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MHPSTUDY

INDUSTRY 4.0 BAROMETER 2023

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Content

Foreword 7

Summary 8

Key results 10

1.0 Barometer presentation 12

1.1 Details of the study 14

1.2 Expert interviews and success stories 14

1.3 Participants in the study 15

2.0 Results of the study 18

2.1. Status quo of Industry 4.0 20

Interview Michael Straughan Aston Martin Lagonda 30

2.2 Shopfloor automation – Automation in production 34

Success Story MHP FleetExecuter @Faurecia 36

Success Story Fiege Logistics 39

Interview Dr. Frank Scheppe Läpple Automotive 52

Interview José Gascon Sanofi 56

Success Story FlexFactory & V Frames 62

2.3 Sustainable Operations – Sustainability in the Value Chain 64

Success Story Catena-X & VW 74

3.0 Conclusion and outlook 76

4.0 Additional Information 80

Foreword

Ladies and Gentlemen,

Present times are marked by the continuing impact of the coronavirus pandemic and the consequences of the unexpected war in Ukraine. In the long term, we are also facing challenges such as climate change, demographic change, and digital transformation. This makes it more important for us to look ahead and invest in future-oriented topics even during these difficult times.

This year's Industry 4.0 Barometer deals with exactly these topics: "shopfloor automation" and "sustainable operations" show that the progressive digitalization of production is crucial to remaining competitive by increasing efficiency, especially in difficult times. This is because a higher degree of automation and digitalization in production enables a more efficient and therefore more sustainable use of resources. This will play a key role in the future of companies who face depleting raw materials, exploding energy prices, and a shortage of skilled workers. Furthermore, skills such as flexibility and responsiveness are important success factors in a constantly changing environment.

Transformation and sustainable business success will only be possible if you master these components – from top floor to shopfloor, from strategy to implementation, from development to sales, whether on your own or with an experienced partner such as MHP by your side.

I would like to thank Professor Dr. Johann Kranz from the Ludwig-Maximilians-Universität in Munich, with whom we were able to implement our Industry 4.0 Barometer survey for the fifth time, as well as the 900 plus participants, experts and all interview partners who took part in our study. Together we are working on future-oriented solutions for a crisis-resistant, digital, and better tomorrow. In keeping with our purpose: Enabling You To Shape A Better Tomorrow.

I wish you all the best for 2023, and hope you enjoy reading this report.

Regards,

Markus Wambach
Member of the Board of Management
MHP Management- und IT-Beratung GmbH

Summary

The Industry 4.0 Barometer 2023 provides a comprehensive overview of the current state of Industry 4.0 for companies in various industries in 2022. Companies in the DACH region, the United Kingdom, the USA, and China were asked about their initiatives and their progress in digitalization. This year, the focus was on shopfloor automation and sustainable operations.

The year 2022 was marked by the various crises that have demanded a high level of attention from companies. This had a negative impact on day-to-day business, which, among other things, led to a slowdown in the progress of digital transformation. In particular, the focus areas of automation and sustainability still have considerable potential that companies are not yet using. Despite the difficult situation overall, we did note improvements in some areas compared to the previous year. For example, in IT security. Or in the supply chain – compared to the previous year, significantly more companies can now track their products from incoming logistics to customer service.

Companies still need to catch up on using certain technologies such as the digital twin. The same applies to shopfloor automation. Companies only use automation solutions sparingly. This can also be seen in the degree of automation, which varies widely across all companies. Nevertheless, the majority of companies surveyed consider autonomous transport to be the technology with the greatest potential. Most companies have an Industry 4.0 strategy and want to use new technologies but are largely focus on classic economic indicators. Often, companies lose sight of the big picture, ignoring synergies between technologies. For this reason, uncertainty about the return on investment is the biggest obstacle to the introduction of new technologies from a purely economic point of view. A similar contradiction can be seen with regard to the issue of sustainable operations. The majority of companies have a sustainability strategy. However, most companies surveyed are still performing poorly in terms of effective implementation due the lack of measures that have been actually implemented. This is in contrast to activities of corporate social responsibility. In this area, the companies consistently demonstrate commitment to the objectives and implementation.

Companies are evolving and, despite the crises, have shown no regressions in relation to Industry 4.0. However, the speed at which digitalization is progressing is slowing down. This is partly due to the current crises and the challenges these bring. But it is also due to the fact that there is often a lack of competence and expertise within companies, whether due to inadequate opportunities for further training or a lack of specialist staff. Over the last year, we have seen the number of challenges continuing to rise due to the coronavirus pandemic and the war in Ukraine. Unexpected events can occur at any time and resilient business structures are required. We must see these resilient business structures as being able to continually improve to change, and not, as many interpretations suggest, as models for maintaining the status quo. Only those who now focus on their Industry 4.0 and sustainability strategies, consistently implement them, recognize the market-specific opportunities and barriers, and use them to their advantage will be able to operate profitably in the future.

Key results

General

Return on investment (ROI) is the most relevant factor: Cost efficiency has the highest priority in deciding to use Industry 4.0 technologies. Improvements in sustainability, quality, flexibility, and efficiency play a smaller role.

Shortage of skilled workers: The lack of qualified employees and a lack of training measures are still the biggest obstacles to the implementation of Industry 4.0 technologies.

Cyber security is more relevant than ever: Increasing attacks on IT infrastructure have made companies focus more on IT security.

Increased supply chain resilience: Companies have learned from past crises and are now able to increase supply chain transparency through successful implementation of Industry 4.0 technologies.

Shopfloor Automation

Only half of all processes are automated: Companies overestimate both their own competencies and the extent to which their shop floor is automated.

Incorrect rationalization: By focusing on economic efficiency, investments in holistic automation solutions are neglected, therefore, only stand-alone solutions are implemented in most cases.

Automated Guided Vehicles (AGVs) as the most important key technology: Companies see the greatest potential in AGVs; at the same time, they are the most widely used Industry 4.0 technology.

Sustainable Operations

Lack of sustainability: Sustainability measures are not consistently and holistically implemented by companies – economic efficiency takes priority.

Pioneer USA: The circular economy is being driven forward, especially in the USA and the UK, while the DACH region and China still need to catch up.

Hurdles are too big, future prospects too uncertain: The high initial investment slows down the substantial change toward sustainable economic management.

1.0

Barometer presentation


S/N 212793
SUMMARY
Diagram
Quick start
PROPERTIES
0
TAGS
Datasets
3
Pipelines
2
IngressPipeline
MahoutPipeline
Linked services
4
Data Stores
3
OPERATIONS
Alert rules
S/N 212793
0 rules
C-8H
C-8F

Industry 4.0 is no longer a distant vision of the future, but has long been a reality in many companies. What this reality looks like in detail, what understanding of Industry 4.0 prevails and at what level of maturity technologies are used is recorded by the Industry 4.0 Barometer for companies of different sizes and industries. It therefore provides a benchmark for the state of development and the use of various technologies and initiatives. This means we can identify gaps and potentials in relation to Industry 4.0. The Industry 4.0 Barometer also shows how companies can close gaps, exploit potential, and extend their lead.

1.1 Details of the study

In order to provide companies with a sound overview, MHP has created the fifth Industry 4.0 Barometer together with the Ludwig-Maximilians-Universität in Munich (LMU). The results of this benchmark study offer important insights into the status quo of Industry 4.0 activities at companies in the DACH region, the United Kingdom, the USA, and China.

The underlying questionnaire is based on four thematic clusters each year:

- **Technology:** efficient use of Industry 4.0 solutions
- **IT integration:** increasing the performance of the corporate IT infrastructure
- **Strategy and objectives:** strategic focus of Industry 4.0 activities
- **Drivers and barriers:** positive and negative factors of implementing Industry 4.0 solutions

In addition, current digitalization topics are included in the study every year. In the Industry 4.0 Barometer 2023, the following focus topics were examined in more detail:

- **Shopfloor automation:** designing operational processes in production that become more efficient and flexible through automation.
- **Sustainable operations:** the pursuit of a sustainable use of resources in which negative environmental influences are reduced while also enabling a profitable and forward-looking operation.

1.2 Expert interviews and success stories

In addition to the survey results, each Industry 4.0 Barometer includes interviews with industry experts and success stories on the use of Industry 4.0 solutions in practice. This year is no different, with contributions from the DACH region, China, the United Kingdom, and the USA. In addition to the focus topics, interviewees were also asked to give a personal appraisal of the current status of the industry with regards to the digital transformation, and to provide examples of applications and digitalization initiatives within their own organization. Discussions were held with the following industry representatives:

- **Michael Straughan**
  Chief Operating Officer (COO) (Aston Martin)
- **José Gascon**
  Head of Digital Industrial Affairs Technology Expertise and Innovation (Sanofi)
- **Dr. Frank Scheppe**
  Lead of Operations (Läpple Automotive)

The success stories turn a spotlight on successful use cases for Industry 4.0 solutions and technologies. In addition to the initial challenges faced by the users, the success stories also outline the procedures for implementing the solution and the most important outcomes. In this context, the success story of the MHP FleetExecuter @Faurecia showcases a new way for shopfloor automation. In another example the success story of "FlexFactory," a joint venture between MHP and Porsche and Munich RE, is also examined in detail. The simulation-based and cross-process warehouse optimization of highly automated systems at Fiege Logistics rounds off the success stories on the topic of shopfloor automation. Finally, Volkswagen group's application of the Catena-X data ecosystem is presented as a success story in the area of sustainable operations.

1.3 Participants in the study

The results of the Industry 4.0 Barometer 2023 are based on the responses of 899 participants from German-speaking countries (DACH, 239 respondents), the United Kingdom (226 respondents), the USA (224 respondents), and China (210 respondents) (Figure 1).

Figure 1: Distribution of respondents by region n = 899

A look at the company sizes involved in the survey reveals a heterogeneous picture. Almost 53 percent of the participating companies are small and medium-sized enterprises (SMEs) with fewer than 1,000 employees. About 26 percent of companies employ 1,000–9,999 people, while 21 percent employ more than 10,000 (Figure 2). People from all levels of the hierarchy were interviewed – from the operational base to the board level. About three quarters of respondents can be hierarchically assigned to the top three levels (Figure 3).

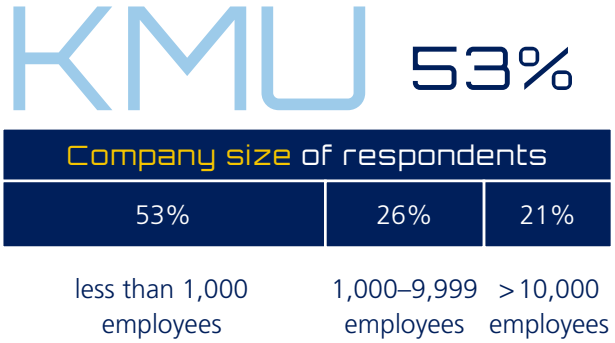


Figure 2: Distribution of respondents by company size n = 899

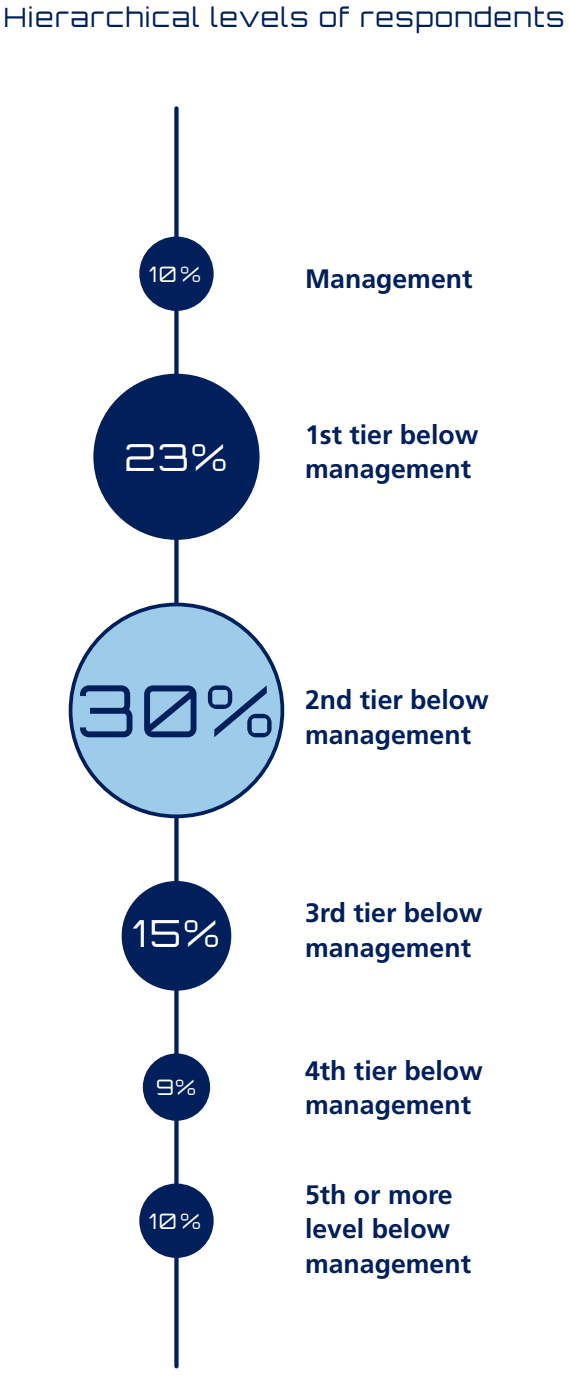


Figure 3: Hierarchical levels of respondents n = 899

Distribution of respondents by industry

Employees from more than **20 industries** took part in this year's Industry 4.0 Barometer. With ...

26%

the **automotive industry** (26 percent) is the most strongly represented, followed by communications and advertising (12 percent) and mechanical engineering (10 percent).

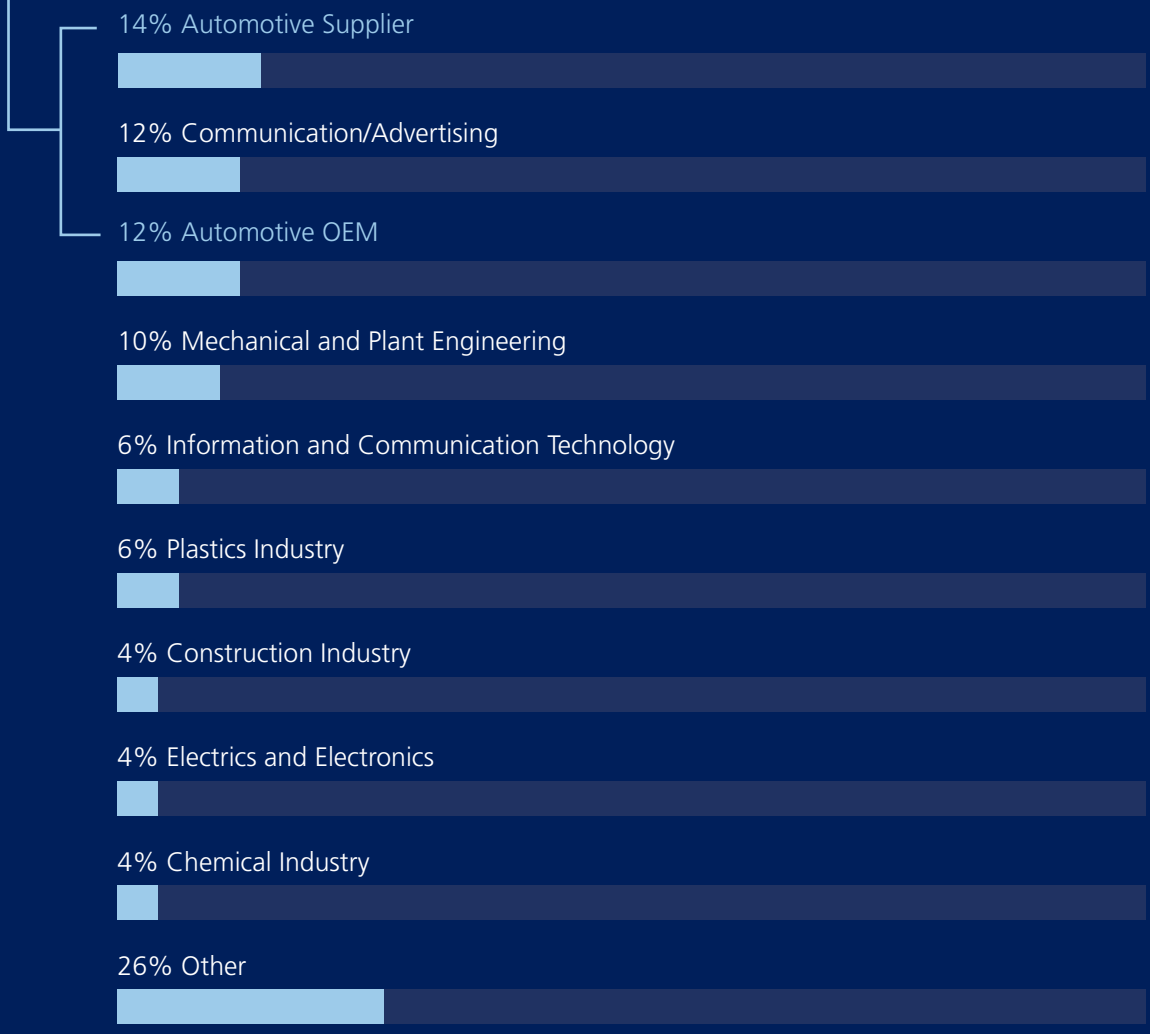


Figure 4: Distribution of respondents by industry n = 899

Distribution of respondents by department

The participants in the study come mainly from the specialist departments of **production** and **IT** with

36%

This corresponds to the focus of the Industry 4.0 Barometer.

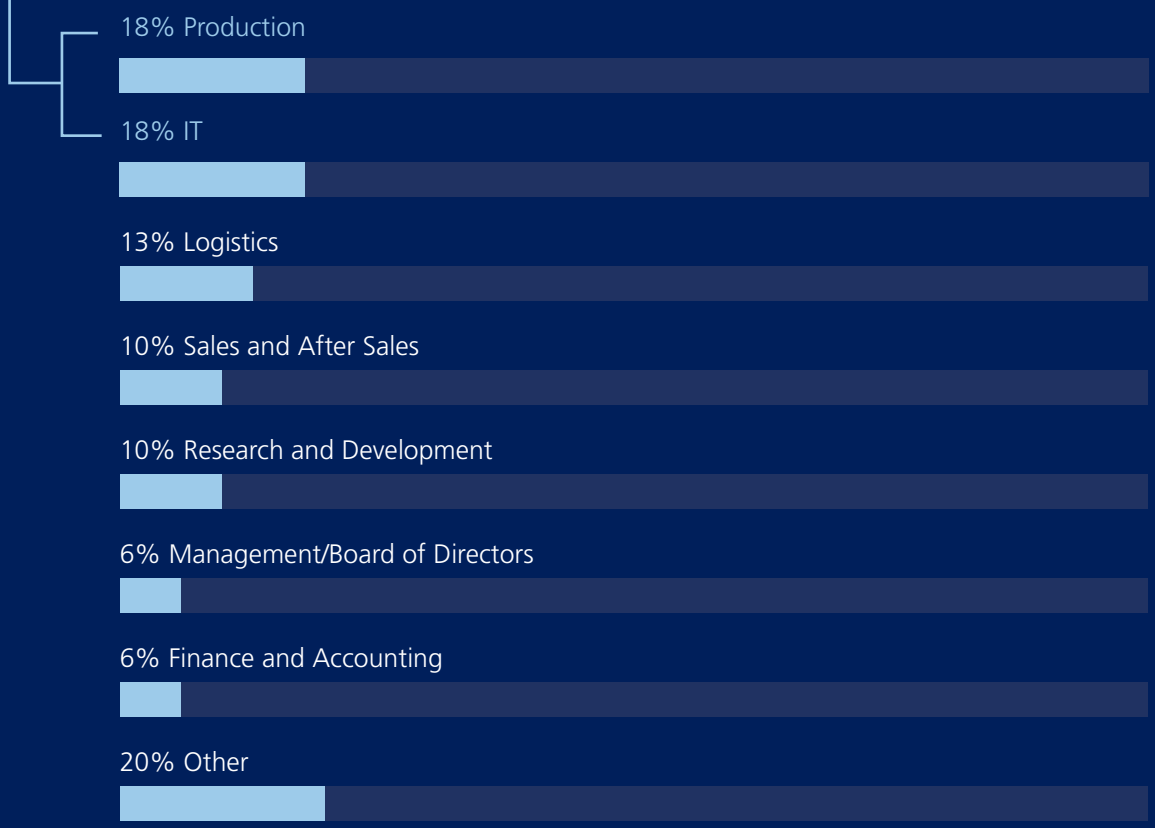


Figure 5: Distribution of respondents by department n = 899

2.0 Results of the study

2.1 Status quo of Industry 4.0

The term Industry 4.0 has been in use for more than ten years now. However, the topic itself, the associated high-tech strategy and, above all, the necessary transformation are more topical than ever. Companies are currently faced with two main challenges:

Firstly, transformation processes are urgently required but are being implemented very slowly. The reasons for this are both technical and social. Software is becoming increasingly important for production and products in all industries. At the same time, companies are now facing additional, enormous tasks that have not previously been pursued with the necessary commitment due to the growing awareness of the need to act sustainably in all areas. The consequences of demographic change are also becoming increasingly noticeable; the associated shortage of skilled workers means that the transformation is slowing down or grinding to a complete halt. There are also new industry-specific challenges, such as in the automotive industry, which must deal with the transformation known by the acronym CASE (connected, autonomous, shared, electric). Not only must vehicle manufacturers and suppliers adapt to this change, but they must also face up to disruptive innovations. This is also explained in the interview with Aston Martin's COO, Michael Straughan, using specific use cases, for example, in the area of production automation. Additionally, in the Interview with Läpple Automotive's Lead of Operations, Dr. Frank Scheppe presents the company's approach for digitalization from their perspective of a medium-sized automotive supplier.

Secondly, unexpected and unpredictable events and crises have occurred very recently – from the coronavirus pandemic to the war in Ukraine. These crises exemplify or even intensify the already enormous challenges of digital transformation. And they have made it very clear that the rapid growth we have experienced in the past 70 years can no longer be achieved so simply.

These challenging times demand that the focus be sharpened and concentrated on actions and initiatives that help solve complex problems of the present and future. A crisis can be seen as an opportunity to rethink current production systems and processes and transform them with the help of innovative solutions. Industry 4.0 provides the necessary solutions for this. These solutions help address the challenges posed by the crises and create a flexible and resilient business. For example, intelligent and automated systems can be used to avoid a shortage of raw materials or at least alleviate the associated issues. A flexible production system could therefore adapt the program planning at short notice, thereby reducing downtimes if no material is available. In addition to the short-term political and economic crises, there has long been an additional global challenge: dealing with climate change and the associated transformation toward resource-saving and climate-neutral production.

