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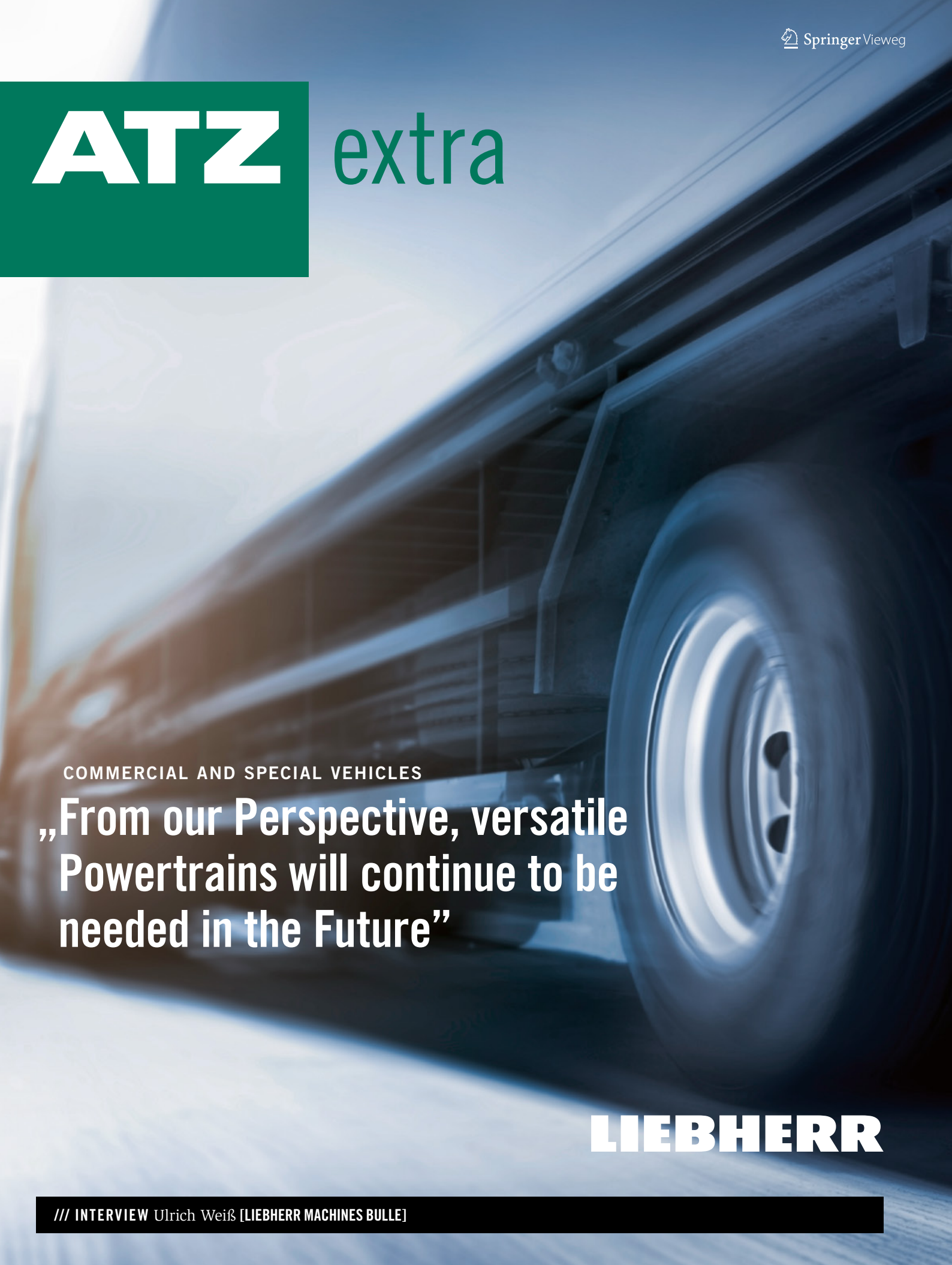
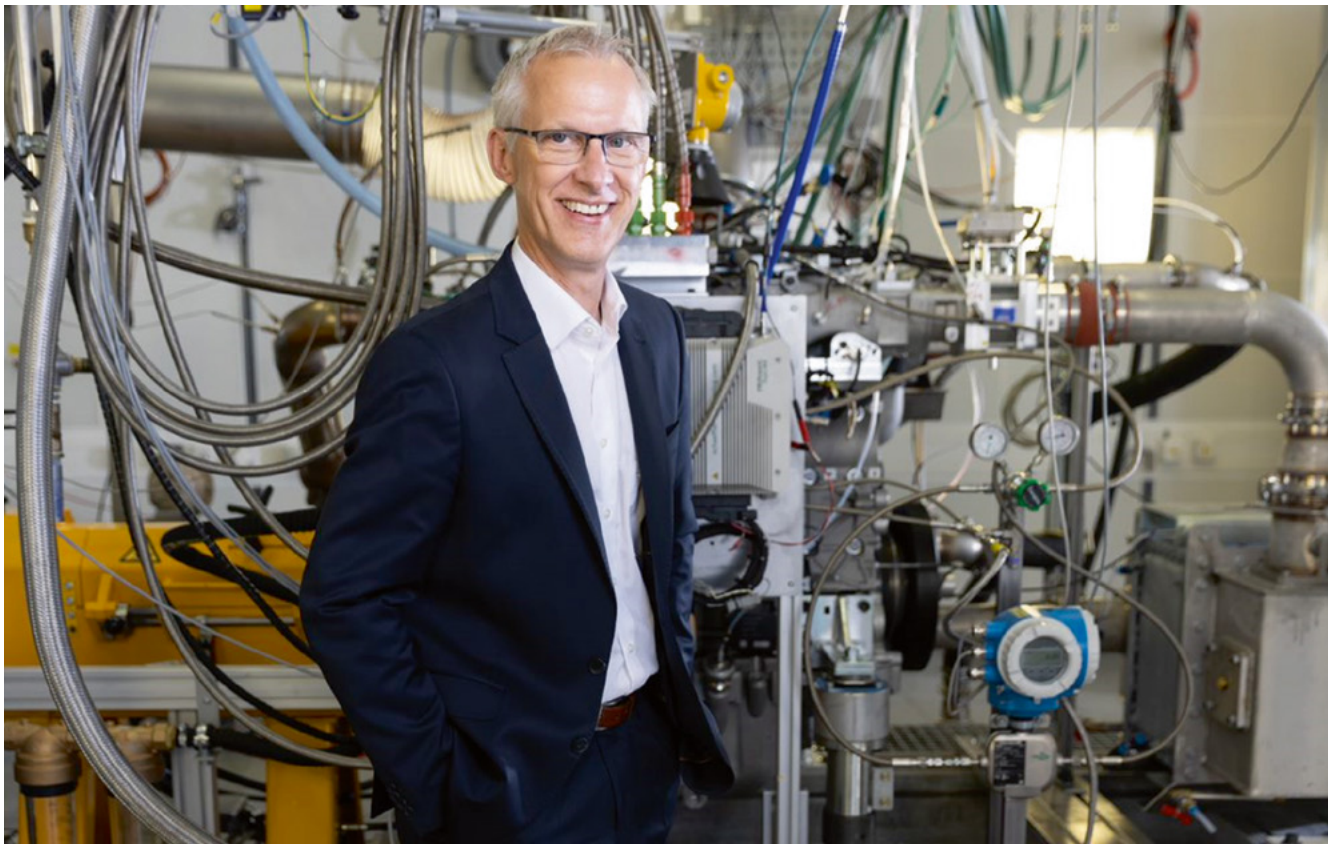


