Press Kit BMW Group Production.
Contents.

1. The BMW Group's strategy: Production follows the market.

The BMW Group aims at achieving balanced growth in all markets and on all continents. To this end, the BMW Group's highly efficient, flexible and agile production network applies the principle of 'production follows the market'. Thanks to its international alignment, the BMW Group Production operates full plants in key markets such as the NAFTA area, China or Europe, which produce vehicles for both the local market and the export.

The company continuously monitors and analyzes market developments and customer demands. If trends are changing significantly, the BMW Group can react flexibly by taking the respective product and site decisions. At present, the BMW Group sees the emerging markets in Asia and the Americas as major growth drivers. Consequently, a new production site is being built in San Luis Potosí, Mexico (start of production: 2019); most recently, the BMW Group set up a plant in Araquari, Brazil (start of production: fall 2014) and opened another Chinese plant in Tiexi (2012). In addition, the company is expanding its U.S. plant in Spartanburg.

Globalization and production in Germany are not antipodes.
However, it is important to note that the BMW Group does not shift capacities away from Germany or Europe, but caters to additional demand outside of Europe. Globalization and production in Germany are not antipodes. The best solution for the BMW Group is the intelligent combination and cooperation within a global production network, which currently comprises 30 sites in 14 countries. The great flexibility of these international production structures is a competitive advantage the BMW Group applies depending on the respective market developments and customer demands. This is why, for instance, the company has decided to build the BMW X4 in Spartanburg and the BMW 2 Series Active Tourer in Leipzig. In China, the BMW Group plans the production portfolio in close cooperation with its Chinese joint venture partner, Brilliance China Automotive Holdings Limited.

The BMW Group maintains its commitment to Germany as a production location: 2013 marked the third consecutive year in which the company produced more than one million vehicles in Germany. For the company, the country offers clear benefits, such as the excellent vocational training level, which is also 'exported' to the BMW Group's foreign locations. Other positive factors include the extensive experience and outstanding expertise of the workforce as well as the presence of numerous technology suppliers.

Access to new markets with long-term growth potential.
Besides making vehicles, the local production units are responsible for tapping into and/or expanding new markets: Local production sites facilitate the access to new markets with long-term growth potential.

This is the strategy the BMW Group primarily pursues in such markets whose high customs duties impede the import of finished vehicles, and thus also further market penetration. Local assembly plants allow the BMW Group to offer products at competitive prices in these markets as well, making the company a 'local player'. Currently, seven assembly plants put together cars and motorcycles from imported parts kits and add locally produced components. The BMW Group's foreign assembly sites include Rayong (Thailand), Chennai (India), Kaliningrad (Russia), Cairo (Egypt), Jakarta (Indonesia), and Kulim (Malaysia). In addition, there is a motorcycle assembly plant in Manaus (Brazil).

Production sites and a correspondingly high purchasing volume in significant sales regions with different currencies furthermore help to balance out the streams of goods as well as currency fluctuations and risks (natural hedging).

South Africa as the first step towards becoming a global player.
For the BMW Group, globalization has been an important element of the corporate strategy for more than four decades now. As early as in 1973, the first foreign plant was set up in Rosslyn/South Africa. By 1997, the assembly site in Rosslyn was extended step by step into a full plant, comprising the core technologies, i.e. body shop, paint shop and assembly.

Today, the BMW Group's Rosslyn plant is an illustrative example of how a local production site can drive a successful market entry: First off, the sales figures went up considerably, thanks to the local production and therefore the bypassing of high import duties. Since the omission of customs restrictions and the full expansion of the plant, the BMW Group has been producing 3 Series Sedan models both for the local market and for global export. As an established 'local player', the BMW Group's local production supports sales in South Africa where now more than 27,000 vehicles of all model series are sold per year.

Production in the NAFTA area.

An important milestone in the BMW Group's commitment to the NAFTA area was the decision, taken in 1992, to establish a production site in the U.S. The plant in Spartanburg, South Carolina, was opened in 1994. On the occasion of the site's 20th production anniversary in 2014, the BMW Group announced the expansion of the U.S. plant. In a clear commitment to North America as a production location, the company is going to invest a total of one billion U.S. dollars by the end of 2016, making the site in Spartanburg the largest BMW Group plant worldwide in terms of annual capacity: Spartanburg's production capacity is going to increase from currently 300,000 vehicles a year to 450,000 in the future, an increase of 50 percent and up threefold from the capacity at the beginning of 2010.

According to a study published by the U.S. Department of Commerce, the annual export volume of the BMW Group's Spartanburg site stands at 7.5 billion dollars, making the BMW Group's U.S. plant also the number one car exporter in the United States in relation to the total export volume, excluding NAFTA markets. About 70 percent of the vehicles made in Spartanburg are shipped abroad.

Furthermore, the BMW Group is investing another 200 million dollars in the joint venture carbon fiber plant in Moses Lake, Washington, earmarked for an expansion of the site and for tripling the local production capacity in the long term. This investment will make Moses Lake the world's largest carbon fiber plant. By 2019, the BMW Group will have invested a total of 2.2 billion dollars in the NAFTA region. At the same time, the BMW Group set up a new plant in Araquari in the Brazilian state of Santa Catarina, which went

on stream in October 2014. Thanks to its sites in the U.S., Mexico and Brazil, the BMW Group will in future have significant production capacities at its disposal in key locations in both North and South America.

Tapping Asian growth markets with major potential.

The first step into the Asian market was taken in the 1980s. Today, the BMW Group operates two assembly plants with external partners in Jakarta (Indonesia) and Kulim (Malaysia) as well as two own assembly plants in Rayong (Thailand) and Chennai (India). In addition, BMW cars have been built at a plant in Shenyang in Northeastern China since 2004; the site is operated by a joint venture with Brilliance China Automotive Holdings Limited and solely caters to the Chinese market. The location in Shenyang comprises not only the Dadong plant in Northeastern Shenyang but also a new site in Tiexi, which started production in 2012.

Made in England: MINI production in the UK.

The MINI brand has been closely linked to the UK for several decades now. And the production of MINI in Oxford is not only a commitment to the brand's identity but at the same time a consistent implementation of the company's successful strategy of 'production follows the market'. The BMW Group is currently investing another 750 million British pounds in the British production triangle: The investment, to be completed in 2015, is part of the international growth strategy for the MINI brand and secures the long-term future of the Oxford plant and safeguards jobs at the Swindon press shop and at the Hams Hall engine plant near Birmingham.

As the MINI brand is showing substantial growth, the BMW Group needs additional, external production capacity on top of the capacity of the MINI plant in Oxford which stands at about 260,000 units per year in the medium term. So as another important step in the implementation of the global growth strategy, the BMW Group is currently expanding its overall production capacity. Splitting production of the new MINI Hatch between Oxford and the contract manufacturer VDL Nedcar gives the BMW Group's global production network greater flexibility for other models. At the same time, the UK production triangle is and will remain the heart of MINI production.

2. Efficient production: Flexibility is the top priority.

Flexibility and acting within a strong international network: these are the cornerstones of the BMW Group's production operations. Even with a growing number of models and variants, the global production network can react quickly and flexibly to changes in the markets and to individual customer demands thanks to its 'breathing structures'. This way, it manages to counter the increasing market volatility. After all, in an increasingly fierce competitive environment, it is not only the product substance and quality that count, but also how quickly new products can be launched and how reliably customer demands are fulfilled. A high-performance production network also has to meet the increasing demand for individually produced vehicles as well as accommodate the wide range of variants and the complexity of products and processes.

As the BMW Group follows a customer and order specific approach in building cars (built-to-order), the company permanently aligns the production programs at the individual sites within the highly flexible production network to the demands of the markets. This includes shifts in the model mix as well as shifts in timing and regional allocation between the plants, depending on the respective sales markets. For the BMW Group, this fine-tuning is a common and continuous process.

Extraordinary strength: mastery of complexity and flexibility.
An extraordinary strength of the BMW Group production network is mastering complexity and increasing flexibility through globally applicable standards as well as product and process modules. Thanks to this comprehensive approach, the company can develop new products efficiently and produce them economically, despite an increase in the number of models and variants. At the same time, customers are offered a higher level of individualization. Even vehicle variants with smaller lot sizes can be integrated into series production, such as hybrid models or security cars. This approach is further strengthened by the great flexibility alignment of the production processes, which anticipates defined variation ranges for the respective

production volume at the vehicle plants.

As a premium manufacturer, the BMW Group identifies market and technological trends early on, includes them in the development of successor models, and acts with sound concepts and flexible structures at the production sites. This is why, as a rule, the vehicle plants are always aligned in a way that allows for the inclusion of additional models into running production. The assembly areas are designed to facilitate the integration of successor models without requiring major reconstruction. This way, variants of different model series can be integrated into the existing facility structures even at a later point.

'The neutral main line': ensuring maximum flexibility.

A crucial element in this setup is the 'neutral main line': Thanks to state-of-the-art logistics processes, individual scopes are pre-assembled in modules according to the customer's requirements at a supply center, usually located close to the vehicle plant, and are then fed to the assembly's 'neutral main line' just in sequence. This way, various models can be fitted flexibly on a single assembly line, ensuring the perfect capacity utilization of the plants. BMW Group locations that apply this concept include the production sites in Regensburg and Leipzig.

Flexibility is further enhanced by the setup of the vehicle assemblies in the form of a finger or comb structure, which was implemented for the first time when the BMW Group's Leipzig plant was built. Today, it is also applied at the site in Spartanburg. Thanks to the patented structure, logistical routes can be reduced to a minimum and further production steps can be inserted flexibly, simply by extending individual 'fingers'; a stoppage of production is not required. This is important as the high capacity utilization of the production facilities is indispensible for the plants' profitability.

Another core element that strengthens flexibility is the BMW Group's range of innovative working time models. They separate a person's working hours from the plant's operating hours, resulting in an improved work/life balance for staff members. At the same time, the company can respond flexibly to fluctuations in demand. A good example is the motorcycle production in Berlin, which has to deal with major seasonal differences in capacity utilization.

