FROM INDUSTRY 4.0 TO SMART FACTORY

Guidance for managers and engineers

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Ladies and Gentlemen!

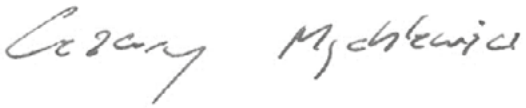
Industry 4.0 is attracting more and more attention. Most of us must have heard about the latest industrial revolution, but the concepts of Industry 4.0 are probably not clear and obvious for everyone. That is why we have decided to create a single, comprehensive document containing the basic knowledge on the subject, and to include in it not only the bare information but also examples showing how Siemens understands Industry 4.0 and what business advantages are possible thanks to implementing this idea.

This publication starts with the basic concepts of Industry 4.0 explained, with the emphasis on the benefits and on the role of individual technologies, and then presents organizational aspects put into practice, thus helping readers understand how to implement Industry 4.0 in their enterprises. At the end of this document, you will find a glossary of terms useful in the context of Industry 4.0.

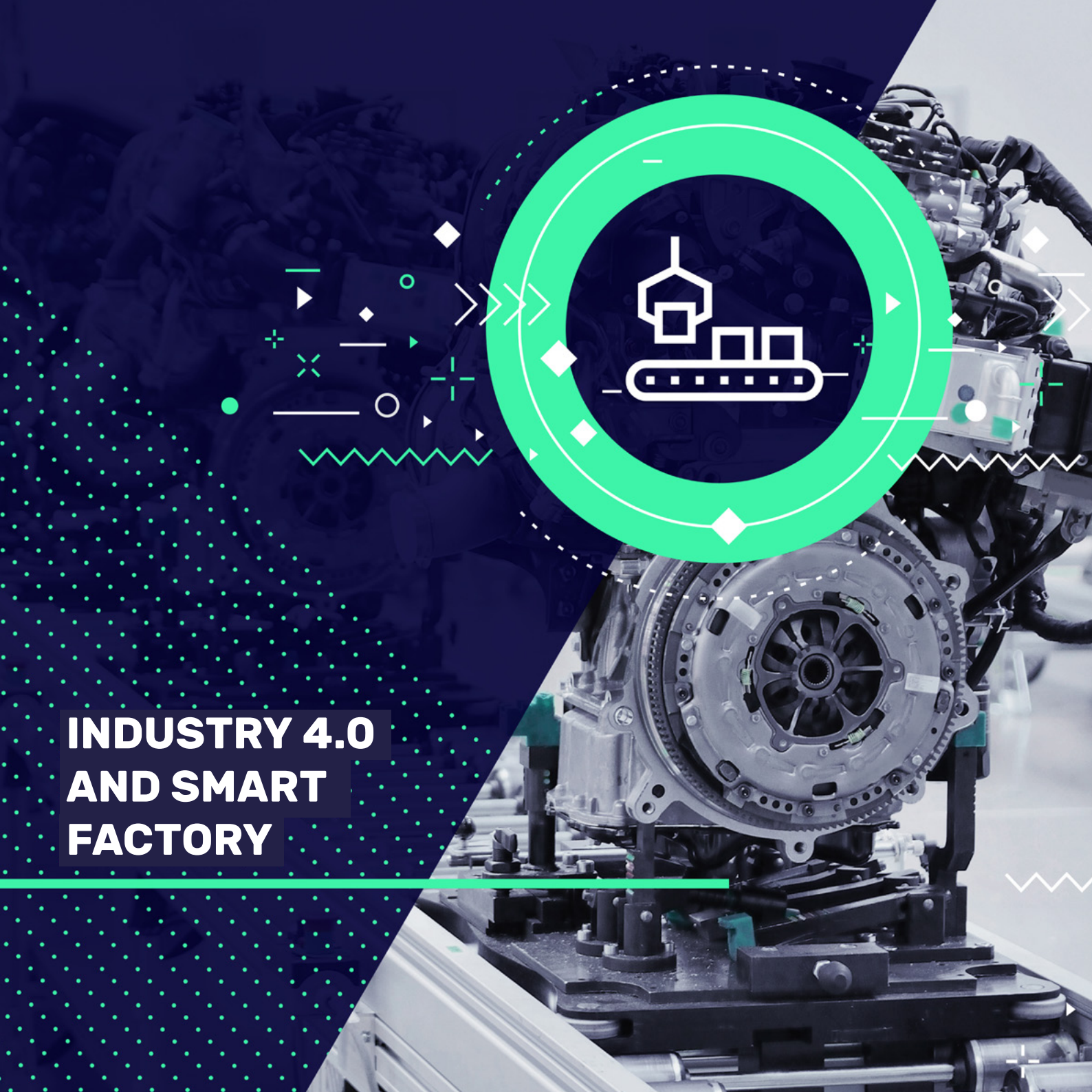
The approach to Industry 4.0 taken in this guidance focuses on discussing practical aspects, that is on what the business results of implementing Industry 4.0 are. However, we still felt that the solid theoretical background as well as the figures supporting the subject in question should not be left out.

If you are a manager at a production company or an engineer, you might need to know the idea behind Industry 4.0, the technologies and business processes it introduces, and the future solutions it offers. We hope you will find this paper both enjoyable and useful.

Cezary Mychlewicz



Marketing Director for Industrial Sectors at Siemens



INDUSTRY 4.0 AND SMART FACTORY

Industry 4.0 and Smart Factory

Although the term “Industry 4.0” has been in use for almost seven years (it first appeared at Hannover Messe in 2011), it remains vague for many people, and is interpreted in a number of ways. The thing is that Industry 4.0 is not associated with one specific technology or one specific change in terms of production management.

The fourth industrial revolution is about using automation, data processing and exchange, and about implementing various new technologies that make it possible to create so-called cyber-physical systems and to change manufacturing methods. It also applies to the digitalization of production, where technological equipment and systems communicate with one another, for example through the Internet, and where large amounts of manufacturing data are analyzed. Industry 4.0 is understood in this case as an aggregate notion that includes a number of new technologies, such as for example the Internet of Things, cloud computing, Big Data analysis, artificial intelligence, additive manufacturing, augmented reality or collaborative robots.

Another dimension of Industry 4.0 focuses on the production management, business activities and value chain. The most significant phenomena we observe here is the change in the production management systems architecture, and the transition from linear processes and traditional, pyramid-based production management systems to a network of connections and non-linear production. The combination of the innovations mentioned before with new possibilities in terms of artificial intelligence may lead to a revolution in terms of production management methods, where highly autonomous systems will be able to dynamically change their structure and functions within an organization. This business area is also discussed in this paper, with an emphasis on the features that are most important from the perspective of managers.

The phenomena described above allow us today to change the manufacturing paradigm and introduce flexible, highly customized and also cost-effective production solutions. Industry 4.0 is also part of a larger megatrend, namely the digital transformation which covers many different industries, including in particular the financial and logistic sector.

What is Smart Factory?

Smart Factory is a concept related to Industry 4.0. This type of plant is based on cyber-physical systems and their integration using the industrial Internet of Things, and on new production organization methods. It is designed to ensure a high degree of product customization and to enable manufacturing processes to take place with minimal human interaction.

