



Industry 4.0

Upgrading of Germany's industrial capabilities on the horizon

April 23, 2014

Author

Stefan Heng
+49 69 910-31774
stefan.heng@db.com

Editor

Lars Slomka

Deutsche Bank AG
Deutsche Bank Research
Frankfurt am Main
Germany
E-mail: marketing.dbr@db.com
Fax: +49 69 910-31877

www.dbresearch.com

DB Research Management
Ralf Hoffmann

Industry 4.0 will upgrade Germany's industrial capabilities. With trade flows becoming increasingly internationally interlinked, automation, more flexible processes as well as horizontal and vertical integration are becoming more important features in a modern, competitive production structure. Germany in particular with its especially favourable fundamental features will find that "Industry 4.0" (aka integrated industry) provides a major long-term opportunity for the country to consolidate its leading position in the global marketplace – even against its fast-growing emerging market competitors.

Germany has been and will remain an industrial heavyweight, creating one-third of the EU's value added. German firms create one-third of the EU's total industrial value added. A long way behind comes Italy, followed by France, the UK and Spain. Since in other countries the value added share is steadily on the decline, Germany should retain its leading position as the industrial backbone of the EU for the foreseeable future.

The potential for upgrading industry is particularly pronounced in Germany. Industry 4.0 can progress if there is close exchange between the fields of electronics, electrical engineering, mechanical engineering and IT. With this approach Germany has special strengths as the "factory outfitter of the world". These strengths are based on the country's good general education system, its established development partnerships between suppliers and users, its market leadership in plant and mechanical engineering, its strong and dynamic SMEs and its position as the leading innovator in automation methods.

Industry 4.0 has largely been a matter for big companies, today. However, vertical and horizontal integration are also becoming increasingly important for small and medium-sized companies involved in international competition. The myriad benefits associated with Industry 4.0 are shown by Agco, BorgWarner, Bosch Rexroth, Bruker, Festo, Harting, Homag, Introbrest, Kaba, Seca, Sick, Trebing + Himstedt, Trumpf or Wittenstein with their promising approaches.

Country-specific challenges are holding back progress. In order to be able to comprehensively leverage the potential of Industry 4.0 in Germany the issues concerning supervisory control, security, confidentiality, standardisation, legal framework and infrastructure provision (power and communications networks) need to be addressed now – and consequently this means not focusing solely on Germany or Europe.

Industry 4.0 offerings are still suffering from overblown expectations and the lack of a clear definition of what the term stands for. Following the hype that typically surrounds such issues and the subsequent disillusionment it is possible that the term Industry 4.0 will already have been forgotten in a few years' time – the idea associated with it will nevertheless continue to become established.



Upgrading of Germany's industrial capabilities on the horizon

Blessing and curse of the hype

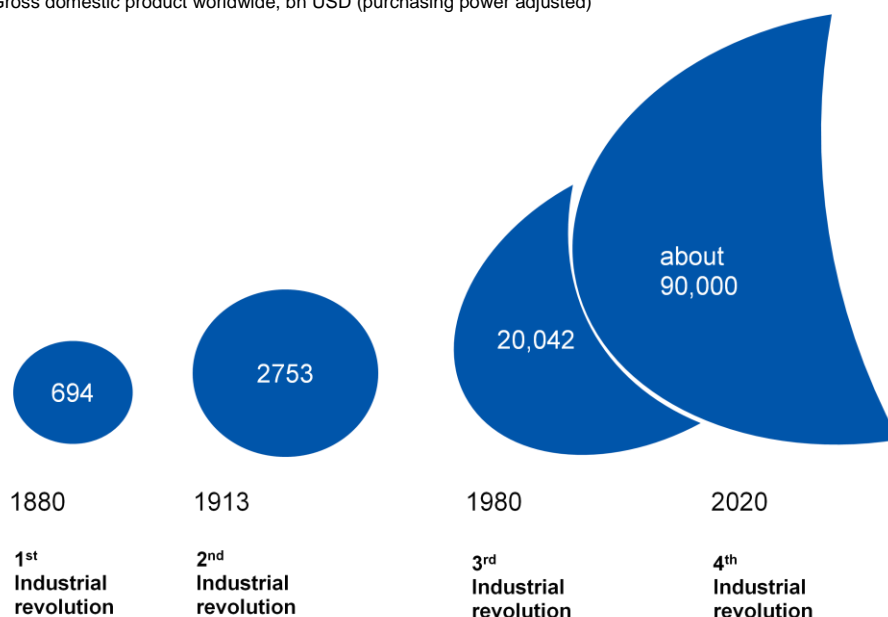
Industry 4.0 (also known as integrated industry) is on everyone's lips. Big companies, the *Mittelstand* and certain members of the public are examining the new opportunities associated with it. This interest has undoubtedly been boosted not only by the focus that Industry 4.0 received at the Hanover Fair, a major international industry fair, but also by the German government's support provided by a number of ministries, which besides raising its profile at the "IT Summit" includes grants totalling EUR 200 m. However, in the vast expanse encompassing Big Data,¹ cloud computing,² cyber-physical systems, RFID chips,³ Internet of things and services,⁴ machine-to-machine communication and Smart X (i.e. intelligent features in many things)⁵ the term Industry 4.0 remains imprecise – which is possibly the intention of many marketing strategists. This imprecise definition of Industry 4.0 repeatedly gives rise to overblown expectations, which are then not met and lead to disappointment. Providers advertise Industry 4.0 offerings as completing automation and thus also enabling cost-effective adaptation of production to individual requirements.

The PR campaign surrounding Industry 4.0 has ensured that numerous companies and institutions are now aware of the concept. However, with expectations raised by this campaign what happens all too often is that the fundamental idea of boosting efficiency via sensible automation gets lost in the hype surrounding the buzzword.⁶

Development of economic output since first industrial revolution

1

Gross domestic product worldwide, bn USD (purchasing power adjusted)



Source: ZVEI, 2013

¹ See BITKOM (2012). Big Data im Praxistest. Berlin.

² See Heng, Stefan (2012). Cloud Computing. Deutsche Bank Research. Frankfurt/Main.

³ See Heng, Stefan (2009). RFID-Funkchips. In Pradel, Uwe-H., Wolfram Süßenguth, Jochen Piontek and Armin F. Schwolgin. Praxishandbuch Logistik. Cologne.

⁴ See Bullinger, Hans-Jörg and Michael ten Hompel (2007). Internet der Dinge. Berlin, or Heng, Stefan (2008). Web 2.0. Pago-Report: Trends im Kauf- und Zahlverhalten. Cologne.

⁵ See Auer, Josef and Stefan Heng (2011). Smart Grids. Deutsche Bank Research. Frankfurt/M.

⁶ Scheele, Ulrich (2013). Industrie 4.0: Beherrschung der industriellen Komplexität SysLM. Berlin.