External production partners take some load off internal structures.

In order to launch certain products even faster and to gain a competitive edge, the BMW Group draws on additional capacities at external production partners, such as Magna Steyr Fahrzeugtechnik in Graz, Austria, for the series production of the current MINI Countryman and MINI Paceman models or the production of the MINI Hatch at VDL Nedcar in Born, Netherlands, since July 2014. These collaborations take some workload off the Group's structures, create leeway and provide valuable competitive advantages. In line with the corporate philosophy, the brand-defining expertise as well as the control and assessment authority in design, engine production, testing, purchasing, and service remains with the BMW Group.

3. Business is people: Our employees drive our success.

Besides sophisticated work processes and state-of-the-art installation engineering, people play a key role in the production of the BMW Group's premium products. Each member of the team is an important part of the international production network and responsible for the impeccable product quality. Great initiative, permanent control of one's own work quality, and the willingness to continue training for new tasks are all elements of the BMW Group's corporate culture, which the entire workforce has incorporated. The great commitment, strong identification and, most importantly, the excellent professional expertise of the employees have a significant share in ensuring the company' success.

Knowledge transfer across plant boundaries.

As part of a sophisticated network, people foster the knowledge transfer across plants. With their exemplary commitment, they ensure a timely start of production at the highest premium quality level – from the word go – also at other BMW Group production sites or when new models are introduced.

More than 300 working time models, a consistent profit-sharing system, potential assignments abroad, the cooperation with colleges and universities as well as a wide range of vocational training courses are some of the elements of a sustainable HR policy that makes the BMW Group one of the most attractive employers. Further offers include flextime, part-time, job-sharing, telecommuting and sabbaticals.

Diversity and inclusion – the key to success.

Modern society is characterized by diversity, bringing about vastly different population structures and concepts of life. This transition is mainly driven by the globalization, the demographic development, and a shift in values. In light of this development, the BMW Group pays great attention to establishing a diverse workforce as well as an appropriate gender balance and age mix also at their production sites. This is a prerequisite for guaranteeing that the BMW Group's workforce will continue to have the required skills at their

disposal to perfectly cater to existing sales markets, to tap into new markets and changing customer groups, and – given the demographic change – to make best use of people's expertise. At the BMW Group's parent plant in Munich, for instance, people from more than 50 different nations work closely together.

At the BMW Group, the term 'diversity' refers to a holistic concept on dealing with the personnel variety at the company: People's uniqueness and the differences between them constitute a valuable asset and offer great potential to both the individual and the company. Given the increasing skills shortage and the need to perfectly cater to existing sales markets while also tapping into new sales markets, a balanced age mix, an intercultural workforce and an appropriate number of women in management positions both among permanent employees and in talent programs are gaining in importance. Moreover, the company promotes the diversity of its workforce when it comes to work-life balance and the integration of disabled people. Since 2011, when the BMW Group signed the Charta of Diversity, the company has obligated itself to create a work environment that is free of bias.

When setting up new plant sites such as in Araquari, Brazil, or in San Luis Potosí, Mexico, the BMW Group pays attention to recruiting a mixed-age workforce, thus preventing spikes in the age structure and making strategic use of the strengths of different age groups.

Comprehensive demographic program, 'Today for Tomorrow'.
The average age of the population is continuing to rise; in 2030, a billion people will be 65 or older. This development, as well as the skills shortage expected in the long term and the changed demands of employees, have an effect on the BMW Group's HR planning. As 70 percent of the BMW Group's about 110,000 people work in Germany, the company is a mirror of the development in society in this respect. The average age of workers in Germany is going to increase by 2020, with the share of people over 50 rising from about a quarter to more than 35 percent. This is why, back in 2004, the BMW Group launched a comprehensive program – 'Today for Tomorrow' – to actively respond to the demographic change and to keep the company innovative and competitive even as the workforce is growing older.

'Today for Tomorrow' is a comprehensive package of activities and as such geared towards all age groups among the BMW Group's workforce in Germany. The program aims at creating a lastingly productive workforce, primarily through preventive action. Among other things, the project studied which production structures would be suitable for an aging workforce and how people's fitness for work could be maintained in the long term, also in assembly line positions.

First pilot project at Plant Dingolfing in 2007.

As early as in 2007, the BMW Group ran a pilot project, 'Production system 2017', which included depicting the age structure expected for 2017 at a line section of Plant Dingolfing. The simulated average age at this line section was about 47 years, compared to about 44 today. Thanks to a great variety of ergonomic activities, load-oriented staff rotation, as well as age and health appropriate activities, the company back then optimized the production flows and work relations at the pilot line. The result: An older workforce is as efficient as comparable areas with considerably younger workers. The findings from the pilot study are now being transferred across the board to other national and international sites (in South Africa and the U.S., among others). One example: When the new axle transmission assembly facility at the BMW Group's plant in Dingolfing was built, the company installed the world's first inherently age-appropriate component production in the automotive industry.

It is the combination of many small individual steps that have improved ergonomics and have created today's age-appropriate work environment at the BMW Group's plants. These include, for instance, joint-sensitive wooden floors and swivel-mounted screens displaying larger fonts. Other features are ergonomic seats, height-adjustable shelves for the provision of parts at the assembly line, and the possibility to take turns working sitting and standing up. Last but not least, the company has introduced a load-optimized workplace rotation and individually adjustable cycle times for certain workflows.

No 'older worker lines', but a comprehensive approach for an age-appropriate work environment.

Competitiveness, appreciation and good working conditions for all employees are not antipodes at the BMW Group; on the contrary, they are mutually dependent. It has been a very deliberate decision when

designing the demographic program ‘Today for Tomorrow’ to not install special ‘older worker lines’ or a certain number of light-duty workstations. The company aims at creating workplaces and a work environment everywhere, in which also younger workers can age healthily and remain productive in the long run. This is why the BMW Group does not talk about the vision of an age-appropriate, but of an aging-appropriate production. Consequently, ‘Today for Tomorrow’ comes in as early as in the vocational training of young people. At the BMW Group’ German location, over 20,000 people already benefit from the program.

4. One for all – All for one: The BMW Group's production network.

The BMW Group currently produces at 30 sites in 14 countries on four continents; the production network comprises 13 automotive and motorcycle plants (incl. contract production at Magna Steyr Fahrzeugtechnik, Graz, and VDL Nedcar, Born) as well as seven assembly plants (for cars and motorcycles). The engine plants in Austria, the UK and China as well as the engine plant at the BMW Group's Munich site provide the full range of different drivetrains to the vehicle production. The production network is completed by seven component plants.

A high-performance production network – efficient, reliable and flexible – is a key prerequisite for the successful implementation of the BMW Group's growth strategy and the company's long-term success. As part of the growth strategy, the BMW Group invests in the expansion and the long-term future viability of its production sites, such as at the new plants in Brazil (SOP: October 2014) and Mexico (SOP: 2019).

Contract production to create additional leeway.
Due to the growth in volumes, the company also pursues a second route, securing additional capacities it needs at external production partners, e.g. in the series production of the current models of the MINI Countryman and MINI Paceman at Magna Steyr Fahrzeugtechnik in Graz (Austria) or the MINI Hatch production at VDL Nedcar in Born (Netherlands) since July 2014. These arrangements allows the BMW Group to react even more quickly and flexibly to new and changing requirements and conditions as well as to make the plant allocation as effective as possible. These long-term partnerships entail valuable competitive advantages and make a significant contribution to achieving great profitability.

The BMW Group's strategy of 'production follows the world's key markets' also applies to smaller car markets with development potential, in which issues such as customs regulations hinder the import of finished vehicles. In such markets, the BMW Group draws on assembly plants. For the

production at the currently seven assembly plants for cars and motorcycles, certain parts and components are packed as a part kit in exactly determined assembly steps at the original plant of the vehicle model and exported for assembly in the respective countries. For the local vehicle production in these markets, the imported part kits are then supplemented by components sourced from the local supplier industry. The BMW Group's foreign assembly plants include Rayong (Thailand), Chennai (India), Kaliningrad (Russia), Cairo (Egypt), Jakarta (Indonesia) and Kulim (Malaysia). In addition, there is a motorcycle assembly plant in Manaus (Brazil).

The same standards apply to all the BMW Group's plants worldwide as regards quality, safety and the considerate use of resources.

The production network: One for all – All for one.

While in the past, the individual plants had to find the most favorable solutions by themselves, today's focus is on the idea of the network: the BMW Group's plants support and complement each other, striving for the most efficient solution for the entire network. For one thing is a given: the network can only advance by turning the individual plants' best practice solutions into standards for all sites and by implementing solutions that can benefit the entire network.

Consequently, the plants support each other with production launches of new models; for instance, the BMW Group's Regensburg plant provided support to the external production partner VDL Nedcar before the launch of the MINI Hatch.

5. Automotive production: The BMW Group's vehicle plants.

BMW Group Plant Munich.

Established in 1922, the plant in Munich is the BMW Group's parent plant. Initially, the site produced BMW aircraft engines and motorcycles; the automotive production started in 1952. Since then, more than 9.3 million cars have rolled off the assembly lines. Today, the plant combines supreme engineering and innovative strength with the passion of approx. 7,250 employees from over 50 nations for the BMW brand and the company. It is situated in the north of Munich, directly next to the Group's headquarters, the BMW Museum, the BMW Welt and the FIZ Research and Innovation Center. At present, around 950 cars roll off the assembly lines every workday, including units of the BMW 3 Series Sedan, the BMW 3 Series Touring, the BMW 4 Series Coupe the BMW M4 Coupe.
Besides the automotive core production, the engine production has long been a core competence of the Munich site; more than 2,000 engines are produced per workday. The engine range comprises BMW 3, 4, 8 and 12-cylinder petrol engines, BMW 6-cylinder diesel engines as well as 8-cylinder high-performance engines for the BMW M models.

BMW Group Plant Dingolfing.