One of the practical examples of such an approach is the replacement of a traditional belt-based assembly of equipment units within a production line with a system of autonomous transport trucks that carry necessary sub-assemblies to relevant work centers. Thanks to RFID tags placed on the manufactured products, machines are able to automatically pick the right tool and to perform the operation required in the case of a given product item (a different operation for each item). As a result, production can be fully customized and the minimum lot size can be reduced to one.

Another example is to use the technology of industrial Internet of Things and introduce a network of wireless sensors that would monitor production and energy consumption by machines and facilities. By capturing the data they provide and using the right analytical software, it is possible to optimize production, both for a single factory and for all production units of a given company around the world through determining efficiency benchmarks.

How is Smart Industry / Industry 4.0 understood by Polish managers?

Polish industrial companies equate smart production most of all with operational efficiency perceived from many different perspectives. Such an approach can be found in the conclusions presented in Siemens's "Smart Industry Polska 2016" report. The most popular answers to the question about how the respondents understand the concept under analysis focused on:

- Efficiency in terms of production management, including the use of smart equipment and new technologies
- Production cost optimization possibilities
- Flexible response to customers' needs, with processes optimized in accordance with the customers' orders
- Modern communication that also includes sharing information directly with product consumers

Tomasz Haiduk
Director for Industrial Sectors,
Member of the Management Board at Siemens

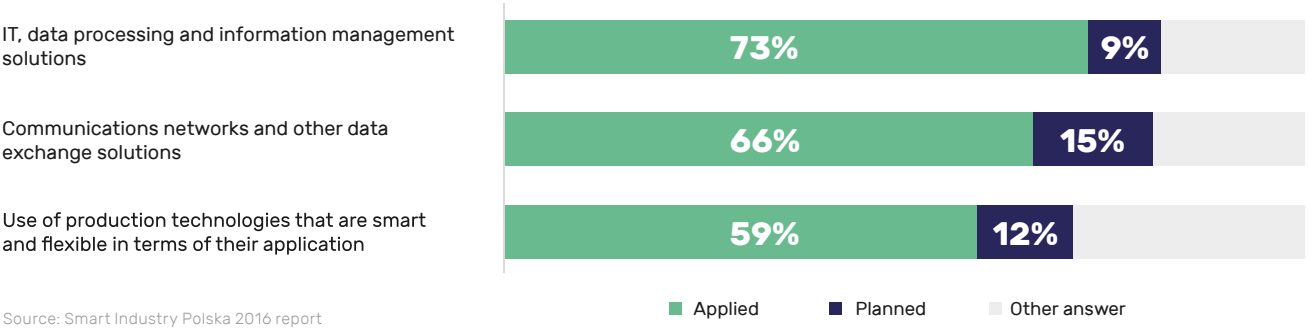
Industry 4.0 is a definition of digital transformations witnessed by economies all around the world. We would like to popularize a holistic approach to this concept, thus making it possible for people working in the field of technology to look in a more comprehensive way at the solutions available for this sector, and to search for technologies that would prove to be the best not only in terms of attaining current objectives, but also in terms of preparing their factories to what the future will bring.

The fourth industrial revolution is a chance for development, especially for medium-sized industrial enterprises. That is mostly because state-of-the-art technologies are getting more and more accessible, while companies are getting faster and more flexible as regards responding to market needs.

Smart Industry in Polish companies

The study conducted by Siemens and Millward Brown showed that only 25% representatives of Polish production companies were familiar with the concept of Smart Industry. At the same time, a significantly higher number of people declared that their organizations used technologies and solutions characteristic of smart factories.

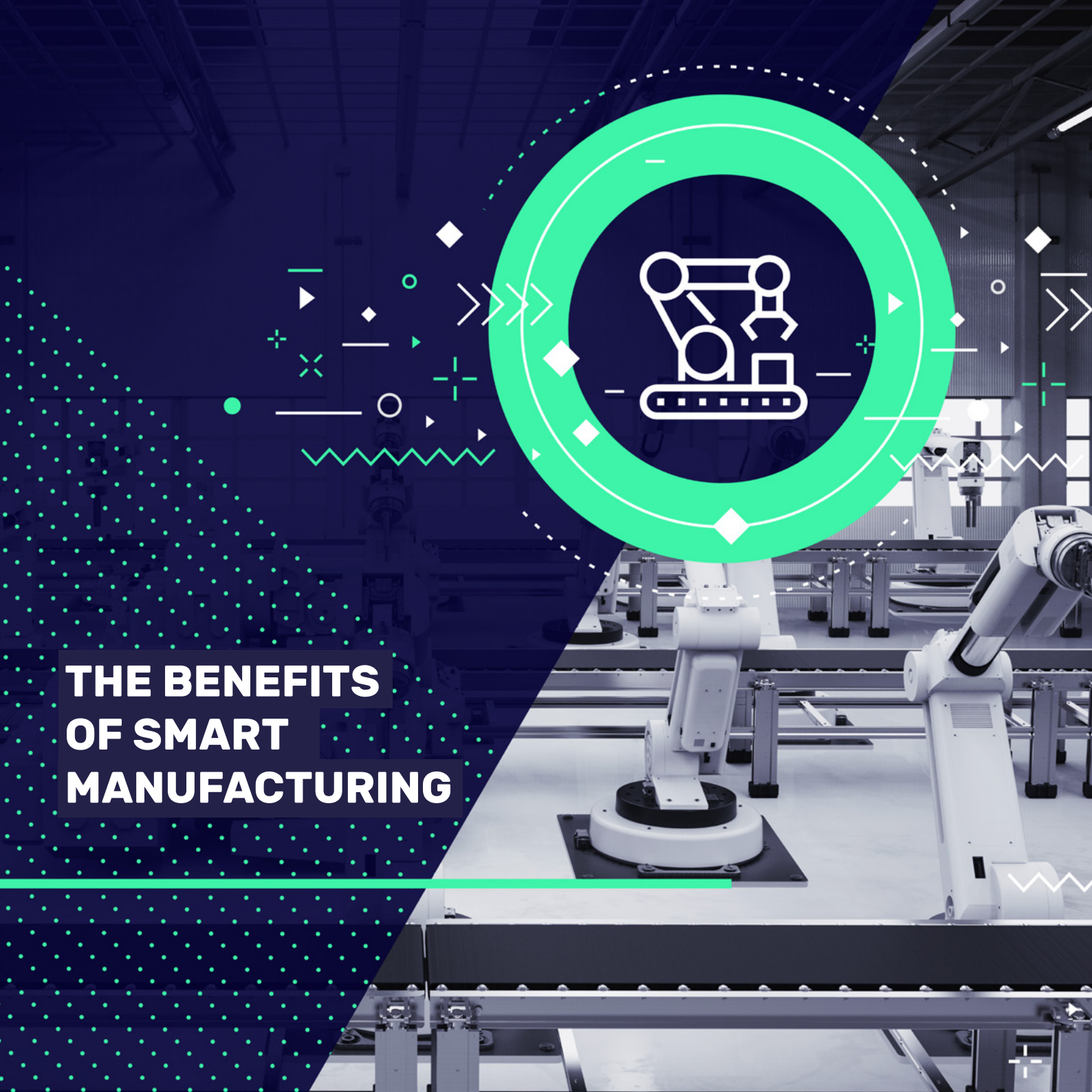
Which Smart Industry elements can be found in Polish companies?



