SHW
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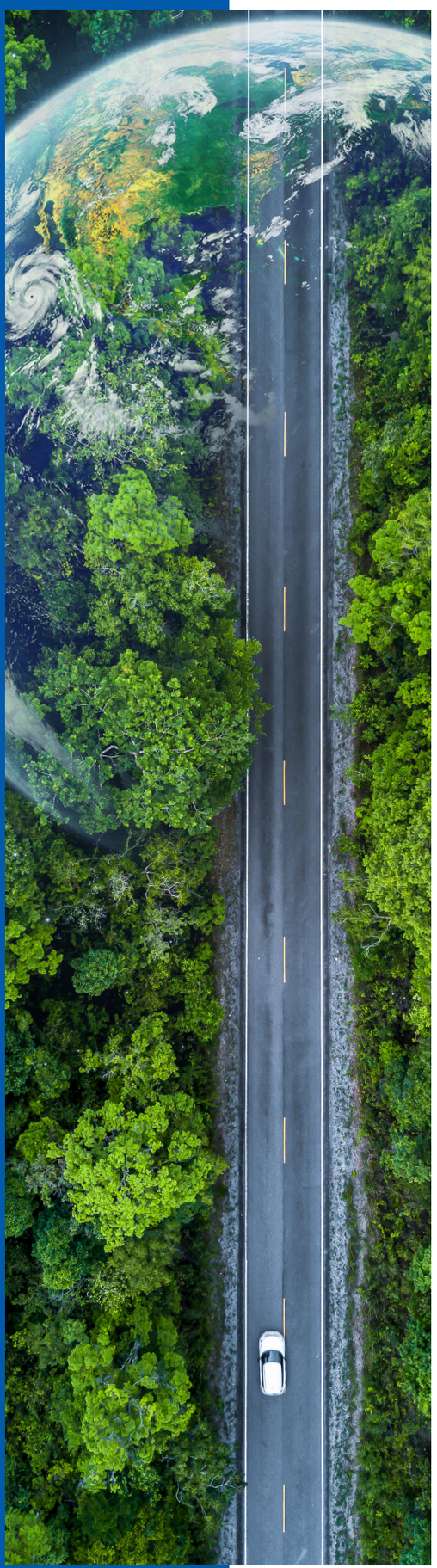
Future mobility and challenges of modern E-Drive

Whitepaper E-Mobility 2023 SHW Automotive GmbH



EXECUTIVE SUMMARY WHITEPAPER

Innovations have always been the key drivers of the automotive industry. Thus, innovative ability is a key indicator of how successfully automotive manufacturers and suppliers can meet the challenges of electrification.

The main challenge is to respond to customer needs, regulatory requirements, and technological developments by creating innovative product solutions.

Compared to 2020, the sales of new electric vehicles more than doubled in 2021, with a growth rate of 51.8 percent. This meant that sales of electric vehicles accounted for around 5 percent of global passenger car sales.[1] Such growth especially resulted from attractive subsidies as well as increasingly powerful technical components.

In addition to factors such as affordability and climate neutrality, a long driving range and short battery charging time play a particularly significant role. Many potential buyers still have doubts and fears that the performance will not meet their expectations. However, the fact is that the population do not travel more than 40 kilometers by car per day, and thanks to improved battery capacities, driving ranges of between 200 and 600 kilometers are now possible, depending on the vehicle.

In this context SHW has analyzed the requirements on the component level that particularly challenge automotive manufacturers in the development of EVs and is presenting possible solutions that will contribute to a higher range, battery life and shorter battery charging time.

In order to operate an electric vehicle with a high efficiency, it is necessary to keep the temperature of the electric motor, the power electronics and the battery within an optimum temperature range. This can be achieved - depending on the component - with integrated oil and cooling management.

Thus, SHW is taking part in rapidly creating the necessary technical conditions to drive mobility forward on a nationwide and sustainable level.