COMMERCIAL AND SPECIAL VEHICLES

„From our Perspective, versatile Powertrains will continue to be needed in the Future”

LIEBHERR

/// INTERVIEW Ulrich Weiß [LIEBHERR MACHINES BULLE]



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“From our perspective, versatile powertrains will continue to be needed in the future”

Even the utility and special application vehicle sector is undergoing a technological shift. At the same time, the off-highway sector often requires individual solutions. ATZheavyduty spoke with Ulrich Weiß, Managing Director for the Design and Development of Combustion Engines at Liebherr Machines Bulle about the challenges the sector has to face.

ATZheavyduty _ The construction of charging and filling infrastructure is lagging the rapid technological shift toward climate-neutral powertrains in the utility and special application vehicle sector. Are the EU and the Federal government sufficiently active?

WEISS _ Liebherr pursues a technology-open approach and addresses both, currently and foreseeably available technologies for energy conversion and their suitable energy carriers. Every powertrain technology has its strengths and weaknesses, requires a specific infrastructure, and therefore has suitable and less suitable fields of application. Which powertrain technology is ultimately applied is influenced by the region it will be used in and its infra-

Ulrich Weiß studied mechanical engineering at the University of Stuttgart. He started his professional career in 1994 as a test engineer in racing for Audi Sport. In 2001, he moved to a position as project manager in the Formula One area at Daimler AG. He was responsible for the design of heavy-duty commercial vehicles at Daimler AG from 2005 to 2011. Weiß then returned to Audi, where in March 2012, he assumed the management position for diesel engine development. He has held the position of Managing Director for the Design and Development of Combustion Engines at Liebherr Machines Bulle S.A. since April 1, 2019.

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structure. There is currently no one-size-fits-all solution for such heterogenous fields of application that exist for utility and special vehicles. Instead, it is true that the more exact the powertrain technology, application and region of application are matched to each other, the higher is the contribution to value creation and also to climate-neutrality. In addition, all limits need to be re-evaluated in the context of tank-to-wheel and extended in the context of global warming to well-to-wheel or even cradle-to-grave.

Does the slow construction of infrastructure have an influence on your business? At the end of the day, the fuel in the off-highway sector tends to come to the machine …
In our sector, it is true that it isn't the machine that goes to the filling station, but normally the filling station comes to the machine. However, an appropriate energy supply still needs to be ensured in the region of application. This obviously requires a suitable infrastructure so that machines can be successfully operated, as well as acceptable energy costs be planned and calculated.

E-fuels could play an important role in the decarbonization of the transportation sector. How would you judge the outlook?
We are examining different powertrain technologies and fuels. Apart from electrical energy, these include hydrogen, ammonia, methanol, biodiesel, Hydrated Vegetable Oils (HVO) and also fossil diesel and e-fuels. The latter will play a greater role in the future and are also gradually asserting themselves in a political sense. However, in order for them to make a notable contribution to the reduction of greenhouse gases, they will have to be produced from renewable energy sources. Thanks to e-fuels, the existing fleets that used to be powered by diesel, can now be easily and rapidly converted into greenhouse-gas-neutral fleets. All Liebherr engines have already been certified for use with e-fuels according to EN 15940. We are also working on fuel injection technologies, whereby e-fuels act as an ignition aid, for example H_2. HVO as a fuel can also make an important contribution toward defossilization, since compared to fossil diesel, it produces lower emissions and reduces greenhouse gases by up to 90 %. Our engines are also certified for use with HVO.

"There is no one-size-fits-all solution for the utility and special vehicle sector"

Liebherr has a large portfolio of machines for use in a wide range of applications.
In which fields do you see opportunities for extensive electrification?
Extensive electrification will start first with machines with low drive power up to around 140 kW. On the other hand, there will be machines that are operated locally, such as in a recycling yard or in a harbor. These will be operated in dual mode and equipped with a battery for the short ranging journeys and energy supply via charging cable for the high-load work. However, electrification will depend largely on the application and be determined by the customer. For example, we have concrete requests and projects for the electrification of mining trucks. Which machines will be electrified at the end of the day, where electrification will assert itself, all this will naturally be determined by economic and technical aspects.

Which other alternative powertrains except for combustion engines, do you estimate, have relevant chances on the market?
Apart from working on the development of powertrain concepts, such as electrification, we have also spent many years

examining the fuel cell and its fields of application. We have had a prototype of our hydrogen engines on a test bench since 2020. Just as for electrification, the success of this technology depends on the specific environment and application.

Apart from further reductions in the limits for particulates and nitrous oxides, Euro VII also contains stricter regulations regarding emissions behavior under light load and during cold starts. Which technologies will Liebherr be using to meet these challenges?
We expect that a Stage VI off-highway regulation will be derived from the current Euro VII on-highway regulation. From our point of view, fulfilling these targets will require far-reaching adaptation and changes. These will include the development of a two-stage exhaust gas aftertreatment system with one stage in extreme proximity to the engine and a suitable downstream stage, which would require SCR catalysts and a diesel particulate filter. It is undefined to this day, whether the limitation of nitrous oxide forces the use of vanadium as a catalyst material. But we assume that internal engine exhaust gas recirculation will be unavoidable. Further development foci are measures for the rapid heating of exhaust gas after engine start that we are working on and must implement. However, we need to wait for the final regulation.

