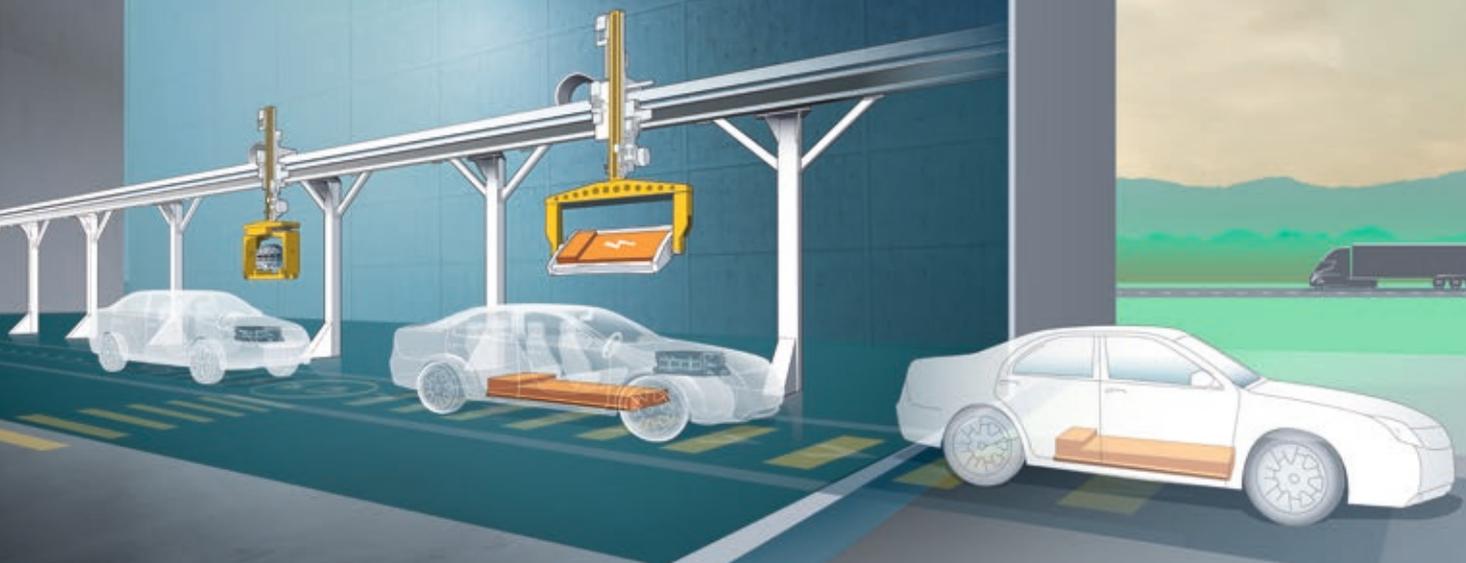

We drive change

E-mobility solutions

As a provider of solutions for producing drive train components, we have combined all of our expertise to offer innovative automation systems for e-mobility.

LIEBHERR

Automation systems



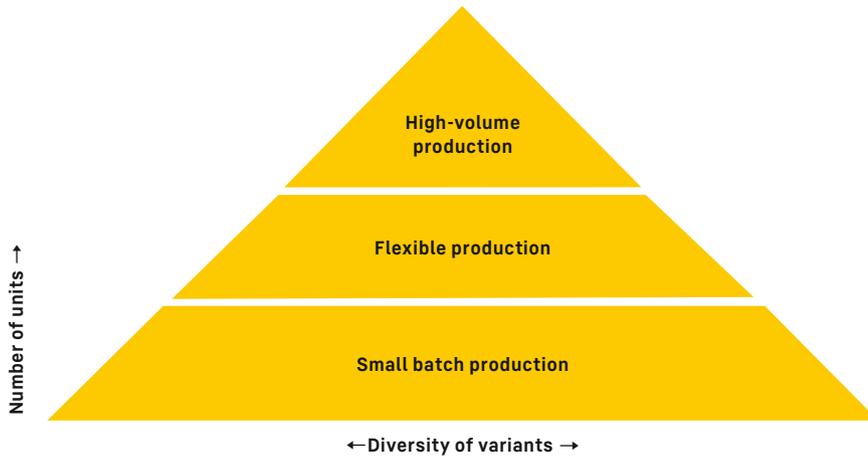
Production solutions for the mobility of the future

Liebherr offers a wide range of automation and technology solutions for modern, high-efficiency production. These solutions help to reduce production costs and enable a flexible response to changes in the market: Systems can be retrospectively expanded, maximizing production capacity or adding additional functions. Our focus is on ensuring that our products are cost-effective, user-friendly, high-quality and reliable, with great flexibility.

As a system provider, we make use of our broad product portfolio, consisting of gantry robots, pallet handling and conveyor systems, and robot cells and technological solutions.

We combine these products intelligently for small and large projects, from varied small batch production to fully automated high-volume production.





Our product areas for diverse requirements

E-mobility poses some major challenges for the automotive industry. In order to meet the growing demand for battery-powered electric vehicles, intelligent solutions are needed to produce battery systems efficiently. We support our customers in this area, taking an active role as development partner to help shape this transformation. As a solutions provider, our aim is to design production systems that are efficient and to offer customers innovative solutions, processes and technologies. The requirements of the customer are always our priority. In this dynamic market environment, constant market surveillance is crucial to allow us to offer our customers state-of-the-art solutions at a moment's notice. At our Tech Center, we research new production methods and technologies for the mobility of the future.

Economy

Automation is crucial to the success of this mobility revolution, allowing vehicle components to be produced economically in large volumes. The key to economical production is ensuring optimum supply to the machines connected to the system. The focus here is on keeping the total cost of ownership (TCO) of the system as low as possible to rapidly amortize the capital investment (ROI).