1 Statista (2022): Electric Vehicles - Market Data Analysis & Forecast

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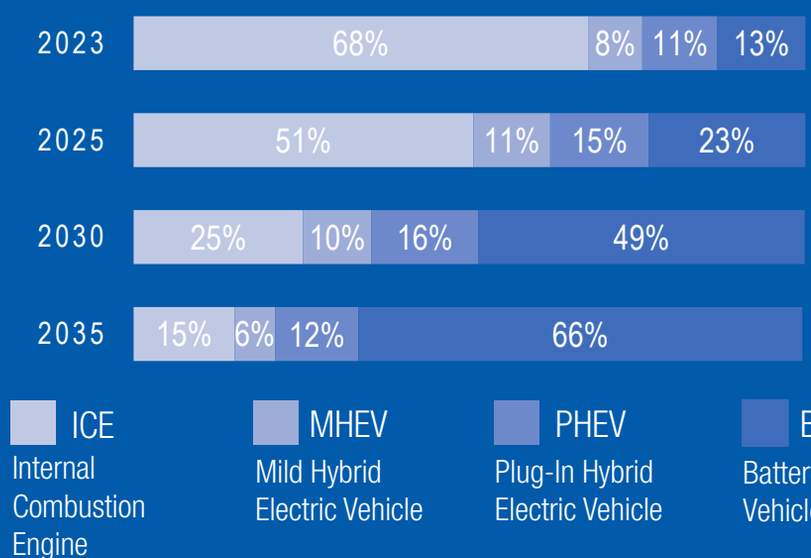
PREAMBLE

By 2034 EVs and Hybrids will account more than 80 % of all global light vehicles that will be produced.

Abb.: Global Light Vehicle Production Forecast, Propulsion System Design (Source: IHS Markit, September 2023)



The market segment is changing significantly, not least as a result of the elimination of vehicles with internal combustion engines in the EU from 2035 onwards, and therefore also the requirements and needs of the customers.

That means new challenges for the supplier landscape. The suppliers evaluate their current strategic positioning and set the course for the future with an appropriate transformation strategy.

Environmental protection, sustainability and renewable energies have been placed in the media for years. CO_2-neutral production and compliance with new environmental requirements are just a few of the new challenges for the automotive industry.

As a result of political pressure and government support programs, the market share of Battery-Electric (BEV) and Plug-in Hybrid (PHEV) Vehicles has increased significantly and is expected to change the automotive market in the long term. This is forcing automotive manufacturers and suppliers to develop and finally implement transformation strategies.

CHALLENGES & REQUIREMENTS FOR BEV‘S

The customers are expecting from modern Battery Electric Vehicles (BEV´S) long driving range, fast battery charging, fabulous acceleration, big in-cabin room and high reliability.

For the driving range of BEV’s is not only the capacity of the battery pack responsible. In fact the efficiency of all components and systems has an huge impact on the possible milage. Due to a better overall system efficiency the battery pack, as the main cost and weight driver, can be reduced in size without compromising the driving range.

As well the weight is an important factor for efficiency. Any additional kilogramm is increasing the necessary power for acceleration and has a bad influence on the friction losses. Even if some energy can be saved by recuperation, you loose efficiency due to exceeding weight.

To give the designer enough freedom to combine dynamic styling, comfortable in-cabin space and plenty available space in frunk and trunk space, battery pack and e-axles need to be very compact. High functional integration levels and rightsizing of the subsystems help to get very compact solutions.

The battery charging time is for the customer an important argument for or against the decision to buy an BEV. To shorten the charging time, there is a clear trend for high voltage and high current charging stations.

To enable a battery pack for high current loading over the complete loading cycle, a pre-conditioning of the battery temperature is necessary in advance, and effective battery cooling is required during the loading process to keep the cell temperature within the allowed safety limits.

Many customer have the expectation on BEV's, especially in the mid and higher class product range, to impress them with very fast acceleration and high power and torque. For e-axles and transmissions a proper cooling and lubrication system is required to ensure the system reliability even at peak power demands.