BMW Plant Dingolfing is one of the BMW Group's largest production sites worldwide. Every day, approx. 1,500 vehicles of the BMW 3, 4, 5, 6 and 7 Series roll off the assembly line at Automotive Plant 2.4. At present, the plant employs a permanent staff of approx. 17,500 and 800 apprentices. Besides the automotive core production, the site also makes vehicle components such as pressed parts, seats as well as chassis and drivetrain components. Due to the body shop's outstanding expertise in processing aluminum and the many years of experience in building alternative drives, BMW Plant Dingolfing also supplies Plant Leipzig with key components for the new BMW i models, such as high-voltage batteries, e-transmissions and the Drive structure. Also thanks to the great aluminum expertise, the plant makes all bodies-in-white for Rolls-Royce. The site's Dynamic Center, a large-scale storage unit and trans-shipment point, provides original BMW parts and equipment to the global

BMW and MINI dealership organization.

BMW Group Plant Regensburg.

In the 1980s, when the BMW 3 Series became a smashing success, the BMW Group's production capacities had to be expanded, resulting in the decision to establish a site in Regensburg that started production in 1986. Today, the BMW Group's Regensburg plant employs around 9,000 people who build approx. 1,100 BMW cars per workday. Since the plant went on stream, about 5.5 million vehicles rolled off the assembly line; the product portfolio includes the BMW 1 Series 3-door and 5-door models, the BMW 3 Series Sedan, the BMW M3 Sedan, the BMW 4 Series Convertible, the BMW M4 Convertible and the BMW Z4 Roadster.

BMW Group Plant Leipzig.

The BMW Group's Leipzig plant is one of the world's most modern and sustainable car factories, setting new standards with its building structure and architecture: the body shop, paint shop and assembly are grouped under one roof, arranged like the spikes of a star around the central building designed by Zaha Hadid, which has won a host of architecture awards. Another special feature is the floor plan of the assembly hall: thanks to its finger or comb structure, supplier parts can be fed to the assembly line directly from the outside and just in sequence. Since March 2005, Leipzig has built BMW cars for customers all over the world; its production capacity is 740 cars daily. In Leipzig, the BMW Group does not only produce conventional vehicles but also vehicles with an electric drive and CFRP lightweight body. The plant's product range comprises the BMW 1 Series 5-door, BMW 2 Series Coupe, BMW 2 Series Convertible, BMW 2 Series Active Tourer, BMW X1, BMW i3 and BMW i8. With the BMW i production, the site has taken sustainability to the next level: the specific water consumption has been reduced by 70 percent, energy consumption by 50 percent. At present, BMW Group Plant Leipzig employs a total of over 4,000 people.

BMW Group Plant Spartanburg, USA.

BMW Group Plant Spartanburg in South Carolina, USA, is the best example for the successful strategy of 'production follows the market'. Since the plant went on stream in 1994, it has produced over 2.6 million vehicles for BMW customers all over the world. At present, Spartanburg produces the

following models: BMW X3, X4, X5, X5 M, X6 and X6 M. In addition, the production site is supposed to start making a hybrid version of the BMW X5 in the near future. Over 8,000 people work on the premises of the BMW Group's Spartanburg site and manufacture around 1,100 vehicles per workday.

BMW Group Plant Rosslyn, South Africa.

Plant Rosslyn near Pretoria was the first foreign site of today's BMW Group. It opened in 1973 and produced all BMW model series for the local market up until 1996. Following the opening of the South African production for export markets, the site was successively extended into a full plant for the production of the BMW 3 Series Sedan until 1997. Today, more than 3,200 people in Rosslyn make BMW 3 Series Sedans for both the local market and export markets.

BMW Brilliance Automotive Shenyang, China (joint venture).

Since 2004, BMW cars have been rolling off the assembly line at the Shenyang site in Northeast China. Plant Shenyang is operated by a joint venture with Brilliance China Automotive Holdings Limited and solely produces vehicles for the Chinese market. The production site in Shenyang comprises the Dadong plant in Northeast Shenyang, which makes the BMW 5 Series long version, and the Tiexi plant in West Shenyang in the Chinese province of Liaoning, which went on stream in 2012 and produces the BMW X1, BMW 3 Series long version, BMW 3 Series Sedan and ZINORO cars. Another part of the Shenyang production site is a stand-alone engine plant that supplies both vehicle plants, Dadong und Tiexi, with the powertrains for the BMW vehicles made there.
The joint venture BMW Brilliance Automotive invested a total of one billion euros in building the Tiexi plant and in expanding Dadong (completed by the end of 2011).

BMW Group Plant Oxford, UK.

Oxford is the heart of the British production triangle that also includes the plants in Swindon and Hams Hall. Plant Oxford currently produces the MINI Hatch, MINI Convertible, MINI Roadster and MINI Coupe. The success of the MINI brand is clearly reflected in the positive development of the Oxford site since 2001: Back then, the approx. 2,400 workers produced about 300 MINIs a day in one-shift operations. Today, the plant employs around 4,000 people who make up to 1,000 MINI vehicles a day in three-shift operations. All in all, over three million MINI cars have rolled off the assembly line so far. Since 2000, the BMW Group has invested a total of 1.75 billion pounds in their British sites. Between 2012 and 2015 alone, the BMW Group has invested 750 million pounds in the British production sites in Oxford, Swindon and Hams Hall.

BMW Group Plant Araquari, Brazil.

In December 2013, the BMW Group hosted the groundbreaking ceremony for a new plant in Araquari (State of Santa Catarina) in Southern Brazil. The new plant in Brazil that went on stream in October 2014 is a crucial element in the BMW Group's international production network, contributing significantly to the BMW Group's profitable and globally balanced growth. The production infrastructure comprises the technologies body shop, paint shop and assembly. The planned production capacity stands at up to 30,000 vehicles annually, with the product portfolio comprising the MINI Countryman, BMW 1 Series 5-door, BMW 3 Series Sedan, BMW X1 and BMW X3. A total of about 1,300 jobs will be created at the production site in Araquari.
In 1995, the company founded its National Sales Organization, followed in 1999 by the setup of a Financial Sales Company for Brazil. The BMW Group has been building motorcycles at Manaus, Brazil, since 2009.

BMW Group Plant San Luis Potosí, Mexico
(currently under construction, SOP: 2019).

In July 2014, the BMW Group announced that the company would build a new plant in the close proximity of the Mexican city of San Luis Potosí in the state of the same name. This move once again demonstrates that the company consistently implements its strategic guideline of balanced global growth. Over the next few years, the BMW Group is going to invest

one billion US dollars in the new production site. In the course of the first year of production, 2019, approx. 1,500 people will work at the plant. The BMW models to be produced at San Luis Potosí will be announced at a later point. The BMW Group has run a National Sales Organization in Mexico since 1994.

Rolls-Royce Manufacturing Plant Goodwood, UK.

At the Rolls-Royce Manufacturing Plant in Goodwood, close to 1,000 highly skilled experts make Rolls-Royce vehicles according to the individual demands of their customers. Production comprises the Rolls-Royce models Phantom, Phantom Drophead Coupe, Phantom Coupe, Ghost and Wraith. The longstanding tradition of hand-making automobiles is complemented by state-of-the-art precision tools and technologies, ensuring the unparalleled quality level.

6. Engines, components, contract production and motorcycles: The other sites in the BMW Group production network.

In addition to the automotive plants, the BMW Group's production network comprises further production sites, including a motorcycle production plant in Berlin, four engine plants, seven component plants, seven assembly plants for cars and motorcycles, as well as two contract production sites.

BMW Group Motorcycle Plant Berlin.

The plant in Berlin has one of the longest histories among the BMW Group's production facilities. Just like at the parent plant in Munich, BMW's site in Berlin began with aircraft engine production in 1939; motorcycle parts were added to the portfolio in 1949. Twenty years later, in 1969, the entire motorcycle production was moved from Munich to Berlin. Today, the plant in Berlin produces up to 600 motorcycles of the different model series as well as maxi-scooters a day. Since 1979, the team of almost 1,900 employees also makes components for BMW's automotive production, such as brake disks for various BMW models.

About 80 percent of all BMW motorcycles and maxi-scooters made in Berlin are exported to more than 130 countries. This is why BMW Motorrad is expanding the network of international production sites. Local motorcycle assembly plants, e.g. in Brazil and Thailand, are increasingly gaining in importance, with the Berlin plant remaining at the center of this production network.

BMW Group Engine Plant Steyr, Austria.

Established in 1979, the production site in Upper Austria is the BMW Group's largest engine plant today. At the same time, it is the group-wide development center for BMW diesel engines. At the Steyr site, 3, 4 and 6-cylinder diesel engines as well as 3 and 6-cylinder petrol engines, including the high-performance engines for the BMW M models, roll off the assembly lines. Every workday, about 2,800 employees produce up to 5,000 engines. The BMW Group's total investment at the engine production site in Steyr currently stands at close to 5.5 billion euros.

BMW Group Engine Plant Hams Hall, UK.

The engine plant in Hams Hall near Birmingham has been a part of the BMW Group's production network since 2001. At the engine plant, about 690 people produce 3 and 4-cylinder petrol engines for BMW and MINI. Since the start of series operations, Hams Hall has produced over 3.5 million drivetrains.

BMW Group Plant Landshut.

At the BMW Group's Landshut site, around 3,500 workers make engine and light metal chassis components, plastic component for the vehicle exterior, carbon body component, cockpit and equipment scopes, electric drive systems, special engines and drive shafts. These components are dispatched worldwide to all BMW Group vehicle and engine plants. As the center of innovation and production for the future technologies of lightweight construction and e-mobility, Plant Landshut gets involved in the development of new vehicles at a very early stage.

BMW Group Plant Wackersdorf
(at the Wackersdorf Innovation Park).