Flexibility

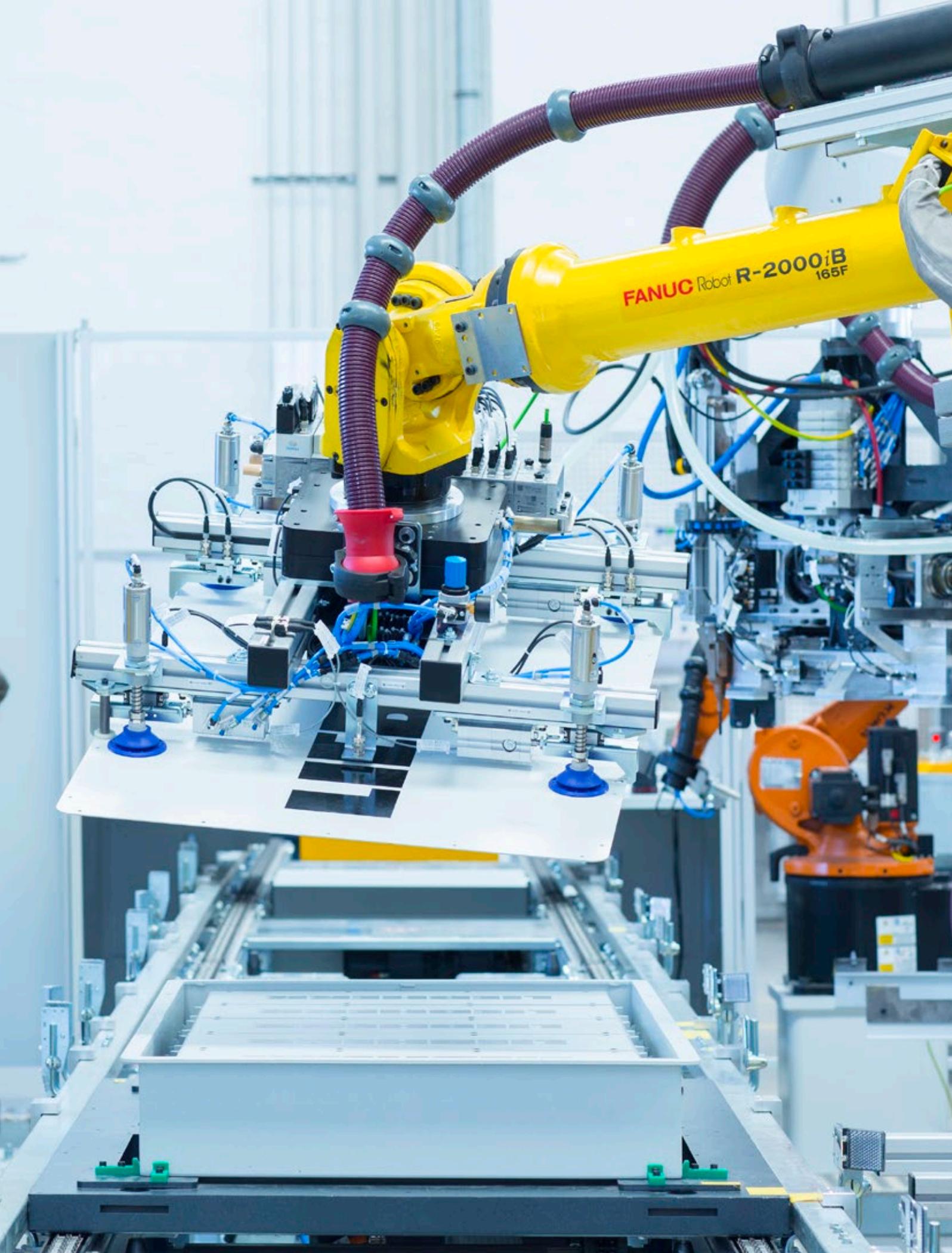
Liebherr attaches great importance to modular design, scalability, and networking of components. Thanks to the modular platform system, automation solutions from Liebherr are particularly flexible and versatile. Standardized interfaces allow the separate modules to be individually configured to customer-specific systems. In this way, it is possible to design scalable, partially automated systems for small-batch numbers or fully automated lines for large-volume production. As Liebherr produces a large proportion of its components in-house, we are able to implement customer-specific requirements quickly and expertly.

User-friendliness

An optimum working environment provides the foundation for a smooth production process. Layout planning for Liebherr systems takes into account the optimum utilization of available space, the optimum flow and supply of parts, and maximum accessibility to machines and plants. Intelligent system control digitizes production processes, from dynamic planning and order management to fully automated resource provisioning. This ensures that operators are given the best-possible support when carrying out their work and that the consequences of human error are kept to a minimum.

Quality and reliability

Quality is the ultimate priority at Liebherr. Every manufacturing stage is consistently monitored in order to achieve optimum results at all times and to ensure reliability and long product life. Liebherr-Verzahntechnik GmbH's quality management system is certified in accordance with ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018, as well as VDA 6.4. Moreover, many years of experience and state-of-the-art technologies flow into product development. This high standard means that our automation systems guarantee high availability and part quality for the end customer.



FANUC Robot R-2000iB
165F

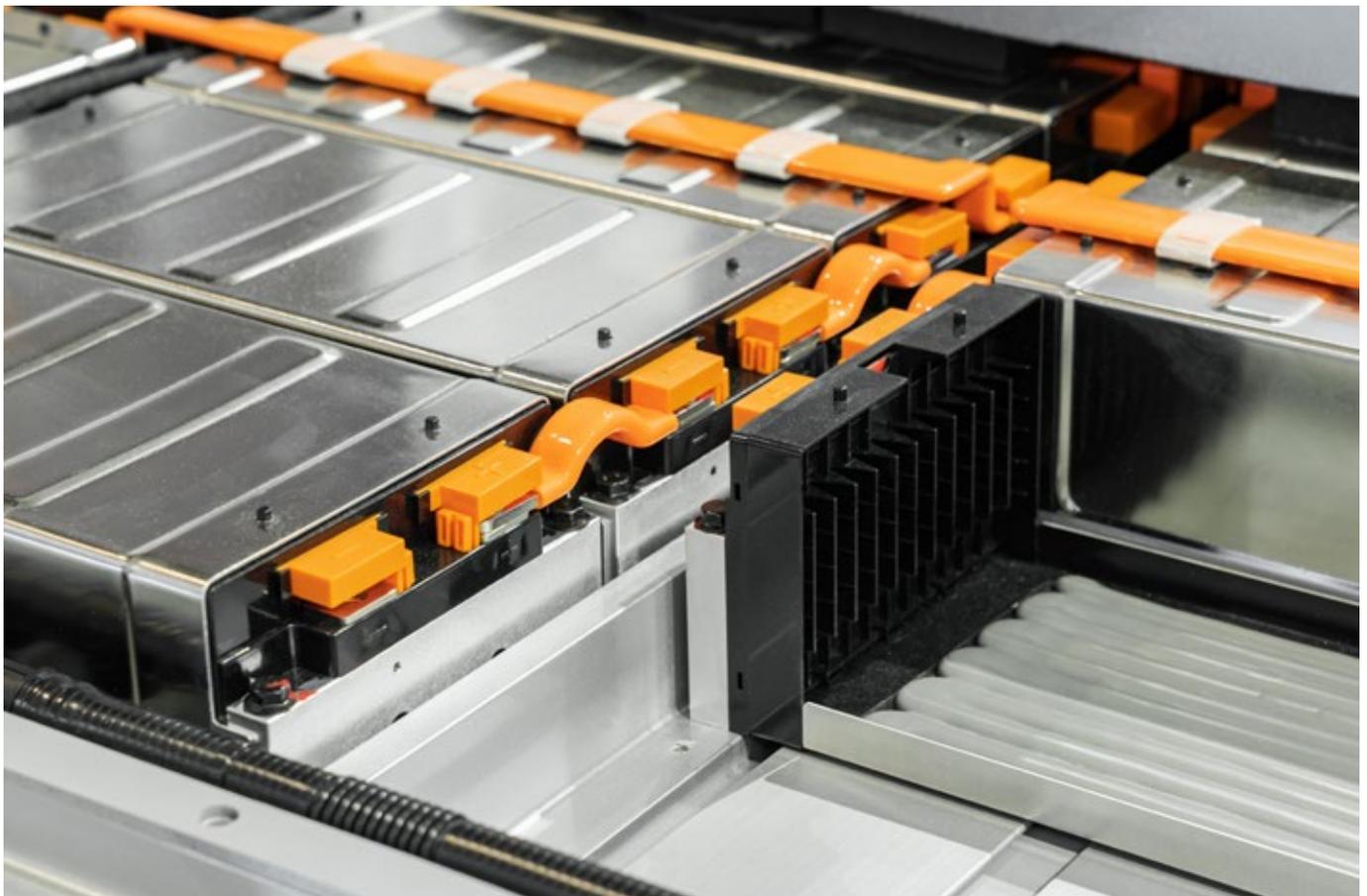
The high voltage battery – the heart of e-mobility

The high-voltage battery is the heart of any electric vehicle. No other vehicle component is as crucial to determining range, charging time, vehicle price, and comfort.