Source: Smart Industry Polska 2016 report

Industry then and now

Old-time factories, for example Siemens&Halske, were loud and filled with the smell of lubricating oil. Modern production plants that we see today, such as a highly automated Siemens factory in Amberg, Germany (on the right), are not only clean and quiet, but also extremely productive.



THE BENEFITS OF SMART MANUFACTURING

Production-related benefits

- Increased productivity that translates into better use of the assets held, and downtimes reduced to a minimum
- Better planning and monitoring of manufacturing processes
- Costs optimized production thanks to losses identification and costs monitoring
- Visibility of production-related information at different organizational levels of a given company, possibility of real-time tracking of machine operation statuses
- Manufacturing "smart" products that might be tracked (e.g. using RFID tags) during their entire lifecycle – from production, through transport and servicing, to recycling
- Implementing new production models
- Possibility of implementing predictive maintenance strategies
- Better production scalability, e.g. using cloud-based platforms
- Easier use of crowd-sourcing platforms

Opportunities for the entire organization and for business

- Increased competitiveness, possibility of creating a unique market offer
- Possibility of manufacturing customized products that meet customers' preferences, with marginal costs of production reduced to a minimum
- Transforming the offer for consumers, building closer relationships with customers, creating a customer-centric organization
- Better adjustment to market requirements, faster response to changes
- Shorter time-to-market
- Integration of production, storage and logistic processes
- Possibility of creating new revenue streams and of using new business models
- Easier management of production in the case of geographically dispersed production units
- Possibility of offering the use of the data from smart products and systems as a service
- Better control over the entire lifecycle of a product, also while it is in use, thanks to the possibility of transferring the data monitoring the parameters of a product being used by a customer, and also by means of the technical condition diagnostics.

Łukasz Otta
Business Development Manager
at Siemens

Digitalization of an industrial plant in the context of Industry 4.0 should be understood as acquiring as much data as possible about production processes, condition of machinery, stock levels, utilities consumption, energy costs, production quality, staff availability, number of orders and order delivery dates, indicators resulting from the company's market strategy, etc., and the parallel processing of such data so as to continuously ensure optimal operating conditions for the company.

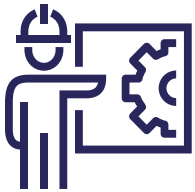
BUSINESS-RELATED CHANGES

Business-related changes

The idea of smart production plants is connected with a much broader concept of digital transformation that is connected with the organization as a whole, with the business-related changes, and with the process of implementing innovations inspired by digitalization and new technologies. While industry 4.0 is usually referred to in a technological context, it should be pointed out that it also entails strategic changes, both at the operational level and at the level of relations between producers and customers.

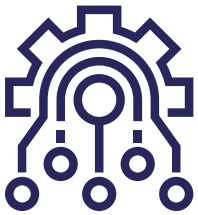
Mass Customization

The changing customer requirements as regards product personalization are among the main reasons for modifying the manufacturing model. Today, customers are more and more often looking for products that are tailored to their individual needs and made to order. This changes the manufacturing paradigm as mass production, with the customer being dependent on the manufacturer and its initiative, is becoming less popular. Such a method of manufacturing customized products at low marginal costs is known as “mass customization.”



Change in the Manufacturing Model and Customer Development

The Internet makes it possible to stay in direct contact with customers who can not only customize the products they buy, but also provide feedback on their future needs (thus modifying the offer and the activity model within the so-called Customer Development process). This changes the “producer–consumer” relationship but also requires that changes be made throughout the company in order to create a customer-centric organization. The development of relationships with customers also strongly depends on data analysis.



Value Chain Transformation

Michael Porter's traditional value chain framework is experiencing fundamental changes today as a result of a digital transformation. What we see here is the two-dimensional integration:

- Vertical integration – thanks to availability of the data about processes, production, etc., it is possible to better integrate various processes within an organization, from R&D and purchases, through production, to logistics and marketing. It allows you to comprehensively manage products lifecycles as well as assets.

- Horizontal integration – smart supply and logistic systems (including on-site logistics) as well as the traceability and management of raw materials and products make is possible to optimize logistic and manufacturing processes and to improve the quality of planning, while the availability of digital data and the "visibility" of production enable easier exchange of information between the organization and its contractors and suppliers on the one hand, and its customers and companies within a distribution network on the other.

New Business Models

The digitalization of production and of the related processes makes it possible to introduce new business models, such as for example the ones known from the e-business domain. Product-as-a-service is also an example of a popular model used by the industry. It gives you the opportunity of reducing investment costs by replacing them with operating expenses such as standing charges, leasing expenses, etc. For example, instead of buying industrial robots, an enterprise may lease necessary machines, or instead of investing in 3D printers – it may use increasingly popular additive manufacturing services.

There are also many new services available on the market, including the ones in the field of data analysis or equipment resources management. In most cases, they are provided using digital technologies of data exchange or online communication.

Integration of Products Lifecycles

Thanks to traceability (e.g. using RFID systems) as well as digitalization of production and of value chains, comprehensive management of products lifecycles is possible. This also includes digital designing and prototyping (by creating the so-called digital twins) as well as the use of management software. In addition, the systems and methods of modern data analysis make it possible to collect information about the use of products and services in order to make them adjusted better to customers' future needs.

Ryszard Jania
President
Pilkington Automotive
Poland – NSG Group

The idea of Smart Industry and the actions taken in line with it allow companies to switch from offering simple items to providing products with added value and to competing with others through process excellence. This applies to cooperating with potential consumers from the stage of product designing, through simulations, production optimization and real-time monitoring, to after-sales services. Such global methods are applied at the NSG Group, one of the world's leading manufacturers of glass and glazing systems, and also at its plants in Poland.

Industry 4.0 means integration

KEY TECHNOLOGIES

Key technologies

From the technological point of view, Industry 4.0 is a set of new and developing technologies that form a basis for the transformations discussed in this document. Those technologies also make it possible to implement new methods of manufacturing as well as production and information management.

Smart Factory core technologies

Industrial Internet of Things

- Communication using distributed sensors, devices and other network components
- Implementing technical and business solutions based on Internet technologies

Data Analysis and Production Optimization

- Use of data processing and analyzing software in real time
- Availability of current production information at the company's management level (management cockpits)
- Possibilities of far-reaching production optimization and predictive maintenance methodology implementation

IT/OT Integration and Cyber-physical Systems

- Creating cyber-physical systems (CPS) where mechatronic, electronic and communication systems are intertwined with the right software
- Integration of production systems with the IT and the business (management) layer

Cybersecurity

- Implementing security measures in order to minimize cyber threats, both inside and outside of an organization
- Strategies that cover the adequate methodology of designing industrial systems

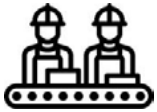
New and increasingly popular industrial technologies

Artificial Intelligence

- Technologies that make it possible for machines to learn and to solve complex problems
- Implementing advanced decision-taking algorithms and learning systems

Additive Manufacturing (3D Printing)

- Possibilities of rapid prototyping of elements and of manufacturing parts that have unusual shapes and functions
- Low- and medium-volume production using plastics, resins and metals



Digital Twins and Digital Factories

- Software that allows creating virtual representations of physical systems and simulating them
- End-to-end management of products lifecycles

Cloud Computing

- Distributed computing structures that allow remote data storage and processing
- Virtualization of resources and easily scalable systems
- Concerns about data security and cybercrime