At first glance, operating sustainably and optimizing production are conflicting goals. Yet both goals can be achieved through Industry 4.0. Sustainability and Industry 4.0 are not opposites but enable and empower each other. It is becoming clear that production is subject to a number of challenges – in particular costs, flexibility, time, quality, globalization, and security resilience. The extent to which companies are implementing Industry 4.0, the differences that can be seen in the international comparison, the best practices that are useful, and the opinions of various experts – all these are presented in this study.

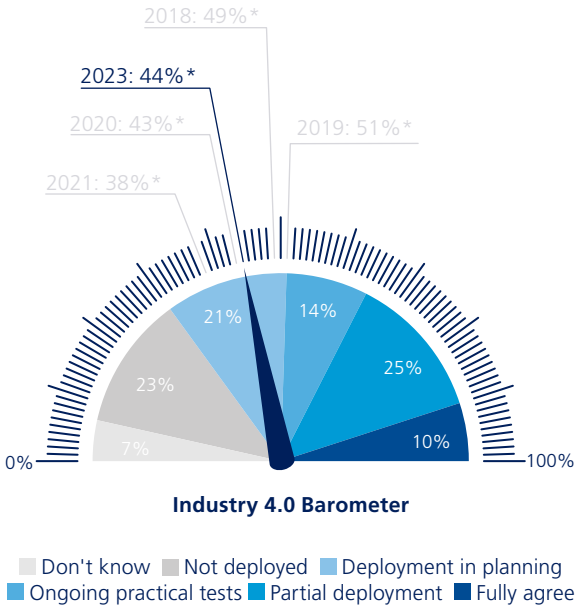
Survey results

Industry 4.0 is not short of advantages and potential. However, the survey results in this study show the extent to which these are used in practice. The term Industry 4.0 and innovative technologies go hand in hand, because only the ability to implement these in a targeted, profitable, and scalable manner will enable the path toward Industry 4.0. One of the main problems that companies around the world have been dealing with in recent years is the supply of production material. The problem lies in correct planning, which is made difficult by global volatility and complex supply chains. However, modern technologies that enable parts to be located in the supply chain can map this complexity and allow us to make it more manageable. The study shows that 14 percent of the companies surveyed are making full use of technologies that can be used to locate individual parts of products or end products, and 28 percent are making partial use of these technologies (Figure 6). This is a significant improvement compared to the previous year, when only 8 percent of the participants stated that full use was possible. A comparison of countries shows that companies in the USA and the UK are struggling in particular. On the other hand, these problems are minimal for the Chinese companies surveyed. No significant progress can be seen

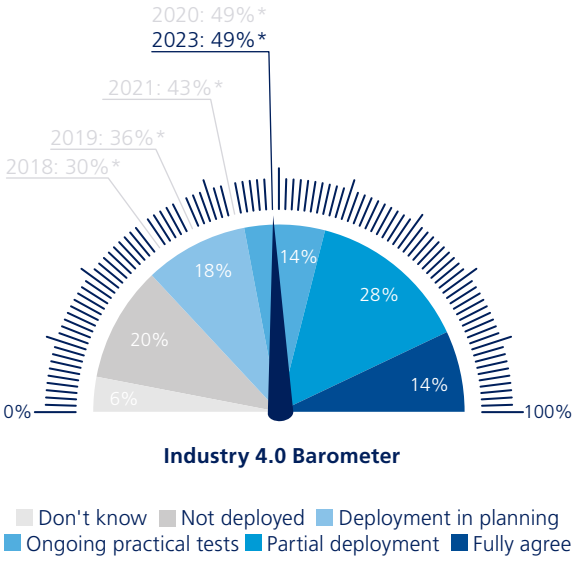
when it comes to equipping production plants and systems with sensors to record environmental parameters and status data. Of those surveyed, 35 percent of companies use sensors for all or some of the possible applications. Nearly a quarter of the companies surveyed still do not use sensors at all for this purpose. Looking at this year's Barometer score, it can be seen that companies have improved by 6 percentage points compared to 2021 in both areas – the collection of status data and location in the value chain.

What implementation status has your company achieved?

Our plants and systems in production, warehousing and logistics are equipped with sensors to record and transmit environmental parameters and condition data.



We can locate all individual parts of our products as well as end products across the entire value chain (from inbound logistics to production, to customer service).



*Barometer value: Weighted arithmetic mean as percentage value

Figure 6: Technological equipment along the entire value chain

More advanced technologies, such as the digital twin, have a slightly lower application rate and adaptation rate. Approximately 30 percent of respondents say that their company uses a digital twin for some or all of the applications to simulate, control, and improve production equipment, products, or the entire logistics. The proportion of companies that do not use a digital twin at all, at around 30 percent, is higher than the proportion of companies that do not use sensors to record environmental parameters (Figure 7). Looking at the Barometer score, it is clear that companies have expanded their activities to implement a digital twin in logistics compared to last year, with an increase of 11 percentage points. However, in the case of products, the use of aforementioned technology has declined slightly.

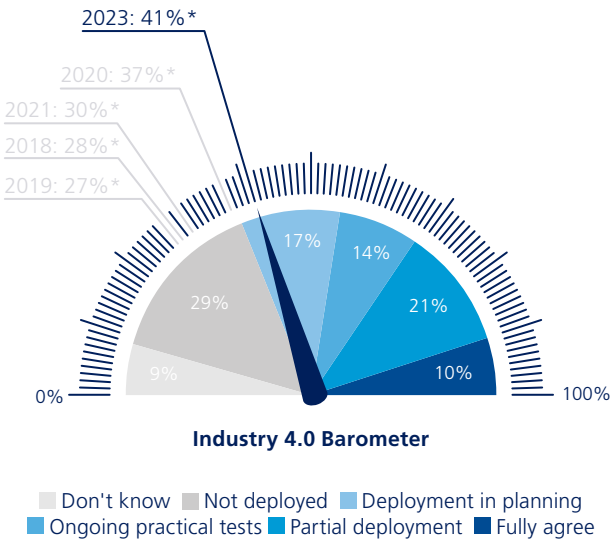
"IIoT is one of the most promising technologies of Industry 4.0. It is evident from the results of the Industry 4.0 Barometer 2023 that only about one-third of all companies are already using sensors and taking advantage of IIoT. However, there is a noticeable trend towards data acquisition and networking of plants and systems in production, warehousing and logistics.

The challenge to best utilize the benefits of IIoT, such as efficiency, productivity and cost savings, is to implement holistic solutions in all production areas."

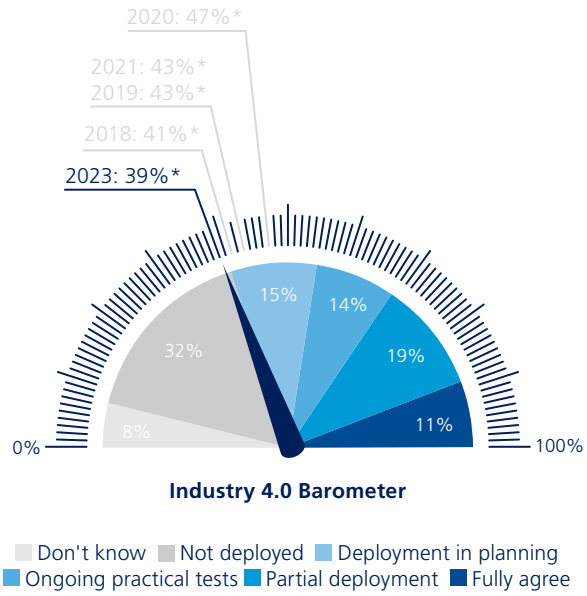
Dr. Walter Heibey
Partner, Operations Performance & Strategy, MHP

For simulation, control and improvement, we have a digital twin that collects process and condition data, from ...

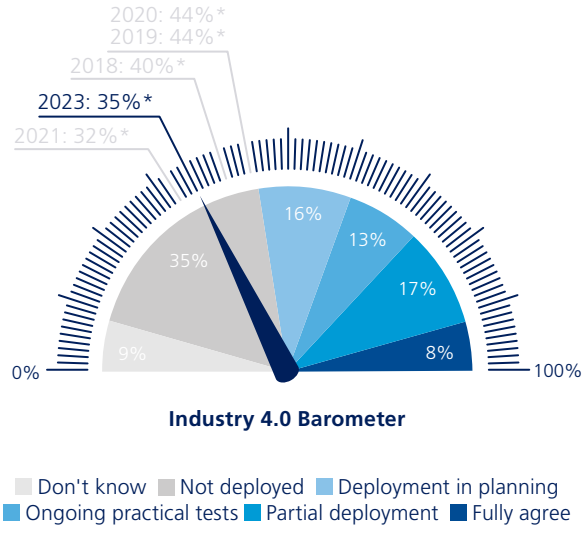
... our entire logistics (incoming and outgoing).



... our products.



... our production facilities (e.g. plants, machines, vehicles).



*Barometer value: Weighted arithmetic mean as percentage value

Figure 7: Distribution of the digital twin

The advantage of having a Chief Information Officer (CIO) on the board of management is clear to see for the digitalization of the entire company. For 69 percent of companies with a CIO on the board, the IT architecture is modular, while only 38 percent of companies without a CIO on the board have a modular IT architecture (Figure 8). The same is true for real-time communication networks such as 4G/5G and WAN in the plants: More than 70 percent of companies with a CIO on the board have installed these in their infrastructure, while for companies without a CIO on the board, this figure is only 55 percent (Figure 9). These and other added values are designed to encourage companies to recognize the high profile of a CIO as part of the executive board and take necessary action, if this has not already been done.

Influence of a CIO in the management on the IT architecture of companies

Our IT-architecture is modular which means that software modules can be rapidly integrated and assembled through defined interfaces.

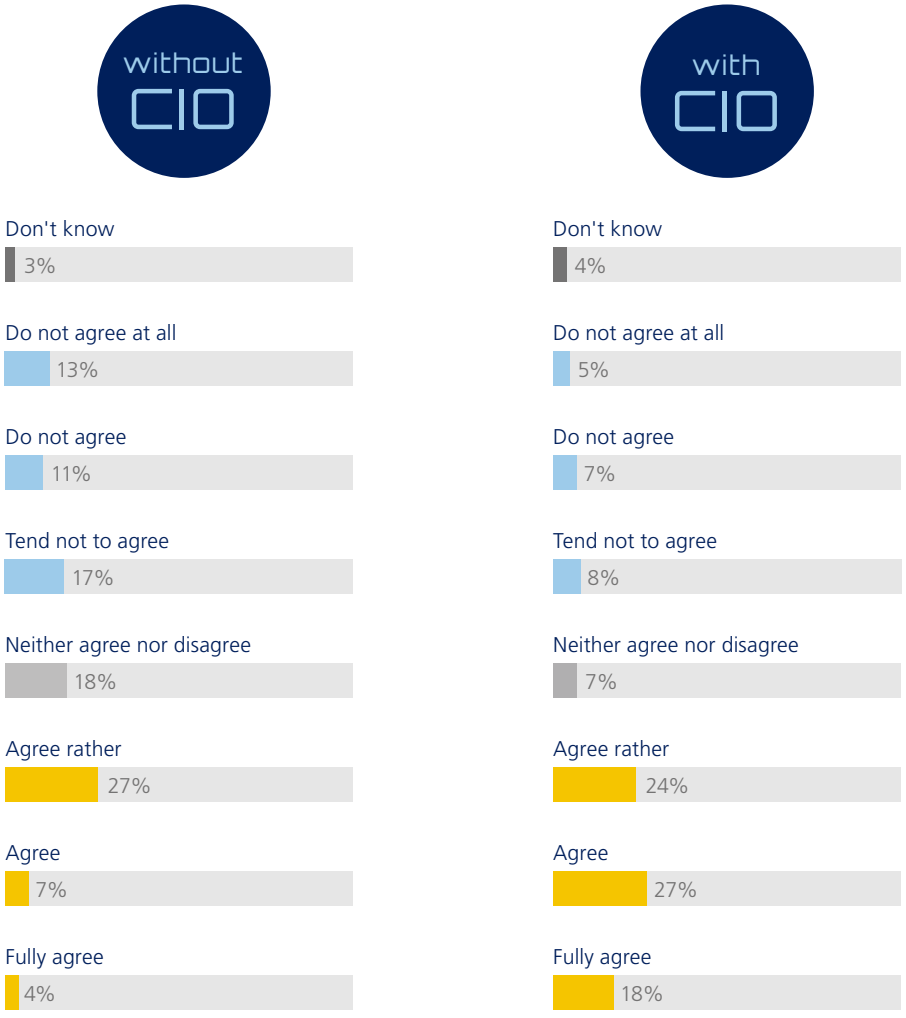


Figure 8: IT architecture with/without CIO in the management

Influence of a CIO in the management on the communication networks of companies

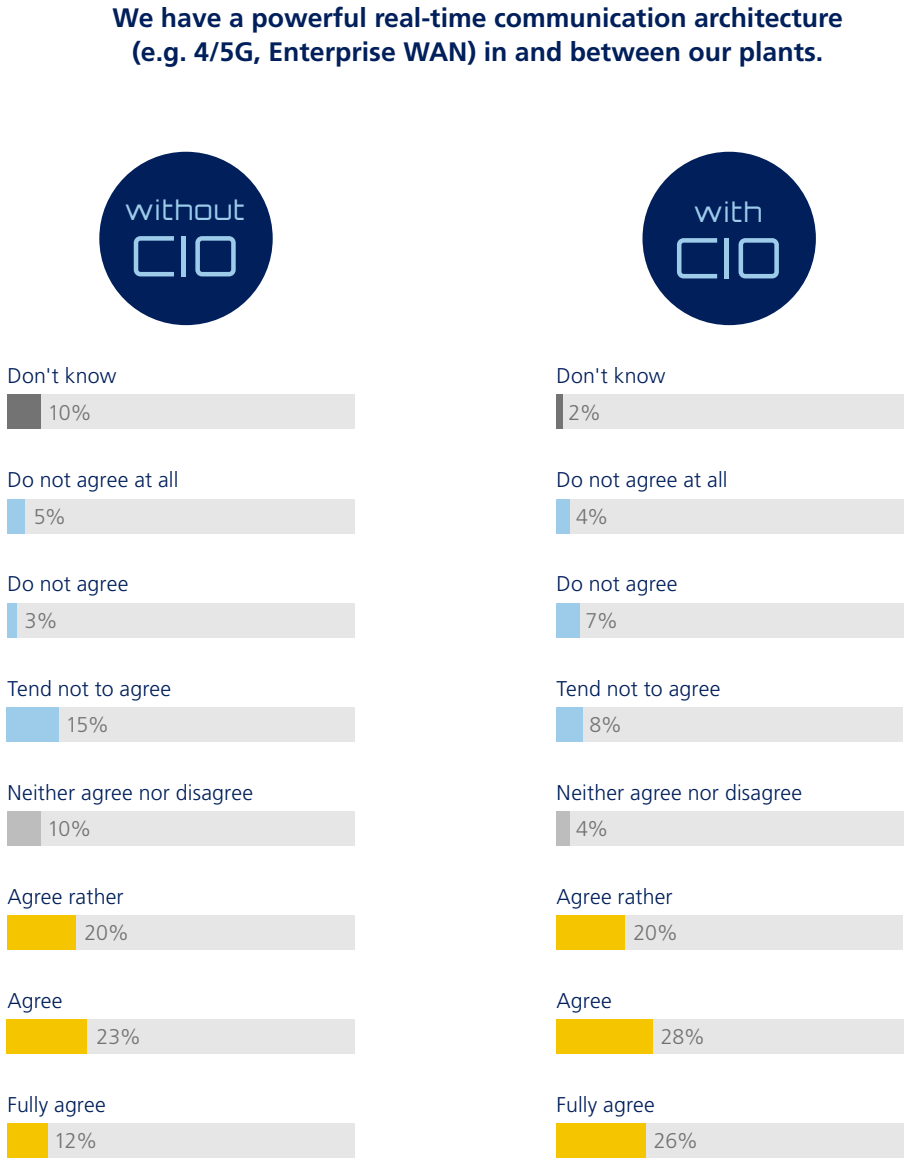


Figure 9: Communication networks with/without CIO in the management

We are currently seeing an increase in hacker attacks on companies. Almost every week, there are new reports in the media about decommissioned IT infrastructures, data theft, and the resulting incapacitated or damaged companies.

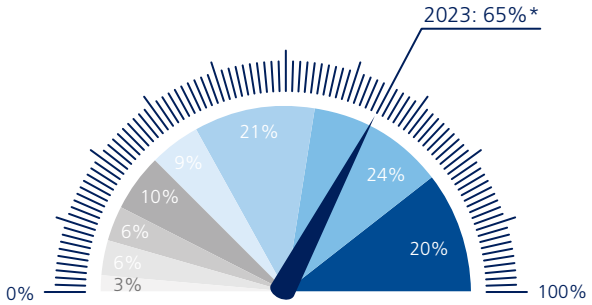
This news has an impact on companies. We have observed that IT security is now highly prioritized and that own competencies in this area are of high priority: For example, the majority of respondents, 64 percent, have regulated access to company data through

You can find more information on this topic in our Cyber Security Risk Report.

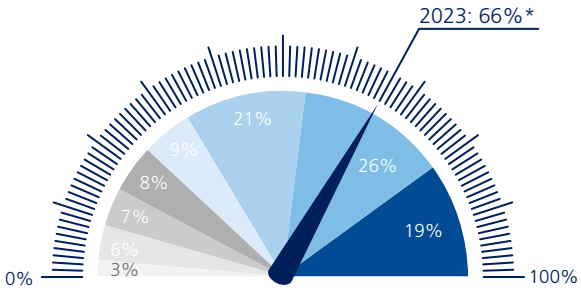
a uniform authorization concept (Figure 10). Similarly high scores have been recorded in terms of existing cyber-attack capabilities within Western businesses, as well as the importance and impact of IT security management on key business decisions. As in last year's survey, Chinese companies are generally lagging behind when it comes to IT security, especially in comparison to Western companies.

Status of IT security in the companies

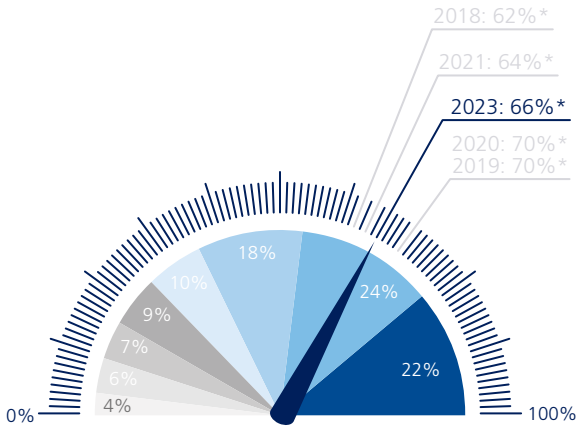
In order to defend against cyber attacks, our company has sufficient and adequate competences.



Our IT security management has high impact and power on fundamental company decisions.



Access to operating and machine data is regulated by a uniform authorization concept.



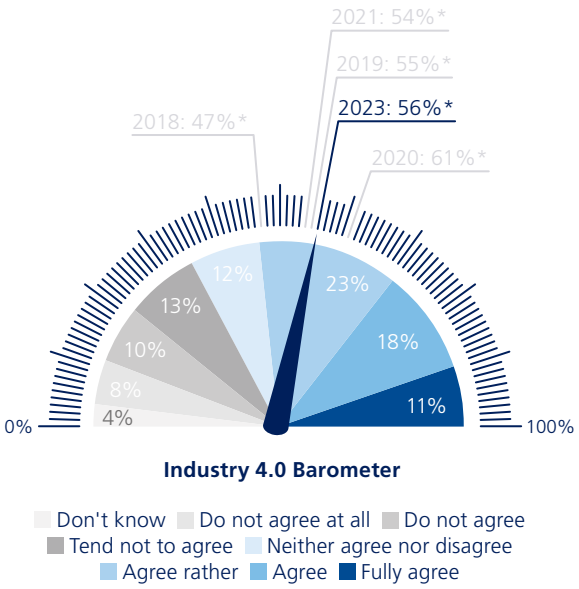
*Barometer value: Weighted arithmetic mean as percentage value

Figure 10: IT security

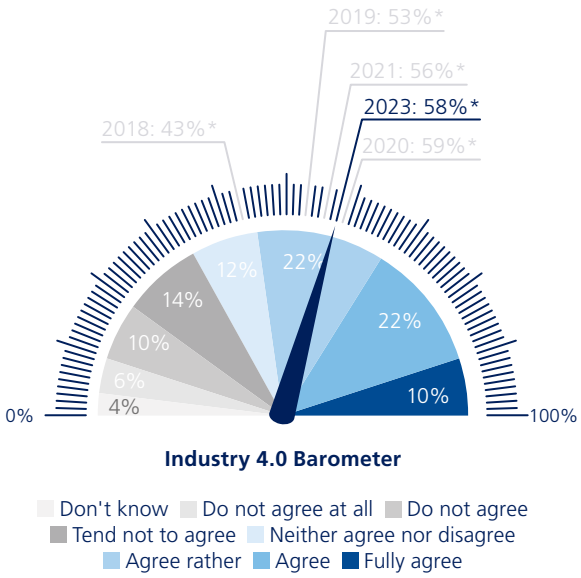
The scalability of the IT infrastructure currently looks less positive. Companies are struggling to use features like cloud solutions to scale their IT infrastructure up or down quickly to meet demand. The connection of business partners to the IT and communication systems via API interfaces is still up for further improvement (Figure 11). Compared to last year, there was only a minimal improvement in the Barometer score in both areas.

Scalability of the IT systems in the companies

We can flexibly and rapidly integrate business partners into our IT and communication systems (e.g., APIs).



We can quickly scale our IT infrastructure up or down (e.g., through cloud solutions).



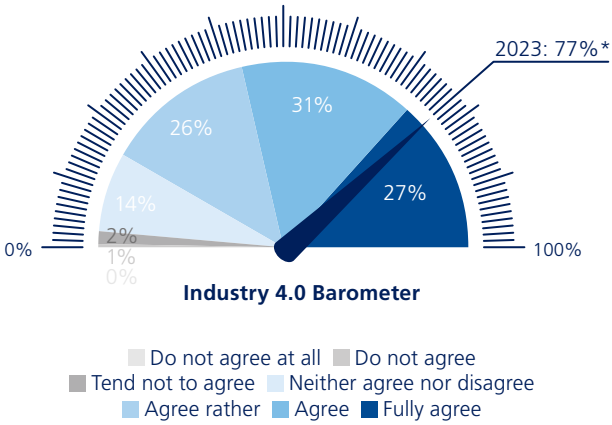
*Barometer value: Weighted arithmetic mean as percentage value

Figure 11: Scaling of IT systems

A proven approach to minimize the failure of projects in the Industry 4.0 environment is to involve the IT department in these projects at an early stage. For example, 58 percent of respondents agreed that projects in the Industry 4.0 environment are more successful if the IT department is involved at an early stage (Figure 12).