Lithium-ion batteries are currently the norm in electric vehicles. However, research has also repeatedly been carried out into alternative cell technologies, in an attempt to increase the performance parameters of vehicle batteries.

Automation plays a key role in ensuring that high-voltage battery systems can be produced economically in large volumes.

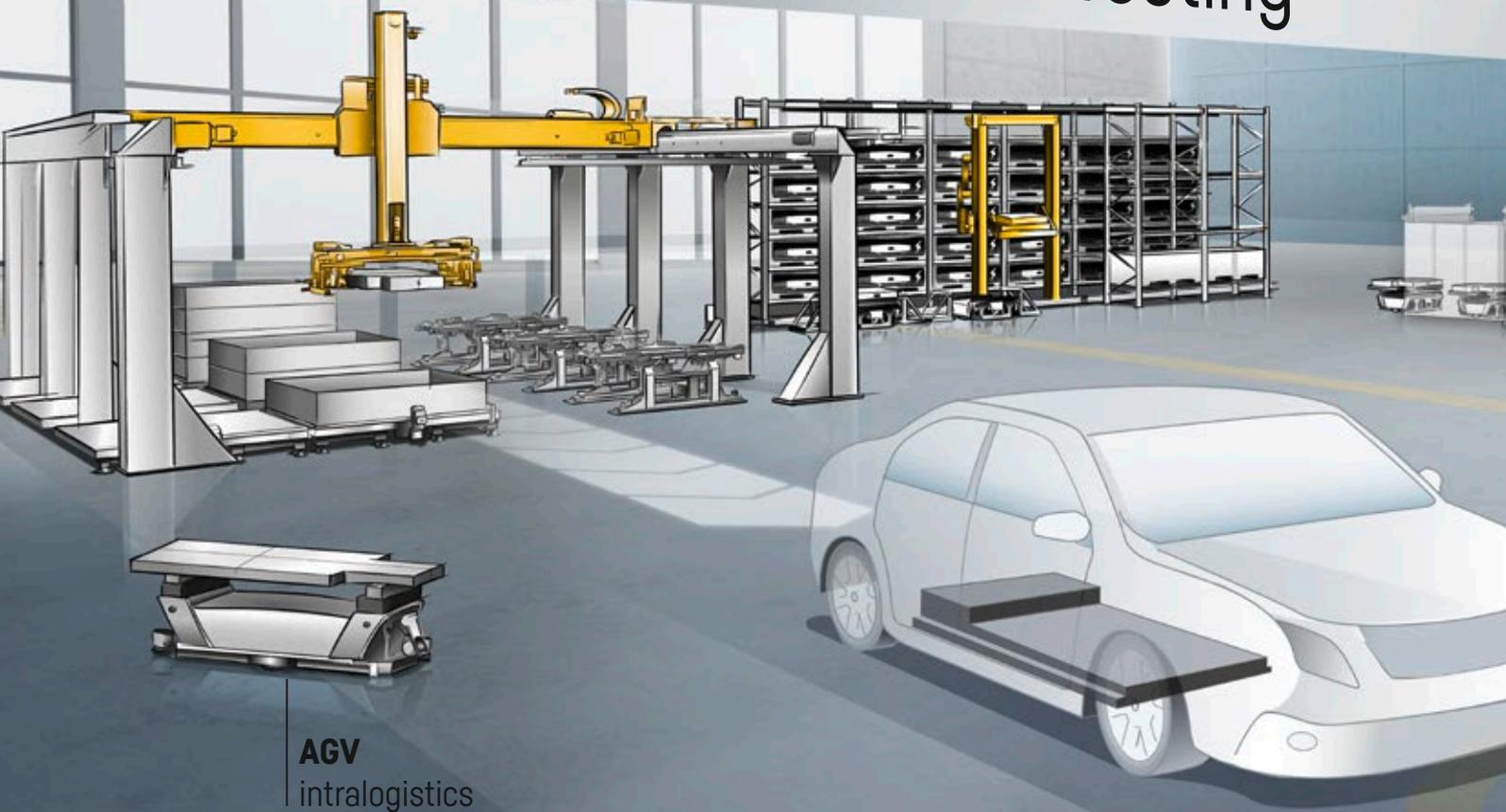
The future of e-mobility and its significance for the environment and society depends, to a large extent, on technical advancements in the field of electric vehicle batteries. This vehicle component is thus the key to reducing the costs associated with electric cars and enhancing performance parameters.



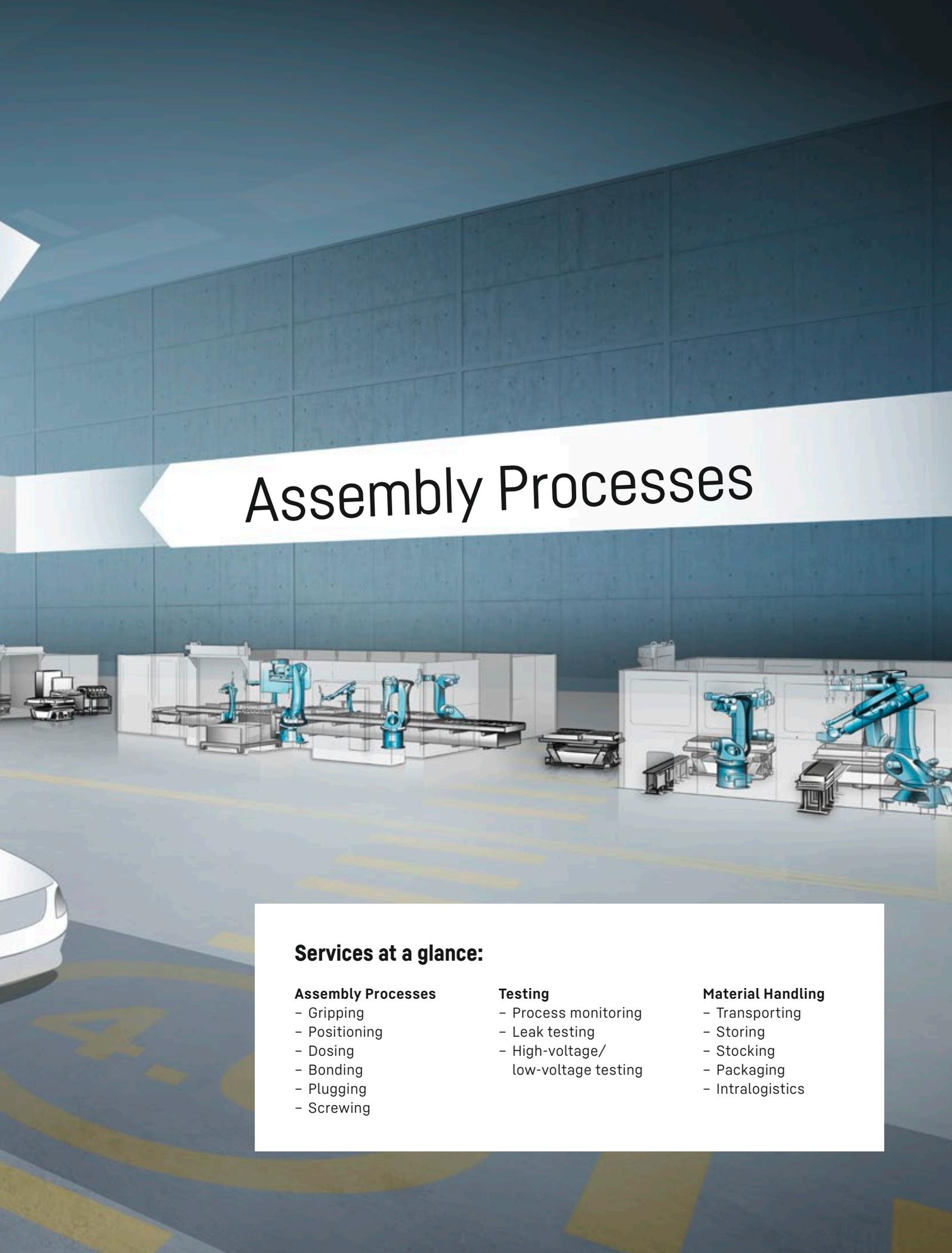
Solution Provider for Automated Battery Pack Assembly