In 1990, the BMW Group began producing car bodies for the BMW 3 Series Convertible in Wackersdorf. Today, the site in Wackersdorf comprises the BMW cockpit production, the BMW foreign plants supply as well as further supplier companies. Every day, the BMW cockpit production makes up to 4,000 dashboards for the BMW 1, 2, 3 and 4 Series. The Wackersdorf Supply Center is a major logistics hub of the BMW Group. From here, more than 2.5 million parts are sent to the partners in the production network every day, providing the BMW Group's foreign plants and further assembly partners on four continents with vehicle parts. The supplier companies manufacture components for the BMW Group's plant in Regensburg as well as for the BMW Group's production network. Moreover, the joint venture SGL Automotive Carbon Fibers (ACF) in Wackersdorf makes carbon fiber laminates for the BMW i models. All in all, about 3,000 people work for a variety of companies at the Wackersdorf Innovation Park, including more than 700 BMW Group employees.

SGL Automotive Carbon Fibers (ACF) Moses Lake, USA (joint venture).

The site in Moses Lake in Washington State, USA, produces carbon fiber; it is operated by SGL Automotive Carbon Fibers (ACF), a joint venture of the BMW Group and SGL Group. At present, the Moses Lake plant operates two production lines, exclusively for BMW i, with an annual output of approx. 3,000 tons of carbon fiber. In summer 2014, SGL Automotive Carbon Fibers in Moses Lake commissioned a third and fourth production line, doubling the plant's capacity to 6,000 tons a year. The planning for two additional production lines is currently underway; these facilities will triple the carbon fiber plant's capacity to 9,000 tons annually in the medium term. The energy needed for the carbon fiber production is fully generated from environmentally friendly hydropower. The expansion will be funded by an investment of 200 million US dollars, in addition to the previously invested 100 million US dollars. The site expansion, scheduled to be completed by early 2015, will make the plant in Moses Lake the world's largest carbon fiber factory. With the anticipated creation of 120 new jobs, the headcount at the joint venture in Moses Lake is going to rise from currently 80 to about 200 people. The expansion of the site in Moses Lake will make it possible for the BMW Group to apply carbon fiber material also in other model series in the future, at competitive costs and in large quantities.

SGL Automotive Carbon Fibers (ACF) Wackersdorf (joint venture).

In addition to Moses Lake, the joint venture SGL Automotive Carbon Fibers (ACF) operates another site for the production of carbon fiber laminates at the Wackersdorf Innovation Park. The fiber rovings produced in Moses Lake are sent to the Wackersdorf Innovation Park for industrial processing into lightweight carbon fiber laminates. The approx. 500 employees at the joint venture location in Wackersdorf make several thousand tons of carbon fiber laminates a year, the textile needed for the CFRP production at the BMW Group's plants in Wackersdorf, Landshut and Leipzig.

BMW Group Tool-Making Plant Eisenach.

In 1990, the BMW Group decided to establish a factory for large press tools at a place with a rich production history, Eisenach. In operations since 1992, the plant now employs close to 250 people. At the Eisenach

site, the BMW Group produces tools for the production of medium-sized and large sheet steel body parts, such as front lids, doors, fenders and roofs. The site's range also includes mechanizations, flanging tools, engineering services, design models, the production of prototyping tools and parts as well as small series pressing. On top of that, the team in Eisenach manufactures body shell parts from sheet steel, aluminum and high-grade steel for the Rolls-Royce Manufacturing Plant in Goodwood/UK as well as parts for BMW's motorcycle production in Berlin. Innovative issues, such as aluminum stretch forming, hydro-mechanical forming and volume-optimized tools complement the range of tasks. The plant in Eisenach benefits from a consistent process chain, ranging from design consulting to the finished tool. Accordingly, the production site strategically applies all possibilities offered by high-tech, from stretch simulation to high-speed cutting (HSC treatment).

BMW Group Plant Swindon, UK.

Swindon Pressings Limited was founded in 1955 by Pressed Steel Company. In 2000, the BMW Group acquired the company as a full subsidiary. Located about 90 minutes west of London, the press shop is equipped with highly complex press lines and pre-assembly facilities. In Swindon, about 800 employees manufacture high-quality pressed parts and complex body components like doors and lids.

Contract Production Magna Steyr Fahrzeugtechnik (MSF) Graz, Austria.

Contract production is a key instrument applied to support the flexibility of the BMW Group's production network. A current example is the contract production of the MINI models Countryman and Paceman at Magna Steyr Fahrzeugtechnik (MSF) in Graz, Austria. To ensure that the MINI vehicles produced are of the same supreme quality, a new production line in keeping with the BMW Group standards was erected at the plant. In mid-2014, the one-millionth vehicle for the BMW Group rolled off the assembly line in Graz.

Contract Production VDL Nedcar, Born, The Netherlands.

Since July 2014, VDL Nedcar in Born, Netherlands, has been producing MINI Hatch vehicles for the BMW Group. At full capacity utilization, about 2,000 workers at the plant are responsible for the production of MINI cars. The planned MINI production volume at VDL Nedcar is going to be in the five-

digit range even in the first year of production. The same high quality standards apply to the MINI production in Oxford and Born. In order to ensure these quality standards, the VDL Nedcar team received in-depth training on the BMW Group production system at the BMW Group's plants in Leipzig, Oxford and Regensburg.

BMW Group Manufacturing Thailand, Rayong.

The Rayong-based assembly plant of BMW Group Manufacturing Thailand opened in 2000. Spanning about 75,000 square meters, the plant is located on Thailand's eastern coast, in the Amata City Industrial Park (Rayong Province), about 115 kilometers from Bangkok. At the assembly plant in Rayong, approx. 400 workers make a wide range of models – the MINI Countryman, BMW 1 Series, BMW 3 Series, BMW 3 Series Gran Turismo, BMW 5 Series, BMW 7 Series, BMW X1, BMW X3 and BMW X5 – for the local market. In addition, the plant produces a BMW motorcycle model, the F 800 R, making Rayong the only plant in the global production network that produces products of the brands BMW, MINI and BMW Motorrad.

BMW Group Plant Chennai, India.

The BMW Group's assembly plant in Chennai, India, was set up in 2007. Located in the region of Mahindra World City, about 40 Kilometer northwest of Chennai in Southwestern India, the site comprises about 13,000 square meters. State-of-the-art systems engineering, more than 500 highly qualified employees and sophisticated manufacturing processes: these are the prerequisites for the production of premium cars in keeping with supreme quality standards. At present, the product range of the Indian assembly plant comprises the MINI Countryman, BMW 1 Series 3-door, BMW 1 Series 5-door, BMW 3 Series Sedan, BMW 5 Series Sedan, BMW 7 Series long version, BMW X1, BMW X3, BMW 3 Series Gran Turismo, and BMW X5.

Partner Plant Russia, Kaliningrad.

Russia is one of the key growth markets for the BMW Group. Once again acting in keeping with the motto of 'production follows the market' early on, the company was the first German premium manufacturer to start local vehicle production back in 1999. Since then, the assembly plant in Kaliningrad has been run in cooperation with an assembly partner, Avtotor. The local product range includes the BMW 3 Series Sedan,

BMW 5 Series Sedan, BMW 7 Series Sedan, BMW 7 Series long version, BMW X1, BMW X3, BMW X5, and BMW X6.

Partner Plant Egypt, Cairo.

Since 1997, the BMW Group has been cooperating with production partners to produce BMW vehicles for the Egyptian market. In 2004, the BMW Group's local partner Bavarian Auto Manufacturing Company (BAMC) put a new factory on stream. The Cairo-based plant, which comprises a body shop, paint shop and assembly, currently produces the BMW 3 Series Sedan, BMW 5 Series Sedan, BMW 7 Series long version, BMW X1, and BMW X3.

Partner Plant Indonesia, Jakarta.

In Jakarta, the BMW Group cooperates with a local production partner, Gaya Motor, to make vehicles for the Indonesian market. The product range comprises the BMW 3 Series Sedan, BMW 5 Series Sedan, BMW X1, and BMW X3.

Partner Plant Malaysia, Kulim.

Since 1979, the BMW Group has been manufacturing cars for the Malaysian market together with local production partners. At present, the plant in Kulim, operated in cooperation with Inokom Corporation, produces the following models on two assembly lines: MINI Countryman, BMW 1 Series 3-door, BMW 1 Series 5-door, BMW 3 Series Sedan, BMW 5 Series Sedan, BMW X1, and BMW X3.

Partner Plant DAFRA, Manaus, Brazil.

The DAFRA partner plant in Manaus, Brazil, produces BMW motorcycles. The model range comprises the BMW G650 GS, BMW F800 R, BMW F800 GS, and F800 GS Adventure.

7. Quality from the outset: How a car is made.

The same standards for quality, safety and a considerate use of resources apply at all production sites within the BMW Group's international production network. Innovative production technologies and the employees' high level of expertise guarantee that more than 20,000 individual parts can be turned into premium vehicles 'made by BMW'.

The agile and innovative production at the BMW Group plants is geared toward the customer benefit. It makes it possible to meet individual customer wishes on schedule as well as swiftly and flexibly. The required processes are very complex and can only be run within highly flexible structures – both issues the BMW Group masters well.

Press shop.
The production of a car starts in the press shop. Every working day, body parts are made using huge sheet steel and aluminum coils. Each BMW car body consists of several hundred individual parts: from the tank cap to the side frame. 20 different kinds of steel, ranging in sheet thickness from 0.7 to 2.2 millimeters, are processed. The starting point for the production of body parts are the so-called coils of high-quality galvanized sheet steel or deep-drawing sheet steel. These coils can contain several kilometers of sheet steel and weigh up to 30 tons. On the pressing lines, the sheets are given their final shape in a multi-step process.

Body shop.
In the body shop, the individual steel parts are connected via different joining technologies such as welding, adhesive bonding and riveting to form a body-in-white ready for painting. The result is a highly safe car body with the highest-possible reduction in weight. The procedures at the body shop are almost fully automated. Robots carry out the highly complex production tasks with maximum precision. The use of robots also means that unnecessary physical strains for workers are omitted, such as handling heavy welding guns. Thanks to the high level of automation, different car body variants can be manufactured on a single line. Each car body consists of several

hundred pressed parts.

Paint shop.