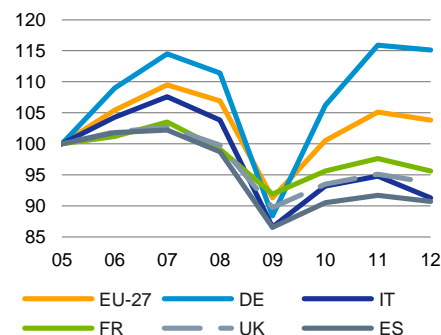


Upgrading of Germany's industrial capabilities on the horizon

Germany stretches its lead again

2

Manufacturing sector, gross value added, Index (2005=100)

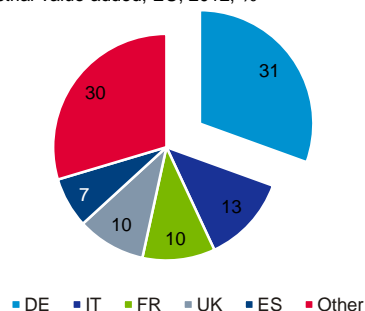


Source: Eurostat, 2013

Germany has highest scores in industrial values

3

Industrial value added, EU, 2012, %

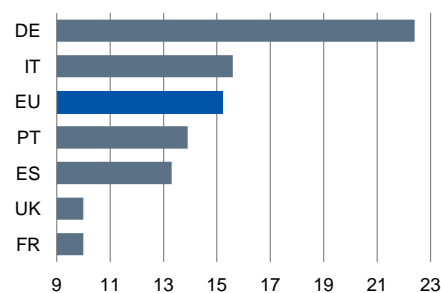


Source: Eurostat, 2013

Germany – an industrial nation

4

Manufacturing share in gross value added, 2012



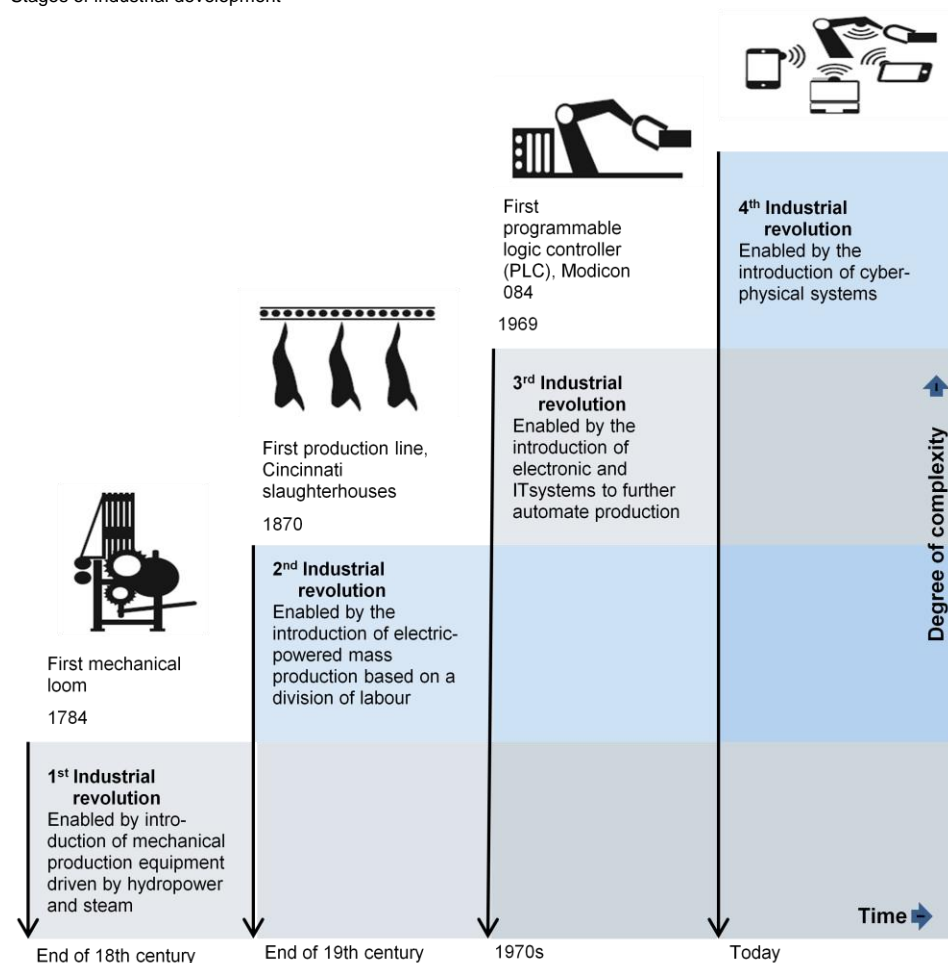
Source: Eurostat, 2013

This report analyses the commercial potential of Industry 4.0. The first section of the report examines the principles of Industry 4.0, identifying the most important terms and concepts as well as the key drivers and obstacles. The second section provides a forecast of how things will develop further. The third section presents a number of examples of Industry 4.0 ideas. The fourth section ends with a conclusion and the forecast.

Cyber-physical systems are the basis of the new industrial revolution

5

Stages of industrial development



Source: DFKI, 2011

Structural change in industry progressing at the international level

Germany creates the lion's share (31%) of industrial value added in the EU. A long way behind comes Italy with a share of 13%, then France with 10%, the UK with 10% and Spain with 7%. In terms of internal value creation structure there are marked differences between the individual countries. In 2012 the industrial share was 23% in Ireland, 22% in Germany, 16% in Italy, 13% in Spain, 11% in the UK and 10% in both Greece and France.⁷

For some time now, however, the industrial structure has been undergoing significant changes. In the eurozone the industry share of gross value added fell

⁷ See for example Sendler, Ulrich (2013). Industrie 4.0. Berlin, or Heymann, Eric and Stefan Vetter (2013). Europe's re-industrialisation: The gap between aspiration and reality. EU Monitor. Deutsche Bank Research. Frankfurt/Main.

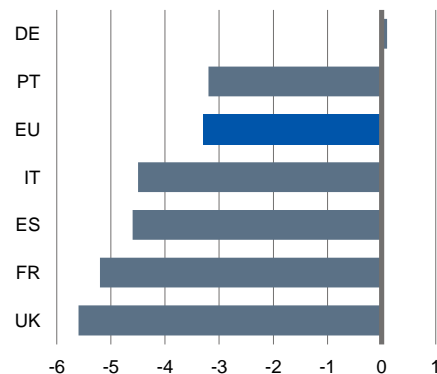


Upgrading of Germany's industrial capabilities on the horizon

Germany the exception among the majors in manufacturing

6

Manufacturing share of gross value added
change 2012 vs.2000, percentage points



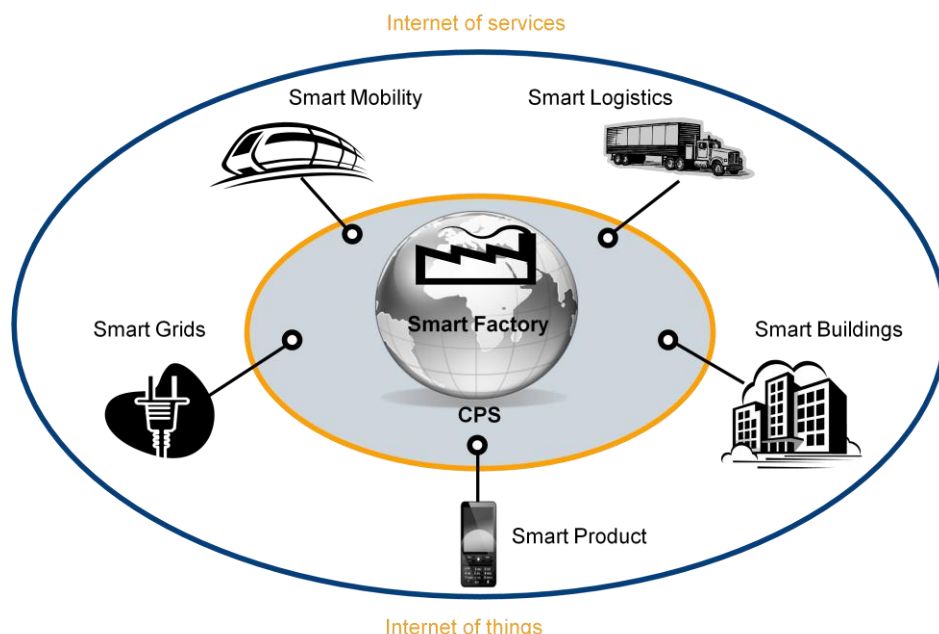
Source: Eurostat, 2013

from 19% to 15% between 2000 and 2012. Nevertheless, this trend is progressing at very different rates in the individual countries. Between 2000 and 2012 the industry share in Germany remained constant at 22%, whereas in Spain and Italy it fell by five percentage points, and in the UK it even fell by nearly six percentage points.