IT business collaboration

Industry 4.0 projects are more successful if the IT department is involved at an early stage.



*Barometer value: Weighted arithmetic mean as percentage value

Figure 12: IT business collaboration

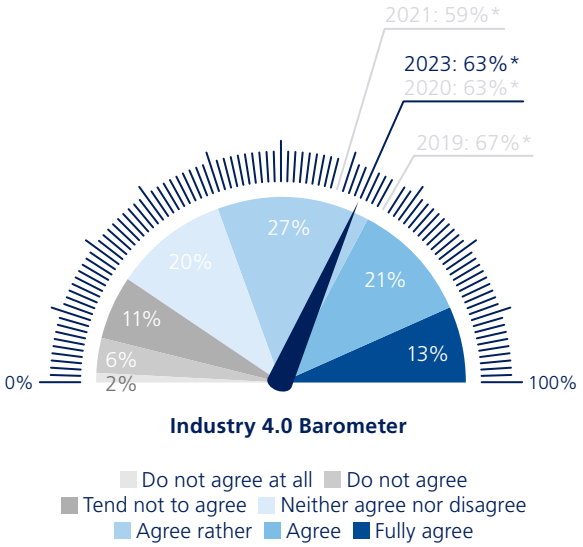
While digitalization and Industry 4.0 are progressing in some areas, development is stagnating in others. The reasons are varied but a key aspect is the difficulty in calculating the return on investment: With a new machine, it is very easy to compare the (monetary) benefits of the investment and the costs incurred, and to compare them with previous investments. The benefits of improved data analysis, a digital twin, or high scalability are hard to quantify.

Another aspect is legacy IT with 61 percent of participants saying that established and historically grown systems make integration more difficult (Figure 13). This is mainly because these systems are often based on non-universally compatible data, meaning they cannot be connected via interfaces, are very maintenance-intensive, and often cause compliance problems. However, in terms of the Barometer score, there is a slight improvement of 4 percentage points compared to 2021.

We can conclude that the state of digitalization has developed by an average of around 9 percent across all the technology categories surveyed compared to last year. This finding is also reflected in the results of the 2021 Digitization Index, where the index value in Germany was 108 points, an increase of 8 percentage points compared to the previous year. Above all, companies are focusing on security-related aspects, which is quite understandable due to the current increase in cyber-attacks. In many areas, companies are on the right track but there is still a great deal of catching up to do, especially in advanced stages such as the digital twin. While the USA is a pioneer across most of the technologies, the DACH region still has problems implementing many Industry 4.0 technologies.[1]

IT barriers

The implementation of Industry 4.0 technologies is delayed in our company, because established, historically grown IT systems make integration difficult.



*Barometer value: Weighted arithmetic mean as percentage value

Figure 13: IT barriers to the introduction of Industry 4.0

[1] More information: www.de.digital (DE.DIGITAL – Digitalisierungsindex)

Interview
Michael Straughan
COO
Aston Martin Lagonda

Aston Martin Lagonda – Short profile

Aston Martin Lagonda is a globally recognised luxury brand and a leader in the high luxury sports car market. For more than a century, the brand has symbolised exclusivity, elegance, power, beauty, sophistication, innovation, performance and an exceptional standard of styling and design. Our cars sit primarily within the HLS car market and our market leadership position is supported by award winning design and engineering capabilities, world-class technology and modern facilities, creating distinctive model line-ups. Our rich and prestigious heritage of delivering beautiful awe-inspiring cars defines Aston Martin as something truly unique within the automotive industry.

Michael Straughan – Short Vita

Michael Straughan is Chief Operating Officer of the ultra luxury motor manufacturer Aston Martin Lagonda. He joined the business in December 2020. Straughan has significant international experience gained through a range of senior management positions in different automotive brands and regions. The past 10 years have been spent in high value luxury product manufacturing in both the automotive and marine industry. He has over 30 years of automotive experience, starting in the lean manufacturing environment of Nissan Motors then holding senior positions in Volvo Cars, LDV, Jaguar Land Rover, joining the board of Bentley Motors in 2011 before becoming COO of luxury yacht manufacturer Sunseeker in 2017 and then COO of Aston Martin Lagonda in 2020.

Interview

Participants: **Michael Straughan** (Aston Martin Lagonda), **Timo Haug** (MHP), **Mohammad Wasim** (MHP), **Dr. Christina Reich** (MHP)

Dr. Christina Reich (MHP): At the moment, everyone is facing geopolitical conflicts, scarcity of resources, and new trends, that are challenges for all automotive manufacturers. How is Aston Martin as a high end sportscar manufacturer affected by these challenges? And is Aston Martin affected by these challenges to the same extent as other manufacturers?

Michael Straughan (Aston Martin Lagonda): What we witnessed was an incredible market recovery coming out of Covid. I don't think anyone could have expected that. Interestingly on the small volume manufacturers side, the microchip and PCB issue didn't affect us the way we thought it would, when looking at the bigger players. We kept running, I think, because of our low volumes, so it was easier for the tier 1 suppliers to keep us going rather than stop us, which was quite fortunate. But what we did see, particularly in Europe, was labour shortages. So many of our suppliers complained that access to skilled labour was increasingly difficult. Particularly when every car manufacturer was asking for more components, and thus demand increased.

Michael Straughan, COO Aston Martin Lagonda

Reich: Did you use any key technologies or strategies to face this situation? Or did you use more insourcing, or domestic market sourcing?

Straughan: This was a very serious discussion preparing for Brexit on what our supplier base should look like. Quite frankly, the UK supply base is not particular-

ly strong. So, there weren't many options. If we could not get electrical components from China than there weren't many companies in the UK who we would look at for supply.

Haug: The trend towards more local sourcing and re-evaluation of the current supply strategy is something we experience with all our customers. Do all those things that are happening right now effect the plan of investment for those technologies?

Straughan: No, we decided that we really needed to upgrade the technologies, not only in the product, which we will come onto later when we talk about electrification, but also in the infrastructure and the way we do business internally at Aston Martin. We were very clear that we needed to continue the investment to remain competitive. So, you're right, Timo, sometimes at times like this it is easier to stop investing and preserve cash, but, in this case, I think it would be completely the wrong thing to stop investing into Industry 4.0 technologies the supply chain.

Reich: What are the challenges in the luxury car segment? Especially now with the electrification of the cars and with the smart manufacturing plant under construction in Silverstone?

Straughan: Manufacturers like Aston Martin, Ferrari and Lamborghini; the one thing we all do – and it is a very important part for Aston Martin in our product offering, is we allow customers to create their own car. I think this is one area where new technology can really help us. It goes right through the supply chain. So, good information out of suppliers allows us to create a high variety product offering. Also, to the point where we add value on the shopfloor. If we have got this huge complication of products coming down the line for a production operator – and by the way, having been in the industry for so long, what I don't expect to see in the short term is robots replacing assembly workers on the shopfloor, we tried that for years and years. In our low volume environment, plus with the complexity that we deal with, we need to get the material and the information to the operator to allow them to build a car, which meets the requirements of the customer. What I see a lot of is, "how do I get the right information to the supplier so they can provide very complicated components back to us? And then, how do we assemble this complexity into vehicles?"

Haug: And when you think about the last two years, how did the shopfloor change over that period?

Straughan: What we did over the past few years, which was very difficult but not impossible, was to integrate the two sports car production lines into one. So that means we are now building six completely different product variants, all on the same production line. Without access to information at the point where the operator works, we wouldn't have been able to do this. We fully kit a car to the line. Kit assemblies follow the body. Operators select parts which are kitted in the warehouse, so therefore the kit of parts has to be 100% accurate. To allow us to develop this complex production line with different assembly hours per car, we have to balance out the different assembly content so that we can build a consistent number of cars every day. I think if you would have gone back 3-4 years, people would have said it was impossible to do, but we managed to balance six very complicated products into one assembly line. This is important for the future when we look to battery electric vehicles, because what we do need in Aston Martin is turn around space, we need to generate the space to allow us to introduce new products whenever that comes in the future.

Reich: How do you get the parts to the production line? Do you use technologies like AGVs?

Straughan: No, not at the moment. With automation in the low volume environment, it's always very difficult to generate the business case behind it. When we look at our future production line where we will have battery electric vehicles, and possibly a mix of battery electric vehicles and internal combustion engines, then I'm pretty certain that the old-fashioned Taylorism production line, with a chain and a fixed position for each car, will become a thing of the past. It will offer flexibility if the system was AGV driven, which allows us to change the sequence of product on the line and even greater capability to balance variation in product.

Reich: Are there also measurable achievements that you've already seen, resulting from the successful automatization or digitalization of the production line?

Straughan: Again, this is a question of appropriate automation, and when I say appropriate, we won't replace lots of people with robots because our cycle times are so long. But there are certain areas where automation from a quality perspective is the right thing to do. Our body construction system is quite unique: we use predominantly aluminium with adhesive and some mechanical fasteners, structural strength and the quality assurance system comes from how much glue we put between two components. The necessity of having

accurate dispensing of glue is critical for the structure of the car, and therefore we choose automation where it makes sense to make the product better, not necessarily for efficiency reasons, because again in our low volume environment often it doesn't make sense.

Reich: By 2030, Aston Martin aims to drive the net emissions from its manufacturing plants to zero, and with supply chain emissions down to 30%. By 2039 net emissions across the supply chain are also to be reduced to zero. Which technologies and initiatives will you utilise to achieve your sustainability goals in production?

Straughan: There are a lot of fundamental initiatives which companies have been using for years, you know the basics: zero plastic waste to landfill for example, and we've been on this journey for a couple of years now. We started the process of people getting used to how important sustainability is for the future. When we did the analysis of how we get to net zero, we saw that even though we are a small manufacturer, where as an example the paint shop is our highest energy user at the moment. There are not many options to natural gas as a heating medium for the paint shop, and we knew we had to do some things which are fundamentally different. Because energy prices have changed so rapidly over such a short amount of time, and I'm sure it's the same in Germany. It became a lot easier to engage people into thinking very different to what we do in the future and therefore, as we stand without any technology changes, the simple disciplines of "let's make sure that we optimise the paint shop running", - we shut it off at the right time at night, how do we make sure that the factory is in darkness when the last car is made? We got good engagement immediately from the workforce on how we do the simple things well, because it's just so expensive to run a car factory now.

Reich: Which further measures were taken to improve sustainability for Aston Martin as a company?

Straughan: Then when it came to "Okay, what are the game changers? What are the things we can do?", the purchase of sustainable energy was important, with our energy provider "TOTAL" (we are certified user of sustainable energy). Then we've looked at the energy usage in the factories to make sure that we can look at what we can do to reduce our own energy, so we're in the process with the local government in Wales to create a full roof of solar arrays in St. Athan, which will generate a proportion of our energy, but also allow us to supply back into the electricity supply system at weekends, so sell it back into the network. The term "Sustainability" is of course broader than just energy. If you look outside the main HQ offices in Gaydon, it is set in wonderful countryside with a pond outside with protected newts. We've just introduced a number of bee hives into the grounds, and it's a nice environment for our employees to be engaged in the broader use in terms of sustainability. We are in the process of introducing a short woodland walk on site which provides employees with the opportunity to engage with nature during their break times.

Reich: When considering the whole supply chain, what are the challenges that you face with regard to your suppliers considering sustainability?

Straughan: When we talk about suppliers, this is where it starts to get much trickier, and we talked about the whole supply chain, and getting a good transparency on the supply chain is never going to be easy. We benefit from the fact that we are a small car manufacturer and therefore we probably have a reasonable number of suppliers to go out to, but still finding our way down their supply chain to make sure that we can be sure that their supply chain is sustainable is not an easy task, and we're working quite intensively to make sure that we can get that information and data. As a publicly listed company I think it's important that this becomes a hygiene factor, you know this isn't a "nice to have" now, the investor rating companies look very closely at your environmental credentials and that was why the publication of "Racing Green" (which is our approach to sustainability) is so important, because there are so many people on the outside now looking at this (including our customers). It certainly is rapidly becoming an important criterion, when people are purchasing products, including cars.

Reich: Where do you see the biggest potential inside of Aston Martin for more sustainability? Is there anything else that could be improved?

Straughan: So, we have discussed energy which is an important element. Waste, whether its water or plastic, or recycling of our general waste and what we can do with the materials we use. Then in the future we're studying materials like sustainable aluminium. Also, is the supply chain that we use credible, as it the material they supply goes into the product and therefore needs to be traceable for their sustainability credentials. We need to innovate from a material perspective, for example the use of vegan leathers in the future: How attractive is that for customers and is it really an offering that we can make to the customer?

Mohammad Wasim (MHP): Michael, what would be the dream factory if there were no constraints and what would that look like?

Straughan: The Net Zero factory is the aspiration, and you could almost say it's a dream, because at the moment I don't think all of the technologies are available to allow us to do that. An important part of this is that our intention is not to offset in order to achieve net zero. In the past I think people have given these aspirational promises and then the last step is to offset by planting trees in rainforests, and that is not our intention. We would like to do it through the use of good technologies, through the right use of the resources, to make sure that we don't overuse resources. That target is an extremely aggressive and ambitious target. If in my career, I could achieve that, then I would be extremely satisfied to have done my part.

Reich: With regards to the last three years with all the challenges we were facing or are still facing: How did Aston Martin manage that all of these sustainability goals did not fall behind?

Straughan: In the current environment it would be easy to put a squeeze on product development, downsize the company significantly, stop investment in new technologies. The benefit we had was a sense of knowing that driving sustainability was the right thing to do for our customers, and our investors expected it of us and therefore there was no discussion or "let´s stop doing this stuff". Because you're right, in some cases it is expensive, and the benefits might have a payback many years in the future, but we knew it's the right thing to do, and being a responsible business, a responsible employer, we just knew that we had to do these things.

Reich: Would you say that sustainability is more a challenge for Industry 4.0 technologies, or would you even say that these technologies may actually support you to reach sustainability goals easier?

Straughan: There are certain things where you can see the clever use of technology, for example when it comes to energy reduction. You can see a direct relationship between the building management systems which would control energy usage when things are live, to energy reduction, so you can see a complete link. But again, it comes back to, and I keep saying this: It's the appropriate use of technology for a business like ours. And in larger companies where the volume is higher, the cycle times are lower, you can often get the link a lot easier than it is in this low volume environment. But when it comes to complexity and the use of information and AI, then that's where I think it would give us a competitive advantage. As an example, not sustainability related: We have just installed a camera system which inspects every car in the Gaydon Sports line area of the business and using machine learning, it will eventually get to a point where it will tell us where the defects are on the external surfaces of the car. It's incredible how quickly we now rely on that machine to tell us what the paint quality is like and whether there are any small scratches or damage on a surface, much more consistently than any technician could ever do. There is no doubt that new technologies will create significant advantages for a business like Aston Martin. The challenge we have is identifying and then selecting those technologies which will create the biggest benefits.

Reich: Let's go 10 years back or something, the entire sustainability topic wasn't so prominent, but now it has to be considered by every company. Were there some cases, where the pressure that came from sustainability goals facilitated the development of new technologies faster?

Straughan: We have probably the newest paint plant in Europe. In St. Athan where we manufacture the DBX SUV, we installed that paint shop just over two years ago. If we would design the paint shop now, we would select different technologies, but at the time this was probably the best technology available. It just shows how very rapidly technology is progressing which supports sustainability and is at the top of many company's agenda. Interestingly, I think this will mean equipment and facilities will be replaced not only determined by changes in product but also to meet the company's glide paths towards net zero and sustainability aspirations.

Reich: What do you think is most important to take for the next five or ten years regarding the sustainability challenges we are, but also were facing the last two or three years; with regard to Covid, with regard to the Ukrainian war. What would you say is the most important?

Straughan: I think a big learning point for me is to expect the unexpected more than I have ever considered in my career in the past. I think it's this concept of plan for the unexpected and be ready and flexible with your approach that allows you to react to whatever you see.

2.2 Shopfloor automation – Automation in production

In order to survive on the market, companies must continuously improve their productivity. This is nothing new in itself, but the challenge has increased significantly in recent years. This is being driven by both increased cost pressure and increased energy costs, coupled with competitors from all over the world – especially from the Far East – as well as the worsening shortage of skilled workers, including the time-consuming and often unsuccessful search for qualified employees. In terms of production, further automation of production processes could be a way out. There's nothing new about this either; these are no longer novel technologies. Companies have been driving automation forward for decades but, conversely, automation is still often seen in the public forum as a threat to jobs. In fact, automation and the associated increase in productivity mean that companies can operate successfully on the market and, at the very least, maintain new business models and jobs overall.

When talking about automation in companies, this is initially associated with machines and conveyor belts. If these thoughts about automated equipment are carried further, we find that robots and fully automated production cells are already at the next level. The final stage of development could be a factory without any human workers and the value-adding activities are freely interlinked and centrally controlled. Automation is therefore a versatile term, not only in its form, but also in its place of application. In companies, a variety of processes can be automated. This study relates to companies' production facilities – known as the shopfloor – which includes automated plants, production cells and more. However, people have a clear advantage over machines: They are flexible and creative. Yet it turns out that human skills are not ideal when it comes to repetitive activities. In times of increasingly individual customer wishes, strong market fluctuations, and a shortage of skilled workers, this is an indispensable asset, at least in Europe. The products and therefore the production facilities must be able to map the highly individual customer requirements as well as different products using the same infrastructure. An automation solution must therefore stand out in the face of these changed customer requirements. Shopfloor automation refers to the automation of repetitive and employee-intensive processes with the aim of increasing efficiency and flexibility. This is only possible through the comprehensive orchestration of the individual process steps.

While the idea of automation has existed for a long time, the implementation approach has evolved with the changing requirements. Solutions should be resilient, flexible, end-to-end, and ideally intelligent. All areas must be integrated, from intralogistics to quality assurance and shopfloor management. This means increasing networking and the digitalization of previously isolated production processes. IT systems (information technology) and OT systems (operational technology) must be combined. Not only the processes, but also their control, must be implemented automatically in an intelligent factory. In concrete terms, we can use an Automated Guided Vehicle System to show the interaction between IT and OT. The vehicles that belong to the OT category drive automatically, while the IT systems supply these vehicles with the necessary information so that they know where they are needed without direct human intervention. The automatization of the shopfloor will in this case be enabled through the use of AGVs. This is illustrated by the success story at Faurecia, which covers the implementation of a dynamic supermarket using MHP FleetExecuter to control AGVs.

Modular production, in which the process sequence can be changed permanently, is also only possible through the comprehensive orchestration of the individual process steps. The interview with José Gascon, Head of Digital Industrial Affairs Technology Expertise and Innovation at Sanofi, shows what an approach to the modular production looks like in the pharmaceutical industry. One field of application that only becomes possible through the use of automated solutions like AGVs is the Dark Warehouse. The name derives from the fact that there is no need for the lighting in this fully automated warehouse as opposed to a warehouse with people working on site. Using information from production, processes controlled by artificial intelligence (AI) can provide solutions for operational planning that would not be conceivable by conventional means. The list of technologies that can be used in production, is constantly growing and is becoming increasingly long. An approach for automated warehouse optimization in logistics is illustrated by the success story at Fiege.

Finally, the automation of the shopfloor brings a wide repertoire of advantages. Companies can gain a sustainable competitive advantage through increased efficiency, flexibility, and lower long-term costs. These obvious and measurable benefits should encourage companies to continue to invest in digitalization. However, as the survey shows, companies are still very cautious about this, which will be discussed in more detail in the following chapter.

Success Story
MHP FleetExecuter @Faurecia

Implementation of a modern warehouse system in combination with fleet management software for AGVs

The Industry 4.0 Barometer 2021 has already shown how the automotive supplier Faurecia is successfully using Automated Guided Vehicles (AGV) and MHP's fleet management software FleetExecuter. Another success story is presented below. This new use case explains how Faurecia used the MHP FleetExecuter to implement a dynamic supermarket.

Dynamic supermarket

There are many different uses of AGVs in logistics and production. Last year's Industry 4.0 Barometer featured the "Goods-to-Man" system, which described the use of AGVs to automate logistics activities that were previously performed manually. The FleetExecuter is a central control unit that operates between the global material flow control system, the vehicle control system, and the peripheral devices. Through networking, the FleetExecuter enables shopfloor control of logistics orders for the entire production and material flow. In the latest FleetExecuter project at Faurecia, the focus is on the introduction of a dynamic supermarket to supply the assembly line with the necessary parts and components.

Summary

At Faurecia, AGVs are used in the production of seats for the automotive industry. The MHP FleetExecuter fleet manager ensures dynamic replenishment (dynamic supermarket) of the assembly line with an AGV based on consumption signals from SAP Manufacturing Execution (SAP-ME). The FleetExecuter automatically generates transport orders for both filled and emptied containers, which are forwarded to the AGV and executed.