Big Data

- Analyzing large and diverse datasets using advanced analytics and AI algorithms
- As far as industrial applications are concerned, it is used to optimize processes, detect irregularities, and interpret production data

Virtual and Augmented Reality

- Supporting engineers and technicians in their design and service work by using goggles or other VR or AR devices
- Virtual training courses that reduce the costs associated with inducting new employees

Collaborative Robots (Cobots)

- New-generation robots that can collaborate with people without safety fences
- Such machines are easy to implement (no programming specialists needed) and flexible in terms of application

Automated Guided Vehicles (AGV)

- Autonomous vehicles for on-site intralogistic applications
- Capable of replacing traditional conveyors
- Application flexibility – easy changeover and programming

RFID

Radio-frequency Identification

- Data storage as well as communication with both product management and storage systems
- Possibility of creating smart products that communicate directly with the production machinery

Mobile Interfaces

- Mobile devices that allow users to view the production information and to control machines and systems
- Used in modern maintenance applications
- Possibility of implementing augmented reality solutions

Blockchain

- Technology of distributed records containing transaction data
- Possibility of making so-called "smart contracts" between entities without any guarantor (a third-party company or institution) needed

Geolocation

- Geographic location identification, typically using GPS or an IP address
- Used in logistics or for managing dispersed assets, fleet vehicles and remote staff teams

Steffen Leidel
Director for Industrial Automation Systems at Siemens

Digitalization is first of all about sharing and using the production process data thanks to modern IT tools. This can be seen, for example, in the case of transmitting data to a cloud that provides a number of possibilities in terms of analysis, remote diagnostics and online work management. Such solutions are already being provided by Siemens.

However, we understand industry digitalization as something more than just upgrading products by adding new functions. We believe that it is possible to apply IT solutions to almost every process taking place at a manufacturing company, be it product designing and simulation or building a process line. I am thinking here about the concept of a Digital Twin, where a physical system has its digital counterpart.

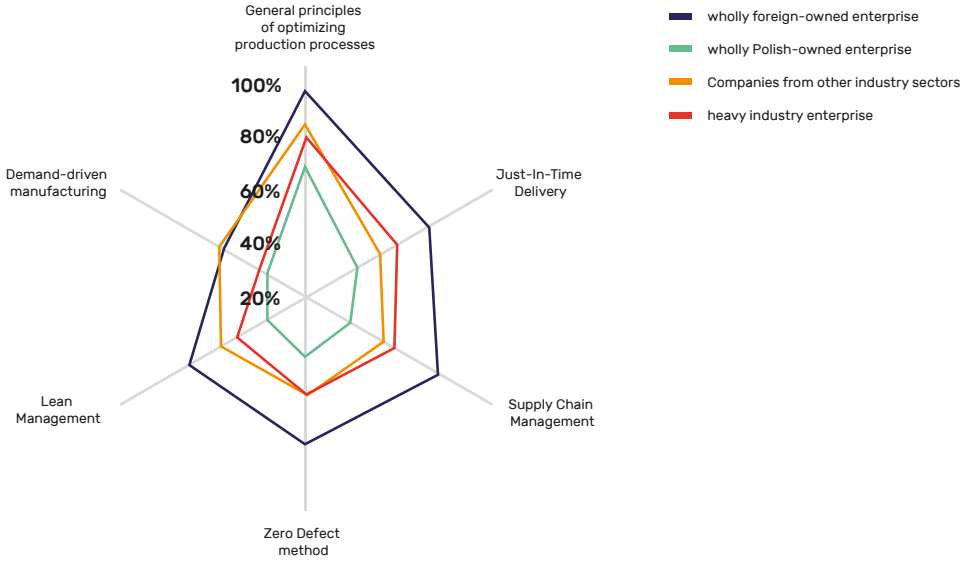
CHANGING MANAGEMENT METHODS

Changing management methods

Industry has long been using a number of production management methods, which are also being transformed these days. Most of them are well known to managers and applied to Polish production plants. The results of the study on their use are presented in the Smart Industry Polska 2016 report. They showed that the most popular methods were as follows:

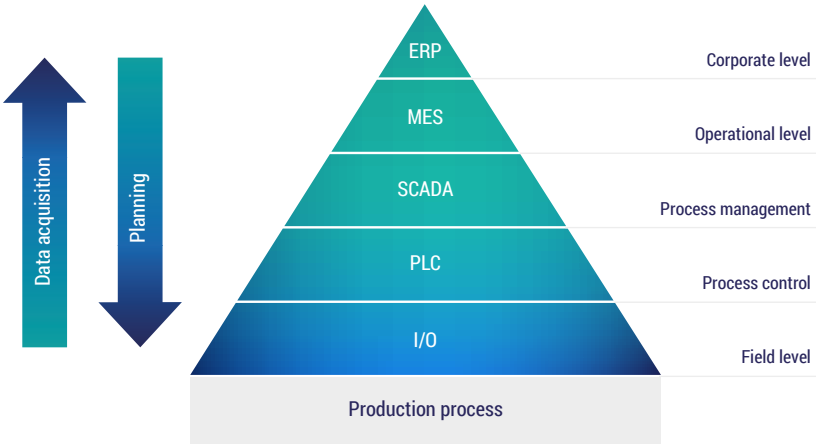
- Optimization of production processes – its general principles were applied by more than 80% of the companies taking part in the study
- Quality management – methods such as Zero Defects, Six Sigma, etc. were used by more than half of the manufacturers
- Lean Management – various Lean Management methods were used by over 50% of respondents
- Supply Chain Management, including in particular the Just-in-Time concept, was appreciated by more than half of the study participants
- Demand Driven Manufacturing – this production management method was employed by a relatively small number of manufacturers

It should be noted that the use of the methods in question was highly dependent on the size of a given company and its sector of operation. In general, the methods that are most popular among Polish manufacturing companies are the ones focusing on production optimization (especially in terms of costs) and quality improvement.

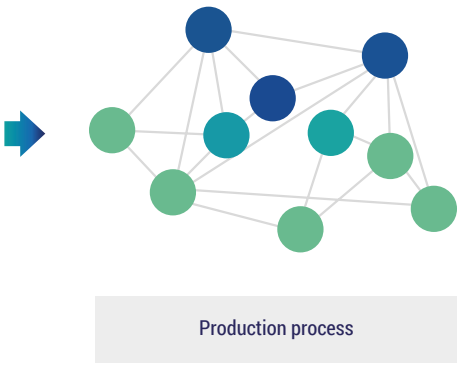


In the era of Industry 4.0, the issues discussed above are still relevant. Also, new methods are being developed in the area of management. By acquiring large amounts of data from production systems, companies can, for example, implement advanced maintenance and machine servicing strategies. While production companies have so far usually serviced their machines at regular intervals (which is an approach known as preventive maintenance) or when a failure actually happened, a smart factory would be more likely to implement the concept of **predictive maintenance.** The data coming from devices and smart sensors are used in this case to evaluate the current condition of machines and their sub-assemblies. If there is a probability of a failure, maintenance services are notified early enough.

Cyber-physical systems that are capable of exchanging data and of operating autonomously either in full or in part make it possible to change the architecture of a **production management system.** For many years, the layered structure of production systems (see image) was prevailing in the manufacturing sector. As a result of technological innovations, the production management system architecture is changed, and linear manufacturing processes transform into networks of connections between individual devices and cyber-physical systems, and into non-linear processes. In order for these processes to take place, it is necessary to ensure a high level of operational autonomy in the case of system components, and to implement a dispersed decision-making system based on the current production status.