Smart factory in focus

7

Smart X components



Source: acatech, 2013

Stages of industrial development

The stages of industrial development have different names depending on the geographical location and the area under examination (e.g. environment, technology). In this analysis we seek to follow the logic of industrial development, which was developed especially in Germany in close cooperation with the academy of technical sciences, acatech (the National Academy of Science and Engineering), and the Forschungsunion Wirtschaft – Wissenschaft.

All started with the steam engine

According to this logic the first industrial revolution commenced at the end of the 18th century with the introduction of mechanical production equipment, such as the mechanical loom for goods manufacturing. With the advent of electrically powered machinery used for mass production based on the division of labour came the second industrial revolution at the turn of the 20th century. The third industrial revolution then commenced in the 1970s. It was based on the use of electronics and information technologies to automate production processes. This entailed machinery performing not only a large proportion of previously manual tasks but also a number of the intellectual tasks.



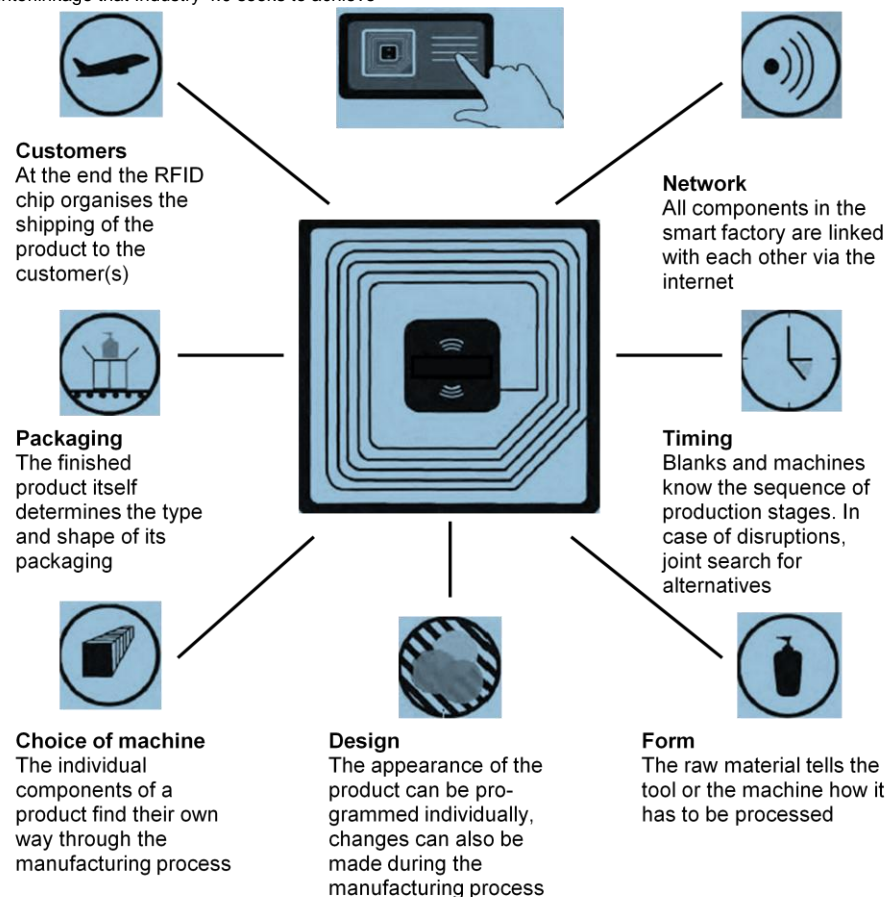
Upgrading of Germany's industrial capabilities on the horizon

The fourth industrial revolution, or Industry 4.0 for short, is to become a reality in the coming decade. The political debate about the term Industry 4.0 focuses equally on the important and abstract objectives. For its promoters, Industry 4.0 is not only about improving Germany's international competitiveness, it is also seen as a tool for tackling the most pressing global challenges (for example, the consumption of renewable and non-renewable resources) as well as specific national challenges (for example, the labour supply that is changing due to demographic shifts).⁸

Communication is everywhere

8

Interlinkage that Industry 4.0 seeks to achieve



Source: Deutsche Bank, 2013

Idea is a source of great fascination

Industry 4.0 is focused on smart products, procedures and processes (smart production). A key element of Industry 4.0 is therefore the smart factory. The smart factory controls the fast-growing complexity while also boosting production efficiency. In the smart factory there is direct communication between man, machine and resources. Smart products know their manufacturing process and future application. With this knowledge they actively support the production process and the documentation ("when was I made, which parameters am I to be given, where I am supposed to be delivered."). With its interfaces to smart mobility, smart logistics and smart grids the smart factory is an important element of future smart infrastructures. Conventional value chains will thereby be refined and totally new business models will become established.

Where am I and where
do I want to go?

⁸ See Baum, Gerhard (2013). Innovation als Basis der nächsten Industrierevolution. In Sendler, Ulrich. Industrie 4.0. Berlin.



Upgrading of Germany's industrial capabilities on the horizon

Boundaries becoming blurred

Industry 4.0 basically describes the fourth stage of industrial development, with increasingly smart systems being formed in ever more closely integrated value chains. The Industry 4.0-compliant production facility is thus a completely integrated smart environment.

Fully integrated intelligent environment

Accordingly, the implementation of Industry 4.0 seeks to leverage existing technological and market potential, to tap it in a systematic innovation process and to bring this overall concept together with expertise, services and the knowledge of employees to create an optimised whole. Companies embarking on the road to Industry 4.0 will pay particular attention to the following aspects:

- Vertical integration of the necessary process stages along the value chain
- Horizontal integration at one stage of the value chain
- Seamless end-to-end digital information flow across the entire value chain

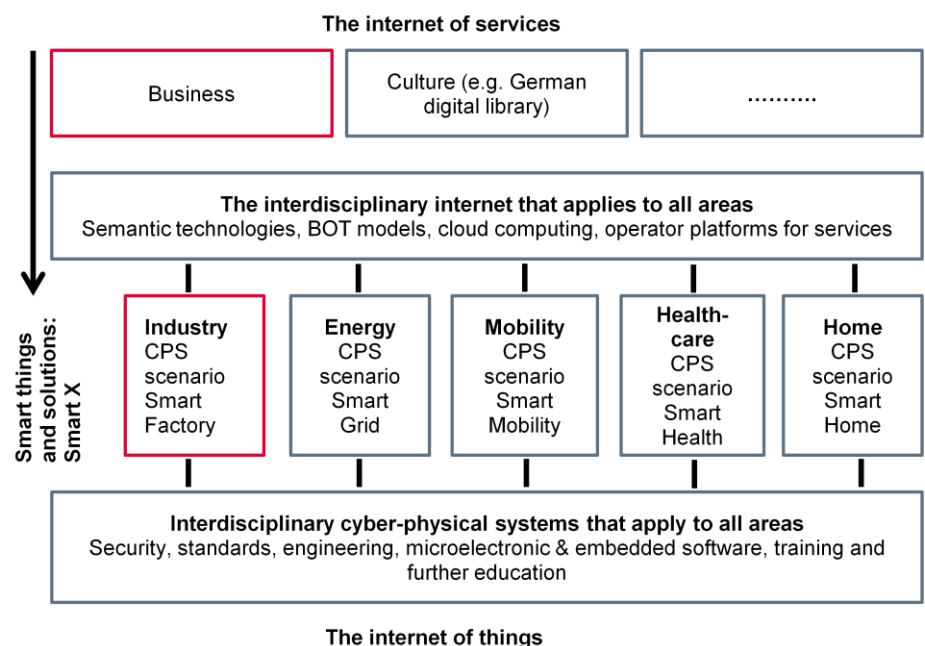
IT link between production, marketing and logistics

The Industry 4.0 concept must therefore encompass not only value creation per se, but also work organisation, business models and downstream services. It does this by using information technology to link up production, marketing and logistics and thereby captures all resources, production facilities and warehousing systems. The re-organisation thus extends from the energy supply and smart power grids through to advanced mobility concepts (smart mobility, smart logistics)⁹. On the technical side the concept is based on integrating cyber-physical systems into production and logistics and the rigorous end-to-end implementation of the internet of things and services in industrial processes. In this smart environment the concept of the internet of things and services that was already devised a decade ago will actually now become a reality.