In case of sportive BEV's, in addition the g-forces during race-track driving needs to be considered in the layout of the lubrication circuits.

To avoid fast power degradation caused by critical battery temperatures, the battery pack must be effectively cooled down.

CHALLENGES OF THE E-AXLE

Lubrication and oil management

E-axles in the lower power range have only less requirements for cooling and lubrication. In some cases it could be sufficient only to let the drive-gears splash into the oil and spread the oil around inside the transmission.

For e-axles in the mid and high power range active lubrication and cooling is essential. Electric oil pumps are necessary to supply the right amount of oil for cooling and oil pressure to ensure under all conditi-ons the oil film in all bearings and gear contacts.

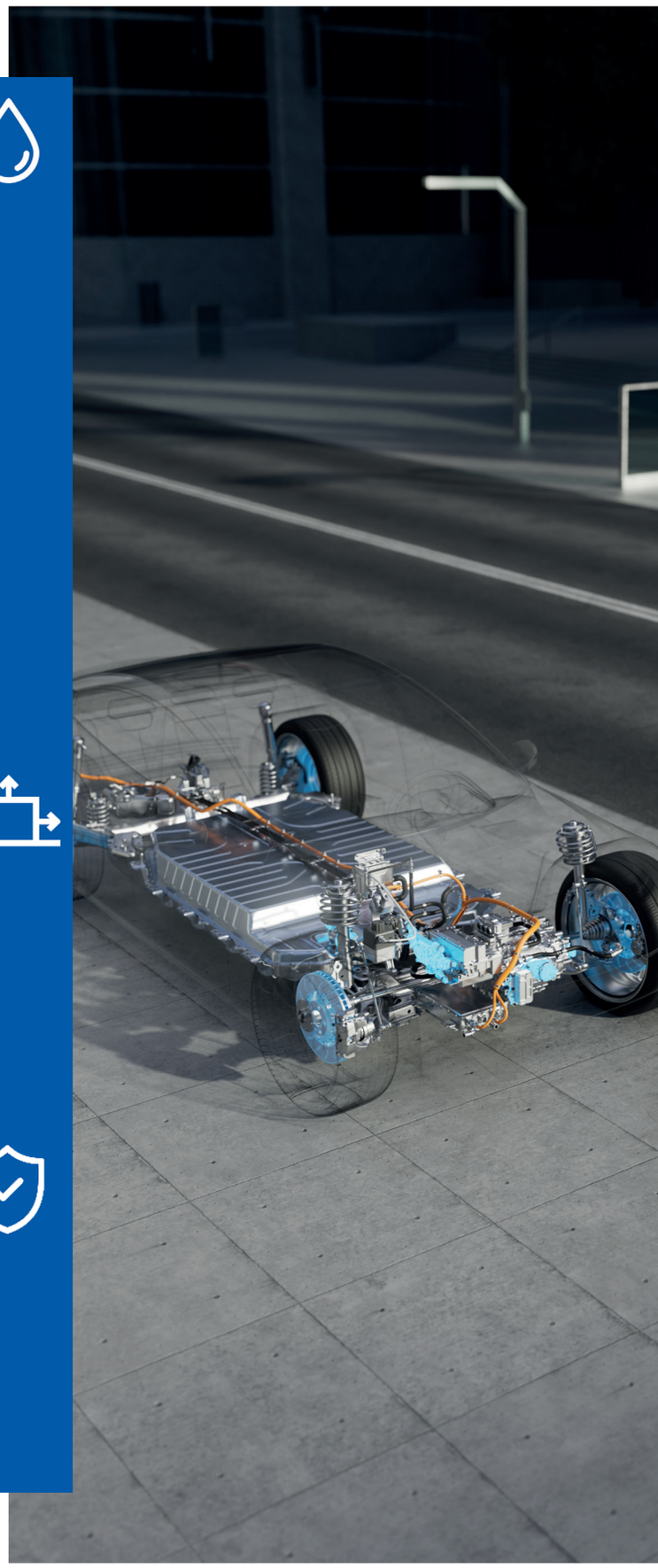
High-power e-axles for sportcars should have a low center of gravity and need oil circuits which are able to withstand high g-forces. Both requirements leads to the need for dry sump lubrication system with one or more additional scavenge oil pumps.