Initial situation and challenges

There are various options for supplying materials to the assembly line. The challenge is to efficiently coordinate and execute all handling steps while maintaining

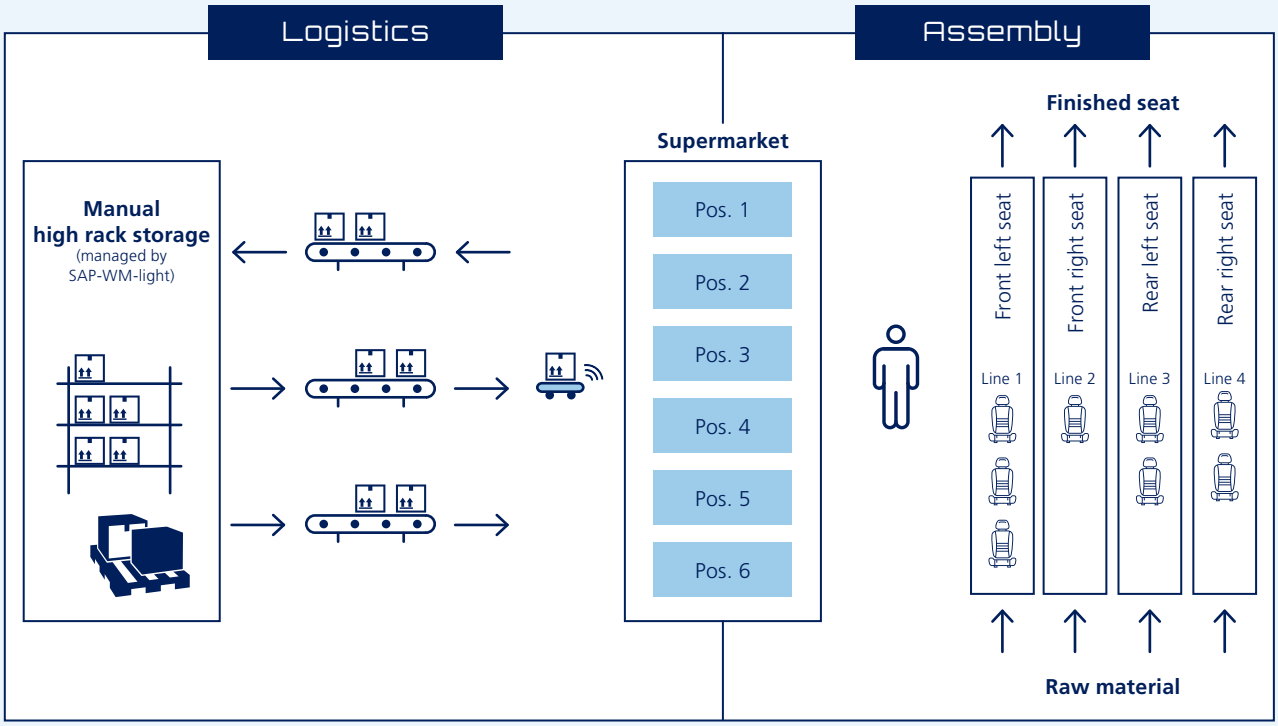


Figure 14: Schematic representation of logistics and production at Faurecia

the material supply of the assembly line. Since Faurecia produces seats for premium vehicles with particularly varied customization options, this results in numerous different product variants. One way to solve these challenges is to implement automation solutions such as AGVs, which are centrally controlled by the FleetExecuter and therefore ensure the supply of the assembly line

Procedure and operation

Production at Faurecia focuses on the area between logistics, which in this case is a manual high-bay warehouse, and the assembly line (Figure 14). A temporary storage facility for supplying the assembly line, the dynamic supermarket, is supplied by an AGV. An employee responsible for commissioning takes the parts from the temporary storage. These parts will then be installed on the individual assembly lines. This allows the assembly worker's range of motion to be minimized, as he does not have to worry about replenishment, resulting in increased assembly productivity.

The concept of a dynamic supermarket

While every item has a fixed storage position in a typical logistics solution, this is not the case in the dynamic supermarket. Due to the dynamic design of the supermarket, there is always at least (or exactly) one free slot where the next good to be stored can be placed. This means that the location of the next good to be stored changes with each storage operation. The MHP FleetExecuter fleet management software, which manages the locations of the items/materials and their stock, always directs the AGVs to the nearest empty location in the supermarket. Therefore, there is no need to wait for the residual stocks to be emptied or temporarily store the goods that will be entered into storage. This dynamic solution compensates for the lower handling speed of the AGVs (when shunting) compared to conventional forklifts. This concept of a dynamic supermarket, paired with the advantage of the continuous availability of the AGVs due to the elimination of required driving personnel, represents an efficient solution for supplying the assembly line.

Use of a scanning glove

Since the parts are always assigned different storage locations, it must be ensured that the employee does not have to search for the items despite having a variable storage location. This is ensured by using a scanning glove with display (such as ProGlove Mark Display) (Figure 15). By scanning a barcode on a container for components at the assembly station, the glove shows the commissioning employee the storage location and inventory of the item in the dynamic supermarket. This allows the employee to quickly locate the required item within the temporary storage and bring it to the assembly station. The glove not only provides the employee with the necessary information, but also ensures that containers are reliably reported as empty by the employee. The order commissioner scans a supermarket position and the quantity of the container at this location is set to 0. The FleetExecuter receives the consumption of the materials for automated subsequent delivery via an interface to the SAP-ME system. This interface is used in FleetExecuter to automatically adjust the existing stock as soon as an item has been installed in the assembly line. If more items are used than planned due to malfunctions or quality defects, the position of the item is scanned when the last item is removed from the supermarket, indicating to the system that the container has been completely emptied. The system checks whether a reorder has already been placed or automatically triggers it. This ensures that parts are continuously supplied to the assembly.

Results and Outlook

The MHP FleetExecuter for controlling AGVs paired with an efficient scanning glove with a display provides a connected system for supplying the assembly line. In this project, the system was individually adapted to Faurecia's 20 assembly stations. MHP provided the software as part of the project with the MHP FleetExecuter and took over all project areas from conceptual design to simulation and implementation to ongoing production.

By using AGVs in combination with the MHP FleetExecuter and the scanning glove, it was possible to save the labor costs of two employees who would usually operate forklifts. With implementation costs of around 200,000€, an ROI of less than two years could be achieved within a project duration of only five months. In addition to the direct financial savings in labor costs, this process also ensures a continuous and error-free supply of materials to the assembly line in the future, thereby reducing or eliminating downtimes on the line.

Figure 15: Scan-Glove ProGlove Mark Display

Success Story Fiege Logistics

Simulation-Based, Cross-Process Warehouse Optimization of Highly Automated Systems

Due to a significant increase in customer requirements with regards to depth and breadth of the product range, product availability, and delivery times, manufacturing companies and retailers often decide to outsource logistical processes to specialized logistics service providers like Fiege, who meet these requirements using Logistics 4.0 solutions.

Challenges and Areas of Responsibility

Depending on the requirements, Fiege can draw on highly automated warehouse solutions – such as the solution implemented for an omnichannel retailing company, where the challenge was to holistically plan the branch distribution and the e-commerce business together with the associated returns processes in order to generate time and cost benefits. To achieve the required flexibility with short throughput times, Fiege chose AutoStore – an automated storage and picking system with the appropriate conveyor technology.

In order to align the storage processes with the customer-specific articles and quantities, MHP was commissioned with a material flow simulation of the storage process with the associated conveyor technology (see Fig. 16). Furthermore, it was analyzed how the inventory would behave over the entire year if the expected stock placements and stock removals were taken into account. Finally, strategies were defined and tested as to how compaction processes should run in order to prevent the warehouse from overflowing by redistributing the items and to always have enough empty containers available.

Approach

First, order data was generated for stock placements and stock removal. This was done using historical data, which was extrapolated in close consultation with Fiege based on estimated order growth in the branch and e-commerce areas. Through the data analysis, the existing order structure as well as the article base could thus be used to create a more detailed order basis. The goods receiving processes with the workstations for repacking the goods as well as the conveyor technology for feeding the AutoStore containers were mapped in the software Plant Simulation. The aim was to validate the dimensioning and capacities carried out by Fiege and to identify bottlenecks. To map the inventory over a complete year, taking into account the storage and retrieval data generated a simulation model of the warehouse was created in Python, which ran on the AWS cloud. It was shown that compaction processes have to take place to empty opened containers so that they are available for the storage process.

Finally, approaches for the compaction process were developed; the existing simulation model was extended to include these strategies so that their effects could be mapped. The decisive KPIs were the time required and thus the capacity for the compaction processes per day as well as the number of available containers.

Results and Outlook

By combining the expertise of the divisions Big Data & IoT Technologies and Digital Supply Chain Solutions, MHP was able to offer Fiege a comprehensive solution approach and respond flexibly to the challenges that arose in the project. The simulations with the generated order data enabled Fiege to make process changes and plan capacities early, i.e. during the planning and implementation phase of the new storage system.

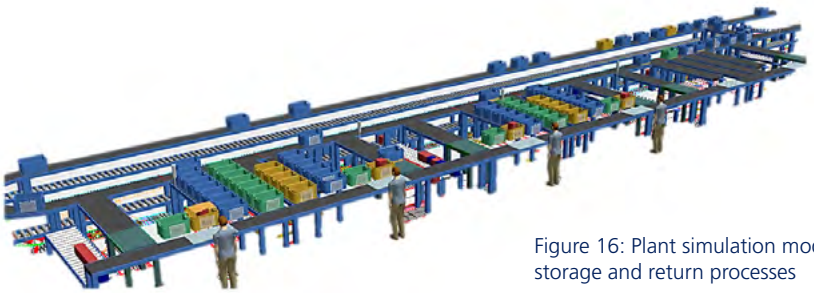


Figure 16: Plant simulation model of the storage and return processes

Survey results

The advantages of comprehensive shopfloor automation are clear. However, the survey results show a mixed picture. In 80 percent of the companies surveyed, the degree of automation is between 0 percent and 70 percent. This shows that the degree of automation in production varies greatly. On average, the companies surveyed have a degree of automation of 49 percent (Figure 17).

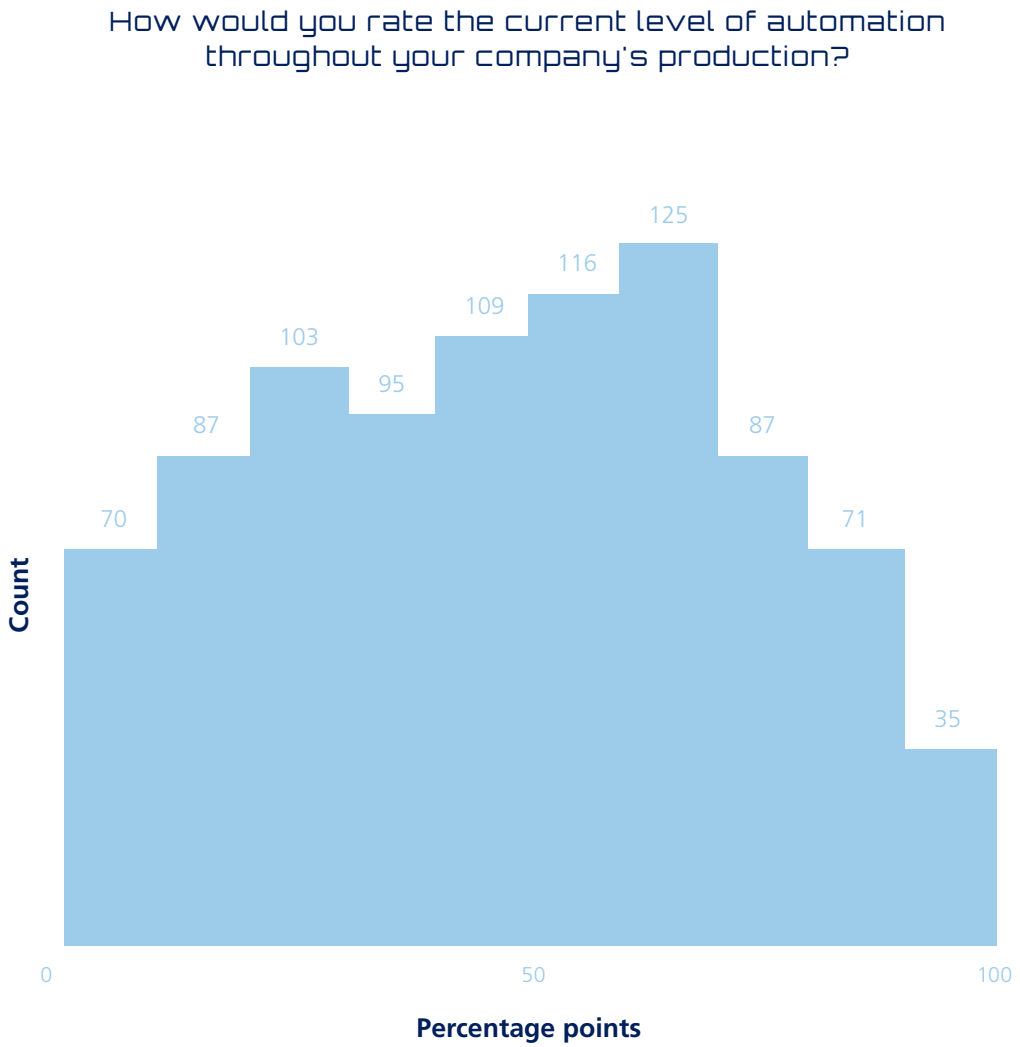
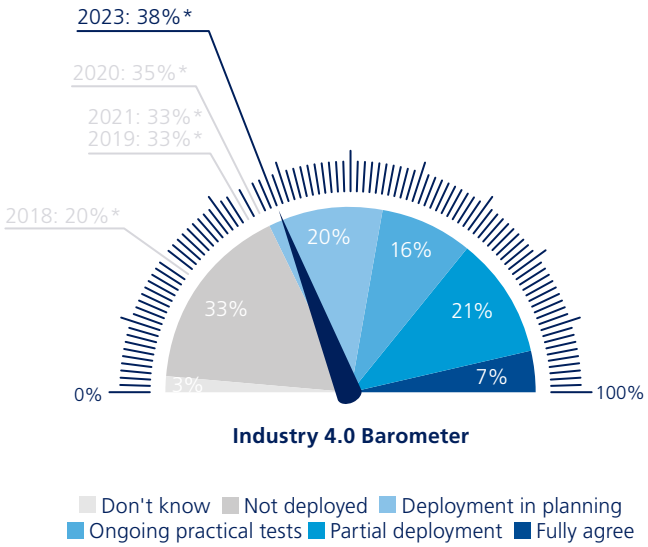


Figure 17: Level of automation

It is also worth noting that certain technologies are not used at all by a significant number of companies. For example, one third of respondents do not use autonomous machines and robots such as AGVs at all, and only 20 percent plan to use them (Figure 18). However, we can also see that two thirds of the companies surveyed are already addressing the use of autonomous machines and robots. Compared to the previous year, the Barometer score shows an increase of five percentage points, which highlights the increasing importance of autonomously operating machines and robots for companies.

What implementation status has your company reached?

We use machines and robots that can operate autonomously, control or improve themselves independently (e.g. autonomous guided vehicles).



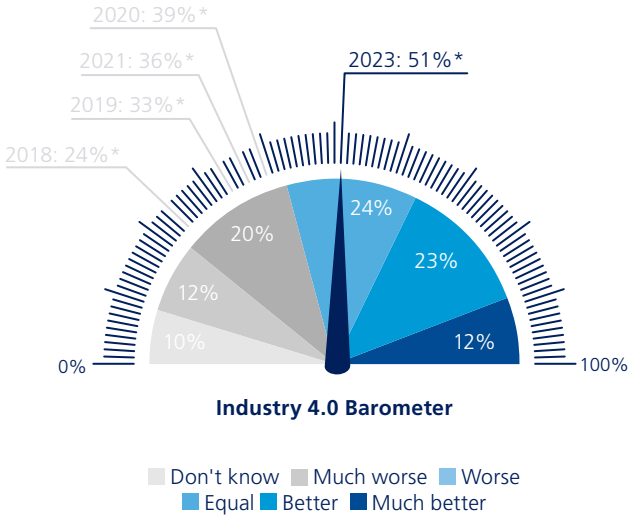
*Barometer value: Weighted arithmetic mean as percentage value

Figure 18: Automation and autonomous systems

Although the degree of automation is not yet very high in absolute terms, most companies consider their level of automation to be relatively good. For example, 24 percent of the participants see their company as being at the same level as their competitors in terms of partially and fully automated production processes (Figure 19). Another quarter of respondents even rate their company's ability as better. This misconception is alarming since the survey showed that a large proportion of companies do not have a high level of automation in their production. This is demonstrated by the limited use of self-guided machines and robots, the low amount of partially and fully automated production processes, and the mediocre degree of automation. At the same time, however, companies consider themselves safe when it comes to automating their production, even though there is a consistent need for the industry to catch up in these areas. A comparison of recent years shows that companies have improved by 15 percentage points, particularly in terms of partially and fully automated production processes.

Please rate your company's data analysis capabilities against direct competition in terms of:

Production processes with partially and fully automated decisions (e.g. through artificial intelligence or machine learning).



*Barometer value: Weighted arithmetic mean as percentage value

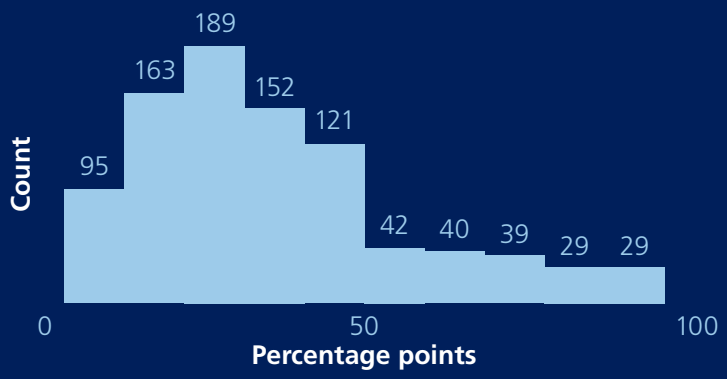
Figure 19: Partially and fully automated production processes

The reasons for the low use of automation solutions in production are mostly economic. In practice, cost reduction is the dominant aspect when evaluating automation solutions. However, companies will miss out on many benefits if they only consider costs in this assessment. The second highest prioritized goal of shop floor automation is to increase quality. There is little commitment to other benefits, such as increasing flexibility or offering new services to existing products (Figure 20). In contrast to this is the success story of the "FlexFactory" joint venture, which focuses on flexibility in production and thus opens up new potential in the area of production automation and sustainability.

Characterize the strategic Industry 4.0 focus of your company:

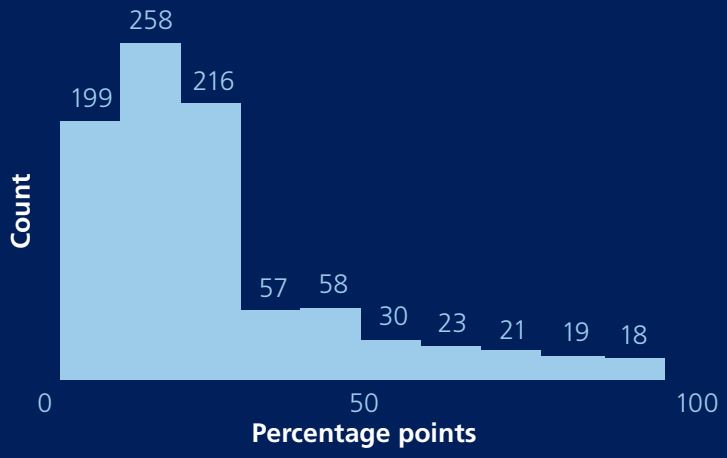
Priority 1

Increase profitability (cost/income ratio).



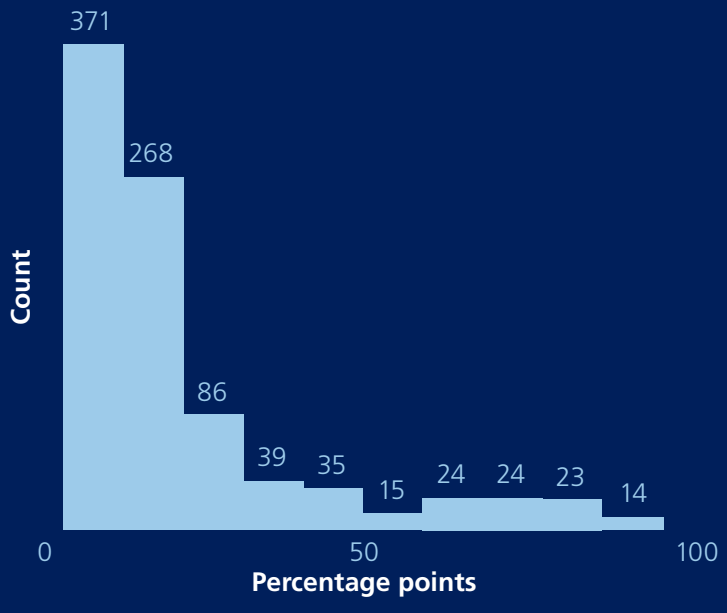
Priority 2

Increase the quality of our production and products.



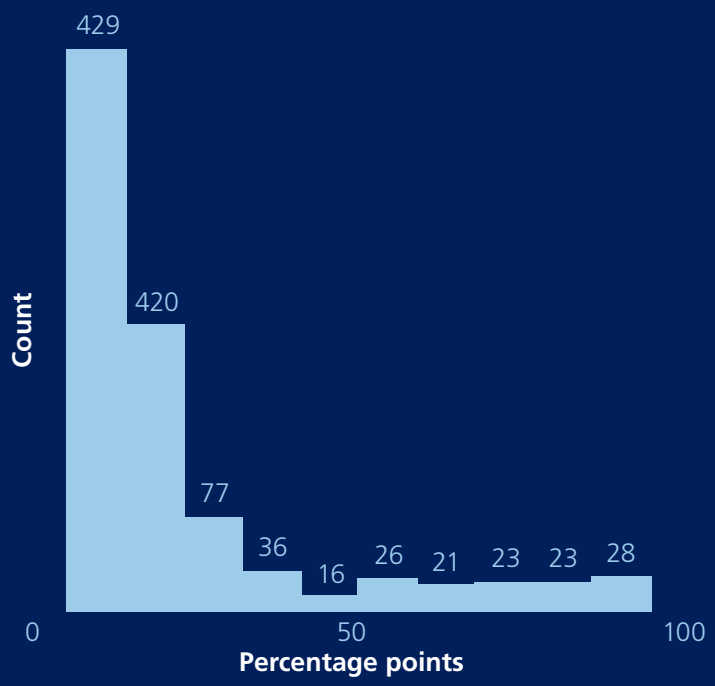
Priority 3

Develop new market and customer segments.



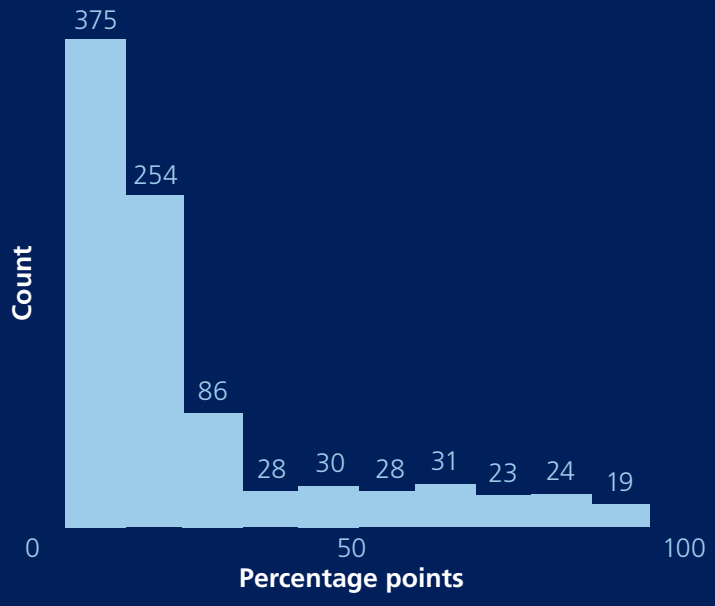
Priority 4

Offer new services for existing products.