Physical and virtual world converging

9

Application areas for cyber-physical systems



Source: See Forschungsunion Wirtschaft – Wissenschaft, 2013

⁹ Heng, Stefan (2004). Verkehr und Informationstechnologien - Stau ade? WiSt – Wirtschaftswissenschaftliches Studium. Munich.



Upgrading of Germany's industrial capabilities on the horizon

Numerous cost-cutting options

The user firms want Industry 4.0 to help them implement cost-efficient manufacturing. What is new here is that the optimisation is performed constantly during ongoing operation and across the entire value chain. The main areas where such potential lies are as follows:

- **Capital costs:** Companies that optimise their value chains and increase their manufacturing automation thereby reduce their tied-up capital.
- **Energy costs:** Companies can cut their energy costs via efficient use and smart control of their plant facilities. Little attention is paid to this cost item by many companies, but it is usually quite a significant sum.
- **Personnel costs:** Companies with highly automated production processes tend to require a declining number of low-skilled employees.

Overall effect difficult to gauge

Making a sound assessment of the overall effect (including the costs of training, implementation and maintenance) within the company will prove difficult in most cases, though. This is particularly the case because numerous user companies, especially SMEs, can often only very vaguely estimate their actual costs (and thus also the necessity to undertake restructuring).

Industry 4.0 offers more than cost-cutting

Boost efficiency, increase flexibility

10

The vision for Industry 4.0



Source: See Siemens, 2013

Industry 4.0 is, however, by no means limited to the area of costs. Rather, the concept is broad in scope and is described by experts as extremely relevant. For instance, in what is undoubtedly an optimistic projection, acatech asserts that firms could boost their productivity by 30% with the aid of Industry 4.0.

The main parameters that open up the potential for this increase are flexibility, lead times, batch size, new services and work structuring. We shall address these parameters below:

- **More flexibility:** Networking enables business processes to be structured more dynamically. Production procedures in particular are to react more flexibly to changes in demand or breakdowns in the value chain that occur at short notice. At Industry 4.0 companies individual production lines organise themselves independently according to demand. If one machine on this line breaks down, production is reorganised autonomously via an alternative channel.
- **Reduce lead times:** Seamless data collection enables the rapid use of production-relevant data for near-term decision-making regardless of the location. This means Industry 4.0 users can reduce market lead times for innovations. Start-up firms in particular are presented with especially attractive options by Industry 4.0.
- **Adapting to customer requirements with small batch sizes:** Industry 4.0 allows the incorporation of individual customer-specific criteria concerning design, configuration, ordering, planning, production and operation as well as enabling modifications to be made at short notice. Industry 4.0 is intended to ultimately even enable rapid and inexpensive low-volume production runs right down to one-offs (a batch size of 1); for example in the automotive or furniture manufacturing sectors. Smart production organisation and new technologies such as 3D-printing processes are going to be used.

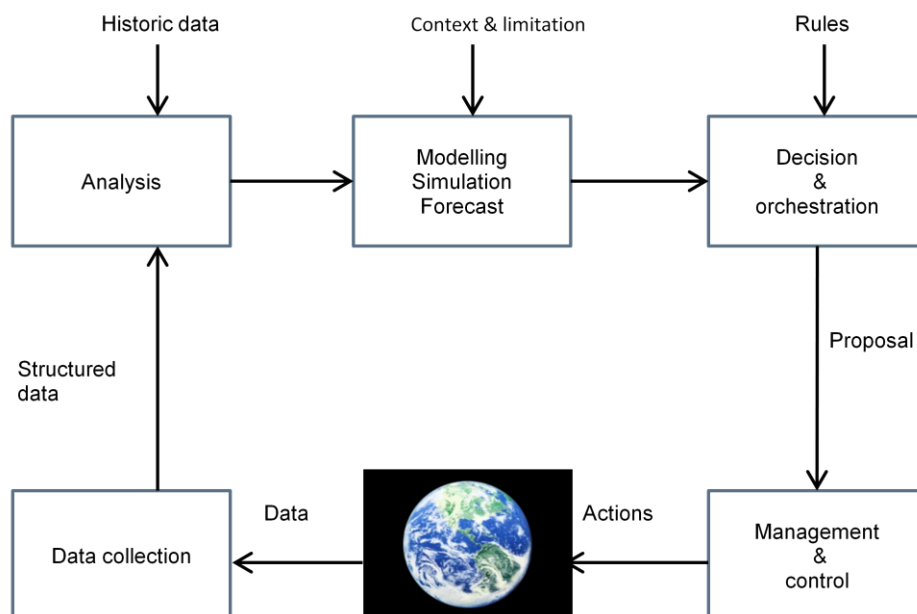
Accommodate customer wishes cost effectively with small batches

Upgrading of Germany's industrial capabilities on the horizon

New business models in the data space

11

Big data value chain



Source: See IBM, 2013

- **New offerings of downstream services:** In the business-to-business segment Industry 4.0 opens up potential for high-performance services for the near-term evaluation of big data.

New business models provide new opportunities

12

Applications for Industry 4.0 exemplified by automakers

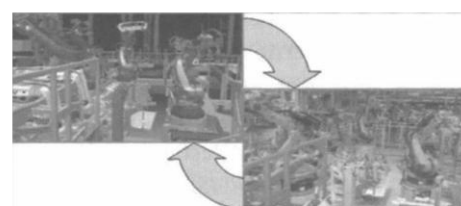
Attractive products
via networked systems located
inboard and outboard



Examples:

- Mercedes Benz Intelligent Drive
- Car-to-car communication (simTD)
- Car2Go
- In-car digital life

Efficient processes
Via horizontal and vertical
integration



- Digital life at work
- End-to-end IT process chains: PLM, ERP, NX
- Digital factory and virtual commissioning
- The flexible factory (ARENA 2036 project)

Source: See Daimler, 2013

Using flexibility to achieve competitiveness

- **Attractive work structuring:** Modern organisational structures enable more flexible production. This chronological and spatial flexibility is likely to be attractive to many workers. This in turn is also a positive argument in a labour market that is changing due to demographic developments and given the shortage of skilled workers that is set to become increasingly acute.¹⁰

¹⁰ The employer-friendly Institut der deutschen Wirtschaft (IW) Cologne estimates that there is already a shortage of 123,000 skilled personnel in the science and technology field. BITKOM, i.e. the association of the German telecommunications and new media sectors, estimates that there



Upgrading of Germany's industrial capabilities on the horizon

After all, a company with advanced, flexible work models should have the best prospects in the contest for increasingly scarce "top talents"; this applies all the more if it also becomes involved in the design of the required further education and training measures.