Friction reduction and lubrication

Any friction is causing losses in efficiency, potential wear on mechanical components and generates heat. To ensure low friction values, the trend is going to oil types with very low viscosity. This leads to higher demands on the oil pumps, but as well on the oil as under no situation the oil film in bearings and between drive-gears should get lost.

Software and functional safety

The e-axle system components and the e-axle system as a whole has high demands on the Soft-ware and the functional safety. This requires a tightly interlocked development of all electric controlled systems.



CHALLENGES OF THE E-AXLE

Cooling

Even with the high efficiency grade of today's e-motors, many heat energy is conducted into the e-drive system at high load demand. In addition, all bearings, transmission gears and differentials heat up as well due to the unavoidable friction when the power is transferred to the wheels. All that thermal energy must be dissipated over oil and/or water jackets to heat-exchangers or coolers.

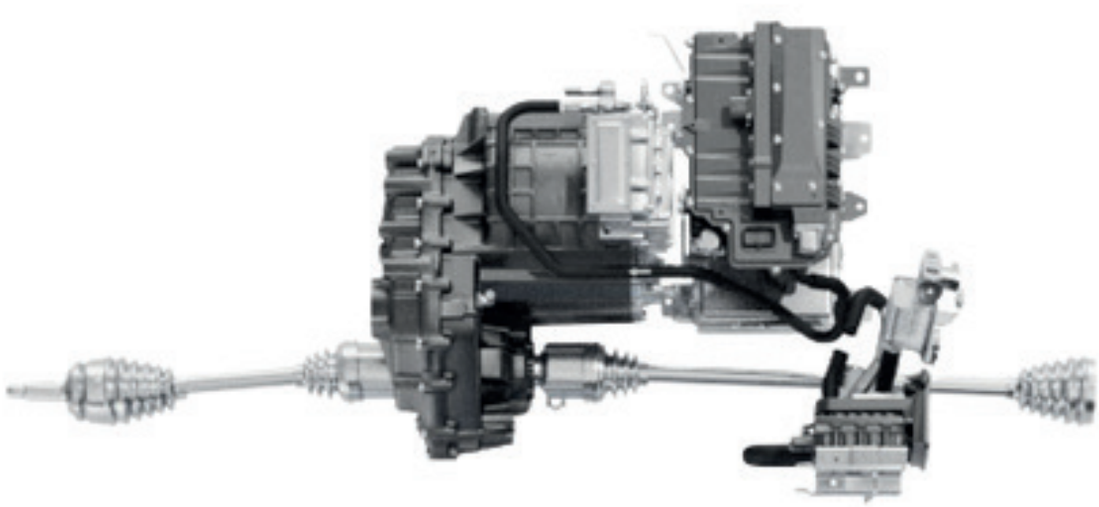
Thermal management

With a clever thermal management solution, motor, transmission, cabin and battery system will be kept in a proper temperature range without consuming much electric energy.

Over electric controlled coolant valves several coolant circuits can be regulated. The parasitic heat losses from e-motor and the drive-train friction can be partly recovered with heat-exchangers and used i.e. for cabin heating to save battery capacity.

Low weight & packaging

High functional integration level of subsystems and the combination in multifunctional modules allows to reduce weight and packaging space compared to standalone subsystems. The usage of plastic compound materials gives further potential for weigth optimization of the e-axle.