A brilliant color, maximum corrosion protection and a supreme appearance: the car bodies receive their color and shine in the paint shop. In all activities at the paint shop, eco-friendly processes and state-of-the-art application procedures are top priorities. The altogether five functional paint coat layers are about ten times the diameter of a human hair and protect the car body against corrosion and environmental damage.

Following the pre-treatment, in which the car bodies are thoroughly degreased and treated with alkaline cleaner in a dip basin, a zinc phosphate layer is applied, also in a dip basin. It serves as a primer for the following four paint layers and protects the paint against corrosion. In the following cathodic paint-dip process, the first paint coat is applied. The car body is negatively charged at copper rails at the basin rim (cathode) and then fully dipped into the paint. The paint particles are positively charged and thus attracted by the negatively charged car body. The paint dries immediately on the surface of the car body.

The next step is the application of the filler, which serves as visual protection for the previously applied cathodic dip paint coat, levels out any unevenness to a thousandth of a millimeter, provides a good foundation for the top coat, and increases its gloss. Then, the vehicle moves on to the top coat line where it receives the color chosen by the customer. There is a choice of hundreds of different series colors, plus several hundred individual color options. In a last step, a hard, permanent clear coat layer is applied to ensure the protection and gloss of the car body.

Assembly.

In assembly, workers complete the painted car bodies by adding the equipment selected by the customer. The result is a finished premium vehicle. The top priorities here are the customer's wishes and individualization options. Only a few days before the start of assembly, the assembly receives the customer order, establishes the assembly sequence and automatically sends material call-offs to the suppliers. The BMW Group's customer-oriented sales process offers customers to make changes up

to six days prior to the start of assembly. Production allows for an almost endless number of equipment variants. For instance, in the production of the BMW 7 Series at Plant Dingolfing, theoretically up to 10^{64} equipment variants can be made. In other words: basically no two vehicles that roll off the assembly line are the same.

Depending on the customer order, assembly calls up the painted car bodies. The vehicle now receives its identification number and is allocated to the specific customer. The order-based production with a multitude of variants is about to begin. All required parts are provided to the assembly line just in sequence and just in time. High ergonomic standards and tools such as handling devices, roller stools and swiveling assemblies provide employees with the easiest and healthiest options to do their jobs.

Following the paint process, the swivel mount first of all moves the car body in a way that people can work on the undercarriage of the vehicle in an ergonomically optimized position. This is where the tank as well as the fuel and brake lines and other components are mounted. Next, the interior parts are fitted: these include the carpet, ceiling, cockpit, control panels, seats, doors, and window panes.

In the 'marriage', the drivetrain is joined to the car body. This step initiates the last stage of production, the final assembly. Now the wheel arches are covered and the wheels mounted; the vehicle is filled with operating fluids, and its track is adjusted. The final assembly is completed on the roller dynamometer, on which numerous systems are once again tested in full drive mode.

The entire assembly process is highly efficient: Individual parts are pre-assembled into a larger component (e.g. cockpit, frontend, doors, drivetrain unit) in a separate assembly space and provided to the main line just in sequence. This allows for maximum flexibility at the 'neutral' main line.

Engine production.

For decades, the production of engines has been a core competence of the BMW Group, the 'Bavarian Engine Works'. Engines are a vital element of the proverbial 'sheer driving pleasure', combining outstanding driving

characteristics with minimum fuel consumption and CO_2 emissions. The supreme running behavior and driving pleasure are based on most demanding production technologies. The BMW Group's engine production teams in Munich, Steyr (Austria), Hams Hall (UK) and the joint venture site with Brilliance China Automotive Holdings Limited in Shenyang manufacture the entire engine portfolio of the BMW Group – from 3 to 12-cylinder engines.

For all engines, several hundred individual parts are finely machined with a precision of a thousandth of a millimeter and then mounted. Before being fitted into the vehicle, each engine undergoes specific test cycles, such as the cold test that allows for a full function test in close to no time and without the use of fuel. Subsequently, the completed engines are dispatched to the assembly line of the respective assembly plant just in sequence.

8. Sustainability is a given: Clean Production.

Economic success, a responsible use of resources and social responsibility are the pillars of lasting growth and a continuous increase in company value. Therefore, the BMW Group has solidly incorporated the consideration of ecological and social criteria along the entire value chain as well as a clear commitment to the conservation of resources.

The BMW Group intends to be not only the leading but also the most resource-efficient premium provider of individual mobility. This is why the company applies a consistent group-wide environmental management, considering environmental aspects early on in investment decisions and continuously monitoring environmental KPIs as well as the achievement of ambitious targets. Furthermore, tried-and-tested approaches are transferred to the entire production network.

Long tradition in environmental protection.
Environmental protection at the BMW Group has a long tradition; its roots lie in the production division. Back in the early 1970s, the company's first environmental officer was appointed, a novelty in the automotive industry. The environmental guidelines adopted in 1993 are based on the ICC Charta for Sustainable Development and the principles of the Agenda 21. In keeping with their Clean Production philosophy, the BMW Group aligns the production processes in a way that keeps the environmental impact and resource consumption to a minimum. The company also obligated itself to adhere to these standards by signing the International Declaration on Cleaner Production of the United Nations Environment Program in 2001.

The BMW Group aims at making a contribution to the fight against climate change. Consequently, the company keeps greenhouse emissions, in particular carbon emissions, as low as possible. This is accomplished with highly efficient vehicles and production processes, the application of renewable energies and a considerate selection of sites.

Clean Production.

As early as 2007, the BMW Group laid out the target to reduce the resource consumption and the emissions per vehicle produced by an average of 30 percent across the monitored measuring parameters between 2006 and 2012. This target was exceeded, with an efficiency improvement amounting to over one third. The measuring parameters included energy, water, process wastewater, waste for disposal, and solvent emissions.

Given how highly efficient the processes already are, achieving additional reductions has become a major challenge. Nevertheless, in 2012, the BMW Group set another ambitious goal for 2020: to reduce the resource consumption per vehicle produced by 45 percent from the 2006 level. So far, resource savings and emission reductions of 40 percent have been achieved.

Going beyond the own production, the BMW Group also requires compliance with and improvement of environmental standards from their suppliers. For instance, the company requests that, if applicable, suppliers have an environmental management system in place. The BMW Group continuously strives to reach improvements also in the cooperation with the joint venture partners SGL Group and Brilliance Automotive Limited. A good example in this context is the collaboration with SGL Automotive Carbon Fibers at the joint venture plant in Moses Lake (USA) where the entire carbon fiber production runs on regenerative energy from hydropower.

Energy consumption and emissions.

A vision of the BMW Group is to establish a completely carbon-free energy supply. By 2020, the company intends to be in the lead regarding the utilization of energy from renewable sources. In addition, energy consumption and emissions per vehicle produced are reduced year by year. It remains a challenge to establish an energy supply that is both safe and economic as well as ecological. All BMW Group production sites are instructed to use the energy resource that is most sustainable in both ecological and economic terms. At present, the share of green energy of all energy procured stands at 49 percent.

The continuous reduction of the energy demand as well as the increasing in-house energy generation and procurement of energy from local,

renewable sources improve the BMW Group's autonomy and security of supply, especially with regard to potential energy bottlenecks in production. The energy consumption is constantly monitored and optimized, applying a energy management system that is based on the environmental management systems ISO 14001 and EMAS.

Development of renewable energy sources.

Besides the intelligent use of energy, the BMW Group is mostly concerned with the development of renewable energy sources. The company operates power cogeneration systems at currently eight production sites; with these facilities, the plants can not only to make use of the generated power but also of the process waste heat. Furthermore, the BMW Group Production continuously improves the processes in vehicle production, introducing innovations such as the Integrated Paint Process (wet-on-wet coating) as well as optimizing the efficiency of ventilation systems and closing energetic circuits in the paint shops. Given the rise in energy prices, the resulting reduction in energy costs makes a significant contribution to the BMW Group's profitability and competitiveness.

For the BMW Group, reducing carbon emissions is not only an ecological but also an economic duty. Each new plants strives to set new standards in terms of energy efficiency in order to become the benchmark for all other plants. The most recent example is the factory in Tiexi (China), opened in 2012 as part of the joint venture BMW Brilliance Automotive Limited (BBA). Its concept builds strongly on the experiences and innovations of other plants, such as a ground water-based cooling system.

Reference system for sustainable construction.

When buildings are constructed or remodeled, the BMW Group applies the reference system for sustainable construction, which stipulates principles and concepts for the BMW Group's entire real estate portfolio and facilitates the monitoring of activities throughout the individual project stages. The goal is to minimize the consumption of energy and other resources at all stages of a building's life cycle – in planning and construction, utilization and remodeling, as well as dismantling. On top of that, the BMW Group aims at keeping the environmental impact to a minimum. Based on this reference system, for instance, the company received the certification according to the

Leadership in Energy and Environmental Design (LEED) for all the buildings erected at the Leipzig plant for the BMW i3 production.

Using renewable energies.

It is the BMW Group's vision to be able to cover the entire energy demand from green energy. However, the company does not focus on specific renewable sources but decides for each location, which concept would be the most appropriate under the local conditions.
At the engine plant in Steyr, for instance, about 30 percent of the heat is provided by an adjacent biomass cogeneration station fed with wood scrap from the region. This setup reduces the site's carbon emissions by approx. 3,000 tons annually. Another good example is the production of the BMW i3 in Leipzig, which is supplied with carbon-free energy. To this end, the BMW Group has installed four wind turbines on the plant premises that account for a combined power generation of ten megawatts of green energy.

At the component plant in Landshut, waste heat from the smelter is fed into the plant's internal hot water network. Every day, the Landshut-based light-metal foundry uses liquid aluminum at a temperature of about 740 degrees Celsius; the waste heat from the smelting furnaces is stored and used for heating the buildings in winter. In summer, it supplies an absorption refrigerator that generates cold for different production processes at the plant. Combined with the three power cogeneration stations on the plant premises, a unique and highly sustainable energy cycle has been created. Each year, the Landshut site saves about 10,000 tons of CO2 and reduces the energy consumption by 15,000 megawatt hours, saving the company an annual total of over one million euros.