The challenges at the technical, economic, organisational and legal level

While there are highly promising benefits associated with Industry 4.0 it does also present several technical, legal, economic and organisational challenges for companies in the value chain. The most important of these challenges lie in using the collected data in real time, the utilisation of production capacities, the complexity of production organisation, integration in the value chain as well as the issues of data protection and data security.

Data to flow along the value chain in real time

- **The real-time evaluation and utilisation of the high volumes of data created in the value chain:** The be-all and end-all of the Industry 4.0 concept is that data collected along the value chain is evaluated for its relevance in real time and utilised for organising production. This necessity represents one major specification for IT systems.
- **Optimum capacity utilisation in autonomously organised production:** Production in an Industry 4.0 company can deal flexibly, efficiently and quickly with fluctuations in production and malfunctions in individual production areas using the available capacities. The resulting optimisation procedure is extremely complex and will come into conflict with discretionary ad-hoc interventions.
- **Integration in the value chain:** The Industry 4.0 idea is based on rapid and efficient data transmission within the value chain. This objective is predicated on infrastructures and processes being coordinated as well as interfaces and protocols being clearly defined. As long as there is no general standard for these technical prerequisites, i.e. that each proprietary system is incompatible with the other, it is extremely costly for a company to switch into a different value chain; and in some cases it is actually economically impossible.

Confidentiality promotes trust

- **Data protection and data security are crucial issues:** Opinions are divided about comprehensive data exchange along the value chain. After all, the advantage of production flexibility is offset by the disadvantage of possibly too close a link between supplier and customer and a disclosure of company processes (i.e. extremely sensitive internal strategic data). The risks pertaining to data protection and data security are serious: the opportunity to be able to flexibly adjust applications does make Industry 4.0 appealing to users. However, the extensive exchange of data that accompanies Industry 4.0 also makes users an attractive target for hackers, though. In such attacks the intention may not only be the theft of relevant data, but also sabotaging the entire production process, so these may be risks with a macroeconomic dimension. Accordingly, when the contract is being drafted the diverse facets of data protection and data security are extremely important to Industry 4.0 users. For example, it needs to be examined whether the exchange of critical data outside the EU already contravenes the legal provisions that apply to the company. This applies in particular because other jurisdictions have completely different rules

are 39,000 IT vacancies that cannot be filled because there is already a shortage of experts. See also Bräuninger, Dieter (2013). Medium-sized enterprises and demographics: Increasing pressure to take action. Deutsche Bank Research. Current Issues. Frankfurt/Main.



Upgrading of Germany's industrial capabilities on the horizon

regarding data protection and data security, especially also regarding the scope for government access to the data.

Explanatory note: Data protection and data security are essential

Data protection and data security
comprise many elements

The EU's legal framework places very much greater emphasis on data protection and data security than that of the US. The US Patriot Act, for instance, requires that US authorities can access all data that is stored or processed by a company headquartered in the US, regardless of where this data is actually physically located. For European firms in particular the requirements of the US Patriot Act thus undermine the provisions concerning the handling of company data that were laid down in the Safe Harbor agreement at the start of the millennium.

Data protection essentially circumscribes the idea that each person can decide for himself which of his personal data is to be made available to whom and when. Data protection can be broken down into its different aspects of protection against misuse of data processing, protection of informational self-determination, protection of the personal rights in the processing of data and privacy protection. Depending on the context the terms "privacy", "confidentiality" or "data protection" are used. Not only private entities and companies but also government bodies are interested in personal information. Since it is becoming much easier to collect, evaluate and disseminate data, the topic's relevance is also increasing rapidly as digital technology extends its reach.

Data security can be broken down into the discrete elements of integrity, availability, and authenticity. Integrity means that data modification should not be able to occur unnoticed. Availability means that system downtimes can be remedied as fast as possible and without major damage being caused. Authenticity describes the characteristics of genuineness, verifiability and credibility of the data. Depending on the context the terms "safety" (functional reliability) or "security" (of the information) are also used.

German structures promote industrial progress

Industry 4.0 can only progress in
close collaboration

The topic of Industry 4.0 should be not regarded in isolation and is being implemented via close collaboration between the fields of electrical engineering, electronics, engineering and IT. With this interdisciplinary approach Germany has special strengths as the "factory outfitter of the world". These strengths are based on the good general education system, the established development partnerships between suppliers and users, the market leadership in plant and mechanical engineering and the position as leading innovator in automation and flexible operation.

As a consequence Germany occupies a favourable position from which to tackle its international competitors. Nevertheless, this presupposes that obstacles in the societal realm (acceptance of technology) and in infrastructure (e.g. expansion of modern power and communications grids) are overcome. Accordingly, acatech regards Germany as particularly well-placed to exploit the potential of this new form of industrialisation.

Levels of affinity vary

Because of the above-mentioned challenges at the technical, legal, economic and organisational levels there is discernible uncertainty among numerous potential users concerning the end-to-end automation and integration of the goods and information flows in a comprehensive value chain. Practical experience shows that the age of the company, degree of specialisation and sector-specific requirements are the key determinants of the affinity to end-to-end automation à la Industry 4.0:

Years in existence, level of
specialisation and sector-specific
criteria determine affinity

- **Age of the company:** The younger the company or the less established its process structure ("greenfield investments"), the greater the likelihood of the monolithic implementation of Industry 4.0.
- **Specialisation level of the company:** The more specialised the company's business model, the more difficult it is to completely automate the value chain.

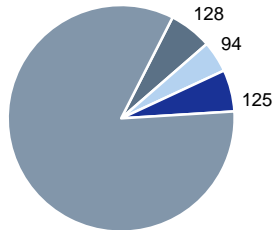


Upgrading of Germany's industrial capabilities on the horizon

One-sixth share to date

13

Market for engineering and plant making with automation subsegment, 2011, EUR bn



■ Process automation ■ Switch gear
■ Electr. powertrains ■ Other

Source: Siemens, 2013

— **Specific features of the sector in which the company operates:** Data protection and control requirements, depth of value added and innovativeness vary between the sectors. Accordingly, for example, companies with links to the automotive industry, with their discrete products and a high degree of customisation, are showing themselves to be much more receptive than the process industry to Industry 4.0 innovations.