THERMAL MANAGEMENT OF BEV BATTERY SYSTEMS

Thermal challenges

Battery lifetime and performance is strongly depending on the operating temperature of the battery cells. Battery quick charging requires high current. To enable the battery pack for high current loading from begin of the loading cycle, a pre-conditioning of the battery temperature is necessary. If the battery temperature is to low, the capacity is reduced and loading speed is limited until the temperature is increased by the internal resistance. But this resistance can rise the temperature at fast loading to much, therefore an effective battery cooling is required to keep the cell temperature within the allowed safety limits. Even during driving cycle a temperature management of the battery pack is required to enable even peak power demands without power degradation caused by critical battery temperatures and to avoid lifetime reduction of the battery cells.

Thermal battery cooling solutions

Battery packs for low power BEV's are using passive cooling technology like heat dissipation to the air or liquid cooling. For the mid- and high power range battery's, a liquid based cooling system with an electric pump must be used. Standard solution is a indirect cell cooling with water-glycol pumped through water jackets as near as possible to the cells. The water-glycol coolant can be controlled by thermal management modules and heat exchangers. Immersive battery cell cooling with dielectric oil is an more effective solution compared to indirect cooling with water glycol cooling systems. The cells are directly in contact with the coolant and oil has higher heat capacity. This immersive cooling in combination with battery cooling modules allows to keep the temperature under control even when in near future higher voltages and current will be used for fast charging.

TODAYS OPTIONS AND SOLUTIONS

To increase efficiency and weight reduction for BEV platforms

There are plenty of systems and components in the BEV's, which have significant influence on the overall efficiency and weight.

Electrical main water pumps in combination with **thermal management modules** are able to replace multiple smaller auxilliary electrical water pumps and save weight and costs. Less pumps, means less pipes, less interfaces and less cables. High content of plastic compound components is increasing the weight saving.

Electrical oil pumps deliver on demand the oil for **lubrication and cooling of the e-axle systems.** The usage of electrical tandem oil pumps can reduce the number of necessary oil pumps and can supply oil to different circuits at various pressure levels with only one pump. The usage of plastic compound material is increasing the weight reduction potential.

Electrical controlled cooling manifolds and **thermal management modules** are made mainly from lightweight plastic compounds and combine flexible coolant flow regulation of several cooling circuits integrated in a compact design. Due to the flow optimized design and the on demand flow regulation, parasitic losses are reduced to a minimum.

Oil management modules integrate multiple components and system functions in a very compact environment. Beside the electrical oil pumps further components can be integrated such as heat exchangers, filters, check valves, sensors, and oil pan. Due to the deletion of many unnecessary pipes, interfaces, brackets and the usage of plastic compound materials oil management modules enable significant weight reduction. The integrated heat-exchanger transfers the heat from the drive system to the water-glycol cooling system, where the heat can be used for the cabin heating.

Lightweight composite brake discs with aluminum bell reduce the unsprung mass up to 3,5 kg per wheel compared to standard brake discs, what gives a significant CO_2-reduction.

Lightweight hybrid brake drum consisting of grey-cast-iron friction ring and aluminum housing saves up to 40 percent weight compared to standard brake drums.

To increase **reliability for high power BEV platforms**

BEV's in the higher classes are showing the trend to more and more torque and power. This is causing an increased amount of heat dissipation due to the high electrical power and the mechanical friction which requires specific cooling devices. The high torques on the other side, which need to be transferred in the drive system, require a reliable lubrication of all involved mechanical components. This lubrication must be ensured under all driving conditions, even with high g-forces during race-track driving.

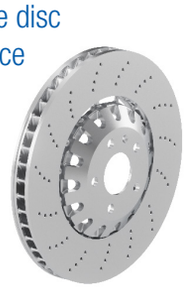
Electrical main water pumps are able to supply on demand high coolant flowrates or if required higher coolant pressure to ensure stabile cooling of the system even under permanent high load conditions.