This innovative form of energy utilization is also applied at the BMW Group's press shops, e.g. in Regensburg, where cooling water protects the facilities against overheating; in winter, the excess heat energy is used to heat the press shop. This heat recuperation system covers about 90 percent of the plant's heat demand in winter.

At the production site of the MINI models, in Oxford, 11,500 solar modules supply the plant with green energy. At 20,000 square meters, the photovoltaic power system is the size of five football fields, making it

one of the largest roof-mounted solar systems in Great Britain. The facility can generate over three megawatt hours of power, a sufficient energy supply for the annual demand of 850 households.

In Rosslyn (South Africa), the BMW Group has requested the independent operator, Bio2Watt, to provide about 25 to 30 percent of the power needed at the plant from a combined heat and power station that runs on landfill gas from 2015 on. The biogas used is generated from the recycling of cattle and chicken farm waste.

When it comes to energy consumption, it is the BMW Group's goal to reduce the energy demand per vehicle produced by 45 percent from the 2006 level by 2020.

Materials usage and waste management.

Given the global scarcity of raw materials, the BMW Group aims at establishing a closed recycling loop. After all, what looks like waste often holds valuable resources and the company intends to make best use of these resources. Once again, the same goal applies: By 2020, the non-recyclable waste per vehicle produced is to be reduced by 45 percent from the 2006 level.

Whenever possible, the BMW Group tries to avoid producing waste in the first place as this is the best solution, both economically and ecologically. Residual material that arises is either reused directly or treated for its reuse in its original area of application. If materials cannot be reused, the BMW Group recycles the recyclable components to feed them back into the loop to replace primary raw materials. Waste material that cannot be recycled is mostly burned, but other recovery options are applied as well. Only a small fraction of the material that cannot be recycled is actual waste for disposal. Innovations in fields like electric mobility or lightweight construction go hand in hand with new recycling procedures for material that is generated in the production or recycling of the vehicles, such as high-voltage battery systems or carbon fiber reinforced plastics (CFRP).

When it comes to material usage and recycling management, the BMW Group Production works with best practice approaches that are gradually

transferred to the entire production network. The vision of a waste-free production is pursued via a number of activities. The iron dust from the special engine production at Plant Landshut, for example, can now also be treated in a recycling process, thus reducing the share of waste for disposal.

Water.

Water is an increasingly scarce resource: More than a third of the global population lives in countries affected by water scarcity. This is why it is becoming more and more important to make considerate use of the world's water supplies. To save water, the BMW Group continuously reduces its consumption. Once again, the goal is to reduce the water consumed per vehicle produced by 45 percent from the 2006 level by 2020. The company's vision is to establish wastewater-free processes in production.

To reach these goals, the production sites have initiated a number of activities. At the plants in Regensburg and Spartanburg, for instance, the BMW Group applies a state-of-the-art dry separation process in the paint shop. It makes it possible to bind overspray paint, which does not reach the car body in the painting process, with stone powder and to discharge it. No water is needed in the process. Over the next few years, the procedure will be rolled out step by step at all production sites that operate paint shops.

The BMW Group's plant in Regensburg has also successfully tried a new procedure to reduce wastewater in the cathodic dip painting process. Applying a membrane technology, the anolyte wastewater is treated and fed back into the cycle. The BMW Group is currently rolling out this technology at all production sites worldwide.

VOC emissions and biodiversity.

Within the scope of group-wide environmental protection activities, the BMW Group also intends to minimize the VOC (volatile organic compounds) pollution. The goal is to reduce VOC emissions by 2020 by 45 percent from the 2006 level. The company also considers its environmental impact on flora and fauna. To this end, the BMW Group determines the ecological value of some select premises via, among other things, a biodiversity parameter.

At an average of 1.59 kilograms per vehicle produced, the BMW Group's VOC emissions are below the strict German limit values at all plants. As the only exception, the South-African plant in Rosslyn close to Pretoria has yet to go below the German limit values, which are stricter than most stipulations worldwide. Planning activities to reduce the VOC emissions in the paint shop are under way. At the Chinese plant in Dadong, run by the joint venture partner BMW Brilliance Automotive Limited, a thermal exhaust air system has lowered the VOC emissions from 5.63 kilograms to less than 1.00 kilogram per vehicle produced.

The BMW Group considers the impact of their operations on flora and fauna at all locations. At the production sites in Leipzig and Regensburg, the company has previously conducted ecological preservations of evidence, making the existing plants and animals on the premises known so that endangered species can be protected.

The BMW Group aims at protecting and restoring natural habitats at all locations. For instance, only a few years after its establishment, the plant in Leipzig was attested a high biodiversity factor thanks to the near-natural design of its green areas.

Efficient transport logistics.

As a global provider of premium products and services, the BMW Group moves a great number of goods and people. The company wants to keep the environmental impact of these transports as low as possible. To this end, the company continuously optimizes transport logistics and expands the share of low-CO_2 carriers. In bids for tender, for example, the BMW Group always intends to strike an ideal balance between capacity utilization and types of carriers; whenever possible, preference is given not to road traffic but to rail transports. Furthermore, the BMW Group is working on reducing the share of airfreight.

Providing the global production network with goods requires highly flexible logistics structures. This is due, among other things, to more ambitious requirements regarding direct, scheduled deliveries and the increasing volatility of the global markets. To ensure this flexibility while incorporating rail freight requires a considerable planning effort.

Rail transport to supply the Bavarian plants.

For years, the BMW Group's Bavarian plants in Munich, Dingolfing, Regensburg and Landshut have received their consignments from the urban centers of Hannover, Wuppertal and Frankfurt via block train. This system helps the BMW Group avoid about 30,000 truck tours a year, or over 13,000 tons of carbon emissions. On top of that, the company makes a significant contribution to reducing road congestion. In the retendering process for the materials supply from Europe to the German plants in 2012, the existing rail transports were guaranteed in the long term, despite considerable additional costs compared to a transfer of loads to truck routes. In 2013, two of these rail connections were converted to power from renewable sources, with the third to follow in 2014. All in all, these measures account for a reduction of 4,000 tons of CO_2.

At present, the average share of rail freight in plant deliveries of vehicles stands at over 60 percent. At the BMW Group's Leipzig site, for instance, the entire volume of export vehicles amounting to about 30,000 cars a year, was transferred from road to rail transport for the distance from Leipzig to the sea port in Bremerhaven. In terms of carbon emissions, this move accounts for an annual reduction of over 1,000 tons.

As part of their 'rail strategy', the BMW Group also managed to secure about 75 percent of the capacities of closed rail transports (i.e. trains with closed wagons) available in Central Europe in the long term. This is a crucial prerequisite for being able to raise the share of rail transports of plant deliveries of vehicles further, especially in urban centers. Furthermore, all new wagons are fitted with 'whispering brakes', reducing noise pollution in transit considerably – a benefit especially for people who live close to railroad tracks.

New rail-based sea freight pre- and post-carriage concept in the USA.

In the US, the BMW Group implemented a new rail-based sea freight pre- and post-carriage concept, moving more than 20,000 containers a year from road to rail transport, a more environmentally friendly way to transport goods between the sea port of Charleston and the plant in Spartanburg. Thanks to a complete redesign of the logistics processes and the booking of railroad capacities, a cooperation with the operators of the port and the

rail track resulted in the construction of a new inland port directly at the rail tracks and in close proximity of the BMW Group's Spartanburg site. Very close to the inland port, a new dispatch center for assembly kits was built. Instead of via truck, over 90 percent of the import containers will in the future move from the port to the inland port by rail; for export containers to the port, the share stands at 100 percent. The implementation of the new concept has reduced carbon emissions by 60 percent from the previous level, or by over 4,000 tons of CO_2 annually.

If rail transport is not feasible, the BMW Group requests that their freight forwarders use eco-friendly vehicles. In Europe, for example, the respective contract specifications include the stipulation that only vehicles may be used that meet at least the EURO-5 norm. New vehicles have to comply with the legally stipulated EURO norm requirement at the time of their acquisition.

Packaging planning – Perfect utilization as the top priority.
When it comes to planning transport packaging, the priority is always the optimum utilization of packaging. This applies to packaging density while ensuring the protection of the product as well as to the best possible use of space when loading the cargo onto the trucks or into the containers.

BMW i production: Fleet of hydrogen-powered fuel cell ground conveyors.
The BMW Group has broken new ground in the BMW i production by introducing hydrogen-powered forklifts and haulers for the transport of parts within the plant. The fleet comprises nine ground conveyors (four tugger train haulers and five forklift trucks) whose fuel cells run on eco-certified hydrogen. The vehicles are part of the research project 'H2Intradrive' (to be continued until 2016) and provide parts in the body shop of the BMW i models. The project aims at testing the environmentally friendly and efficient hydrogen drive for ground conveyors under everyday conditions in a real-life production environment and at developing it to reach series maturity. Besides sustainability aspects, the focus is on charging cycles and maintenance issues. Due to the necessary change of battery for conventional lead-acid batteries, the downtimes of conventional ground conveyors are relatively long. The fuel cell hybrid system of the forklifts and tugger trains, however, only charges for a few minutes and is generally low

maintenance. Consequently, the vehicles' availability is much higher, especially in multi-shift operations.

Plant busses for the sustainable commute to and from work.

The commutes to and from work of the BMW Group's workforce account for a major position in the logistics statement. This is why, once again, the company tries to keep the environmental impact as low as possible. An important step in these efforts is the implementation of a plant bus system that reduces individual car traffic. Plant busses are particularly reasonable in the case of fixed shift times and a great concentration of workers in the area around the plant, ensuring a high capacity utilization of the busses. Plant bus systems exist both at German sites (BMW Group plants in Munich, Landshut, Dingolfing, Regensburg, Berlin) and at the international locations in Tiexi/China and Rosslyn/South Africa. In China and South Africa, about 85 percent of the workforce uses the plant busses; in Germany, approx. 44 of all employees commute to work by plant bus or public transport, with another 6 percent biking or walking to work.