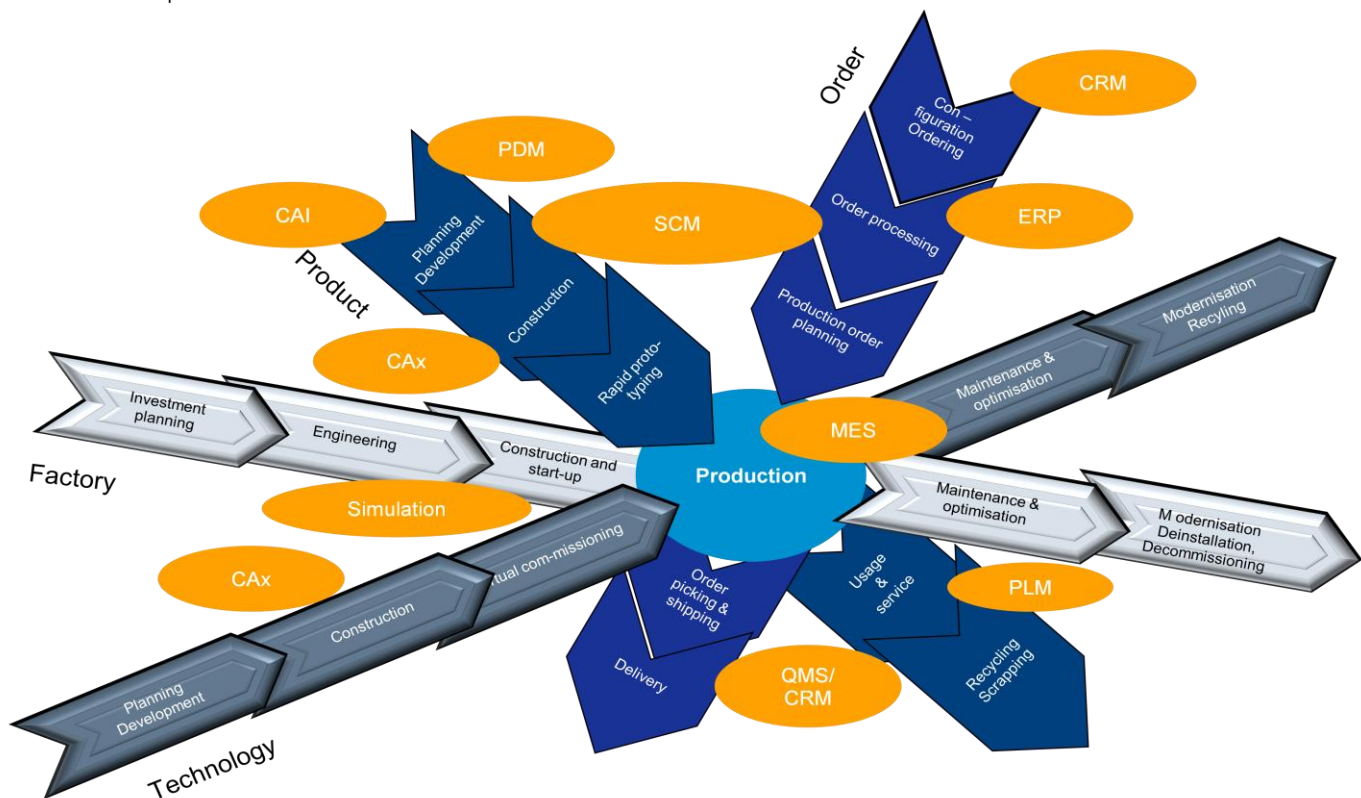
Advancing automation has major market potential

Advancing automation of the development and manufacturing of products has major potential. According to Siemens, the global mechanical and plant engineering market was worth EUR 2,100 bn in 2011. Turnover in just those product segments required for the automation of production amounted to nearly EUR 350 bn. Breaking this down into subsegments, electric propulsion accounted for 27% of total sales, switching devices, switchgear and industrial controls 36%, and measuring technology and process automation 37%.

Dovetailing is key

14

Multi-dimensional requirements



Source: See ARC, Supplementary information from Fraunhofer IPA, 2013

Expectations of users are often not completely fulfilled

Major uncertainty in the new area

Some of the hopes generated by the initial euphoria for Industry 4.0 remain unfulfilled in practice. There is a great deal of uncertainty in this new field – and it is therefore imperative to query more closely the processes and steps required.

This means it is certainly possible that the total savings in a full cost calculation would actually be negligible for numerous firms. There is even the danger that the economic efficiency may decline overall, at least in the short term. Since



Upgrading of Germany's industrial capabilities on the horizon

those companies that choose Industry 4.0 initially have to make significant investments (e.g. for consulting, software, hardware, training and fundamental reorganisation), it will be difficult to make a sound empirical estimate of the overall effect on costs and this will undoubtedly also take many years to be achieved.

Market development still in its infancy

Evolutionary process

The development of the Industry 4.0 market is still largely a vision of an evolutionary process that will not become truly tangible until the second half of the coming decade. This long-term process also intrinsically contains great uncertainties. These uncertainties are also expressed in the surveys and assessments presented by experts. For example, the consultants from techconsult found that, categorised by size and sector, surprisingly few companies are currently really familiar with Industry 4.0. For instance, 35% of the bigger manufacturers (500 to 999 employees), but only 21% of small manufacturers (20 to 99 employees) or 47% of high-tech industry companies and only 22% of process manufacturers say that they can even provide a concrete definition of the term Industry 4.0.

Opposition holding back progress

The current situation is typical of a new trend such as Industry 4.0. The idea is thus gaining ground much more slowly than had been widely hoped. This is also due to the opposition and structural obstacles that exist both on the part of users and providers of Industry 4.0 offerings. This applies especially to the following four aspects:

- **Opposition from the providers themselves:** The comprehensive concept associated with Industry 4.0 forces providers in particular to reexamine their traditional business models. In numerous areas the hitherto usual on-site provision of services, software and hardware will be replaced. With these new offerings the sales channels, value chains and thus also the margins will change markedly. This is likely to encounter opposition within the organisations – at least in the early phase of the reorientation.

People are the key factor

- **Opposition from within the departments of the outsourcing companies:** Before implementation of the restructuring measures the user firms have to persuade the individual departments to cooperate in the execution of these changes. The objective of this persuasion is to ensure that unfounded fears do not prevent the introduction of new technologies and processes that are advisable for the company as a whole. These fears are likely to be wide-ranging – from losing one's job to having one's responsibilities curtailed. Openly addressing all the concerns is thus likely to be a task that the management should not underestimate.

Standards are the be-all and end-all

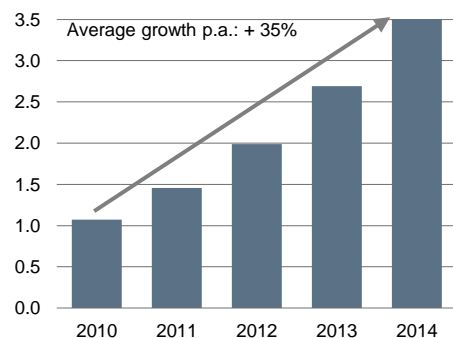
- **The lack of generally applicable standards:** A recognised technical standard could accelerate the universal interoperable use of fully automated offerings from the wide-ranging Industry 4.0 portfolio and overall market penetration; this is particularly true as numerous potential users are currently still holding back because of their uncertainty. These interested parties are particularly fearful of investing considerable resources in an offering which might not correspond with the standard that eventually becomes established. Reaching agreement on a generally applicable standard is, however, likely to prove difficult for a variety of reasons. On the one hand, there are certainly also discernible cultural differences between the companies in the mechanical engineering, electrical engineering, electronics and IT sectors with regard to the multidisciplinary topic, especially also with regard to the path to standardisation. Standardisation in the fields of electrical engineering, electronics and mechanical engineering, for example, has traditionally been more reliant on repeated time-consuming consultations



Upgrading of Germany's industrial capabilities on the horizon

No visible limit to growth

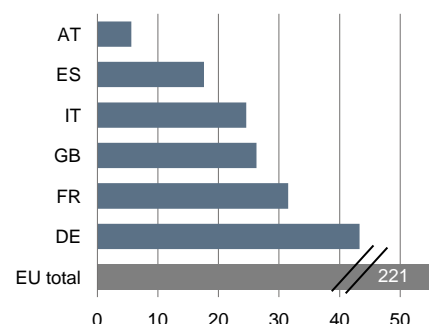
Monthly IP data volume, Germany, exabytes
(10^{18} bytes)



Source: Cisco, 2011

Broadband expansion is a major project

Estimated investment required for broadband expansion, EUR bn



Source: EIB, 2011

Lots of ideas, lots of players

and committee work than on IT. On the other hand, many providers could also make the strategic decision to rely on proprietary offerings. Adopting such an approach could be allied to the hope of using the restrictions on interoperability to make it much more difficult for customers to switch to a different provider.

