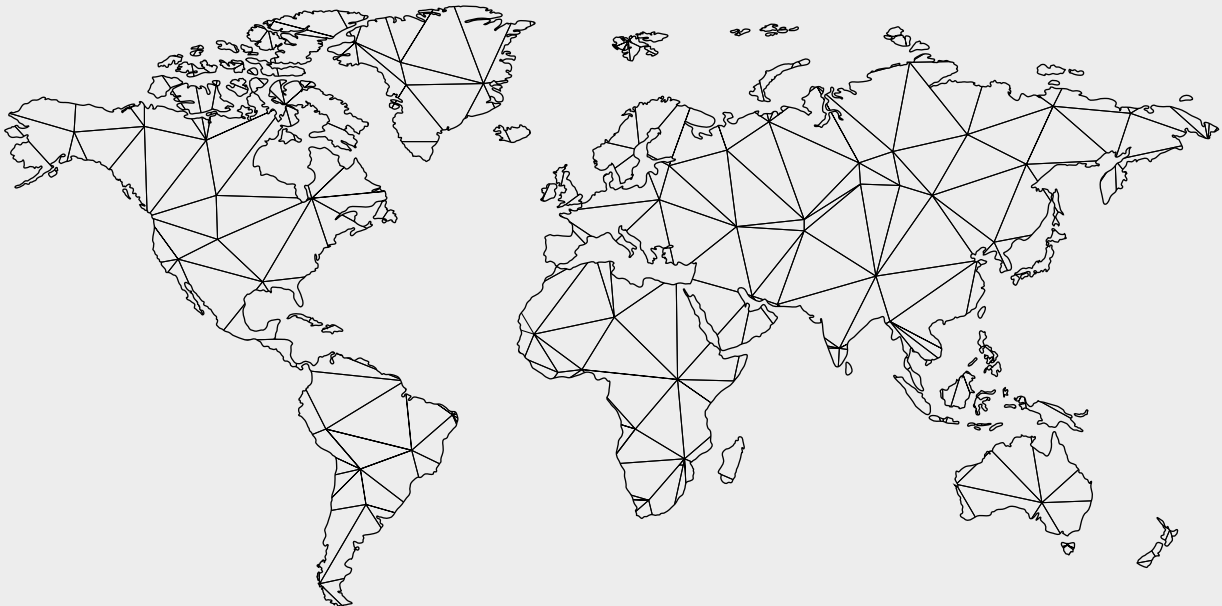
**28 production locations
13,416 employees***

Canada, Mexico, USA

Europe

**64 production locations
31,909 employees***

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



South America

**8 production locations
8,736 employees***

Argentina, Brazil

Africa

**2 production locations
855 employees***

South Africa

Asia/Pacific

**63 production locations
16,382 employees***

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