Material Handling

Testing



Assembly Processes

The background image shows a clean, modern industrial environment. The walls are made of large, dark blue panels. The floor is light grey with yellow safety lines. In the center and right, there are several assembly stations with blue robotic arms. On the left, a white car is partially visible. The overall scene is bright and professional.

Services at a glance:

Assembly Processes

- Gripping
- Positioning
- Dosing
- Bonding
- Plugging
- Screwing

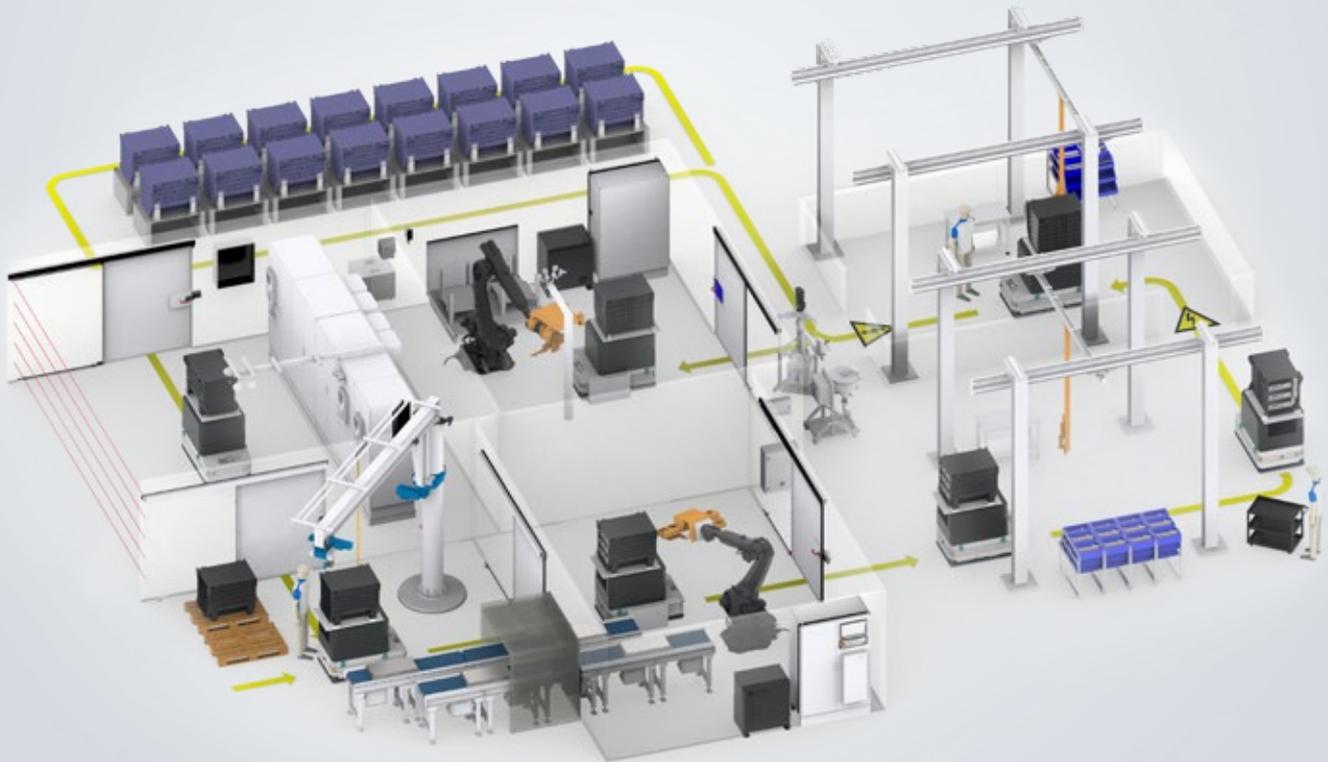
Testing

- Process monitoring
- Leak testing
- High-voltage/
low-voltage testing

Material Handling

- Transporting
- Storing
- Stocking
- Packaging
- Intralogistics

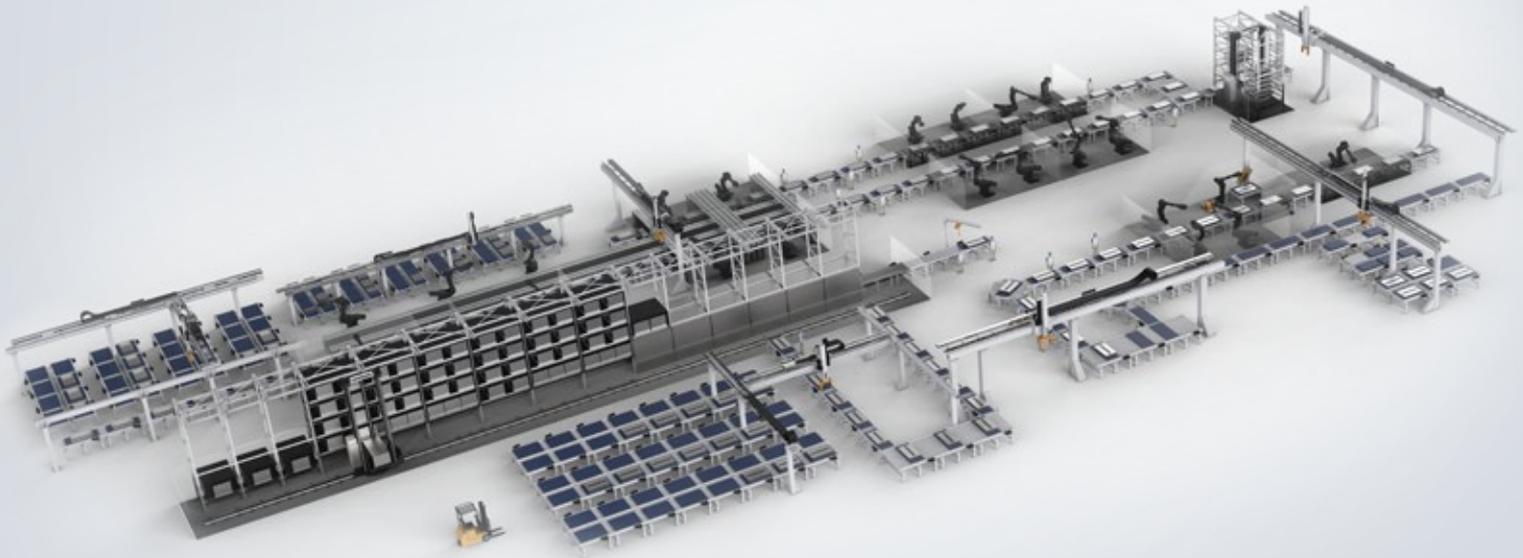
From flexible small batch manufacturing...