Priority 5

Flexibility to adapt our production.



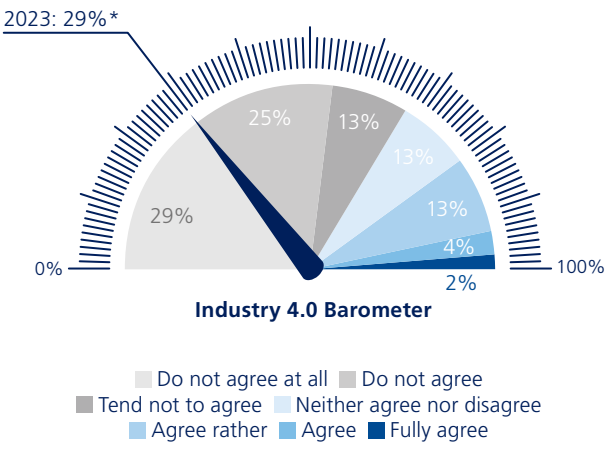
(participants were able to award a maximum of 100 cumulative points for all questions)

Figure 20: Strategic Industry 4.0 focus

The fact that many companies seem to be looking exclusively at profitability is also underlined by the results of the question on the biggest obstacles. For two-thirds of companies surveyed, uncertainty with regard to the return on investment (ROI) is the main reason for a lack of digitalization and automation. In order for a company to be resilient and future-proof, it must take a holistic view, even if the current economic and geopolitical environment justifies a strong focus on costs. This can also be seen from last year's Barometer score, which rose by 10 percentage points from 2021 to 2022. Other barriers, which are classified as less relevant, are the supply chain problem, the war in Ukraine, the shortage of skilled workers, or the excessive involvement in day-to-day business (Figure 21).

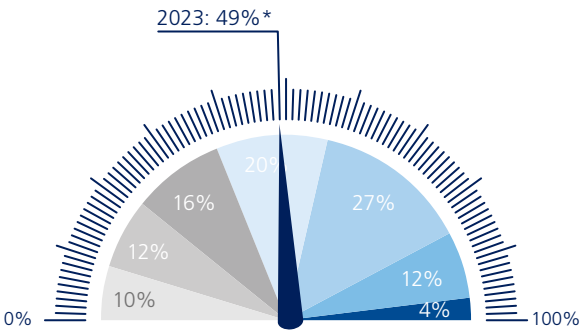
67 PERCENT

of respondents do NOT SEE any delay in the implementation of Industry 4.0 technologies due to the lack of resources caused by the Ukraine war.

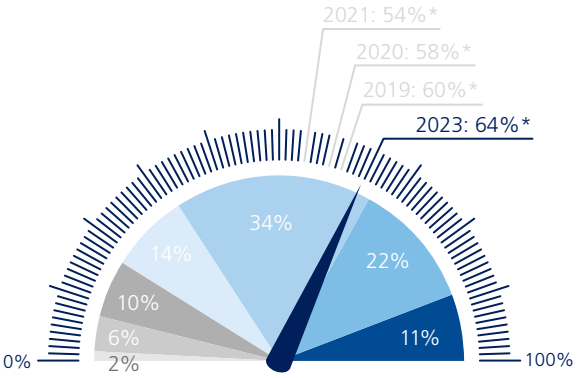


The implementation of Industry 4.0 technologies is delayed in our company, ...

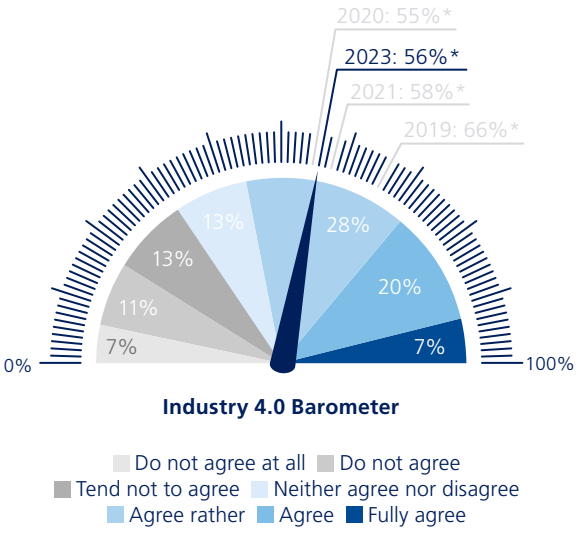
... because necessary resources are lacking due to supply chain issues.



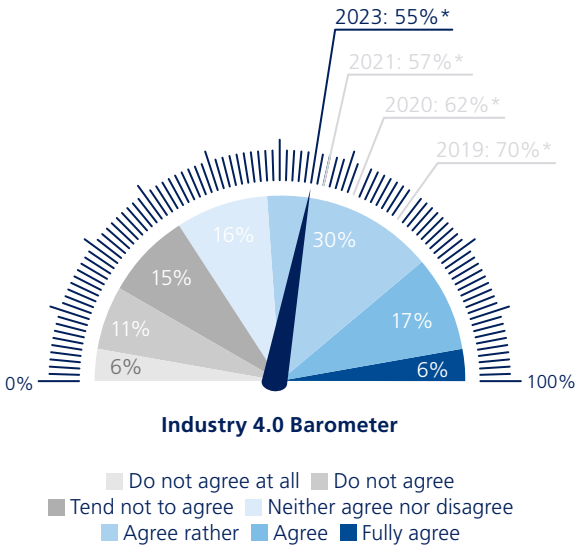
... because of uncertain return on investment (ROI).



... due to difficulties in recruiting qualified employees.



... because day-to-day business does not leave enough capacity.



*Barometer value: Weighted arithmetic mean as percentage value

Figure 21: Barriers to the introduction of Industry 4.0

When considering the three buzzwords digital twin, autonomous transport and artificial intelligence, 43 percent of companies see autonomous transport as the biggest economic potential in terms of automation. Artificial intelligence, which is currently under intense debate, is considered by 39 percent of respondents to be the most economically interesting. The digital twin is lagging behind. Only 16 percent of respondents see the greatest potential here (Figure 22).

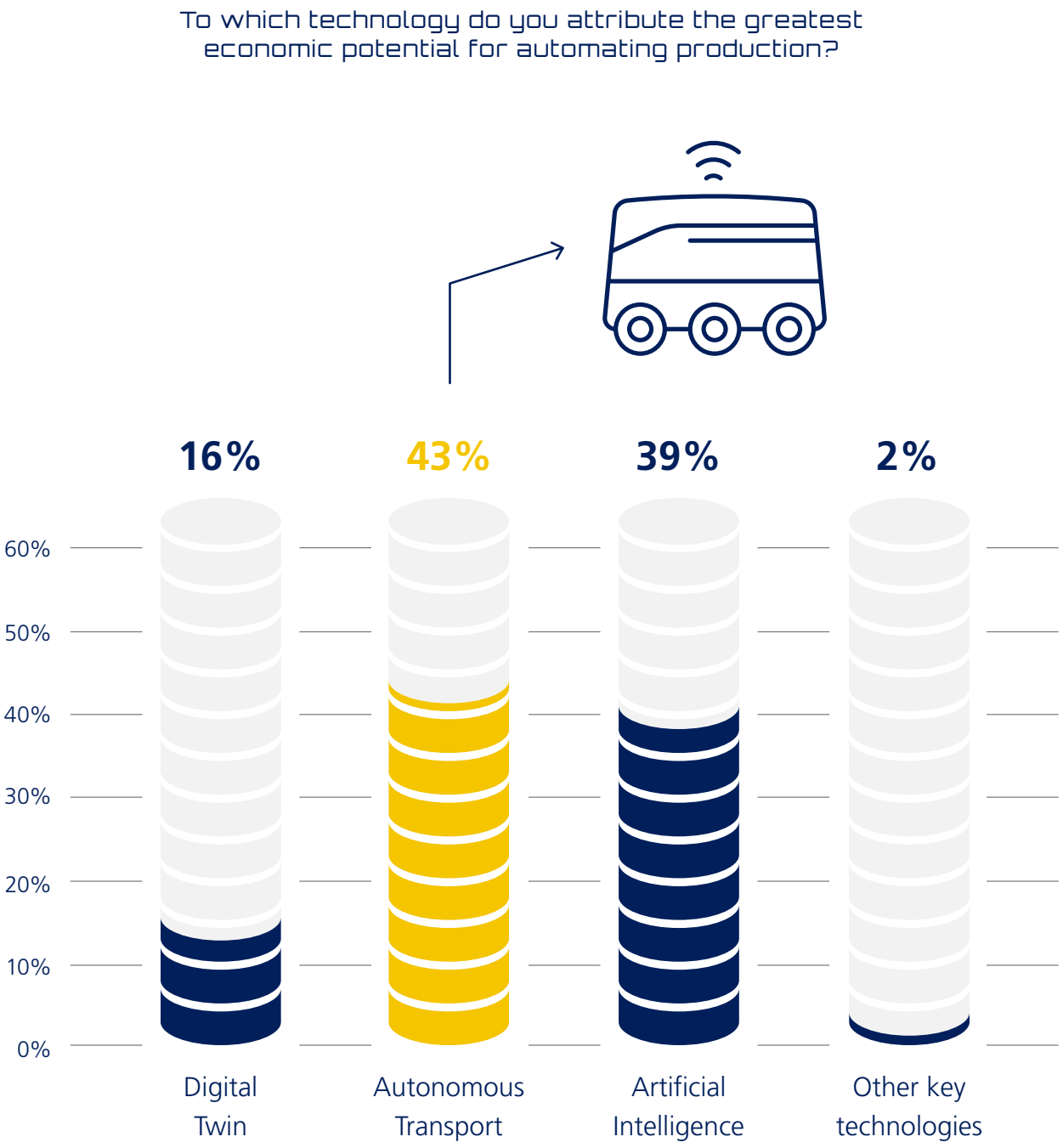
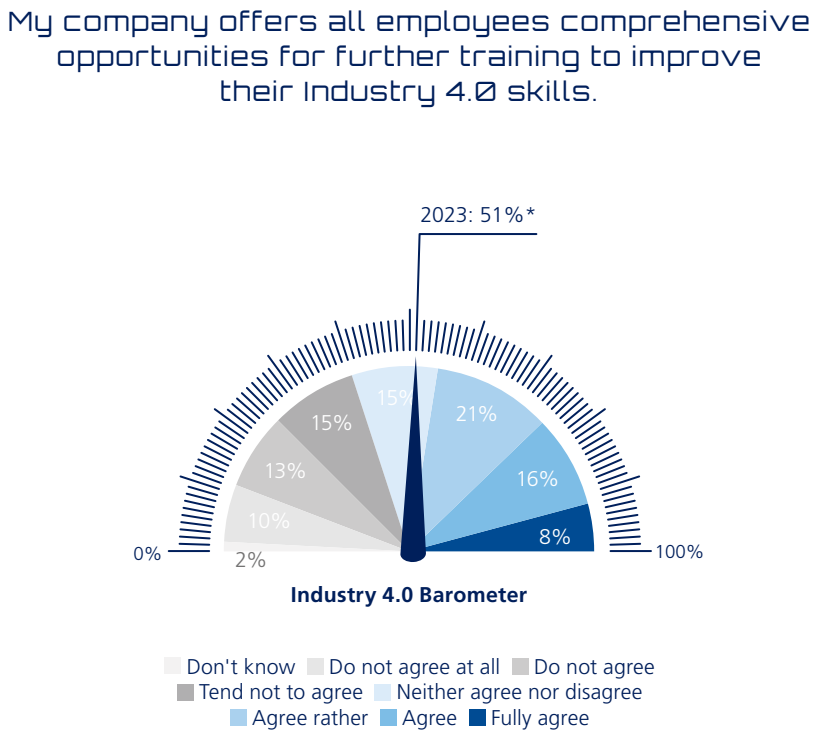


Figure 22: Technologies with the greatest economic potential in terms of automation



*Barometer value: Weighted arithmetic mean as percentage value

Figure 23: Opportunities for further education

Reasons

Reasons for the low level of automation in the technologies considered may be a lack of willingness to take risks. Companies' extreme focus on profitability reduces their capability for innovation. Few companies are willing to raise the necessary resources for sustainable and future-oriented investments in key business areas, such as the shopfloor, using digitalization. But there are always two sides to the coin. Automation simply does not meet the requirements. Michael Straughan, COO of Aston Martin, repeatedly emphasizes an "appropriate level of automation" in the interview. It is still essential to take targets into account and automation must not be forced without due regard to losses. Once the decision to automate the shopfloor has been made, the next steps are far from trivial, and a successful implementation is not guaranteed. Many companies simply do not have the workforce. One reason for this is the continuing shortage of skilled workers. Worldwide, companies lack qualified personnel but especially in the DACH region. Another reason is the strong involvement of existing staff in day-to-day business, which leaves hardly any time for additional digitalization projects. Training the existing staff would be an obvious solution here. However, over a third of respondents are unhappy with the training opportunities offered to them (Figure 23). The problem of a lack of personnel is therefore still omnipresent. More than half of the companies are finding it difficult to recruit qualified employees (Figure 24).

Reasons for delayed introduction of
Industry 4.0 technologies

55 PERCENT

of the companies surveyed have problems
finding qualified employees.

In some cases, the labor market is simply not productive enough to attract enough talents across all experience levels and areas. In addition, it is clear that the companies are strongly focused on current events and the present economic situation. The companies are currently showing a lack of willingness to work with qualified personnel on future-oriented projects. Day-to-day business takes up too much time, yet automation solutions would relieve the burden on employees, giving them more time for future-oriented projects.

Recommended action

It turns out that the potential to further automate processes on the shopfloor using digital technologies has not yet been fully exhausted. AGVs, AI, and simulations are just the start. The associated increase in efficiency is only one benefit. Likewise, every company should strive for increased resilience, flexibility, and quality to meet increasing customer requirements. But companies must act even beyond this promising potential. The lack of progress in digitalization, especially in the DACH region, is still evident. Aggressive competitors, often from the Far East, use considerable resources and have therefore already left many of the Western companies behind. In order to resolve risks such as the shortage of skilled workers, the DACH region, in particular, as an economic location, must continue to drive forward consistent digitalization.

Admittedly, it seems counterintuitive to think not only of present challenges, but also future challenges when we are living in such uncertain times. After all, nobody knows how the economic situation will develop. Creating reserves is therefore a safe strategy but it may turn out to be a fallacy because only those who act today will be able to compete tomorrow and meet the increasing demands. If your own skills are inadequate due to a shortage of skilled workers or a lack of capacity, you should externally procure the relevant personnel for a limited period of time. Certain risks must be taken so you can take advantage of new opportunities. The remarkable increase in data analytics and AI over the previous year offers much hope for the future. But it should also be stressed that automation should not be implemented at any price. Quite the opposite, in fact: There is always a need to assess the relationship between the purpose and benefits of a use case and the risks and any disadvantages that may exist.

Interview
Dr. Frank Scheppe
Lead of Operations Läpple Automotive

Läpple Automotive – Short profile

LÄPPLE AUTOMOTIVE GmbH is a leading provider of sophisticated forming solutions in car body assembly for premium vehicles and a specialist in sheet metal part forming. Our core activities include the production of serial parts and original spare parts. That is what sets us apart – that is our strength. We have a wealth of expertise and many years of experience in handling and processing a wide range of materials, such as steel, aluminum and high-tensile steels. This makes LÄPPLE AUTOMOTIVE a highly competent partner that customers can rely on for any issues relating to body part production.

In total, LÄPPLE AUTOMOTIVE employs 1,120 people at its two sites in Heilbronn and Teublitz (Germany). In 2021, it generated a turnover of approximately 327 million euros. LÄPPLE AUTOMOTIVE belongs to the LÄPPLE Group, an international group of companies which operates within the forming and bodywork technology, automation systems engineering, mechanical engineering and tool making sectors. As a member of this family, we share the same values and responsibilities as every other company within the Group.

Dr. Frank Scheppe – Short Vita

After studying metallurgical and materials engineering at RWTH Aachen, he worked as a scientist in the Foundry Institute at RWTH Aachen. Taking up a position in alloy development at KS Kolbenschmidt GmbH saw him move into the automotive supply industry. After spending an extended period of time in the USA, he took on a plant manager role for KS Kolbenschmidt GmbH at the company's site in Neckarsulm. Other important posts he has held in his career were the Managing Director positions at Federal Mogul Nürnberg GmbH as well as Federal Mogul Valvetrain GmbH. After 18 years in the powertrain sector, he moved to LÄPPLE AUTOMOTIVE GmbH in 2019 as Operations Director.

Interview

Participants: Dr. Frank Scheppe (Läpple), **Dr. Walter Heibey** (MHP), **Caspar Koltze** (MHP)

Dr. Walter Heibey (MHP): What does digitalization look like for you at a midsize company and what are Läpple's focus and goals in terms of Industry 4.0?

Dr. Frank Scheppe (Läpple): Firstly, we have topics relating to Industry 4.0, where the goal is a fully digital production, from EDI (Electronic Data Interchange) to logistics. In addition to the conventional concept of Industry 4.0, we are dealing with Automation 4.0 at the same time. This is not just about monitoring the process, but also about creating a digital twin of the product, based on which I can then make extrapolations and observe the development. This enables me to detect issues at an early stage and react accordingly, for example with the help of AI. Automation 4.0 is another important step toward Industry 4.0.

Dr. Frank Scheppe, Lead of Operations Läpple Automotive

Heibey: Is it right to say that customer demands or your own efficiency and quality requirements act as drivers for Industry 4.0?

Scheppe: We have to be competitive. But how can we achieve that? By digitalizing standard processes, I can

take a step towards achieving a certain level of productivity. The question we asked ourselves is: How can we maximize our plant availability or staff productivity even further? These are the motivating factors for driving forward the topic of Automation 4.0.

Heibey: Implementing digital or Industry 4.0 technologies can be expensive for small and midsize companies. How do you finance the costs associated with implementing digitalization projects? Do you work with other companies or external partners?

Scheppe: We cannot do this on our own. But we know that some initial internal funding is required. This means that we have a digitalization team consisting of R&D, Production and Maintenance, which deals with completely new ideas within the framework of Automation 4.0 as well as the implementation of existing areas. Nonetheless, we need a partner to help us map the entire database structure correctly. We need a solution that is independent of specific individuals in the long term. It was also important that we set aside boundaries between our divisions, especially in the collaboration between Operations and IT. By doing so, each division can mutually benefit from the other's ideas. We have removed these boundaries at the top level, which was crucial to bringing our people on board.

Heibey: There are some low-wage countries, such as China, that have a strong economic position. In my opinion, this is one of the main reasons why we have to address digitalization if Germany is to remain relevant as a place to do business.

Scheppe: Because we produce larger body components, logistics is crucial for us. Our location in close proximity to our customers is advantageous. Due to the logistics factor and the size of our components, competitors from low-wage countries play a minor role. However, our direct competitors have also recognized the advantage of location and based themselves in the customers' vicinity. Therefore, our survival instinct is to have better and more innovative ideas in order to stay ahead of the competition.

Caspar Koltze (MHP): Is Läpple really competitive if you consider the skilled workers and wage structures that can be found abroad?

Scheppe: With our German structures, we will have no chance abroad. It is a misconception that we in Germany are immune to competition, because China has the same technologies and the same knowledge. We currently already source the majority of our press tools from the Chinese market, which largely comply with the usual standards here (e.g. press shop simulation) while at the same time being available at a lower cost.

Koltze: Is it possible for digitalization to compensate for the shortage of skilled workers in Germany?

Scheppe: The shortage of skilled workers is, of course, a major problem for us as well. Digitalization could further reduce the number of people employed at the production facilities. The resources that would be made available could be used to plan new topics ahead of time. However, employees need different qualifications for this. This is why we are faced with the challenge of changing job profiles and training staff accordingly. But yes, digitalization is one answer to the shortage of skilled workers.

Heibey: Is it easier for you to get the digital skills you need on the skilled labor market than those that you actually need in production?

Scheppe: Yes and no. We need to learn to bring people on board and make automotive suppliers an attractive field to work in again. We observe a certain amount of aversion to the automotive industry because it is supposedly stressful and has high workloads. Work-life balance is a crucial factor, especially for the new generation of graduates.

Heibey: This means that a significant part of this digital transformation, which also involves a transformation of the skilled workforce, has to take place in your company.

Scheppe: Yes, that's right. This process of change is a second challenge for me. Installing software or saying that the digital twin is now up and running is one thing, but I also need people who are willing to work with it. They need to take note of a suggestion that appears on the display and deduce what actions are required by themselves – and then implement them.

Heibey: On the topic of Automation 4.0: What steps have you taken in this regard over the past ten years?

Scheppe: I don't have to go back ten years at Läpple, because we only started working on this topic three years ago. We had realized that due to the increased complexity, we were no longer able to simply continue working as we had done before, e.g. by making iterative adjustments to the production systems. Since the increased requirements could not be offset by employing more staff for example, we only had the option of developing ourselves – there was no alternative. The beginnings were therefore born out of necessity.

It's quite different to actually experience something like this rather than just seeing it on paper, because everyone had already read about it.

Heibey: How cooperative were the plant manufacturers and partners with whom you work?

Scheppe: We've now reached agreements with all plant manufacturers so that we receive the process data. In the beginning, nobody really wanted to participate in this initiative, but it has gradually gotten to the point where almost everyone is on board. It is a tough business, but we have made use of our connections to OEMs.

Heibey: One of the problems is a lack of standards.

Scheppe: In our case, the proportion of employees checking parts and maintaining the plant was higher than the number of staff who performed a value-adding activity; we had to take steps to address this. This is now done by a computer, so that we don't need a specialist carrying out manual activities such as measurements or similar. These are now the driving forces that will take us further. We have to implement this consistently.

Heibey: You also have a special challenge due to the number of joining processes that you use. Here it was the digital twin that helped you to understand the context of the data or to model the various joining methods for example. Was that an essential driver to get as much out of the data as possible?

Scheppe: Firstly, we had the digital twin and were able to connect it to the joining data and technologies. Another aspect is that we're now using algorithms, which help us to anticipate further development.

Heibey: Many organizations struggle with data strategies. It's often the case that huge amounts of data are pumped into a data lake and nobody knows what to do with it. That is why it is so important to see and understand the context of the process. This initial understanding of what happens in which joining process and the context surrounding the data is an essential step in a data strategy.