9. Truly one of a kind: What makes the BMW Group Production unique.

The BMW Group's goal is a competitive, sustainable and innovative production network. With its international network, the BMW Group Production supports the global market development and a balanced distribution of value creation (Globalization 3.0). An innovation leader, it sets trends, for instance in production technologies or sustainability, and is an active driver of the technological change.

Based on its flexibility, comprehensive planning and value-added production system, the BMW Group Production is able to safeguard its competitiveness in the long term. A crucial prerequisite is a unique, excellent understanding of leadership.

The concept of the BMW Group Production rests on three pillars; firstly, globalization; secondly, technological change; and thirdly, competitiveness.

The first pillar of BMW Group Production: Globalization.
The BMW Group aims at achieving a balanced growth in all markets and on all continents. The highly efficient, flexible and agile production network adheres to the principle of 'production follows the market'. Thanks to its international alignment, the BMW Group Production is already present with full plants in key markets such as the NAFTA region, China or Europe, producing vehicles for both the local markets and the export business. The company constantly monitors and analyses market developments and customer requirements. When trends are changing significantly, the BMW Group has the chance to react flexible by taking certain product and site decisions.

But the crucial point is that the BMW Group does not shift capacities from Germany or Europe to other countries, but solely responds to the growing demand outside of Europe. As the BMW Group sees it, globalization and production in Germany are not antipodes. The company finds the best solution by implementing a sophisticated combination and cooperation within its global production network. The outstanding flexibility of the

international production structures is a competitive advantage the BMW Group applies according to market developments and customer requirements.

In their plant allocation planning, the BMW Group always follows a comprehensive approach, actively and frequently shaping the setup of their global production network with currently 30 locations in 14 countries. In this process, the company considers a wide range of parameters and factors, ranging from a globally balanced distribution of value creation to the significance of individual vehicle models for certain markets. This approach also allows the BMW Group to offset capacity and flexibility requirements within and beyond plants.

Another essential element in this mix is the intelligent cooperation within the international network, which includes a central pooling of key functions such as production planning in order to ensure a high level of standardization throughout the BMW Group Production. At the same time, the individual production sites frequently enter into an exchange on process improvements and other important issues.

The second pillar of BMW Group Production: Technological change.
The global automotive industry is currently undergoing a fundamental structural and technological change (example: zero-emission driving). As the leading premium manufacturer, the BMW Group pursues a dual strategy of 'evolution and revolution': On the one hand, the company applies its Efficient Dynamics package to optimize the traditional combustion engine and to compliment the range with hybrid versions. On the other hand, the company follows a radically new approach, as it has demonstrated with the development of the BMW i models that are 'born electric', i.e. purpose-built for the electric drive. The completely new vehicle architecture of the BMW i models is also reflected in a fundamentally different production process; there is no longer a self-carrying car body in traditional steel sheet construction, but two modules, which are initially produced entirely separate from each other: the Life module (passenger cell) and the Drive module (chassis structure).

In this concept, new materials such as carbon fiber reinforced plastics (CFRP), or carbon in short, play an important role. Carbon has long played an important role in the aerospace industry and car racing. Whenever a highly resilient but lightweight material with great stiffness and rigidity is needed, designers increasingly turn to CFRP due to the benefits it offers. This is why the BMW Group has also worked in-depth with the high-tech material for the past ten years. Thanks to these many years of development work as well as the transfer of knowledge to the series production of BMW M and BMW i models, the company has acquired a level of expertise regarding processes, tools, and the handling of CFRP unrivalled in the automotive industry as well as a high level of industrialization in CFRP production. The body structure of the BMW i models consists completely of the very lightweight and resilient material, compensating for the additional weight of the battery for the electric drive.

Not only when it comes to carbon but to production in general, the BMW Group can draw on the wide range of knowledge from their global production network for the production of the BMW i vehicles. The BMW i models are made at several plants that are combined in the 'E-Mobility Network of Excellence'. This network includes some of the BMW Group's own plants – Leipzig, Landshut and Dingolfing – as well as the sites in Moses Lake and Wackersdorf, which are part of the joint venture with SGL Group. In this cooperation, the German BMW Group plants have proven to be key innovation drivers: a large share of the production and also the assembly of the BMW i models are carried out in Leipzig.

But at the BMW Group, the technological change does not end with BMW i. In the production of conventional vehicles, future-oriented and innovative production technologies as well as sustainability issues play an essential role as well.
One example: the high-speed servo press technology the BMW Group has recently introduced at all press shops worldwide (Leipzig, Regensburg, Dingolfing, Munich, and Tiexi/China). These innovative high-speed serve presses have a press force of over 10,000 tons and a speed of 17 strokes per minute. The smaller facilities for structural body parts even reach a speed of up to 23 strokes per minutes at a press force of 9,000 tons.
Consequently, both the production time per unit and the space demand are reduced by about half compared to traditional press systems. At the

same time, noise emissions have decreased from 92 to 80 decibels. Last but not least, the high level of standardization is an ideal prerequisite for allowing the BMW Group's global press shops to support each other flexibly and at short notice.

Another example is the Integrated Paint Process, or IPP in short. The BMW Group is currently introducing the innovative and resource-conserving paint technology at several plants. Compared to previous painting methods, IPP completely omits the process step of applying and curing of the filler ('filler-free top coat'). The function of the filler is transferred to one of the two base coat layers. The new procedure was first applied in the production of MINI models at the Oxford (UK) plant. At present, it is also applied in Spartanburg (USA), Tiexi (China) and Dingolfing. Compared with the traditional paint technology involving the separate filler process step, the BMW Group has cut 23 percent of energy, 22 of carbon emissions and seven percent of VOC emissions (Volatile Organic Compound).

Further examples include innovate forms of cooperation of man and machine, such as the collaborative robots now applied at the BMW Group's Spartanburg site. Assisting people in production by taking over hard physical labor, these robots will increasingly shape the factory of the future.

The third pillar of BMW Group Production: Competitiveness.
The BMW Group has always paid great attention to achieving profitable growth and manages its production operations accordingly. A high capacity utilization of the production facilities is thus an essential prerequisite for the plants' profitability. Despite an increasingly high number of models and variants, the global production network is able to respond quickly and flexibly to changes in the markets and to individual customer demands thanks to its 'breathing structures'. This way, it manages to counter the increasing market volatility.

After all, in the competitive environment, it is not only the product substance and quality that count, but also how quickly new products can be launched and how reliably customer demands are fulfilled. In 2014 alone, the BMW Group is launching a total of 12 new models and four model updates. Therefore, the BMW Group's high-performance production network also

has to meet the increasing demand for individually produced vehicles as well as the wide range of variants and the complexity of products and processes. A good example in this context is the BMW Group's Dingolfing plant, which currently produces 17 different models of the BMW 3, 4, 5, 6 and 7 Series model ranges.

As the BMW Group follows a customer and order specific approach in building cars (built-to-order), the company permanently aligns the production programs at the individual sites within the highly flexible production network to the demands of the markets. As a rule, the flexibility alignment of the production processes defines fluctuation ranges for the respective production volume at the vehicle plants. In other words, shifts in the model mix as well as shifts in timing and regional allocation between the plants, depending on the respective sales markets, during the year are common practice.

This setup is only feasible with globally applicable standards as well as product and process modules. A good example for this is the BMW Group's new engine module, which allows the company to simultaneously build 3, 4 and 6-cylinder petrol and diesel engines at various power levels at the engine plants in Munich, Hams Hall and Steyr. The new engine range is based on a uniform construction principle in an in-line setup. All engines of the new modular generation have a turbo charger and a variety of standard elements. These include, for instance, the aluminum crankcase with an identical arrangement of screws, on which the specific cylinder heads for either the diesel or petrol engine can be mounted.

Another important lever applied to master the complexity is the BMW Group's Value-Added Production System (VPS). VPS is a systematic approach laid out to reduce waste in technical and support processes in order to achieve lasting improvements in efficiency, quality and ergonomics. Specific issues covered include workplace design and work organization, the reduction of lead times, as well as a balanced utilization and cycle in production. In keeping with this approach, the material to be fitted in the vehicle, which is provided at the assembly line, is kept to a minimum and arranged in such a way that it is easily accessible to the assembly line worker and does not require unnecessary transit times.

To make sure that the increase in parts variety can nevertheless be mastered, a sophisticated provision of production as well as smart logistics are increasingly gaining in importance. Automated small-parts warehouses with fully automated collection, sorting and conveyor systems serve as 'control centers' close to production. They move with the cycle of production and work according to a principle everybody knows from the airport: Many different loads have to be sorted and distributed. The automated small-parts warehouse at the BMW Group's Regensburg plant, for instance, handles over 1,000 containers – or small-load carriers – with parts per working hour. The tugger trains that move through production on a fixed route every two minutes bring the parts directly to the assembly line.

In order to launch certain products in the market even faster to gain a competitive edge, the BMW Group draws on additional capacities at external production partners, such as Magna Steyr Fahrzeugtechnik in Graz (Austria) or VDL Nedcar in Born (Netherlands). These partnership models take some workload off the Group's structures, create leeway and provide valuable competitive advantages. In line with the corporate philosophy, the brand-defining expertise as well as the control and assessment authority in design, engine production, testing, purchasing, and service remain with the company.

In addition, the BMW Group has further partners, such with China Brilliance Automotive (Huachen Automotive Group); for the past ten years, the two companies have run a very successful joint venture, BMW Brilliance Automotive (BBA). The joint venture includes the Chinese plants Dadong, Tiexi and Powertrain in Shenyang. Another joint venture, SGL Automotive Carbon Fibers (ACF) owned by the BMW Group and SGL Group, operates two plants, the carbon fiber production in Moses Lake (USA) and the carbon fiber rovings production in Wackersdorf.

10. Industry 4.0: The BMW Group's vision of the production of the future.

The BMW Group has a state-of-the-art production network that is developed further on a continuous basis. Some of the approaches summarized under the term 'Industry 4.0', which are currently the subject of public debate, have previously been introduced at the BMW Group or are in their rollout stage.