Traditional automation and industrial software pyramid



Network of cyber-physical devices, direct communication

Michał Kot
Sales Director at Siemens

Our study shows that the majority of Polish companies understand how important innovation is – they purchase new machines or design and implement new automation lines supported by robots. However, some enterprises put too little effort into improving the management system itself.

The fact is that they should focus on this issue more. We do not need what Americans call rocket science. Sometimes it is enough to make some minor management improvements and to understand the possibilities offered by both data collection and its skillful use.

CHALLENGES AND THREATS

Challenges and threats

Though smart factories can offer many benefits, they also involve threats and challenges, both in technological and in organizational terms. The list below includes the most frequent problems encountered also by representatives of Polish production plants.

Management showing no initiative
In order to carry out a digital transformation, company management boards and owners must have a vision and be motivated. Lack of initiative at this level is one of the most frequent reasons that make enterprises passive as regards implementing the concept of Industry 4.0.

(Non-)secure production systems
As a result of a digital transformation, production systems cease to be separate, closed organizational silos. Instead, they become as vulnerable to cyberattacks as traditional IT networks and business systems. Those threats are real, which was shown, for example, by cyberattacks using such malware types as Stuxnet or Duqu, Ukraine's blackout caused by infecting the systems of a Ukrainian energy distribution company, or a recent global WannaCry ransomware attack.

Not enough references
The number of published business cases describing successful implementations of the industrial Internet of Things and Smart Factory concepts is still too small from the perspective of many people who are in charge of making decisions in Polish companies. Because of the diversity of available technologies, there are unfortunately no universal standards that we could refer to when planning, building or implementing new applications. It is also difficult to define the payback period.

Problematic coordination of a digital transformation
In order to implement the solutions in questions, processes need to be changed or often designed anew.
This applies, for example, to logistics, production methodology or to the formation of a feedback loop between the production and R&D, marketing department, and customers. Thus, Industry 4.0 should cover an entire organization and requires a strategic approach to be adopted.

Specialist staff shortages

A deepening competence gap calls for changes in terms of HR. In order to fully benefit from new technologies, it is necessary to cooperate with specialists, for example from the field of data analysis. Traditional knowledge about automatics also requires broadening one's skills in programming and IT technologies. Such problems may get even worse if a company uses outsourced staff.

No effective communication between production and IT

Departments in charge of production and IT have been treated as two separate areas for many years, and they also have had nothing in common in terms of management. Production automation and supervision teams have usually been different from typical IT staff members as well. Nowadays, as the areas mentioned above become more and more integrated, it is necessary for these two groups to effectively communicate and frequently collaborate.

Exposure of sensitive data

To implement Smart Factory solutions, we need to cooperate with external companies and various technology providers that, as a result, have access to sensitive data. This gives rise to concerns about our know-how, especially if there are plans to implement cloud-based technologies and to provide remote access to production systems.

Tomasz Haiduk
Director for Industrial Sectors
Member of the Management Board at Siemens

Industrial manufacturing has always required a large capital to start a factory. Now, if you have an idea, you may produce your own, customized products using 3D printing – at a small scale at first, allowing you to raise the necessary capital in time.

Such an approach makes it possible to quickly grow your business to a size necessary for your idea to be commercialized. All that is possible thanks to Industry 4.0 technologies.

INDUSTRY 4.0 IMPLEMENTED IN AN ORGANIZATION

Steps to be taken to implement the concept of Industry 4.0

Analyze

- Get familiar with case studies and business cases about companies from your sector, and draw conclusions. What digital technologies have been used? What business advantages have they brought? Would such an approach be effective at your organization and would it bring similar advantages?
- Keep up with new technologies related to Industry 4.0. Would it be possible to use them in your factory? What advantages could they bring?

Understand

- Establish a special unit responsible for the adoption of digital technologies at your organization. It should be cross-company in nature, otherwise it could result in a "silo" approach to digital strategies.
- Constantly monitor the literature and publications about digital solutions – this way your knowledge about digital technologies and their use in your sector will always be up-to-date.
- Establish cooperation in terms of digitalization with other equity-related enterprises. It might be a good idea to enter into alliances with partners, customers, research centers, universities or even some competitors.

Plan

- An organizational unit will be responsible for planning the digitalization strategy and for coordinating the actions taken throughout the organization. Such a unit is managed by a Chief Digital Officer (CDO) or a Chief Digital Information Officer (CDIO).

Act

- Run pilot projects followed by projects transforming your company into a digital organization.
- Educate your organization in the field of digital technologies and the possibilities they offer. Popularize digital solutions.

Draw conclusions

- Analyze the risks connected with digitalization.
- Feedback loop: verify the adopted strategic principles and modify them "on the fly." Roadmap changes in terms of digitalization.

The implementation of digital technologies should be understood as a process, not as a group of correlated single tasks. In practice, this means that every work done to implement digital strategies is subject to ongoing verification of the adopted principles, and requires such strategies to be adjusted to the current situation at a given organization and to constant technological changes.
Despite a large dose of uncertainty, the organizational methods consisting in planning and projecting are most desirable. In order to implement digital technologies, most companies prepare relevant documents and the so-called digital roadmap.

Place within the organizational structure

All the measures concerning the implementation of digital strategies and Industry 4.0 are usually coordinated by a Chief Digital Officer (CDO) or a Chief Digital Information Officer (CDIO). Such an officer is responsible for introducing digital technologies and for managing the related processes. This role is most usually performed by a manager having quite wide powers and who is often also a board member.

Digital competence

Implementing digital strategies and Industry 4.0 concepts requires staff with new skills. One of them is data collection and analysis, which requires Big Data and Machine Learning expertise. New skills and new specialists will also be needed in the fields of data security, data access control, and information management.

One of the important elements of a digital strategy is to create the right organizational culture that will make the company attract the most talented, ambitious young people willing to take up any challenge faced while implementing Industry 4.0, modernizing plants or designing products using digital technologies.

Which strategy objectives should you start with?

When you plan to adopt a long-term strategy for transforming your organization into a digitalized production plant, it is best to start with relatively easy objectives giving you quick, measurable effects. Implementing the Real-Time Enterprise initiative may be an example of such an objective – it would make the data accessible more quickly and the access to information on current production more effectively.

What should be the direction of the transformation efforts at your company?

That is not an easy question as the answer depends on the nature of production at a given plant. In the case of process enterprises whose final products are for example electricity, chemical substances or fuels, the digital revolution will make it possible to exercise better control over each process, to increase energy efficiency or to improve the quality of products while keeping the manufacturing costs more or less the same. By collecting digital information, companies will also be able to better calibrate technological processes, to be more predictive (thanks to Big Data analysis and machine learning) and to optimize their businesses. Predictive analytics used for optimization and real-time automatic management of failures, and self-learning algorithms that make it possible to analyze the influence and to support decision-making processes will allow you to attain the most important objectives of a digital transformation.

As far as discrete and hybrid manufacturing is concerned, with such examples as cars produced by automotive companies or food & beverage products, digitalization will lead to changes in manufacturing processes and to making products better adjusted to customers' individual needs. This means that the competitive advantage will consist in the ability to deliver more "tailor-made" cars, or food products in consumer-customized packaging.