- **Enhancing network availability and speed:** Communication networks must be able to handle the constantly rising volume of data and quality requirements. If the communications network has insufficient capacity (especially with regard to system availability and speed), then fully automated processes will be affected by interruptions to operating processes and high downtime costs will thus also be incurred. The prospects of success for the new automation offerings therefore depend directly on the reach and performance of the communication network. The issue of the commercial foundations for Industry 4.0 therefore is closely linked to the central macroeconomic issue of the expansion of the communications network.¹¹

Explanatory note: High-performance communications networks needed

Capacity bottlenecks in the data network are not a distant vision, but are set to become a near-term reality due to the constantly rising volume of IP traffic. Nonetheless, network utilisation varies considerably depending on the time of day, day of the week and user group. For instance, Deutsche Telekom reports that 65% of its data traffic is generated by just 10% of subscribers. In addition, peak loads usually occur between 6 pm and 10 pm – though this can be heavily influenced by unplanned day-to-day occurrences.

Realising the social and economic significance of sufficient broadband capacity, the European Commission has formulated ambitious objectives for expansion. By 2020, all EU inhabitants are to have access to the internet with a minimum speed of at least 30 Mbit/s; furthermore, at least 50% of them are to have access to speeds of at least 100 Mbit/s. Germany has in fact raised the bar even somewhat higher and is targeting an internet speed of at least 50 Mbit/s for 75% of the country's 40 million households by 2015 and for the entire population by 2018.

The ambitious broadband targets require investment in the networks. The European Investment Bank (EIB) in its relatively conservative estimates arrived at a figure of more than EUR 220 bn that would need to be invested in the European Union as a whole.

Wide range of ideas for applications

Experience clearly shows that Industry 4.0 offerings need to be tailored specifically to the company and cannot be supplied "off the shelf". So the idea of Industry 4.0 can basically be conceived in very diverse contexts. The varied benefits associated with this development are shown by projects and prototypes developed by research establishments such as Deutsches Forschungszentrum für Künstliche Intelligenz (DFKI), or Fraunhofer ISS, IOSB, IML or IPA, and companies such as Agco (agricultural equipment specialist), BorgWarner (propulsion technology), Bosch Rexroth (propulsion technology), Bruker (measuring technology), Daimler (automobiles), John Deere (agricultural equipment), Festo (process automation), Harting (network technology), Homag (woodworking machinery), HP (IT), Introbrest (electronic devices), Kaba (security technology), SAP (IT), Seca (measuring technology), Sick (Sensortechnik), Siemens (electrical and electronic equipment), Trebing + Himstedt (process automation), Trumpf (manufacturing technology), Volkswagen (automobiles) or Wittenstein (propulsion technology). The corresponding breadth of applications is indicated by the following examples:

- **Remote maintenance reinvented:** Currently the remote maintenance of highly specialised production machinery requires individual communications solutions. This is how the mechanical engineering specialist links up to the company network of the production facility. Configuring and managing this

¹¹ See Heng, Stefan (2013). The situation surrounding broadband expansion makes creative solutions necessary. Deutsche Bank Research. Frankfurt/Main.

Upgrading of Germany's industrial capabilities on the horizon

Remote service reinvented

17

New forms of labour organisation for service contracts

The present



The future



Source: See Trumpf according to acatech, 2013

link-up is very costly. In the smart factory of the future the production system links up with the appropriate experts via a telepresence platform depending on the situation. The machines autonomously supply the relevant data for the diagnosis.

- **Changing supplier during the production process is made possible:** At present the manufacturer has a very big problem if a supplier is suddenly unable to deliver. It has to be quickly clarified how long the inventory will last, which products are affected and which firm could be the replacement supplier. Resolving such issues quickly enough is very complex and requires high-quality infrastructure. Industry 4.0 will directly enable the overall impact on value added to be estimated, including inventory level and logistical processing. Costs, the action required and risks can thus be derived sufficiently quickly. The comprehensive linking-up of production systems enables alternative suppliers and their capacities to be analysed in real time. Enquiries can then be made to the alternative suppliers in a supplier cloud, for example.
- **Plant engineering resources are to be used efficiently via practical shutdown capabilities:** Many production facilities currently continue to operate even during extended manufacturing downtimes, such as non-working shifts and weekends, and thereby consume large amounts of energy. The plant remains in operation around the clock so that there is no need for a long start-up phase. During production-free periods energy is thus wasted senselessly, especially by robots, extraction devices, laser sources and cooling equipment. Industry 4.0 enables this efficiency-enhancement potential to be tapped more effectively – assuming that the concept is already incorporated into the planning phase. With energy efficiency in mind, production-free periods for the machines are quickly recognised in order to switch them into an energy-saving standby mode. Demand-managed motors are used especially for this on extractor systems. Siemens has calculated that for a typical facility where laser welding technology is used for body-making this instrument could cut energy consumption during rest periods by 90%, which would result in an overall energy saving of 12% (i.e. consumption would drop from 45,000 kWh to 40,000 kWh).

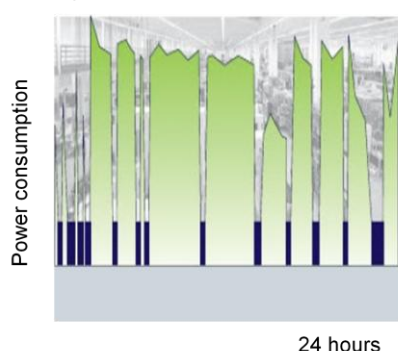
Sensible downtimes wanted

18

Power consumption profile

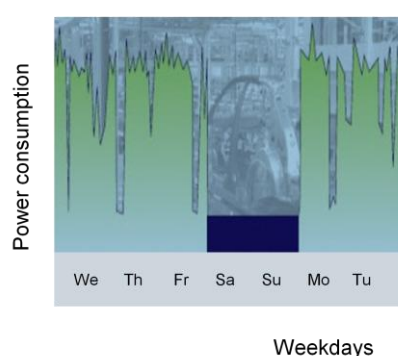
The present

Potential savings from planned and unplanned breaks



The future

Potential savings at weekends



Source: See Siemens according to acatech, 2013

- **End-to-end system engineering enables customised products to be made:** Usually the value chain structure is highly path-dependent and also static in nature. The special requirements of individual customers have hitherto not been incorporated into the production planning process – even though this flexibility in the manufacturing process would in fact be possible in principle. Industry 4.0 enables end-to-end engineering to be implemented. Production is monolithically developed from start to finish and thus coordinated with product development. Consequently customers will be able to combine individual functions and components in the production process inexpensively according to their own requirements. Automaking is currently based on a predetermined production line. The functional scope of the individual stations is statically defined. The workers' tasks are geared directly to the requirements of the respective stations and are usually quite monotonous. If retooling is necessary in order to introduce a new product version this is time consuming and thus also expensive. This means that individual customer preferences, such as the fitting of a component from a different product group from the same firm, cannot be considered. The factory of the future consists of a flexible production line grid. The vehicle to be manufactured then manoeuvres autonomously through the production stations as a smart product. The flexibility of the production process allows a wide range of variation that is not limited by any central guideline.