Scheppe: This is also the first thing that has developed in our company. We started with plant malfunctions and then moved on to joining technology. When we capture and understand the processes, we already have all the data. Here, the data strategy has emerged as a logical part of our activities. This was ultimately an iterative process that has led to us having a digital twin that still lives on today.

Heibey: This means that the digital twin is not only a shadow, but also something that should actually intervene in the process. Part of the process orchestration is then done via the digital twin.

Scheppe: Yes, that's right. Through the digital twin, I can see how something develops. Either I have to intervene externally, e.g. because a wearing part somewhere needs to be replaced, or parameters can be adjusted. Ideally, the plant can do this itself. We have already taken some initial steps with an AI, which so far haven't been very promising. But anyone who learns to walk will fall along the way. There is still a lot to do before AI begins to take control. But I think we have been setting a frantic pace over the last three years and we have that as a tailwind behind us.

Heibey: It also requires a degree of confidence to allow this to happen. At the moment, these are suggested values. It is one thing to present these to the worker. However, when it comes to actually sending them back to the plant, you really have to be sure that they are the correct parameters.

Scheppe: This can only be done by looking at the end-to-end process.

Heibey: Do you have automated guided vehicles in use?

Scheppe: Yes, that is what I understood by the classical vision of Industry 4.0. In our body construction facilities, we currently operate automated guided vehicles that are controlled by the process. This was a next step for us. Previously, we only had driverless transport systems that drove from A to B when instructed to do so. We now have intelligent vehicles in the plant. At this point, production is almost completely digitalized. Our fundamental goal is for the entirety of our production to be completely digitalized. We have achieved this for a large part of our production, now we have to gradually roll it out on new projects as well.

Koltze: Has the quality improved measurably through the use of the described solutions?

Scheppe: Yes, we can see this firstly in the measurement data that we have and secondly in the rejection rate, which is now much lower. We are talking about an improvement of around 10 per cent or more. We have also seen another improvement in terms of plant availability.

Koltze: Both of these issues are important, but it ultimately comes down to economics. Do these digital solutions pay for themselves or are you not yet at the point where you can see a financial gain?

Scheppe: Yes. After all, we do need to make money. You can make initial funding available, which has already happened, but projects like this also have to be backed by a business case. We can see this in terms of personnel efficiency, staff deployment, quality and maintenance, which is why we can now take the first steps to assign employees to other tasks. The result is that I need fewer skilled workers. I am amazed and proud that we have managed to achieve measurable and sustainable success in three years or so. This means that we have been able to achieve efficiency in personnel deployment planning. We monitor this very closely, week by week and month by month.

Heibey: So, I think the room for maneuver that you have as a midsize company is probably quite different from that of a corporation. What is pleasing is that it is a good approach to how medium-sized companies can deal with the topic of digitization.

We would now like to talk about sustainability: What measures have you already taken in your production? For example, in terms of traceability or your CO2 footprint?

Scheppe: The issue of traceability of our components is gaining momentum. We are now able to prove where most of our purchased parts come from. In addition, we have digitalized our entire scrap process, for example – i.e. our presses are equipped with RFID chips. When the container is full and picked up, we know exactly which scrap it contains and from which order, as well as the material quality. As a result, we no longer have steel and aluminum being mixed and can hand over the containers sorted by content, which is an enormously important factor for recycling. To an extent, we are even able to operate what is known as a closed-loop approach. This means that we bring the material we receive from the supplier back to the supplier. As a result, they do not have to accommodate other material quality classes. They get material of the same quality they sent to us back from us as waste after pressing.

Heibey: This is a very interesting point about the extent to which digital controllability and tracking, so to speak, feeds back into these cycles.

Scheppe: Yes, ultimately we have linked sustainability to being economical at the same time. This is a win-win situation. Another topic that we are about to implement is lighting control in the halls. I only want to have lights on in places where work is being done, and only when work is being done there. For example, I also don't need to have lights on where AGVs are driving.

Heibey: How concerned are you that regulatory requirements will become even more stringent, especially in your sector?

Scheppe: I think there is still a lot to come. Whether in terms of energy prices, as we are currently experiencing, or obtaining steel and aluminum as raw material, which is even more of a concern. There simply isn't enough green steel to meet the current demand. It will be interesting to see how we handle it. Simply trading CO2 certificates is not the solution. That is not sustainable, and I see that there is a lot of action still to be taken.

Heibey: If you look ahead even further, what are your long-term goals for the next five years? What will your production look like then?

Scheppe: We will probably not be able to operate the entire factory without staff, but I would like that no skilled worker has to insert any parts in the plants anymore. I imagine that we will also handle maintenance differently compared to today. There will be no specialist standing next to the plant. They will be in another room and will be able to intervene when needed. We are very well positioned thanks to the pace at which we have developed recently – and there is still a lot to come in this respect.

Interview

José Gascon

Head of Digital Industrial Affairs Technology Expertise and Innovation Sanofi

Sanofi – Short profile

We are Sanofi. We are an innovative global healthcare company, driven by one purpose: we chase the miracles of science to improve people's lives. Our teams across the world strive to transform the practice of medicine, turning the impossible into the possible for patients. We provide potentially life-changing treatments and the protection of life-saving vaccines to millions of people, and affordable access to our medicines in some of the world's poorest countries.

José Gascon – Short Vita

I lead the Digital Operations in the Industrial Affairs Digital Center within Sanofi, supporting both manufacturing and distribution with a footprint of 70 sites and 40 000 users. We develop a portfolio of digital solutions for the factories of the future to boost manufacturing performance and distribution channels to support the transformation of ways of working and the manufacturing of drug substances and products. We developed a robust IIoT equipment connectivity to sustain data foundations to perform analytics, machine learning and digital twins that allow site managers to adjust on the go and simulate manufacturing process changes.

Before Sanofi, I worked for more than 20 years in Faurecia, Automotive tier 1, leading the Applications and Enterprise Architecture teams and providing central CoE with focus on SAP, achieving a worldwide deployment of SAP within our over 250 factories.

Interview

Participants: **José Gascon** (Sanofi), **Dr. Walter Heibey** (MHP), **Felix Ludmann** (MHP)

Dr. Walter Heibey (MHP): Talking about Shopfloor Automation: given the fact that the normal problem within the Pharma industry is that factories are unique and not easily adaptable regarding the products they are producing: how is the current situation in the production of vaccines and pharmaceuticals?

José Gascon (Sanofi): The objective is definitively to go towards a much more modularized manufacturing approach. Setting up manufacturing campaigns and being able to adapt the equipment and the manufacturing areas according to these campaigns. It will not be at the level of the Automotive industry, with one-piece-flow. These campaigns will be a group of batches. This enables them to adapt to another campaign with another set of batches, for a different product or a different variant of the product.

José Gascon, Head of Digital Industrial Affairs Technology Expertise and Innovation

Heibey: We all saw that with Covid-19 there is a higher need to become more flexible. What are the trends driven by digitalization allowing you to remain competitive?

Gascon: Clearly the pandemic conditions have been an eye-opener. The most immediate approach to higher supply agility was to reduce cycle times, both in the introduction of new medicines and manufacturing. We have leveraged digital extensively to enable cycle time reduction and eliminate bottlenecks across our manufacturing plants. Another trend is the application of data and analytics to both improve demand planning and deliver better and earlier insights on potential disruptions. Finally, but this takes longer, we also focus on creating higher levels of modularity in our manufacturing assets and production processes. By creating common manufacturing platforms we increase flexibility. This also enables us to ensure we have production backups without overinvesting in capacity.

Heibey: Given your expertise on the Automotive industry, what do you think are the largest challenges for Sanofi in comparison? What is different to the Automotive industry?

Gascon: Well, first, there are probably more similarities than differences in digital transformation challenges. However, one difference is that the pharma quality system, based on GxP (Good Practice), is still deeply infused with human and manual mindset and strict legal consequences. This can be a major blocker for effective digital innovation. We have demonstrated how this can be overcome, but the remaining quality overload of even minor changes is still a blocker to implement continuous improvement dynamics. I should add that in biopharma we cannot rely solely on quality control of the finished product (as in Automotive), because you cannot fully characterize biological molecules. Therefore you need to apply quality control all through the production process. Another point: in Pharma, the backbone of the company is scientific R&D and clinical activities, not manufacturing or marketing as in most consumer goods. This makes it more difficult to apply some of the manufacturing-led digitalization of the Automotive industry.

Heibey: Looking back, which decisions related to Industry 4.0 have added the most significant value to Sanofi in recent years?

Gascon: Probably the decision to start the digitalization journey. Building digital applications, even if some of the foundations are not yet completed, is one of the biggest achievements for me. You will always have to improve integration and automation, but I think what the digital journey really showed us: digitalization is the best companion for improving the foundations. The visibility that digitalization brought helped us to refocus and to go directly to the root cause of certain inefficient processes. I would call it a discovery instead of a decision. Pushing for digitalization is an enabler for improving the foundations.

Also, standardizing shopfloor automation by defining a core standard allowed us to scale the connectivity. Even if we may not be ready to consume and maximize the value of all this data just yet, having an industrialized mechanism to connect and scale helps to bring new ideas and use cases on how to use this data. Now we have big data ready to use. However, through the case-by-case approach you connect best of breed, and at the end you have multiple standards in place to connect your data. This brings new challenges every time you connect new equipment or technologies.

Finally, we made a very important decision to internally own our digital delivery engine. Of course, leveraging external expertise and resources but owning with our own teams the technology choices, architecture and agile delivery practices. We would never have been as successful if we had outsourced all that.

Heibey: I would fully agree to the exposure of the deficiencies, no foundation is perfect, data is never perfect. But having a purpose of what you want to achieve exposes what is really needed and what is not. That drives a necessary foundation which makes the difference.

Vaccines (besides biopharmaceuticals) are one of the most critical products for companies in the Pharma industry. However, they are only demanded seasonally – which leads to downtime in production. You're looking to the modularization to compensate for these things, how far are we with the modularization, is it still going?

Gascon: This doesn't apply for all vaccines, pediatric vaccines for instance have a different profile. Flu is of course seasonal, but we have some balancing with northern and southern hemispheres. It helps being a global player. But overall, yes, the issue remains, and pandemic conditions put it at yet another level of urgency. We have been working on this for a long time. Our recent new biologics plant in Framingham near Boston that opened in 2019 was a great step forward in modularization and flexibility. You have probably also heard of EvF, our upcoming Evolutive Facilities that will be opening in 2025 and are build upon the Framingham concepts but at a significantly higher level of modularization.

Heibey: That means that until then, factories can only produce things that are not modularized. That

is the problem, factories are purpose-built and not modularized.

Gascon: You really need to distinguish between different types of plants. The issue is very different between biologics or vaccine drug substance plants that indeed were traditionally purpose built, and then drug product plants on the other hand, typically filling and packaging syringes. For the latter we have had flexibility for quite some time and we can seasonably support required vaccine capacity from other plants. We are also leveraging digital within our asset performance programs to deliver better volumes with the same production assets, improving changeovers between products on a line as a main driver. For drug substance the challenge is larger, and this is where our investments in Evolutive Facilities come in. But this also requires an investment in R&D and process development.

Modularization is indeed a component to mitigate these challenges with regard to the required seasonality. For instance, when leveraging modularization during the flu season, the factory will do different batches to produce for the flu campaign and then switch to another campaign or be prepared for other vaccines.

Heibey: This is a flexibilization on modularization on a completely different time scale than what we see in the Automotive industry. It is not the one-piece flow we have, but is based on a campaign, because otherwise the whole factory would be at a standstill for the time out of season. At the moment, in times of ambiguity everybody is talking about flexibilization, but they are usually not precise on what scale they want to be flexible. I think this is a very good example where a large scale flexibilization still can have a tremendous impact.

Gascon: I think it is not comparable with the Automotive industry. When you produce a car, you are not going to produce millions of one specific model because you customize to the customer preferences. Within Pharma, outside the case of truly personalized medicines such as cell therapy, we need flexibilization, but ultimately we must produce hundreds of millions of doses of the same drug or vaccine which requires weeks or months to produce the needed volume. In vaccines concretely, we still target focus factories with high volumes of production but with more flexibility to adapt the mix via campaigns. In many cases there is more opportunity in leveraging innovations on process intensification with smaller production assets, continuous flow production instead of batch and overall yield improvement. Again, digital is a key enabler here.

Heibey: That is interesting, because in the Automotive industry one of the theories is that people are converting to micro-factories, that would be quite the opposite. But as you said, it is a completely different regime, they do not have that offset of validation and the GxP efforts that you have. That is why we see a slightly different trend in the Pharma industry compared to what we see in Automotive industry.

Talking about how you achieve the modularization, what technologies have you used for that, for example digital twins or AGVs? To what extent were these things used to achieve modularization?

Gascon: We've used AGVs and fleet manager systems with warehouse integration for many years. The difference is, before, we moved the material from the warehouse to fixed locations and now we need an extra intelligence to dynamically determine the location in which a certain batch is being produced. AGVs bring flexibility to deliver the needed material to each zone in the factory. Automation with the Distributed Control System (DCS) with an integrated, flexible setup allows us to configure the modules much faster. One of the key challenges is really the master data setup. It is complex to set up this environment which includes the bill of process, the different equipment and how you need to set up the equipment for every new campaign. Now we are defining modules to reduce the time for this setup and maximize the efficiency of the campaign. Same as for the Automotive industry where you have frequent changes to adapt to the customization required but you must maximize the value you produce and minimize the time for it.

Heibey: To manage digital continuity would be beneficial, but on the other hand, there is always a certain amount of effort that you have to go through and that is probably a big cultural change. For example, processes that were established manually and paper based to something that is more digital. In the automotive world PLM Systems have relatively well established that link between engineering and production. You have a bill of material that is being transmitted but the rest is manual.

Let's talk about the equipment. I remember there are discussions that some of the bioreactors could be provided by the manufacturer to do the complete fermentation process. So that is only integrated into the DCS

on a certain abstraction level rather than controlling every sensor directly. Is that being done, do you know whether they are pursuing that?

Gascon: It is indeed one of the directions we are pursuing. For bioreactors but also for the different equipment in upstream and downstream processes. As you suggest, the goal is really to construct self-contained modules with a simple and configurable interface towards the DCS.

Heibey: Thus, the machine vendors offer not only the bare machines but also provide capabilities. It's interesting to automate and orchestrate because that's basically something you do in a good software architecture that basically consume certain methods of the underlying of equipment. In the Automotive industry, however, we are miles away from that.

Gascon: The biggest challenge is that some equipment vendors don't have any kind of open data approach. They offer the equipment and in the new model additional services too. While we are interested in new services and embedded intelligence, we are not on a black-box approach and we are also interested in being able to capture the raw data and to analyse that data to improve our knowledge and our expertise of the process. Therefore, it is about interfaces and the openness of that data and how to get the value of that service from this equipment provider, but also integrating the data in our foundations. We are actively working with the equipment providers on this.

By the way, this is not only the case for production equipment but also for lab instruments where we are seeing the same kind of innovation in instrument software without any real standards or open architecture. It is another important area we are progressing on.

Heibey: The machine vendors are quite protective with regard to their data. You have to sell twice, you have to buy twice, you have to buy the physical equipment and then you have to buy the data which is a nice upselling for them, but it's not open as you described it.

In terms of quality controls, is there anything that has improved in that respect? Something like inline tests, continuous quality controls or even automatic quality controls?

Gascon: Moving quality controls inline to the production process instead of sampling and a cycle through the quality labs is a major trend where we are also seeing major innovation in smart sensors that will change the game a lot. It is a gain in productivity, better process control and reduction of cycle time. Another key area is parametric release. If you continue the comparison with the Automotive industry, this is similar to what Automotive achieved with the massive introduction of CAx simulations to reduce the volume of physical crash tests. While this does not mean reducing the crash tests to zero, some crash tests are needed for safety parts. But it saves a lot of time and, above all, improves quality and accelerates the time to market.

With parametric release we obtain assurance that the product is of stipulated quality and meets its specification. Parametric release is based on evidence of successful validation of the manufacturing process and review of the documentation on the additional process monitoring carried out during manufacturing. Consequently, parametric release is used as an operational alternative to routine release testing of certain, specific parameters. We thus expect that the number of mandatory physical tests in the line can be reduced – thanks to parametric release and the comparisons that take place during continuous data collection in the line. This continuous data – which triggers a comparison with the regularly collected volumes and thresholds – shows us when to increase the number of tests or when to maintain the minimum number of tests, as the thresholds and data already provide a level of confidence that does not require us to perform the same number of tests.

Heibey: Talking about validation: is there any idea how industry 4.0 or digitalization in general can support on validating elements? Is there any way of speeding things up? Does digitalization provide you opportunities to speed up or enhance the ability to be GxP compliant to speed up the validation process?

Gascon: This is really an emerging area in Pharma. We have been doing virtual commissioning for some time, mainly for automation. In new process development we are also leveraging digital design of experiments and automation to converge faster on the target design space of the process.

Heibey: What are some specific cases where you use digitalization to enhance the speed of the validation process?

Gascon: Yes, the potential here is huge. For instance, a very promising area we are exploring with our Evolutive Facilities is to leverage lifecycle models of process, equipment and plant to enable simulations and automated qualification and validation of a campaign configuration.

Heibey: In the Automotive industry we have this idea of "factory as a firmware" where you are basically able to deploy new products quite quickly to other locations. And I think what you mentioned: the ability to have that integrated into the PLM Process and have that link is a prerequisite. Otherwise, it is not that easily possible.

If bioreactor provides you with a capability of a fermentation process for example, you don't control it on I/O Level but you control it on a medium level or on a process level. Is there any thought that the supplier of that equipment would basically sell you pre-validated processes? Is that something that might be coming? So basically, you get pre-validated in these boundaries of these parameters, it is always a fermentation process?

Gascon: I think it is a great moonshot ambition, but I am not sure it will happen in biopharma first. For the moment, we probably have too much variability in the biology of our processes for this kind of approach and, trust me, fermentation for biomanufacturing requires some finetuning of the processes. And in the end there is the question of liability that equipment providers are not ready to take on.

Heibey: Yes, I think the equipment provider will shy away from that for liability reasons, so they might only provide critical control parameters. But then the actual validation process still lies with the pharma company.

Let's look on another aspect: which measurable achievements have you already seen as result of successful automation digitalization projects (revenue, net profit, OEE, planned cycle time)?

Gascon: Plant cycle time is one of the ideas that has seen more evolution and better improvements. On one hand because it is an indicator but with many input indicators that are contributing to this one. So, reduction of deviations or improvements on OEE influences this.

The second one, with quite significant benefits, is the reduction of deviations thanks to the AI digital deviations intelligence. We have those clear and measurable achievements and significant reduction of deviations. Also, the product became GxP and was officially adopted by all the vaccine sites massively. The validation of the product has an important effect on the adoption by the users and the results are welcoming.

Heibey: The drawback of the campaign-based manufacturing is the high amount of disposable plastic that comes in between. Is Sanofi or the Pharma industry trying to compensate for that from a sustainability perspective (e.g. for creating waste or using water)?

Gascon: Yes, definitely. We have a program called "Planet Care". So, over the years there have been many initiatives through the program to improve our use of recyclable water. We have also a program on energy utilization, and the current trends on sustainability and carbon neutrality have really boosted this program. We have moved from a few pilots to deployments in 15 locations. Our goal is carbon neutrality, achieving net zero GHG emissions by 2050. To use as much solar energy as possible and recycle the water and heating are just a few examples we promote to optimize our energy consumption throughout production.

Heibey: Do you have some KPIs already that are collected company-wide for some of the sustainability figures?

Gascon: Of course we have general ESG metrics that we monitor within our Planet Care initiative. Since 2019 we achieved 25 percent reduction in GHG emissions, and 59 percent of our electricity across our activities comes from renewable sources.

Heibey: Do you apply some circular economy approaches? If yes, where are your use cases?

Gascon: Yes, we have a few approaches with regards to recycling devices and removing packaging when possible and safe. We are trying to remove as much as possible, for example, moving to digital leaflets and printing barcodes directly on the device. The idea is trying to digitalize the information flow as much as possible and also to simplify and to reuse the packaging of the device. Another approach we are taking, especially for new products, is to perform an eco-design and lifecycle assessment early in the stages of the product. Sanofi has committed that all new products launched from 2025 will have gone through a detailed eco-design approach.

Felix Ludmann (MHP): Reusage and recycling can also be applied to the production, for example bioreactors or production equipment. Is there currently something happening on the production level instead on the product level?

Gascon: Yes, in the classical approach in our industry with the stainless steel bioreactors. But you still need to use a lot of cleaning products etc. that might not be optimal. On the other hand, what I mentioned, when we use reusable plastic bags etc: they are disposable and you need to throw them away or recycle them. You cannot reuse them right away.

Heibey: The flexibility comes with the plastic bags and their ability that you don't have to decontaminate the equipment anymore – because you can just throw away the equipment. But it comes with the costs of higher number of plastics. That makes it inherently difficult to say where the benefit is.

The big question: is industry 4.0 still relevant in the company at all? Are the daily challenges in focus or does industry 4.0 perhaps serve as a key to master these constantly changing requirements and increasing flexibility in the company? What is your view on this question?

Gascon: I would say Industry 4.0 is more relevant than ever. In the Pharma industry the information flow is much heavier than the manufacturing flow. So, industry 4.0 brings the possibility to automatically improve performance and efficiency on the management of this data and information flow. Everything that could help us reach this goal of zero paper or paperless information flow allows us to gain time and speed. Everything that will be digitalized could feed future automation or could even make the decision-making process within manufacturing more agile. So, even without industry 4.0 being a direct part of the manufacturing process, the values that it delivers into the information flow and into the administrative part of the process is huge. It has an indirect effect on the product itself and increases quality in manufacturing and deviations, etc.

Heibey: Does Sanofi have enough know-how and resources to implement new innovative technologies themselves?

Gascon: Yes, I think we have both. In the digital domain and with knowledgeable people we can implement connectivity. And with quite good knowledge and the standard protocols we use in this domain also in the domain of manufacturing, we have quite good expertise in terms of process control and technologies in the manufacturing process.

Heibey: Does the topic of sustainability make Sanofi look beyond the company's own boundaries across the entire value chain already? Because this is a big topic in the Automotive industry. The big OEMs are forcing the suppliers more and more to look into this. Are you doing something similar?

Gascon: As said, our Planet Care initiative is focussed and committed to reduce the potential impact of Sanofi's activities on the environment. We are also member of the Energize program, a coalition with nine other pharmaceutical companies helping suppliers in our shared supply chain to convert to renewable sources and reduce GHG emissions across our value chain. You know we created a company to make sure that we have less dependency on external providers for API substances. These were traditionally imported for years and have almost been removed from Europe. With that, we plan to be more resilient and be able to solve internally for those processes.