From flexible small batch manufacturing through to fully automated large-volume production, Liebherr offers the right solution for any requirement. Liebherr attaches great importance to modular design, scalability, and networking

of components. Liebherr is an experienced partner when it comes to topics such as interfaces, parallel processes, reproducibility, emergency strategies, and availability and tracking of parts.

...through to fully automated large-volume production



Highlights at a glance

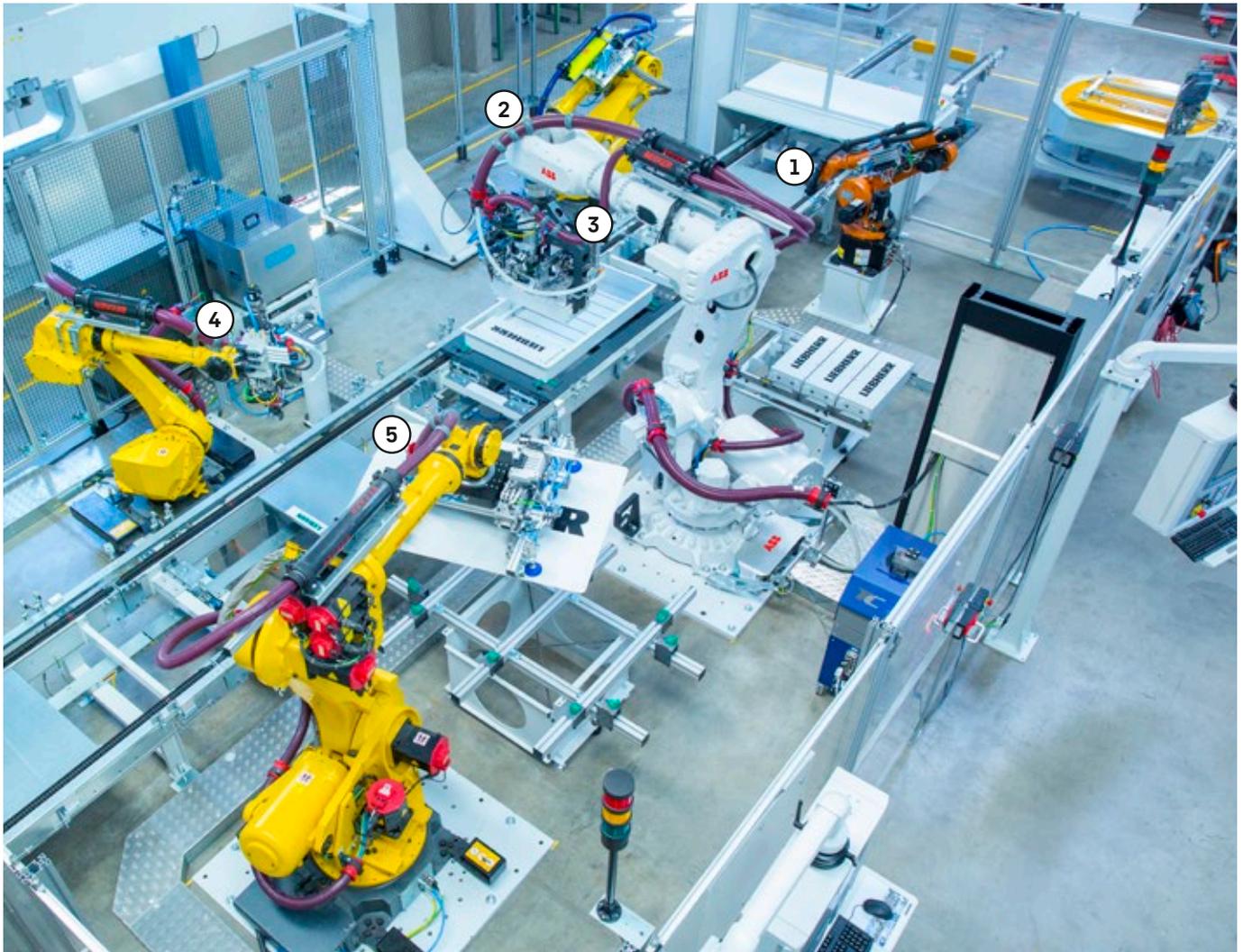
- ✓ **Modular** – from individual stations to turnkey systems
- ✓ **Scalable** – from small batch to large-volume production
- ✓ **Turnkey** – we provide the process know-how and system expertise to create your system



E-Mobility Tech Center

At Liebherr Automation Systems' Tech Center, we research new and innovative manufacturing methods for the battery production of tomorrow. Here, customers can get a "live" picture of how they can automate their manufacturing lines with Liebherr acting as general contractor. Before customers place an order for a large batch manufacturing system, the Tech Center offers them the opportunity to test the core battery pack assembly processes on their own workpiece. This allows us to identify problems at

early project stages in good time and take suitable action to ensure that processes can be automated in series operation. The findings from these preliminary tests are then available when it comes to the series system for scaled-up, high-volume production. In order to meet every possible customer requirement, Liebherr can equip the systems with different robot types from Kuka, Fanuc or ABB.