The role of pilot projects

Pilot projects not only allow companies to gain knowledge about the usability of individual technologies, but they also provide application experience. Such knowledge may turn out to be invaluable. When defining the scope of such projects, one should clearly specify objectives and expected benefits (KPI). All projects, not only the pilot ones, should be based on an analysis of four aspects, including organization, staff skills and knowledge, process organization, and technology. It usually happens that a company is unable to undergo a digital transformation because its staff has not been properly trained. Therefore, it is worth remembering that Industry 4.0 enterprises often need employees with different skills and qualifications than are available today, while the digital transformation require completely new job positions and responsibilities to be created, and staff to be trained in new fields.

Avoiding the “silo” approach

In order to ensure that a digitalization strategy is effective, the so-called “silo” approach should be avoided, that is a situation where individual departments or business units carry out a digital transformation without cooperating with one another and in isolation from a broader perspective of the entire organization. Meanwhile, in order to introduce the concept of Industry 4.0, you need to take a coherent approach and to agree on digital standards and implementation methods in the entire company or group.

It is also important to determine which systems that already function in a given organization could be put into use and then in the future integrated with new digital solutions. This type of cooperation should also be understood as broadly as possible. When carrying out the digital strategy, it is worth extending its scope beyond your own organization to be able to run joint projects with customers, suppliers, partners, universities, research centers and sometimes even with competitors within your sector. The ultimate objective is to bring as much added value as possible to the value chain and, by working together, to be able to achieve more than today’s market offers.

The role of “soft” elements in the management approach focusing on the digital revolution

Even if a project carried out as part of the digital strategy is purely technological in nature (for example when you install a new generation of sensors that make it possible to collect production information on a real-time basis), it is a good idea to let the entire organization know about such plans and at the same time use this project as an opportunity to expand your team’s knowledge and to educate its members on digital technologies. Such an approach makes the entire company more aware of your key objective, that is the factory digitalization. Also, the staff’s positive attitude towards digital technologies allows you all to create favorable conditions for new initiatives and concepts of using technologies that streamline the production process.

Business objectives as a priority

When assessing if a given project is useful, you should focus on meeting your business needs, on providing the customer with added value, on streamlining your business processes and on unlocking any new potential your organization may have. Your ultimate objective, therefore, should not focus on “implementing a specific technology,” but on gaining business benefits. Such goals are often long-term, but if you put them on a roadmap as milestones within your company’s digital development, you will be able to substantiate any expenses necessary to implement a given technology, even if they do not result in direct short-term benefits.

As technologies change quickly, the product-as-a-service approach has made it possible to replace the capital expenditure (CAPEX) with the operational expenditure (OPEX). This protects your enterprise against investing in technologies whose lifecycle turns out to be short after a while, possibly leading to sunk costs. Unfortunately, in the case of heavy or process industry (for example the chemical or power sector), it is often needed to adopt a long-term approach, which makes the capital expenditure quite large. In such cases, it is a good idea to make sure if the purchased equipment and technologies can be expanded and upgraded in the future, both in terms of hardware and software, allowing you to add new functions that will meet the requirements of a plant that keeps pace with Industry 4.0 technologies.

The role of the management board

As with any major organizational change, the implementation of Industry 4.0 solutions requires the management board to be engaged in the transformation and to personally support digital strategies. During the transformation period, both the leadership and the change management are of fundamental importance. It is also necessary to involve all stakeholders inside or even outside of the organization.

INDUSTRY 4.0 IN POLISH COMPANIES

Industry 4.0 in Polish companies

In cooperation with Millward Brown, a research company, Siemens has been carrying out the “Smart Industry Polska” study for two years, with the aim to collect information about how technologically advanced Polish companies are and how ready they are for the fourth industrial revolution.

The study shows that a great majority of respondents (68%) think that the level of advancement of the Polish industry in their sector is similar to the level on which this sector is in Western Europe. Approximately 7% of the study participants claimed that this level was higher, while 3.1% claimed that it was definitely higher. 19.6% respondents said that their sector was less advanced than in Western Europe, whereas 1% were of the opinion that it was considerably less advanced technologically. As many as 60.8% respondents do not wait for their control system components to get obsolete and to pay for themselves – they rather replace them on an ongoing basis. A minority of respondents, most of them being either companies with foreign equity or heavy-industry companies, stated that their approach was to replace control elements only when they became obsolete.

Among the technologies implemented in Polish enterprises, robotization was mentioned most frequently (67%). The Big Data technology also turned out to be quite popular (44%) as compared to typically industrial technologies such as the Internet of Things and M2M. The research also tells us about the respondents’ plans for the future. Only in the case of MEMS (microelectromechanical systems), the number of companies planning to use them is higher than the number of companies that already do it. Apart from that, most companies already use the technologies that are considered to be adequate given the organization’s level of development.

The purpose of the study in question was also to evaluate how advanced companies are in terms of their equipment resources. According to the data provided by the respondents, most of them use foreign machinery. Only 8.2% of participants reported that they used mostly Polish machines (on a 1–10 scale, where 1 was “Only Polish” and 10 – “Only foreign,” they selected a value below 5). The respondents’ replies suggest that not all companies have enough capital or attach adequate significance to the use of modern technologies. Over the past three years, a typical company has replaced 25% of its equipment resources. In total, 39.2% of respondents said that their equipment and machines were innovative, fully automated and flexible. Companies actively replace individual components of their equipment resources – more than 70% of companies have been modernized this way over the last 3 years.

Technological changes encourage companies to cooperate with partners on the market. Over 70% of the respondents stated that their companies had established cooperation with other enterprises operating in related sectors, and more than 60% had carried out their own R&D activities or cooperated with other companies in the same sector. Also, about 60% of company representatives plan to outsource certain work to universities or public research institutions. The percentage of companies that claimed to already have experience with this type of cooperation was only slightly lower (56.7%). The above responses allow us to assume that cooperation with academic institutions will not only be continued, but also extended.

	Flexible and smart technology solutions for manufacturing plants, allowing real-time adjustment and quick response to changing expectations of the target audience	Solutions designed to improve communication, employing modern technologies and networks, both inside and outside of the company	Information digitalization solutions (concerning the way information is collected and managed) that make effective production management possible at all levels (Value Chain Management)
Applied	**58,8%**	**66,0%**	**73,2%**
Planned	**13,4%**	**14,4%**	**8,2%**
Neither applied nor planned	**23,7%**	**18,6%**	**16,5%**
Don't know	**4,1%**	**1,0%**	**2,1%**

As many as 46% respondents claimed to have enhanced security standards in force. When looking at all study participants, there were slightly more companies using basic security standards. This proportion, however, is reversed in the case of companies using foreign capital, where additional, higher standards apply. Such a trend is even more visible in the largest companies – as many as 60.5% of them have implemented higher security standards.