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It is definitely desirable to have an appropriate filling station infrastructure for the off-highway sector, in order to keep up with the rapid technology shift, Weiß says

The H_2 combustion engine is seen as a trailblazer for rapid decarbonization. Liebherr has also described such an engine on the basis of a diesel engine on occasions such as the ATZlive Heavy Duty Conference. What are the highlights of this development and where do you see applications?
The H_2 combustion engine largely combines the advantages of a mature combustion engine technology with the option to be able to offer an emissions-free powertrain even under tank-to-wheel conditions. The advantages of the combustion engine are mandatory prerequisites for off-highway machines. These mainly include robustness, economy, high performance, a wide range of application areas, operation under extreme weather conditions and geographic locations. From our point of view, there also need to be powertrain systems in the future that can be easily adapted for use in a wide range of very different machines. For example, our modern 12-l six-cylinder inline diesel engine is used in excavators, mobile cranes, wheel loaders and tracked vehicles, even though these machines have extremely different load profiles. This versatility will also be required in the future for quality and economy.

“E-fuels will play a major role in the future”

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The challenges pertaining to hydrogen engines, and thus the limitation of their field of application, are determined by the available storage volume for energy and the delivery of the energy carrier, Weiß states

What role will this powertrain play in Liebherr’s future portfolio?
It plays a central role for us. At the moment, Liebherr is developing a wide range of machines with an H_2 combustion engine.

Hydrogen is currently almost exclusively stored in pressurized tanks. Do you also consider the use of liquid hydrogen to be suitable for your machines?
This technology is also being pursued due to the volumetric advantage of liquid hydrogen. At the moment, we are only aware of a few projects and little activity in the industry regarding liquid hydrogen. We assume that the construction of infrastructure lies in the far future, so that the implementation of liquid H_2 would be more realistic in the second or third generation of hydrogen engines. Nevertheless, storage in the form of cryogenic tanks is also of interest to us.

Your company has introduced a method for the optimization of the lifetime of viscous torsional vibration dampers at early stages of engine development. Where does the strength of this method lie and how accurately can you meet the predictions?
Liebherr is developing a digital twin for viscous torsional dampers that is intended to enable the estimation of the remaining lifetime of a damper based on the individual load profile of a unit. The calculated remaining lifetime is then planned to flow into a predictive maintenance concept for engines with unusually high power density or operational lifetime. In accordance with conventional design methodology, the damper has to be replaced after half of the engine's lifetime. Thanks to the maintenance concepts, the exchange can be limited to cases, in which it is actually necessary due to the individual loading of the unit. The accuracy achieved so far in the development of prototype engines is very promising, which has made us to start planning field tests. Apart from the development of lifetime models for components, such as the torsional vibration damper, we are also working on AI-based models for the recognition of abnormal operational behavior of the engine. The goal is to avoid machine downtime due to unplanned maintenance interventions or at least to limit them to an absolute minimum.

From a construction machine point of view, is diesel more of a range extender, analog to the fuel cell as a source of power?
I don't think so. The package, the weight and the axle load of the machines define limits that can only be met to a limited extent with two parallel powertrain systems. In the case of compact machines, hybrid technology will only be able to make limited inroads, whereas for large mining machines, this is certainly conceivable.

At first glance, hybrid technology in working machines only seems to increase complexity. Where are the advantages in terms of saving effect, system costs and TCO?
Saving effects will presumably be compensated for by the higher acquisition costs. This is why, I think, this will not be the driver for hybridization. However, one possible driver could be exhaust gas legislation that may demand that certain operating points can only be run purely electrically, for example during long periods of idling. A further one could be the currently emerging patchwork CO_2 legislation. In a few cities, only locally emissions-free machines will be allowed to operate in the future. Even so, such machines as mobile cranes or concrete mixers will have to cover large distances with high machine weights.

Mr. Weiß, thank you very much for the interesting discussion.

INTERVIEW: Alexander Heintzel

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