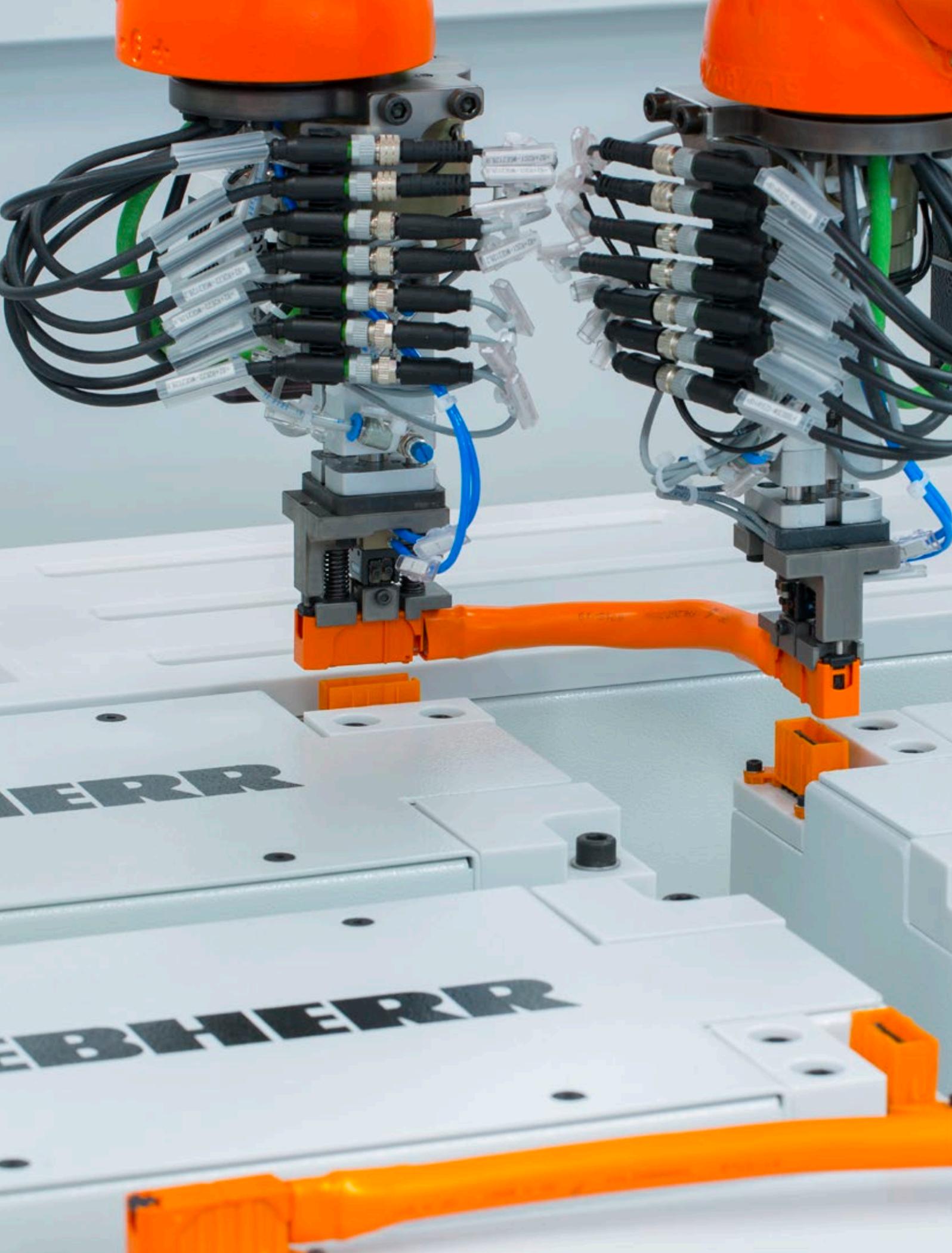


The Liebherr Tech Center has numerous process stations where customers can carry out tests

- | | |
|--|--|
| <p>① Surface cleaning and activation
Some materials, particularly plastics, may require optional pre-treatment of their surfaces. Plasma cleaning creates optimum conditions for subsequent dosing applications. Alternative methods may also be trialed in consultation with the customer.</p> | <p>③ Assembling the module
Inserting and screwing the battery module into the battery tray.</p> |
| <p>② 1K and 2K dosing processes*
The Liebherr Tech Center is also able to process single- and two-component materials</p> | <p>④ Electrical contacting
Inserting and screwing the busbar</p> |
| | <p>⑤ Assembling the cover
Putting on the cover and screwing it to the battery tray</p> |

*1K dosing systems are used to process single-component materials, for example to process adhesives for creating a seal between the battery tray and cover.

2K dosing is more complex than dosing single-component materials. In 2K dosing, both materials must be dosed precisely and directly and also mixed in the correct ratio, for example when applying the gap filler, a heat-conducting paste for thermal connection and cooling of electrical components.



Automated assembling of plug-in battery module connectors

The modules installed in the high-voltage battery are connected in series or in parallel in order to generate the desired voltage and capacity. Once electrical contact has been made, the battery systems can reach output voltages between 400 and 800 volts (DC). At present, screw connections with busbars made of copper material are predominantly used to make electrical contact in the high-voltage range. It is also possible to use plug connections with flexible lines or busbars.

As an alternative to making electrical contact with the battery modules via screwed busbars, Liebherr offers an innovative automation process for high-voltage plug-in module connectors.

Advantages of plug connections

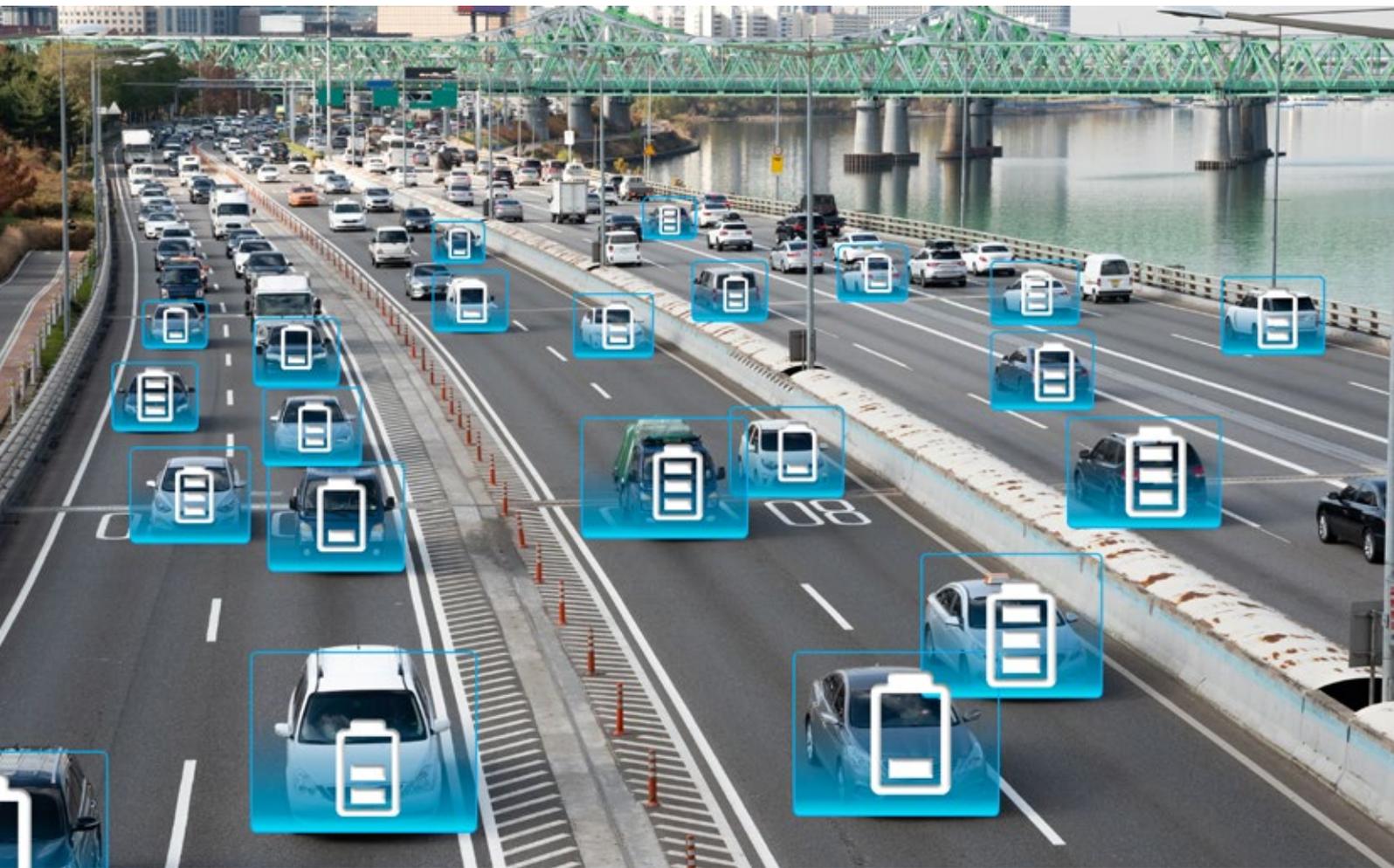
Compared to screwed and rigid busbars, plug connections with flexible cables offer a number of advantages:

- **Safety:** standard-compliant, touch-proof contact parts mean that there is no danger from exposed high-voltage electrical contacts.
- **Easy assembly:** only the plug and counterpart have to be connected with each other. This also facilitates the disassembly of the modules in the battery pack during a later servicing, for a second life or for battery recycling. The flexible lines can also compensate positioning tolerances in the battery modules of several millimeters.
- **Practical robustness:** if there are strong vibrations in the vehicle, screwed-in busbars can detach themselves. The flexible lines with the plug connections can compensate for these vibrations.

Innovative automation solution by Liebherr

In order to ensure that high-voltage plug-in battery module connectors are reliably plugged in as part of the process, two cooperating robots each grip one end of the cable and perform the plugging process synchronously with temporally and geometrically coordinated movements. Using a 2D camera, the robot detects the real position of the slots, thus enabling positioning tolerances to be compensated. The actual, mechanical plugging process is performed using a pneumatic cylinder. A spring assembly limits the force transfer to the module, plug and plug lock to secure the position (CPA). Finally, process reliability monitoring is performed by a stop position sensor. Liebherr can also solve the routing of the cables in the desired position and geometry using suitable cable bend grips.

A reliable partner for e-mobility



Liebherr is the right partner for automated assembly of battery packs for vehicles with electric drives. We draw on decades of experience in automating large batch production in the automobile industry. We apply this knowledge and experience when drawing up concepts and planning layouts. Liebherr systems are renowned for their high availability, efficiency and reliability.



Our services include comprehensive project management from the ordering process to design, right up to final acceptance of the overall system. We are also there to help after production is complete. Our worldwide service network guarantees a quick response and supply of replacement parts to ensure the system operates smoothly.

As a system supplier, Liebherr is responsible for all aspects of the project planning, including system specification and interface clarification with subcontractors. Each project is assigned a project manager, who acts as the central point of contact and is responsible for the entire order processing. With modern ERP and project management systems, we guarantee smooth project processing.

Control books, interface specifications and system descriptions are created in collaboration with the customer in order to ensure compliance with the applicable laws, standards and guidelines. The content of these documents provides the design specifications for all the manufacturers and suppliers involved. The control book describes the control architecture of the Liebherr automation systems, taking the customer specifications into account. The interface specification describes the interface between Liebherr's automation systems and the connected machines. The system description describes the individual functions and processes in the Liebherr automation systems within the manufacturing line. In this way, Liebherr is able to take on responsibility for the overall system's CE conformity.

Quality and sustainability



The highest quality is central to the goals of the Liebherr Group. Alongside this, protecting people and the environment is firmly rooted in our company guidelines.

It is for this reason that we have set ourselves the key objective of ensuring that our products and processes are high quality and sustainable.

We have been certified according to ISO 9001 (quality), ISO 14001 (environment), ISO 45001 (occupational safety) and VDA 6.4 (Code of the German Automotive Industry Association for Manufacturers of production equipment and systems) for a number of years.

Quality management

“The highest quality in everything we do.” In order to live up to this ideal, our quality management system places special emphasis on close collaboration between individual departments. The goal is a uniform process philosophy. Quality is no longer an individual point at the end of the production chain, but a supporting process across all phases of product development. A team of specialists for product and process quality are responsible for this task. On the one hand, the aim is to reduce costs arising from poor quality (e.g., warranty use cases) and, on the other, to reduce costs in the product development process (process quality). Quality assurance is made possible by a coordinated system of intermediate and final testing of the product. Quality processes are constantly monitored and optimized throughout the entire product development process with a meticulously coordinated “Quality Gate Systematics”.



Resource-smart manufacturing and production

“We want to fulfill our responsibility to society and the environment at all times.”

Consumption of energy sources like electricity, gas and district heating is monitored constantly using appropriate performance indicators. One specific example of efficiency in energy usage is our block-type thermal power station. It is driven by a Liebherr gas motor and uses its excess heat to cool (not heat) the production halls by means of an absorption chiller, even in summer. Around 10% of the power requirement at the Kempten site is covered by the block-type thermal power station.

Materials with negative environmental effects like hazardous substances are only used following precise testing. If use of hazardous substances is inevitable, attention is paid to minimize pollutants as much as possible. For



example, a series of measures taken in the paint shop has enabled to us to cut hydrocarbon emissions by more than half in recent years.

Sustainable product development

“We work systematically to always be a step ahead.”

Efficient energy usage and conserving natural resources in the production process is not only an internal aim, but also one which our clients increasingly require of us.

Therefore, we always try to reach our goals using the smallest possible number of materials. A program to completely overhaul used machines (Reman) has been launched, so that we can continue to use materials even after the end of the (first) production cycle. The amount of energy used to operate our machines and systems is being continually optimized through the use of state-of-the-art drive technology.