Innovation work intended to be performed in the next three years

None	Cooperation with a foreign R&D unit being a group member	Outsourcing of R&D work to commercial service providers or independent experts	Purchase of licenses, patents, copyrights, industrial designs, trademarks, know-how	Outsourcing of R&D work to universities or public research institutions	Cooperation with companies operating in the same sector	Conducting of R&D work within the company or group in Poland	Cooperation with companies operating in related sectors	Purchase of new or substantially improved machinery, equipment or software
3,1%	41,2%	46,4%	47,4%	58,8%	59,8%	61,9%	69,1%	93,8%

Jan Filip Staniłko
Deputy Director of the Innovation Department
Ministry of Development

The increase in innovativeness of the Polish SME sector and its transformation to the level of Industry 4.0 is strongly dependent on the degree of diffusion of knowledge about the opportunities offered by Industry 4.0, and on changing the methods of managing enterprises. In the age of Industry 4.0, employees must regularly undergo training and be empowered to make independent decisions, while managers should know how to manage constant change. Success will also depend on the level of cooperation, both between companies (preferably using excellent tools provided by Industry 4.0) and between the private sector and research centers (which still happens relatively rarely through the fault of both sides). The activities of the public sector, apart from designing appropriate mechanisms supporting the financing of purchases and implementations, should therefore also focus on educational and integrating undertakings. Only such a comprehensive approach can guarantee success.

CASE STUDY

Case study

Launched in 2017, after only 23 months of implementation work, the Volkswagen Poznań utility car factory in Września produces 100,000 Volkswagen Crafter cars in about 60 variants every year. Siemens was asked to provide solutions for handling parts and vehicles assembled on production lines. Due to a large number of available vehicle types customized depending on customers' needs, the VW Crafter factory can be viewed as a facility that well represents a company operating in line with the concept of Industry 4.0.

At the Volkswagen Poznań factory in Września, Siemens installed a system providing a comprehensive technology for transporting production components and vehicles. A complete transportation line for the final assembly makes smooth production possible, starting at the paint shop and ending the moment vehicles leave the factory on their own wheels.

The transport line can be divided into two sections, namely the ground-level and the suspended section. The ground-level line consists of transport trucks and conveyor belts based on chain conveyors. 64 SKID transport trucks are responsible for the operation of a 1,600-meter-long assembly line. Two conveyor belt lines are equipped with plastic chain conveyors. The first line uses SKID transport trucks to handle cars that are being assembled, while the second one transports complete cars. There is also the third line – a two-track plate conveyor that transport cars with wheels.

Apart from that, we should mention 25-meter-long transport conveyors, which look like moving walkways, for production workers. They move parallel to the main line with the same speed as the transported cars, thus ensuring higher efficiency during assembly and more ergonomic working conditions for fitters.
Suspension lines are a separate form of transport. The first EHB suspension line is 1,250 meters long and consists of 94 so-called production hangers. It allows vertical and horizontal movement of car bodies at desired speeds. The hangers are suspended from a special steel system attached to the roof structure.

The second and third suspension lines are composed of the following elements respectively: 190 hangers for door transport (this line is 1,000 meters long), and 25 hangers for car cockpit transport (this line is 300 meters long). They are sublines where more equipment is added to doors and cockpits, and then these components are installed in cars. There are also 12 special hangers for installing sliding doors.

Mirosław Salwach
Project Manager at Siemens

In order to meet the requirements set down by the Volkswagen factory in Poznań, we have adjusted the production line in such a way as to technologically facilitate some of the processes. A vehicle is rotated while moving along the assembly line, thus making it easier to install the parts that need to be put at the rear of a van.

The technical solutions developed by Siemens include, among other things, a wide range of Siemens industrial controllers, their related software, the signal lines responsible for controlling and collecting information from sensors and then transmitting them to the central production management system.

The entire car production process taking place at the factory in Września has been divided into assembly belt stages (tacts). The tact time on the production line is 110 seconds, and there are 120 such tacts within the entire assembly line. During the production process, vehicles move along the production line through individual workstations where Volkswagen workers either carry out the activities planned beforehand using modern tools or supervise the work done by robots, responsible for example for the installation of car glass and floor. Each assembly phase should take not more than planned as each such delay stops the entire production process. The speed of work at each workstation is synchronized with the pace at which the transported elements are moved.

Using the technology that covers the elements of infrastructure responsible for the mechanics of transport taking place on the production line and for the solutions designed to control the equipment, the elements of this infrastructure have been adjusted to meet the customer's needs and the needs of utility cars.

It should be mentioned that the process of assembling utility cars differs significantly from that of passenger cars due to the number of possible variants and vehicle sizes. This is particularly important in the case of the rear part of the car, much more complex in vans. In order to meet the requirements set down by the Volkswagen factory in Poznań, the production line has been adjusted in such a way as to technologically facilitate some of the processes. A vehicle is rotated while moving along the assembly line, thus making it easier to install the parts that need to be put at the rear of a van, especially the floor.

Glossary

Additive Manufacturing, 3D Printing – a process of building 3D objects based on computer models

Artificial Intelligence (AI) – a field of knowledge that covers fuzzy logic, evolutionary computation, neural networks, machine learning, artificial life and robotics; in the context of Industry 4.0, it is usually considered equivalent with a set of technologies that make it possible for machines to learn and solve complex problems

Augmented Reality – a system that combines the real world with the computer-generated one; images may be displayed using goggles, mobile devices, etc.

Big Data – a term that applies to large, variable and diverse (so-called 3V – Volume, Velocity, Variety) datasets that are difficult to process and analyze but also valuable as a source of new knowledge

Cloud Computing – a model of data processing based on the services from a service provider without the need for purchasing any license or installing software

Collaborative Robot, Cobot – a robot that can collaborate with people without the need for using safety fences

Crowd-sourcing – a process in which an organization outsources tasks traditionally performed by employees to a usually wide group of people in the form of an open call

Customer Development – a method of developing products, processes or business models in general based on the feedback received from customers, from the market, etc.

Cyber-physical Systems (CPS) – integrated systems where mechatronic, electronic and communication systems are intertwined with software

Cybersecurity – a set of IT and telecommunications issues and technologies concerning the estimation and control of risks involved in the use of computer networks and of the equipment connected to them

Demand Driven Manufacturing – a production methodology where production is based on actual orders rather than on forecasts (demand estimates); this concept is similar to “pull manufacturing” in which only the resources that have been utilized are replenished during production

Digital Factory – a production plant where digital technologies are used for modelling, communication and management of production processes

Digital Twin – a digital replica of physical assets, processes and systems with both static and dynamic features; also used to describe software for creating virtual representations of physical systems and for simulating them

Duqu – a trojan, malware that attacks for example industrial control systems

Enterprise Resource Planning (ERP) – a method of effective planning of organization resource management, as well as any software aiding such processes

Geolocation – identification of geographic location (or the location itself) of people or objects, typically using GPS or an IP address

Industrial Internet of Things (IIoT) – an area within the Internet of Things, related to the use of IoT technology for industrial applications, especially for measurement, supervision and dispersed assets management

Industry 4.0 – a concept of using automation, data processing and exchange as well as various new technologies (mostly digital) to create so-called cyber-physical systems, change production methods, customize products and change the way value chains function; in technology, it is an aggregate notion that includes a number of new technologies, such as for example the Industrial Internet of Things, cloud computing, Big Data analysis, artificial intelligence, additive manufacturing, augmented reality or collaborative robots

Internet of Things (IoT) – a concept according to which objects and devices can collect, process and exchange data via communication networks, mostly the Internet

Just-in-Time (JIT) – a management method used to reduce the stock level and work in progress in manufacturing and warehousing processes

Lean Management – an extension of the concept of lean manufacturing used at manufacturing plants

Lean Manufacturing – a concept of managing production processes, developed based on the principles and tools used in the Toyota Production System (TPS)