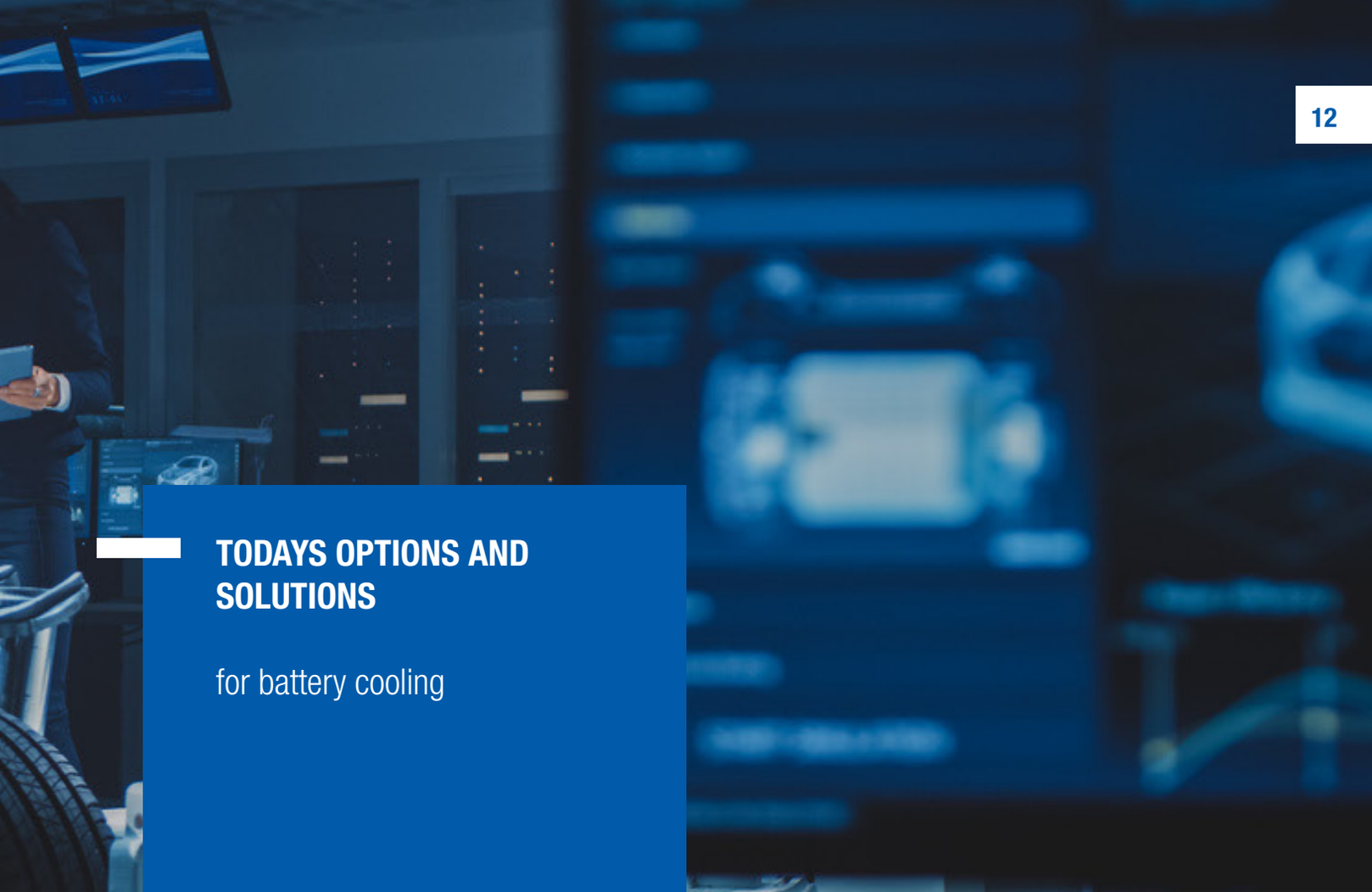
Battery modules with **immersive battery cell cooling** by **dielectric oil** is more effective cooled compared to indirect cooling with water glycol cooling systems. This immersive cooling in combination with battery cooling modules allows to keep the temperature under control even when in near future higher voltages and current will be used for fast charging.