Upgrading of Germany's industrial capabilities on the horizon

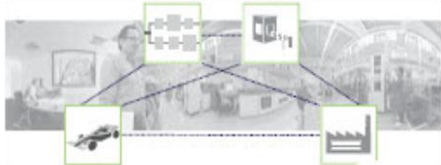
End-to-end engineering is the goal

19

Information flow in the value chain

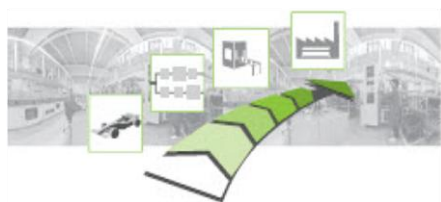
The present

Extensive interfaces between supporting IT systems



The future

End-to-end system engineering along the entire value chain



Source: See Siemens according to acatech, 2013

— **Agriculture is always also an engineering matter:** Agriculture operates with biological systems, such as soil, plants, animals and the weather, which at the abstract level are linked with similar risks to those we know from the industrial environment. In a similar way to industry the agricultural sector also faces global competition. It is thus to be expected that the innovations from the fourth industrial revolution will also transform the agricultural sector. Going forward, making production more flexible and customising products will certainly become relevant in agriculture, too. Integrating customers into value chains (as entities demanding defined product features, such as food retailers who use their own quality standards to try and distinguish themselves from their competitors) is equally conceivable as a cyber-physical system as is the inexpensive creation of standard products. In pilot projects associated with precision farming mechanical engineers and IT experts have joined forces with agricultural experts and are already testing sensor-based fertilising modelled on a cyber-physical system. This also still requires well-qualified personnel, i.e. especially farmers with agro-technical expertise.

Outlook: Imminent industrial developments are already creating a buzz

In conclusion, Industry 4.0 (also known as integrated industry) is on everyone's lips, and this has not only been the case since the Hanover Fair and the German government's IT summit. The concept inhabits the wide-ranging terrain occupied by big data, cloud computing, cyber-physical systems, RFID tags, resource efficiency, the internet of things and services, machine-to-machine communication, precision farming, smart production and smart factories. At present, the offerings associated with the Industry 4.0 buzzword are definitely suffering from the excessive marketing-driven expectations and the lack of a clear definition. It is therefore certainly possible that following the hype which typically surrounds such new ideas and the subsequent disillusionment there will be no-one talking about Industry 4.0 in a few years' time. All the same, the basic idea behind the buzzword has a good chance of being implemented – regardless of the term used to describe it.

The potential for industrial upgrading is particularly pronounced in Germany. Firstly, Germany has been and will remain for the foreseeable future an industrial heavyweight. Germany is home to numerous hidden champions whose specialty solutions put them among the world market leaders in their segments. Furthermore, German firms create one-third of the EU's total industrial value added. A long way behind comes Italy, ahead of France, the UK and Spain. Since in other countries the share of value added is declining constantly. Germany will retain its leading position as the industrial backbone of the EU. Secondly, Industry 4.0 can only gain ground if there is close cooperation between the fields of electrical engineering, electronics, mechanical engineering and IT. With this interdisciplinary approach Germany has special strengths as the "factory outfitter of the world". These strengths are based on the good general education system, the established development partnerships between suppliers and users, the country's market leadership in plant and mechanical engineering, its strong, dynamic *Mittelstand* and its status as the leading innovator in automation and flexible processes.

To date, the application of Industry 4.0 has largely been a matter for big companies. However, small and medium-sized companies are also finding that vertical and horizontal integration are becoming increasingly important factors in the competitive international arena. The wide range of benefits associated with Industry 4.0 are being demonstrated by highly promising projects and prototypes from research institutes, such as DFKI, or Fraunhofer ISS, IOSB, IML

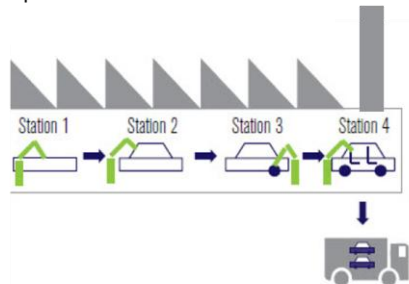
Customer preferences included

20

New forms of automaking

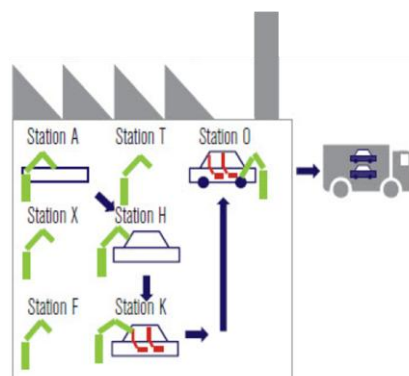
The present

Sequential car manufacturing on the production line



The future

Disconnected, totally flexible and highly integrated production systems



Source: See HP according to acatech, 2013



Upgrading of Germany's industrial capabilities on the horizon

Projects and prototypes demonstrate
the variety of benefits

or IPA, and companies such as Agco, BorgWarner, Bosch Rexroth, Bruker, Festo, Harting, Homag, Introbest, Kaba, Seca, Sick, Trebing + Himstedt, Trumpf, or Wittenstein.

Mittelstand to drive, advise and assist
automation

The implementation of automation requires technology firms, especially from the *Mittelstand*, as drivers, advisors and assistants. This applies in particular since in most cases the providers and the users share a relationship of trust and an understanding of the process that has grown over time. Nonetheless there is still a great deal of catching-up to do especially concerning the strategic orientation of small and medium-sized companies with respect to Industry 4.0.

Promoting projects without hindering
holistic overall solution

One challenge is that in companies which have grown over many years there is usually huge potential for conflict between their existing structures and processes and the implementation of change. The key is performing the balancing act of making project-based progress with automation and gathering experience while not spoiling the opportunity to introduce a holistic overall solution in the process.

Idea with good long-term prospects

All in all, the idea behind the buzzword Industry 4.0 has good prospects that extend beyond the coming decade. With the international web of trade flows continuing to intensify, automation, more flexible processes as well as horizontal and vertical integration will become increasingly important for a competitive, modern manufacturing structure. This will apply all the more if the currently still unresolved issues concerning control responsibility, security, confidentiality, standardisation, legal framework and infrastructure configuration (e.g. expansion of advanced power grids and communications networks) are addressed constructively – and this, in keeping with the basic idea, is not to be limited to Germany or Europe. This means that Industry 4.0 provides Germany, which possesses particularly favourable basic prerequisites, with a major opportunity to cement its leading position in the global arena. This applies not only within Europe but also compared to the increasingly strong emerging markets in Asia.

Stefan Heng (+49 69 910-31774, stefan.heng@db.com)

© Copyright 2014. Deutsche Bank AG, Deutsche Bank Research, 60262 Frankfurt am Main, Germany. All rights reserved. When quoting please cite "Deutsche Bank Research".

The above information does not constitute the provision of investment, legal or tax advice. Any views expressed reflect the current views of the author, which do not necessarily correspond to the opinions of Deutsche Bank AG or its affiliates. Opinions expressed may change without notice. Opinions expressed may differ from views set out in other documents, including research, published by Deutsche Bank. The above information is provided for informational purposes only and without any obligation, whether contractual or otherwise. No warranty or representation is made as to the correctness, completeness and accuracy of the information given or the assessments made.

In Germany this information is approved and/or communicated by Deutsche Bank AG Frankfurt, authorised by Bundesanstalt für Finanzdienstleistungsaufsicht. In the United Kingdom this information is approved and/or communicated by Deutsche Bank AG London, a member of the London Stock Exchange regulated by the Financial Services Authority for the conduct of investment business in the UK. This information is distributed in Hong Kong by Deutsche Bank AG, Hong Kong Branch, in Korea by Deutsche Securities Korea Co. and in Singapore by Deutsche Bank AG, Singapore Branch. In Japan this information is approved and/or distributed by Deutsche Securities Limited, Tokyo Branch. In Australia, retail clients should obtain a copy of a Product Disclosure Statement (PDS) relating to any financial product referred to in this report and consider the PDS before making any decision about whether to acquire the product.

Printed by: HST Offsetdruck Schadt & Tetzlaff GbR, Dieburg

Print: ISSN 1612-314X / Internet/E-mail: ISSN 1612-3158