Manufacturing Execution System (MES) – software (and other technologies) used for real-time manufacturing operations management and for transferring information from the production to the business area

Mass Customization – the use of flexible production systems to manufacture customized products while keeping marginal costs low

Portable robot, AGV (Automated Guided Vehicle) – an autonomous vehicle used, among other things, for on-site and warehouse intralogistic applications

Predictive Maintenance (PdM) – a maintenance strategy according to which the machines are to be used in an optimal way thanks to eliminating failures, and the maintenance services are to work only when needed, depending on the actual condition of a given piece of equipment

Product-as-a-service (PaaS) – a business model according to which customers use products by leasing them against payment

Product Lifecycle Management (PLM) – a business strategy (or strategies) related to business management at various product lifecycle phases; also, software aiding such management

Programmable Logic Controller (PLC) – a microprocessor device whose basic function is to control how a machine or technological equipment works

Radio-frequency Identification – a technology that allows wireless transmission of data and power to RFID tags; in industry, it is used, among other things to label products during their manufacture and during warehousing and logistic processes

Six Sigma – a quality management method which aims to reduce the probability of getting a defect to 3.4 per million opportunities (for example manufactured products)

Smart Factory, Factory 4.0 – a manufacturing plant based on cyber-physical systems, their integration using the Internet of Things, and new methods of production organization; it ensures a high degree of product customization and enables manufacturing processes to take place with minimal human interaction

Stuxnet – a computer worm attacking Windows systems, uncovered in 2010; it was the first discovered worm used to spy on and reprogram industrial systems

Supervisory Control And Data Acquisition (SCADA) – an IT system supervising technological or manufacturing processes

Supply Chain Management – related to the management of flows between the links of a supply chain, including planning, execution, control, and monitoring

Technology of Distributed Records (Blockchain) – a decentralized open source database encoded using cryptographic algorithms, used to record transactions

Value Chain Transformation – changes within the value chain(s): vertical, including the integration of processes within an organization, and horizontal, making it possible to optimize logistic and manufacturing processes, and to enable easier exchange of information between the organization and its suppliers, service providers, contractors, customers and distribution networks

Virtual Reality – a false reality image created using information technology; virtual reality is used in industry for example for designing and simulations

WannaCry – a ransomware-type malware used for cyberattacks, e.g. in May 2017

Zero Defects – a management method aimed at reducing defects altogether through proper organization of processes, infrastructure maintenance and staff training

MARKET COMMENTS

Andrzej Gantner
Polish Federation of Food Industry
Union of Employers

The food industry in the present conditions is under presure of very strong competition. At present, without investing in automation, production processes digitization and robotics is difficult to imagine strengthening of Polish enterprises competitiveness. At the moment, everyone in the world is investing in new technologies, and Polish enterprises that want to gain new markets have practically no choice - they must first learn about the latest trends and, secondly, choose and implement those that will have the greatest impact on improving the market position.

In this context, the Fourth Industrial Revolution will be an important challenge for food industry enterprises that will have to cope with. Polish enterprises have to modernize to keep up with the competition. The implementation of modern technologies related to the introduction of the Internet of Things, industrial internet of Things, robotics, cloud technology and big data will provide enterprises in the industry with better control over production processes. We have to do it, because it will certainly contribute to the improvement of product quality and will contribute to optimization of production costs and logistics.

Paweł Wideł
Confederation Lewiatan Union of Employers of Automotive and Industrial Articles Confederation Lewiatan, President of the Board

In the automotive industry technologies concerning 4th industrial revolution are critical. This is because the implementation of new technologies related to the production processes is strongly and multilaterally linked to the revolution in the society's mobility.

Industry 4.0 concept is only one of elements in the wider digital transformation, which includes, among others, mega-trends in mobility, such as autonomous vehicles - equipped with communication system or shared.

Implementation of these revolutionary changes in mobility announces the transition from the current business model in car industry production, sale and financing to the new model, where the most important is offering the entire spectrum of mobility services. These processes will intense affect the automotive industry.

Car manufacturers will even be forced to take advantage of the new opportunities that become available with the Industry 4.0 concept implementation. Undoubtedly, car manufacturers have to quickly respond to the changing customers' needs adopting or even creating new business models and searching for new sources of revenue. The future of each carmaker will depend on that.

However, there is concern about whether it will be financially profitable to produce personalized products on a large scale in the short term. Therefore, it is reasonable to listen to critical remarks from the industry, not to hamper development and avoid potential threats, including new law regulation.

IMPACT'18 COMMENT

Michał Sobczyk
Impact Research Hub, Impact CEE

Uses of blockchain technology in industry 4.0

From the moment it was first used blockchain technology, as well as the systems of distributed ledgers related to it, was first and foremost associated with areas related to financial services, especially cryptocurrencies. Today, optimists believe that blockchain has the potential to become a breakthrough technology that will rival i.e. the effect of Internet in the 1990s.

Despite the initial misunderstanding and biases towards this technology, part of entrepreneurs are trying to find new uses for it more and more often – not only in the broadly defined industrial sector but also in other parts of the economy.

If an entrepreneur does however decide to build a blockchain-based infrastructure in his company, he should be made aware, not only of the advantages but also of the disadvantages that it offers.

Blockchain has the potential to become one of the key components of the technologies that make up industry 4.0 – offering, among others, a safe and encrypted method to track digital records. Blockchain can also successfully be used in other areas – such as the creation of ledgers of communication between industrial machines functioning in the Industrial Internet of Things. Blockchain has the capability to easily manage and control transactions between various trading partners in a constant way – so that no one along the supply chain can change any previously provided blocks of information. That's why it is manipulation-proof and doesn't require a centralized database. Blockchain also provides an environment conducive to cooperation between several entities that are unfamiliar with each other – this thanks to a simplified interoperability of machines and people as well as transparency of information, a very high level of security and decentralized software components.

Blockchain technology also fits the concept and assumptions of industry 4.0 by making a tremendous contribution to the ecosystem of interconnected companies which exchange huge amounts of data among each other and have to be able to conduct safe, quick, automatic transactions involving systems, objects, processes and people. Yet another use of blockchain are smart contracts – programs that constitute agreements between parties that are carried out in accordance with previously defined circumstances.

In relations to industry 4.0 it is worth underlining that blockchain can make in easier to synchronize the cyber-physical systems that make up the so-called intelligent factory – making it safer for machines to autonomously order required replacement parts, indicate upcoming failures in the supply chain before they happen and optimize the production process for better energy efficiency. The potential of blockchain allows us to more easily adjust to a more productive and flexible business model that is based on the security and confidence of all affected stockholders.

Blockchain technology can be used not only in the industrial sector but also in the energy industry – the efficiency and stability of which is critical to all industrial businesses. Blockchain can also be utilized in the charging of electric vehicles and management of micro networks.

It is, however, important to remember that Blockchain is still a new technology which, aside from the many advantages it provides has also several flaws. If Blockchain is to be used in other sectors of the economy - these flaws need to be eliminated. It is important to note that blockchain is developing at the speed at which the software advances, not the speed at which the infrastructure for it is implemented.

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Manages marketing strategies for industrial sectors at Siemens Polska by coordinating all activities taking into account the company's organizational complexity and international structure.

The aim of his work is to consistently implement the strategy of positioning Siemens as a partner for the Polish industry, including in particular such sectors as automotive, F&B, minerals or safety.

Zbigniew Piątek
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