Electrical controlled **cooling manifolds** can divide the coolant flow flexible to the different cooling circuits, depending on the current driving situation and comfort requirements.

Oil management modules supply the necessary amount of oil for cooling and lubrication into the system, the integrated heat-exchanger keeps the oil temperature even under hard driving conditions in a healthy range. The integrated oil filter avoids any critical contamination. For sportcars, the oil management module can integrate as well the oil sumps and a scavenge pump, preferable integrated to the electrical tandem oil pump. This will enable the lubrication system for engaged driving on the race tracks.

Lightweight composite brake discs with aluminum bell improve brake performance, the response characteristic due to the weight reduction up to 3,5 kg per wheel. Excellent cooling avoids brake fading under hard driving condition. In combination with an optional hard coating, the composite disc shows a extreme long lifetime, rust resistance and very low particle emission.





TODAYS OPTIONS AND SOLUTIONS

for battery cooling

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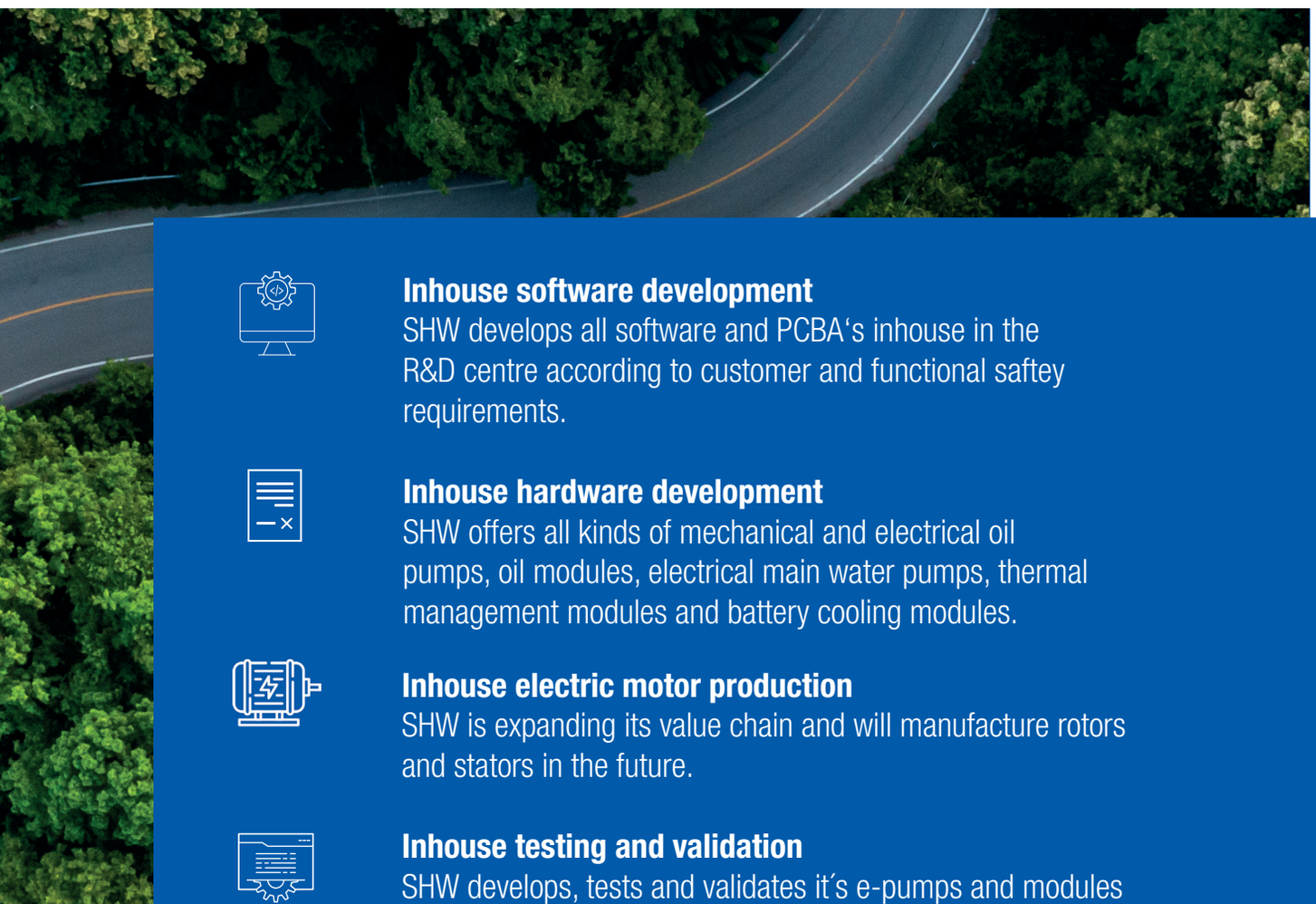
A PARTNER WITH SYSTEM COMPETENCE AND HIGH LEVEL OF ADDED VALUE