Involvement of the BMW Group in research projects and own technology projects.

First off, the BMW Group is actively involved in Industry 4.0 research projects of the German government, such as CyPros (productivity and flexibility improvements thanks to the networking of intelligent systems at the factory) and ReApp (flexible robot-based automation solutions). Secondly, the BMW Group is working on big data approaches to improve energy efficiency (at the BMW Group's plants in Spartanburg and Leipzig) or the application of mobile communication technologies to support production workers. Main objectives are to increase quality and to take some burden off the shoulders of workers at the plants, for instance by improving ergonomics. To ensure the rapid implementation of innovations, the BMW Group has set up respective in-house technology projects.

People are the key to success.

The BMW Group regards its workforce as the key to a lean production that is geared toward the customer benefit. So for the BMW Group, Industry 4.0 does not mean the production without people, and also not necessarily increasing automation. In this context, the main issue is the reasonable application of new technologies so as to provide ideal support to the workers in production and production planning. Sophisticated human-robot systems can significantly improve ergonomically unfavorable work procedures. Supporting workers through automation is a particularly good approach when it comes to simple, highly repetitive tasks, which require considerable physical strength. Robots that assist humans in production and take the heavy work off their hands will characterize the factory of the future.

Opportunities and risks.
As the digital and the physical worlds grow closer together, new opportunities arise that allow people to cooperate more efficiently in the international network. The focus is not on the technical feasibility, but on the specific benefit in production technologies that actually reach the end customer.

The BMW Group has recognized the opportunities early on and participated in the initial research projects on Industry 4.0. In the scope of these projects, various research and industry partners work on new and innovative topics and test their beneficial application in real life. Topics that demonstrate great implementation maturity are integrated in the everyday working life at BMW in order to ensure their rapid implementation. One challenge is that Industry 4.0 is widely discussed right now. So we will need to step up our efforts and develop specific applications of practical relevance. Another challenge will be the definition of comprehensive standards.

Example of application: Innovative man-robot cooperation at the BMW Group's Spartanburg plant.
Robots that assist humans in production and take the heavy work off their hands, will characterize the factory of the future. Their benefits are strength and mechanical accuracy – and they perfectly complement humans' flexibility, intelligence and sensitivity. At the BMW Group's Spartanburg plant, collaborative robots have taken some workload off the assembly line workers since 2013, ensuring maximum production quality. In door assembly, people and robots work side by side – without a safety fence – in one team. BMW's American plant is the world's first automotive production facility worldwide that has succeeded in implementing direct human-robot cooperation in series production.

Four collaborative robots equip the insides of the doors of BMW X3 models with sound and moisture insulation. In a first step, the foil with the adhesive bead is put in place and slightly pressed on by assembly line workers. Prior to the introduction of the new system, workers then carried out the fixing process by means of a manual roller. Today, systems with roller heads on robot arms handle this labor-intensive task, which requires maximum precision. The sealing protects the electronics in the door and the entire vehicle interior against moisture.

The decision for introducing assembly robots in Spartanburg was mainly based on ergonomic considerations. Automation as a means to assist staff is particularly suitable for simple, highly repetitive work scopes, which require considerable strength. The direct interaction of man and machine necessitates top security standards as the robots are placed in the workers' direct surrounding without any protective devices. They run at a low speed within a defined environment and are stopped immediately in case their sensors detect an obstacle in their way. Thanks to the fully automated process, the rolling power applied to the fixing process can be measured exactly. As a result, the processing quality can be monitored on a permanent basis. In the case that the robot's work process is interrupted unexpectedly, a worker carries out the fixing procedure manually again, just to make sure. Better safe than sorry.

The preliminary work for the future-oriented application of collaborative robots at the Spartanburg site was provided by the team of Innovation Management Production at the BMW Group's Research and Innovation Center (FIZ) in Munich. Developed over two years, the project was carried out in close cooperation with the robotics producer Universal Robot. The successful implementation of an ergonomically optimized human-robot cooperation in series production as a major step toward future automotive engineering and the world of Industry 4.0. Further applications of collaborative robots in assembly are being evaluated; the roll-out of the existing facility at other plants in the BMW Group production network is currently in the planning stage.

Example of application: Pilot project on non-contact gesture detection at BMW Group Plant Landshut.

Automated gesture detection has long been introduced in various industries, such as the gaming market. Proof of the fact that the application of camera-based gesture detection systems does not only make sense in the leisure segment but also in automotive production is provided by a pilot project at the BMW Group's Landshut site. Thanks to a non-contact gesture detection system, after bumpers have passed through the paint shop they now undergo an efficient and highly reliable quality control – via hand gestures.

Before bumpers are mounted, workers check the quality of the parts. In order to achieve a 100% quality level, each deviation from the target state

is recorded in a system and evaluated. Previously, workers had to document the result for each component checked at a PC. This setup cost valuable time, especially in cases where the PC could not be mounted directly at the test bench and people had to walk to a different workstation to feed in the data. If several faults appeared at different positions at the same time, the documentation became more complex, with workers being required to remember several details very precisely.

In cooperation with the Fraunhofer Institute in Karlsruhe, the BMW Group's Landshut plant has worked on a solution and developed a program that detects and evaluates gestures. The system recognizes the interaction between the person and the bumper. A wiping motion across the component marks the bumper as flawless. If a worker points their finger at a faulty section of the bumper, however, cameras register this gesture. The program then evaluates it and stores the entry.

The gesture detection system is controlled via two 3D cameras each, which are mounted above the workplaces. They are fitted with sensors that radiate infrared light through a filter. This way, an invisible grid of points with fixed coordinates is beamed across the room. To this end, the 3D bumper model was stored on the system. When a worker points to the bumper, the coordinates of certain points change because they are reflected by the hand. The system stores the data and evaluates it so that people do not have to leave their workplaces any more to evaluate the bumpers. The required sensor technology is installed in such a way that the standard workflow is not affected. Another advantage: Workers do not need additional devices such as special eyewear or microphones. The innovative system speeds up the test process; in addition, the data entry is extremely precise.
The workers have responded very positively to the new technology. The gesture interaction is simple and easy to understand and can be applied intuitively, without requiring extra training time. People do not have to walk to other workstations any more and can concentrate better on their work.
The pilot phase has been completed successfully; preparations for the application of the system in series production are now underway.

Example of application: Customized assembly support from the 3D printer – Pilot project at BMW Group Plant Munich.

In a pilot project in Plant Munich's vehicle assembly, a new and innovative ergonomic tool has recently been introduced: a flexible finger cot, which protects workers against excess strains on the thumb joints while carrying out certain assembly activities. The project is part of a dissertation in cooperation with the Department of Ergonomics at the Technical University of Munich, which is a way for the BMW Group to address and meet the specific demands of an ergonomic production. Each of the flexible assembly aids is a unique piece, customized to the match the form and size of a worker's hand. The BMW Group makes these orthotic devices in-house, using additive production procedures that are currently the talk of the town, namely '3D printing'.

The innovative orthotic devices are applied as part of a pilot project in an assembly area where rubber plugs are fitted. These have to be pressed in with the thumb and close, among other things, the drain holes for the paint coat. Even for people with strong hand muscles, this movement requires a certain effort. In order to prevent the unnecessary overstretching of the thumb joint, the finger cots made of thermoplastic polyurethane are put over the thumb like a second skin. Right at the thumb joints, the assembly aid is open to allow the thumb to move without restriction. At the back of the thumb, though, the plastic material is reinforced. If the thumb is stretched, as in a 'like it' gesture, the reinforced elements collide, forming a stable splint. This way, the effort needed to press in the plug is spread across the entire thumb, down to the carpus. In initial practical tests, the feedback of workers was very positive. It is currently being evaluated how the assembly aids can be applied as standard tools in further production areas.

Each of these finger cots is made specifically for its user. To this end, the worker's thumb is measured with a mobile 3D hand scanner. Based on a standard production layout, the future orthotic devise is then computed and divided virtually into individual layers. Layer by layer, each of them about as thick as a human hair, the tool is then manufactured in a selective laser sintering process. Put simply, the way this additive production procedure works is similar to a 3D printer: A digital data set is cut into individual layers of information. Based on the layer data, a plastic powder is

selectively fused by a CO_2 laser in a pre-heated construction chamber. This way, the plastic does not only mold into the layer presently created, but also merges with the previously formed one.

Thermoplastic polyurethane, the material used, is perfectly suited to making flexible orthotic devices. As a rule, it is elastic, but forms solid and rigid combinations at higher material strengths. The mechanical tensile strength is high, ensuring that the material can resist also strong, continuous strains without tearing. The BMW Group has been involved in research projects that have recently resulted in the market maturity of the highly innovative material, following several years of development. A major benefit: The mechanical component properties can be 'customized' for the respective application via a combination of different process parameters.

BMW Group – A pioneer in additive production procedures.
The BMW Group has applied additive production procedures for rapid prototyping in concept prototyping since 1989 and has developed the process further ever since. Depending on the specific component requirements, the BMW Group uses different procedures and materials. Besides selective laser sintering, these include stereo-lithography, polyjet printing, fused deposition modelling, and stream smelting of metals. The Rapid Technologies Center at the BMW Group's Research and Innovation Center (FIZ) in Munich produces close to 100,000 components a year using these methods. The range includes anything from small plastics holders to design patterns and vehicle components for functional tests. Depending on the procedure and the size of the component, components might be available within only a few days. They are applied in vehicle development and testing, as individual provisions in production or in high-strain sections in the BMW Group's DTM (German Touring Car Masters) vehicles. It is low volumes in particular that can be made at economic costs using additive production procedures as these do not require any forming tools.

11. Further information.

The following is a brief list of useful links to production-specific information on the BMW Group PressClub portal.

CV Harald Krüger, Member of the Management Board of BMW AG, Production.

Press kit: The BMW i8 Production.

Press kit: The BMW i3 Production.

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