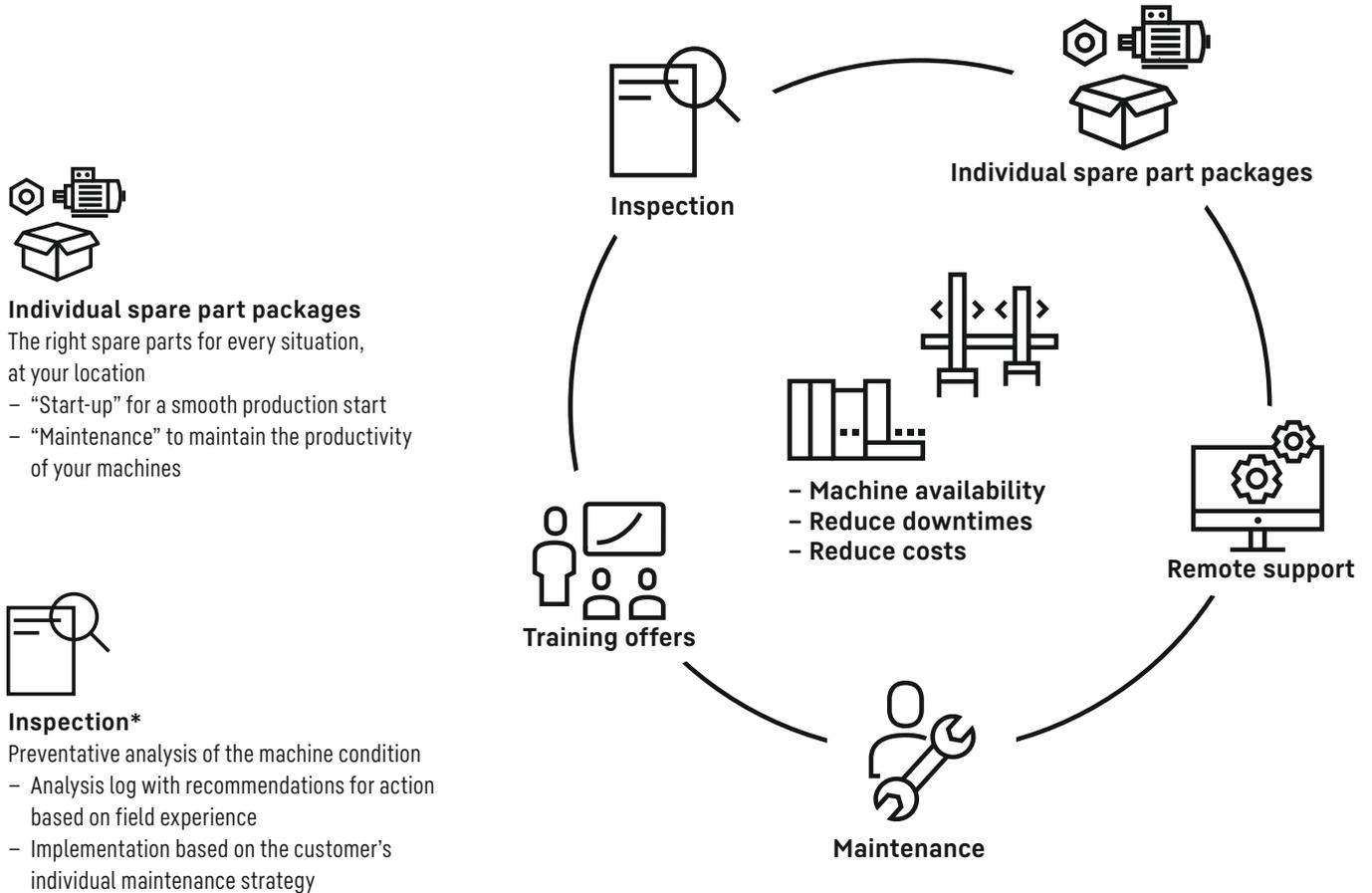
We are a partner of the Blue Competence sustainability initiative. Blue Competence is an initiative of the German Mechanical Engineering Industry Association (Verband Deutscher Maschinen- und Anlagenbau, VDMA) that aims to promote sustainability in mechanical and systems engineering while also raising awareness of sustainable industry solutions. The partner companies in the Blue Competence sustainability initiative agree to follow 12 guiding principles of mechanical and systems engineering. These are linked, in turn, to the 17 Sustainable Development Goals (SDGs) established by the United Nations as part of the 2030 Agenda.

Service over the entire life cycle



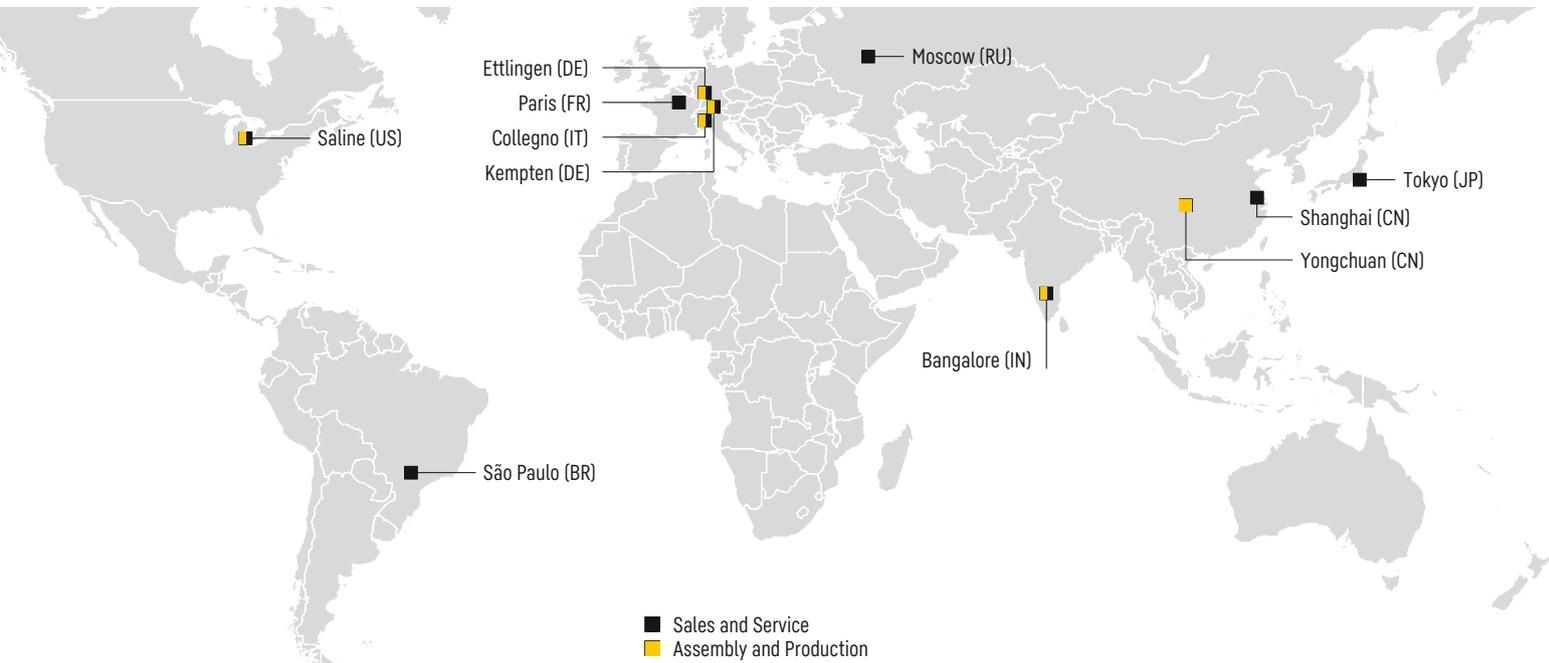
Worldwide presence and spare parts availability

With our main location in Kempten, Germany and global offices and service support points, we guarantee fast response times which enable us to dispatch a service engineer to the customer location immediately if necessary. Our range of services include: inspections, training offers, individual spare part packages, remote support and maintenance or conversion of systems.



*individually or as part of the contract

Your solution provider



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