Ludmann: One of the topics that we found is that companies like to push sustainability back in busy times and in the daily business it has not such a high priority. Can you see something similar happening in your company? That sustainability-related projects are pushed back further?

Gascon: This might be more the case in Automotive and in other industries rather than in Pharma. At Sanofi, we chase the miracles of science to improve people's lives. This comes hand in hand with a mindset to build a sustainable future that will contribute to a better life for people. Sustainability is in the DNA of the organization.

Success Story
FlexFactory & V Frames

FLEXFACTORY
by MHP | Munich Re | Porsche

Development of the bicycle frame factory of the future for V Frames

In a project with the bicycle frame manufacturer V Frames, a concept was developed for the frame factory of the future at its site in Schmiedefeld, Germany. MHP worked on this together with FlexFactory – a joint venture of MHP, Munich Re, and Porsche – to develop a financing and operating concept in addition to the technical concept.

Initial situation and challenges

V Frames has developed an innovative process that allows complete bicycle frames to be produced from carbon composite material using an injection molding process. While conventional aluminum frames are mainly manufactured by hand in low-wage countries, the new technology enables local production in Germany at competitive costs with significantly shorter transport routes and delivery times. Local manufacturing minimizes transport emissions and ensures adequate social standards during manufacturing.

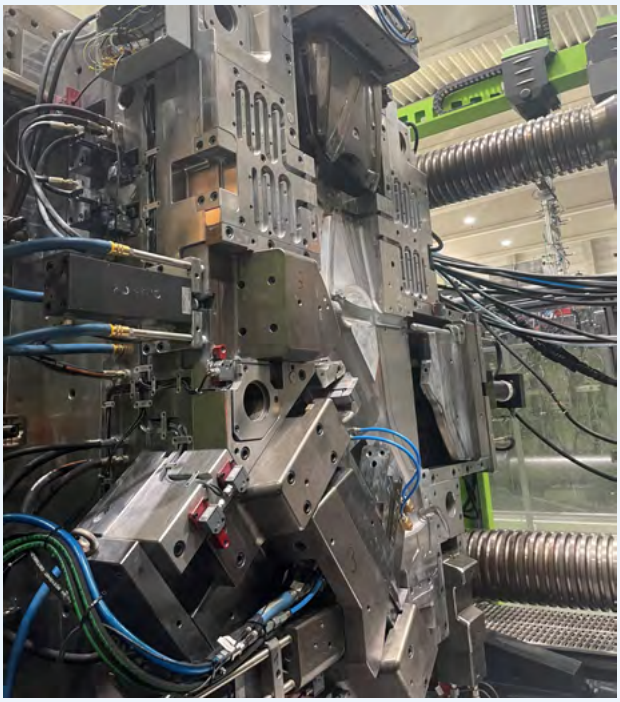
V Frames is facing rapidly growing demand from bicycle manufacturers, which has resulted in the need for rapid scaling of an innovative, capital-intensive frame production. Since there was no space left in the existing factory, V Frames needed a new production facility. The main requirements for the production facility were flexible expandability, transferability to other locations, economic automation and digitalization, as well as external financing.

Procedure and operation

MHP and FlexFactory worked out the target vision for the new factory in five project modules: production process, factory layout, digitalization concept, business case, and financing concept.

First, the future production and logistics process was developed. We had to weigh up the economic viability of different automation solutions. The optimal operating point turned out to be a hybrid model of automation and manual work. For example, the material feed to the injection molding machines is automated with a material transport system, but the tool change is still carried out manually. The structure of the new factory is such that external companies can also use the capacity of the injection molding machines to maximize the utilization of the machines during ramp-up phase. This means that other products, such as boxes and pallets, can also be manufactured in the factory.

The factory layout was derived from the target process. MHP used simulation to determine the size and range of incoming, temporary, and outgoing warehouses. It was possible to optimize the layout of the machines by visualizing the value stream in production. We selected a group layout that is aligned along the value stream, so that the machines can be used and extended as flexibly as possible. By holding



workshops with employees from different functional areas, we were able to ensure that the target layout also meets the needs and expertise of the employees.

A digital twin of the bicycle frame was planned as part of the digitalization concept. Among other purposes, it was designed to parametrize the machines and for the tracing processes in the field. The factory layout also included server rooms for storing the nec-

essary data. In addition to the digital twin, we also allowed for further digital solutions in the factory, such as a light-guided control for curing the bicycle frames.

We transferred specific cost estimates from suppliers into a comprehensive business case, which was designed so that it could be easily reviewed by external investors. We developed and evaluated different options for external financing and structuring of the investment in the factory. Specifically, we weighed up both conventional means of financing – such as bank loans or equity investors – and alternative financing concepts, such as venture leasing and production as a service.

Results and Outlook

The project made an important contribution to VFrames' vision of bringing bicycle frame production back to Germany and making it more sustainable. The structure of the new factory allows external investors to invest tens of millions in machinery, plants, and buildings – with a risk-adequate expected return. Using injection molding equipment externally during the ramp-up phase has reduced the production costs of the bicycle frames by approximately 12 percent during this phase. One of the "lessons learned" is that, in the case of external financing, the conditions and willingness to take risks of the different parties should be coordinated as early as possible. This enables the risk profiles of different investors to be identified at an early stage and the risk-return expectation to be tailored appropriately. In addition, potential providers should be approached as early as possible so that relevant specifications and thought-provoking ideas can be incorporated when planning the layout.

2.3 Sustainable Operations – Sustainability in the Value Chain

In recent years, sustainability has become enormously important both in the media and in the public discourse – driven by numerous natural disasters worldwide, including probably the worst drought in Europe in 500 years due to climate change or the rapidly growing volumes of waste in the world's oceans. In light of this, we are becoming more and more aware that the resources of our planet are finite and "continuing as before" will have a terrible impact. That is why foresight is needed now more than ever. The long-term challenges posed by the constant pursuit of increased economic growth while preserving our livelihoods have not yet been resolved.

As stated in the previous chapter, profitability is still the central goal for companies. The profit margin needs to be as high as possible and this can be achieved by making adjustments in two places: Sales can be increased and costs can be reduced. According to the lean principles, minimizing waste is the first port of call for reducing costs: The less time and resources in a process are spent on non-value-adding activities, the higher the overall efficiency.

But reducing waste has more than just economic benefits This is why companies are focusing on sustainability. Nowadays, it is not just because it sells well and suggests to customers that they are taking responsibility with their consumption and making their contribution to environmental protection. Yet sustainability involves much more than just protecting the environment. Human rights and sustainable economic management are also components of sustainability, which is now being introduced into legislation with the "Act on Corporate Due Diligence Obligations for the Prevention of Human Rights Violations in Supply Chains" (Lieferkettensorgfaltspflichtengesetz, LkSG), which enters into force on January 1, 2023. Sustainable operations means pursuing the sustainable use of resources in production and reducing harmful environmental influences while also enabling a profitable and future-oriented operation.

Companies' supply chains extend far beyond their own boundaries and legal responsibilities, which is a critical issue when it comes to sustainability. Sustainability must be taken into account holistically, even if this means taking more than just your own company into consideration. Such an undertaking entails an enormous amount of effort. There is a need for transparent supply chains and new manufacturing technologies, not least of all to reduce CO2 emissions along the entire value chain. A real-world example is the success story about the data ecosystem Catena-X at Volkswagen. Furthermore, we must find and start to use new alternative energy sources. Ending the use of fossil fuels coupled with an energy shortage caused by geopolitical developments have created a desire to gain more independence and to promote and use green technologies. Industry 4.0 is an important driver for greater efficiency, reducing waste, and stopping emissions.

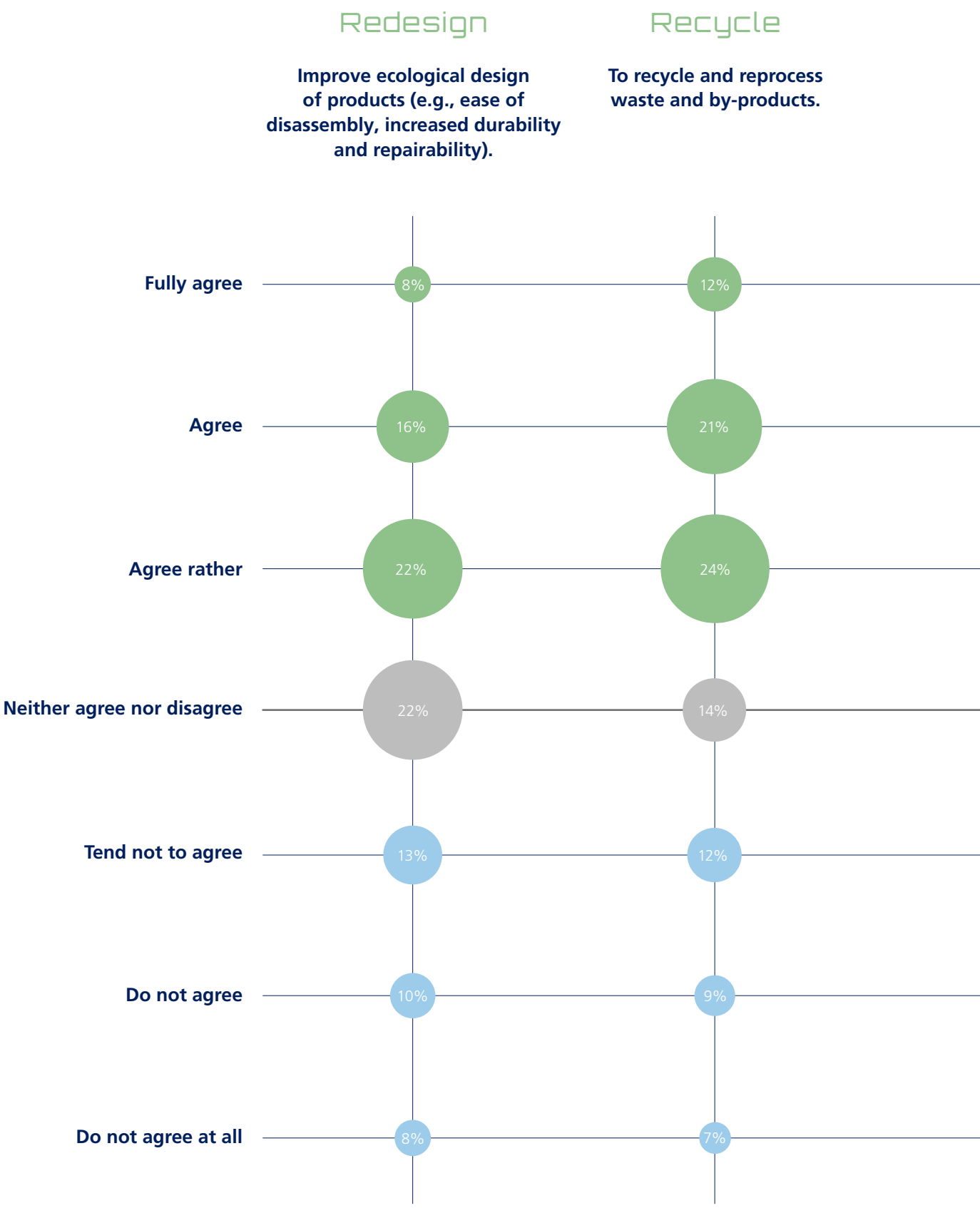
This is where digitalization is taking place, because modern Industry 4.0 technologies can reduce the effort required to improve sustainability. That is because data is the basis for sustainable economic management. If companies want to evaluate their own supply chain for sustainability, they need data not only from their own company, but from all companies along the supply chain. Companies can only make purposeful decisions based on meaningful data and, above all, their professional evaluation. Modern technologies reduce the effort and automate the preparatory processes. Algorithms can be used to efficiently design and reduce the use of energy and resources. Waste and by-products can be reused following circular economic approaches. And thanks to intelligent sensors and retrofitting, even old systems can be operated sustainably. The question of the current status of companies with regard to the principles of Reduce, Reuse, Refurbish, Redesign and Recycle was investigated in the context of the Industry 4.0 Barometer 2023.

Survey results

Given the advantages already highlighted, it should be assumed that sustainability itself is reason enough for companies to push the topic forward with maximum commitment. Nevertheless, minor and convenient sustainability issues are given priority since they do not result in major costs or transformation efforts and are well-received by customers. Companies are much more reluctant to deal with more complex topics whose results are not directly measurable. This is shown by the results on the principles of the circular economy: Reduce, Reuse, Recycle, Redesign and Refurbish. Of the respondents, 67 percent state that their company implements Reduce principles, while 57 percent say that they implement Recycling principles. Both principles have a direct economic impact and can be implemented by simple measures. Redesign principles, which aim to increase the durability and repairability of products, play a role in just 24 percent of companies, while Refurbish principles, i.e. the reprocessing of discontinued or obsolete products, play a role in 22 percent of surveyed companies (Figure 24).

percent of the respondents state that reduce principles are implemented in their company.

My company aims to achieve the following objectives with Industry 4.0:



Refurbish

Collection and reprocessing of products or materials that are no longer used in order to restore their original function.

Reuse

To reuse products, materials, components, waste and by-products.

Reduce

Reduce energy and material consumption and waste in production.

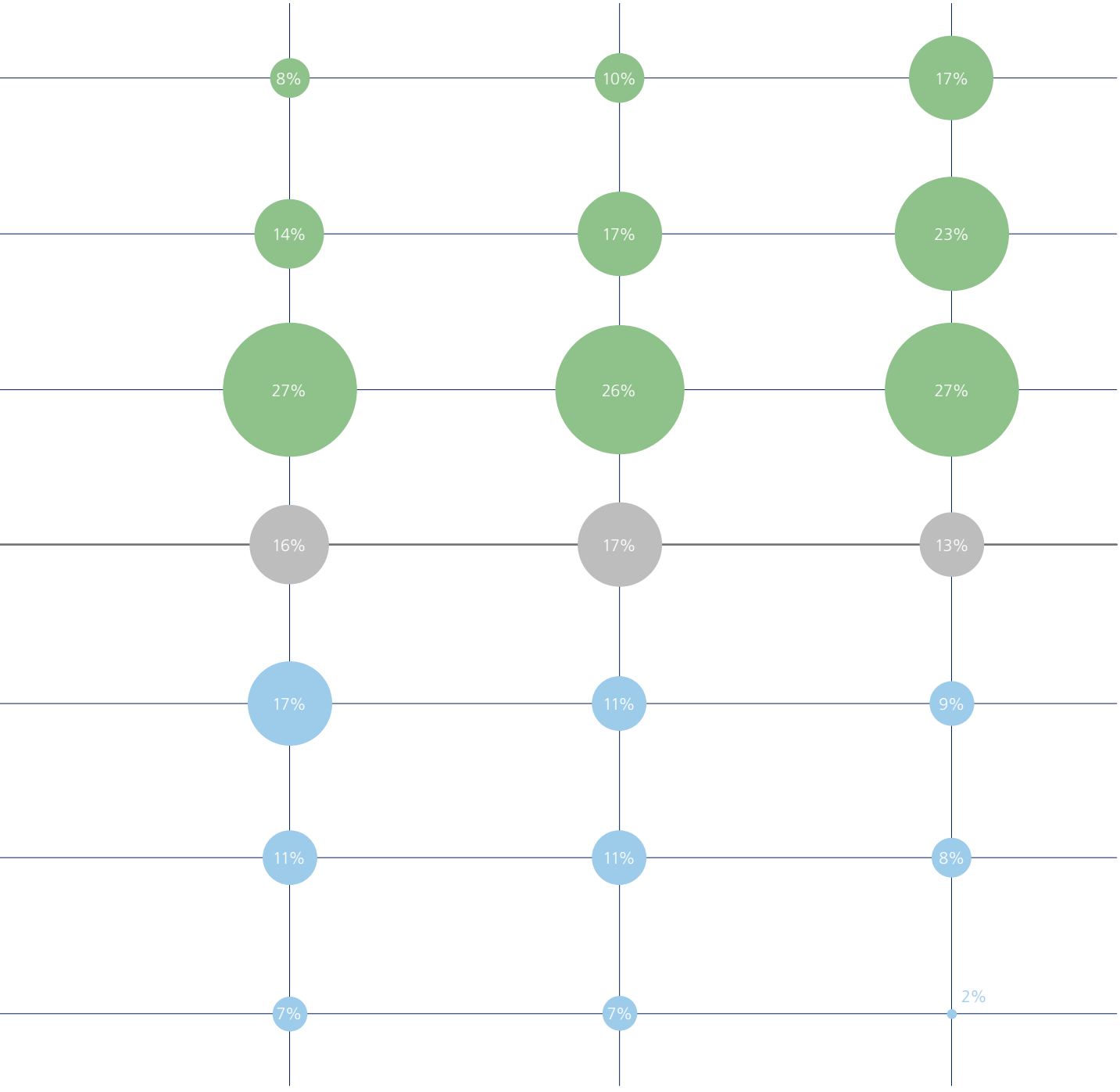


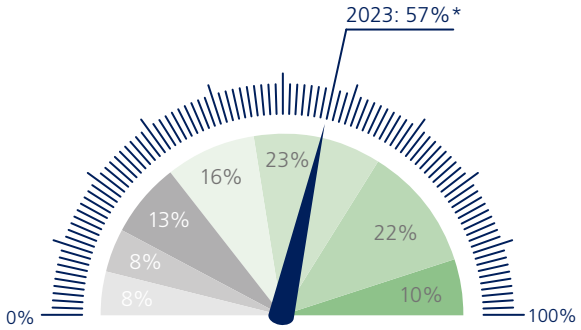
Figure 24. Sustainability goals

46 percent of respondents say that environmental and climate protection is a central strategic goal with specific targets in their companies (Figure 25). 55 percent of the companies surveyed even have an organizational unit that deals with sustainability and to which at least one member of top management belongs.

Nearly 40 percent of the participants surveyed rate their commitment to sustainability as more effective than that of their competitors. Meanwhile, only 18 percent consider it to be worse (Figure 26).

In my company...

... there is an organizational unit or committee that deals with sustainability (environmental, social and economic) and includes at least one member of top management.



Industry 4.0 Barometer

Do not agree at all | Do not agree | Tend not to agree | Neither agree nor disagree | Agree rather | Agree | Fully agree

Only 46 PERCENT

of the companies surveyed consider environmental and climate protection as a key strategic goal.

*Barometer value: Weighted arithmetic mean as percentage value

Figure 25: Sustainability strategy & management

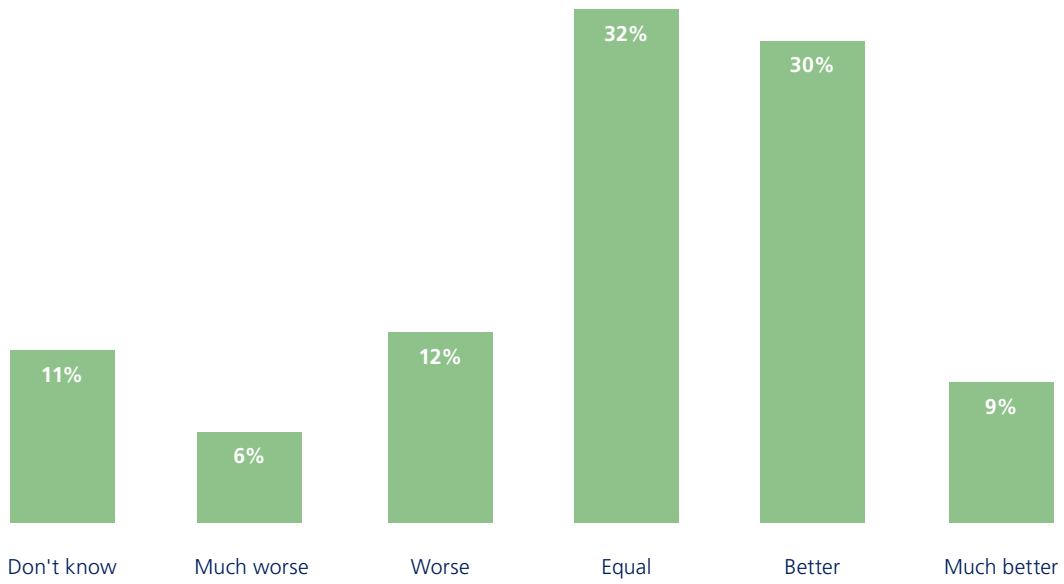


Figure 26: Effectiveness of sustainability measures

But what about the credibility and seriousness of the sustainability goals set and their strategic anchoring in the corporate strategy? For example, to what extent do companies intervene when projects turn out to be problematic in terms of sustainability? Almost half of the companies surveyed do not stop projects or processes if they are not in line with the corporate sustainability goals. Credibility, in the sense of "practice what you preach," is evidently not a practiced principle for many companies.

After all, companies are primarily oriented toward economic efficiency, even when considering sustainability. In comparison, the UK and the USA are at the forefront of the quest for sustainability in production. The DACH region is lagging behind, and there is still a significant need to catch up on issues such as the circular economy. Chinese companies are even further behind with sustainable strategies having little importance to them. Only time will tell for how long such a careless approach to sustainability will be possible.

The situation is different when it comes to Corporate Social Responsibility (CSR), i.e. the responsibility a company has for the social environment and directly for the environment. Here, companies from all markets surveyed are consistently committed to implementing sustainable measures. This is demonstrated by the fact that 57 percent of the companies surveyed actually met their own sustainability goals. 55 percent of companies succeed in recording and avoiding externalities, while 58 percent were successful in logistics, and 58 percent in the production of new products. However, only 47 percent of companies were able to implement measures for increased sustainability in the procurement of primary products and services (Figure 27).

The focus on externalities is a global phenomenon. Contrary to expectations, Chinese companies are not lagging behind in this regard. In fact, the results show that direct consequences of noise, air pollution, and pollutants are taken into account by the Chinese companies surveyed – not least because of the strict laws recently passed by the government. It seems that China has recognized that the rapid growth of recent years cannot be sustained at the expense of the environment.

My company consistently implements measures for sustainable ...