SHW is a member of the Pankl Group and a global player specialized in developing and manufacturing single components in different markets: passenger cars, high performance cars and truck & off-highway.



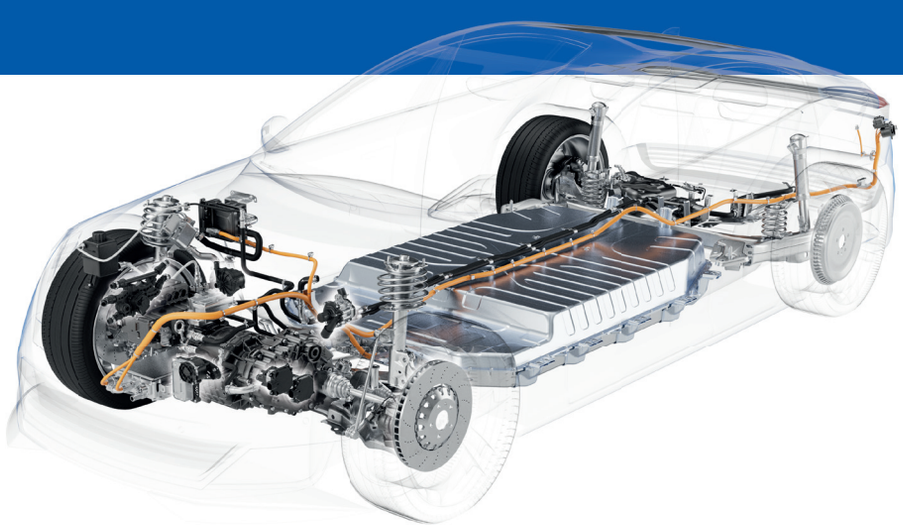
Inhouse software development
SHW develops all software and PCBA‘s inhouse in the R&D centre according to customer and functional saftey requirements.

Inhouse hardware development
SHW offers all kinds of mechanical and electrical oil pumps, oil modules, electrical main water pumps, thermal management modules and battery cooling modules.

Inhouse electric motor production
SHW is expanding its value chain and will manufacture rotors and stators in the future.

Inhouse testing and validation
SHW develops, tests and validates it´s e-pumps and modules completely inhouse.

Global production
SHW serves it´s products globally from the plants in Europe, Northamerica, Southamerica and China.



CONCLUSION

The rapidly rotating development spiral for e-drives requires a high degree of flexibility, innovativeness, willingness to make decisions and to take risks from customers and suppliers.

The rapid conversion from combustion engines to electric vehicles in the most important markets is forcing customers and suppliers to clearly commit to the new technologies.

IMPRESSUM

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