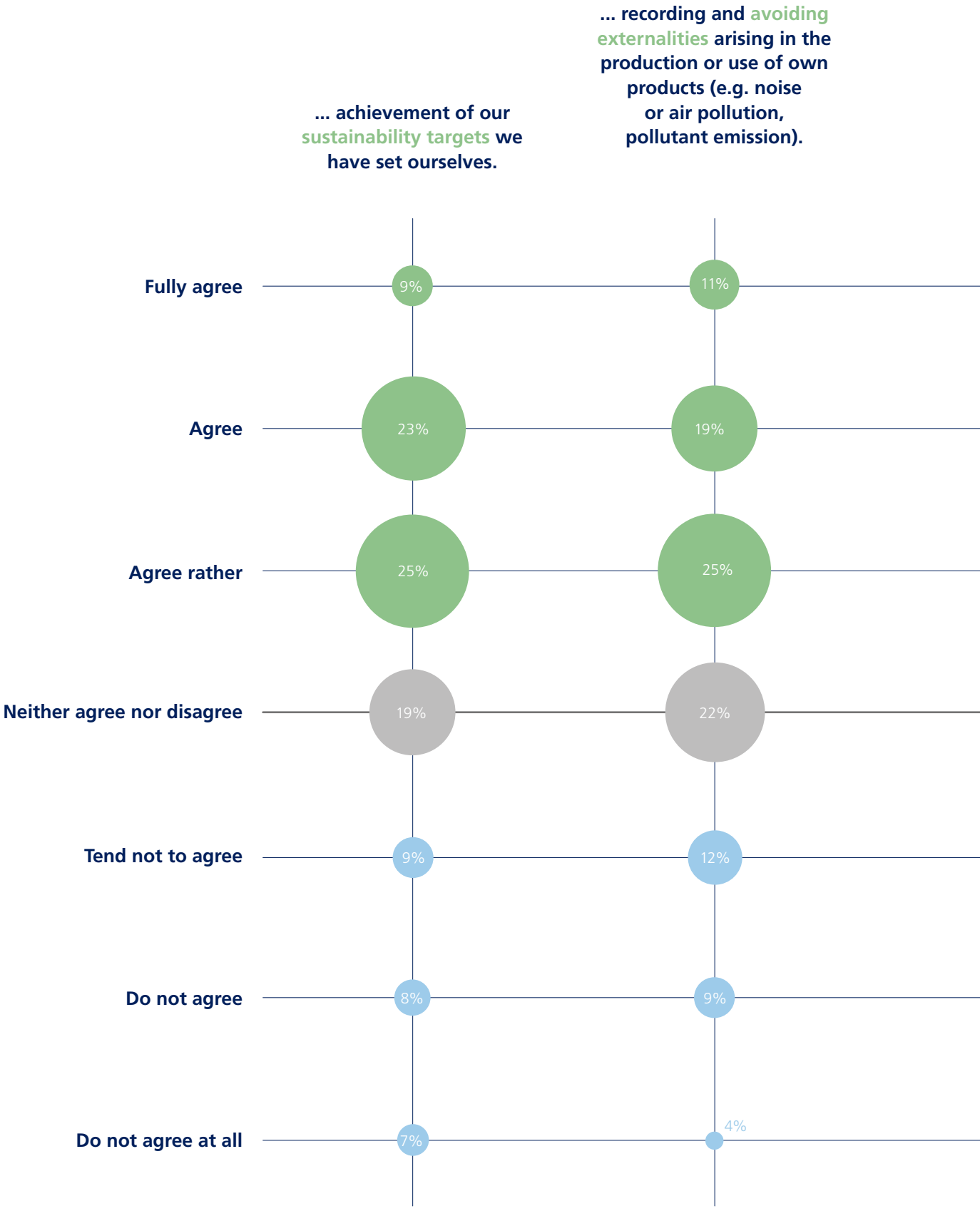


Figure 27: Measures for sustainability


CO2

Reasons

Overall, the survey results show the first steps toward increased sustainability. The companies surveyed are particularly committed if sustainability is a side effect of cost reduction. However, a lack of commitment is still evident elsewhere. The corporate policy driven by greenwashing is reflected in the fact that half the companies intervene if a project is not sustainable.

Companies are still mainly driven by economics. The reasons for this are obvious: First and foremost, most companies need to achieve their economic objectives, especially if they are listed on the stock exchange and the interests of investors need to be safeguarded. Business stakeholders seem to have too little interest in sustainability, which causes businesses to make sustainability a lower priority. The companies that manage to harmonize the topics of economy and sustainability are committed and interested in improving sustainability.

Recommended action

It is clear that many companies are already tackling the issue of sustainability and it is advisable for them to continue on the path they have taken. It is not just about meeting social pressure or even clearing your own conscience. Instead, it is highly likely that more and more incentives for sustainable initiatives will be created in the near future – and may even be written into law. The example of the recently introduced "Act on Corporate Due Diligence Obligations for the Prevention of Human Rights Violations in Supply Chains" shows that many companies are inadequately prepared for new legislative requirements. In addition, sustainability and economics go hand in hand in many ways because they are not opposites and can complement each other. Collecting data about your supply chain and being able to evaluate this data can give businesses a huge advantage in terms of knowledge, which is valuable particularly in times of crisis. Delivery bottlenecks can also be detected at an early stage. Not only do the principles of the circular economy help promote sustainability, but they can also be combined with this topic due to the similarities in lean management – a win-win situation!

The benefits of this symbiosis are obvious but many companies find it difficult to introduce and implement such sustainability measures. There is often one common denominator behind this: a lack of digitalization. Only with the help of digital technologies can an analysis of the supply chain be carried out with manageable effort. Similarly, digitalization and the data available in this context can be used to systematically identify waste in production so that the appropriate improvement measures can be planned. However, overcoming these hurdles requires budgets and additional expertise. A company can only significantly improve its sustainability if the top management is committed to this objective. This should be done sooner rather than later to enable a proactive response to regulations instead of a reactive response.

Success Story
Catena-X & VW

Climate change, geopolitical conflicts and pandemics are also increasing pressure on the global supply chains of the automotive industry, posing challenges to affected companies: transparency in the supply chain, high data quality and reliability, and protection against the disclosure of secret production figures are among the key focus areas. Due to the high level of interconnectivity and resulting interdependence of companies, these challenges can hardly be faced alone.

Collaborative, trustworthy, and open models of cooperation are needed, in which all partners can act on an equal and sovereign footing. To establish efficient processes, innovative business models, and sustainable decisions in product development, procurement, vehicle production, and disposal, the collaboration of the entire value chain is required.

The Catena-X data ecosystem as an accelerator for Industry 4.0

With a focus on the automotive industry, the vision of Catena-X is based on the technologies and ideas of Gaia-X and the International Data Space Association (IDSA). The goal of Catena-X Automotive Network e.V is to provide an environment for the construction, operation, and collaborative use of end-to-end data chains along the entire automotive value chain. Based on an innovative infrastructure, this data ecosystem is designed to ensure a secure exchange of data and a high data quality. The provision of a resilient and flexible supply chain management system is intended to be applicable to both small and medium-sized enterprises as well as global corporations.

A total of ten specific use cases are currently defined under Catena-X as part of a project funded by the Ministry of Economics, with standard candidates being developed for each.

These use cases include topics such as digital twin, manufacturing as a service, and modular production for optimizing collaborative-industrial manufacturing, as well as topics such as traceability and quality management of end-to-end data chains. The focus on sustainability is addressed through working packages such as circular economy and sustainability & CO_2 footprint.

Use case Sustainability & Carbon Footprint – specific, harmonized, and comparable calculation of the carbon footprint using data in the Catena-X data ecosystem

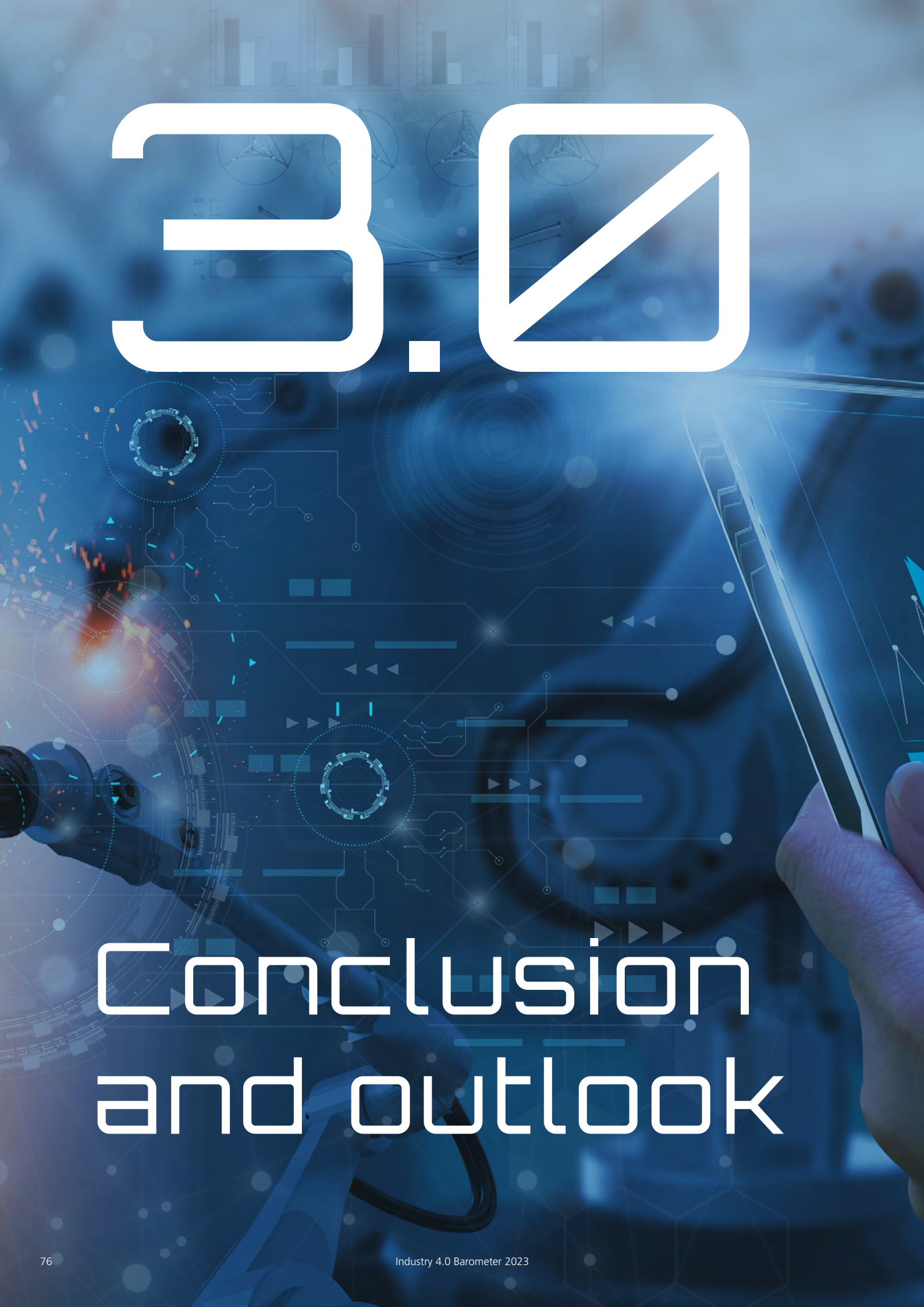
A large part of the CO_2 emissions in the lifecycle of a vehicle shifts from the usage phase to the production phase due to the transition towards electromobility. Avoiding driving emissions with electric vehicles comes with an increase in manufacturing emissions.

To effectively reduce the carbon footprint during the manufacturing process, and thus significantly in the supply chain, data on the respective emissions during the production of individual components are required. However, the effort to determine emissions on a component level is enormous, as OEMs' bill of materials contain an average of about 5,000 components per vehicle. Until now, components have mostly been evaluated using generic data. In the sustainability & CO_2 footprint use case, a group of experts from various stakeholders in the supply chain are developing a harmonized, comparable, and gapless method standard. This standard should form the basis for the calculation of a specific data basis along the entire supply chain, therefore improving the accuracy, reliability, and comparability of the calculation results. Software solutions should support the application of the standard and the determination of the specific CO_2 component footprint. With this standardization and the innovative infrastructure of Catena-X, product carbon footprint (PCF) experts at suppliers and OEMs can request and provide PCFs in a request & respond procedure. The high effort required to create a PCF for a component or entire vehicle can therefore be significantly reduced.

MHP supports the Volkswagen Group in establishing a brand and cross-functional governance to identify synergies and enable existing and new platform projects, including Catena-X. MHP supports in the strategic and operational work in the development and advancement of use cases in the field of sustainability.

"Catena-X will launch as a network of networks starting in 2023. This will enable collaborative, open and multi-tier capable cooperation in the industry for the first time. We believe that this is the only way to solve the major challenges of our industry, such as decarbonization, circular economy and resilient flows of goods. It's actually quite simple: from an ego-system to an eco-system."

Oliver Ganser
Head of Programme – Data Driven Value Chain at BMW Group &
Head of Consortia Catena-X and
Chairman of the Board Catena-X e.V.



3.0 Conclusion and outlook


success
71/99.001

"Next to impossible – this is how we could summarize the challenges that industrial companies are still facing with regard to the necessary Industry 4.0 transformation. High investment requirements to secure the competitive position or improve it – and all this in the face of continuing uncertainties regarding macroeconomic conditions, rising IT expenditures and a lack of skilled workers. But one thing is clear: There is no alternative! The task is to drive technological change consistently, holistically and sustainably."

Timo Haug
Partner, Operations Excellence, MHP

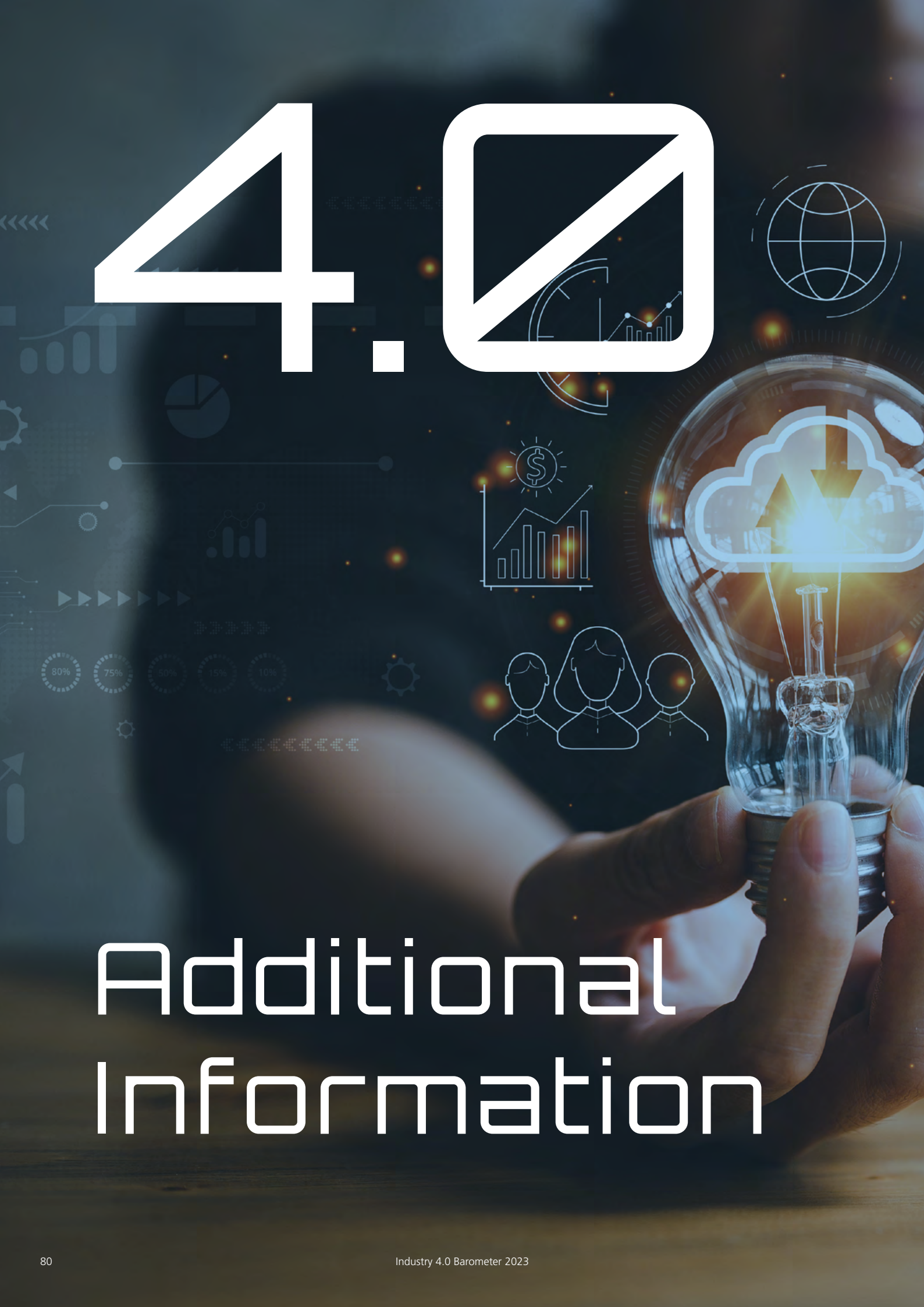
In this year's Industry 4.0 Barometer, we acquired numerous participants again, conducted interviews with experts, and presented success stories. We were able to derive complex insights: Significant improvements were observed compared to the previous year in numerous areas, such as data analysis and the use of artificial intelligence. Especially in IT security, which is probably the most critical area, many companies have identified shortcomings and are devoting resources to reducing them. However, there are other areas where it was only possible to achieve a slight improvement in the level of digitalization or Industry 4.0 within the past year, including complex topics such as the digital twin. The reasons for this are a lack of human and financial resources. In addition, the current crises mean attention is being focused on measures to safeguard current interests and future-oriented investments are being postponed. This is particularly true for large investments in complex technologies or digitalization initiatives. The specific benefits of these investments are difficult to quantify but the strong focus on ROI as the basis for investment decisions is questionable. Many other factors must first be taken into account to determine the benefits of using new technologies, such as reducing the susceptibility to errors and costs, identifying and correcting problems at an early stage through a higher degree of flexibility, or reducing the physical strain on employees. But at the same time, time savings, quality assurance, achieving sustainability goals, and increasing operational resilience play a central role. Often there are also "soft" factors that must be considered when making a decision. The benefits are not always immediately measurable but only have a delayed effect.

It is also true many legacy IT systems are still proving to be a major obstacle for companies trying to digitalize. The current state of shopfloor automation looks similar. Modern Industry 4.0 technologies are already used in isolated cases. However, most companies surveyed are still far from achieving end-to-end digitalization and holistic automation. Automated Guided Vehicles (AGV) are the key technology for automation for many of the companies surveyed. However, artificial intelligence is also on the rise in the context of production. Like most other digitization topics, the automation of the shopfloor is hampered in particular by a lack of willingness to take risks with investments or a lack of human resources.

The fact that profitability is enormously relevant for most companies surveyed also has an impact on sustainability. As long as sustainability goals are in line with the economic goals of the companies surveyed, they will be given high priority. However, when there is no clear, positive assessment of sustainability goals from an economic perspective, there is less willingness to implement them. In addition, only a few projects that are not in line with the sustainability goals are stopped. Therefore, we must ask how serious and sincere the ambitions to improve sustainability in companies actually are.

The specific challenges companies face in the current situation with the war in Ukraine, the coronavirus pandemic, and the resulting shortage of resources, especially in semiconductors, are reflected in the initiatives of the companies. They are acting more cautiously and focusing on actions with a certain economic success. There are still many areas that have significant potential for improvement. But the high percentage of technologies that are already being piloted in many companies gives hope. It also remains exciting to see how companies are responding to the current crises and how digitalization progress will develop over the next few years.

As in previous crises, the following is true: Only those who invest in digitalization and who transform resolutely and purposefully will emerge strongly from the crisis and be able to assert themselves in the market in the future.



4.0 Additional Information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10%

Evaluation Methodology

The responses to the questionnaire are based on five-point or seven-point Likert scales. For a clear evaluation, the participants' responses were clustered. In addition to the distribution of the responses, the weighted arithmetic mean was calculated as a percentage and is referred to as the Barometer score in the study. The Barometer scores from the years 2018 to 2020 refer exclusively to the DACH region. The Industry 4.0 Barometer was first surveyed internationally in 2021, and the Barometer scores therefore only refer to survey results from China, the UK and the USA from 2021 onwards. In addition, for questions on prioritization, the participants were given the opportunity to assign points from 0 to 100 for certain statements. To determine the priorities, the total sum per question could not exceed 100. For calculation purposes, the five-point and seven-point Likert scales were transformed into metric scales with the values 0–5 and 0–7 respectively. After multiplying the metric scale values by the respective relative frequencies from the responses to the individual questions, the weighted arithmetic mean was divided by 5 and 7 in proportion to the scale, to obtain a Barometer score between 0 and 100 per cent. Given that the Industry 4.0 Barometer is a periodic survey, the Barometer score can be used as a benchmark. In addition, the results were compared on the basis of different characteristics of the participants and their companies. The responses were collected and evaluated anonymously.

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Figures

Figure 1: Distribution of respondents by region 15
Figure 2: Distribution of respondents by company size 15
Figure 3: Hierarchical levels of respondents 15
Figure 4: Distribution of respondents by industry 16
Figure 5: Distribution of respondents by department 17
Figure 6: Technological equipment along the entire value chain 21
Figure 7: Distribution of the digital twin 23
Figure 8: IT architecture with/without CIO in the management 24
Figure 9: Communication networks with/without CIO in the management 25
Figure 11: Scaling of IT systems 28
Figure 12: IT business collaboration 29
Figure 13: IT barriers to the introduction of Industry 4.0 29
Figure 14: Schematic representation of logistics and production at Faurecia 36
Figure 15: Scan-Glove ProGlove Mark II 38
Figure 16: Plant simulation model of the storage and return processes 39
Figure 17: Level of automation 40
Figure 18: Automation and autonomous systems 41
Figure 19: Partially and fully automated production processes 42
Figure 20: Strategic Industry 4.0 focus 45
Figure 21: Barriers to the introduction of Industry 4.0 47
Figure 22: Technologies with the greatest economic potential in terms of automation 48
Figure 23: Opportunities for further education 49
Figure 24. Sustainability goals 67
Figure 25: Sustainability strategy & management 68
Figure 26: Effectiveness of sustainability measures 69
Figure 27: Measures for sustainability 71


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About the company MHP

As a technology and business partner, MHP digitizes its customers' processes and products and supports them in their IT transformations along the entire value chain. MHP is a digitization pioneer in the mobility and manufacturing sectors and transfers its expertise to a wide range of industries. This makes the management and IT consultancy MHP a premium partner for thought leaders on their way to a Better Tomorrow.

MHP serves over 300 customers worldwide, including corporations, medium-sized companies and start-ups. Providing both operational and strategic consulting and proven IT and technology expertise as well as specific industry know-how, MHP operates internationally – with headquarters in Germany and subsidiaries in the USA, UK, Romania and China.

For over 26 years, MHP has been shaping the future together with its clients. More than 4,000 MHP employees are united by the demand for excellence and sustainable success. This aspiration continues to drive MHP – today and in the future.

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