BMW i Innovation Days 2013.
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1. BMW i Innovation Days 2013. (Short version)

The BMW Group will launch an electrically powered production vehicle this year with the BMW i3, which represents a new form of sustainable mobility in urban areas. As the first premium electric vehicle, the BMW i3 rises to the social, ecological and economic challenges of our time. With its groundbreaking new vehicle architecture, the concept calls for the use of modern lightweight construction materials as well as innovative production processes. Sustainability plays a prominent role for the BMW Group in this area also. The BMW i3 was the first vehicle project for which sustainability objectives were agreed that were pursued with the same vigour as cost, weight or quality objectives. The aim is also to reduce the environmental impact of production as much as possible, focusing on aspects such as energy supply and water consumption, solvent emissions and waste treatment.

Carbon fibre production with wind and hydroelectric power.
Even for the manufacture and processing of carbon fibre-reinforced plastic (CFRP), BMW attaches the utmost importance to conservation of the environment and resources, and the use of a renewably generated power supply where possible. The BMW Group therefore has control over all process steps, from fibre production to the recycling of fibres and composites. This is illustrated particularly well by the ultramodern CFRP production chain, which starts in Moses Lake in the U.S. and passes to Germany in Wackersdorf and Landshut and on to final manufacturing in Leipzig. In Moses Lake, for example, the required electricity is generated in an environmentally friendly way from 100 per cent hydroelectric power, while at the Leipzig works the entire electricity requirement is met using self-generated wind power.

BMW works in Leipzig: 100 per cent of electricity generated by wind power.
The BMW works in Leipzig is unique in a number of ways. The power required for production is generated directly on site by wind power. In fact, the four wind power systems installed on the works grounds generate more electricity than is needed to manufacture the BMW i models in Leipzig. In addition to the CO_2-free power supply, the works sets other records: compared with the already highly efficient BMW production average, a further 50 per cent energy and 70 per cent water were saved in BMW i manufacture.

CFRP series production: high process safety, fast cycle times.
In the BMW works in Leipzig, series production of the BMW i3 is setting new standards, and not just in environmental protection. The use of carbon components is unique in automotive mass production because large-scale use of CFRP was previously considered too expensive, and processing and manufacture too complex and insufficiently flexible. However, after over ten years of intensive research and optimisation of processes, materials, systems and tools, the BMW Group is the only automobile manufacturer to have the necessary expertise to use CFRP in mass production. The process is unique, and the cycle times unusually short even for complex CFRP components. The same is true for the proprietary bonding techniques developed in-house, which are used to bond the individual components together in the bodyshop in a fully automated process.

First recycling concept of its kind worldwide.
In the course of developing the BMW i, the BMW Group eventually devised the first recycling concept of its kind worldwide for CFRP components, body parts and sorted production waste that was suitable for series production. The valuable recyclable materials are reused in different processes and channelled back into the production process or used in other applications in order to save valuable resources. BMW has even devised useful repurposing for scrapped batteries.

E-mobility: the road is clear.
With a range of up to 160 kilometres, the BMW i3 meets the mobility demands of its users in urban areas. Charging is extremely simple and is possible at home, at work or at public charging stations. In addition, BMW i offers a comprehensive range of products and services under the 360° ELECTRIC label that meets individual customer needs. BMW i is also exerting great pressure together with different partners to advance the expansion of the public charging infrastructure, including convenient reservation and payment systems.

eDrive: reliable, safe and long lasting.
It goes without saying that the reliability and safety of electrical components are very important to the BMW Group. It is good to know that the lithium ion battery of the BMW i3 lasts at least the full lifetime of a vehicle. This is achieved through intelligent battery management and an effective heating/cooling system developed by BMW, for example. Like all BMW vehicles, the BMW i3 also meets the company's strict demands, which exceed the statutory requirements.

Ease of service and repair to a renowned standard.

Even in the highly unlikely event of a fault, defective components can be identified, and individual modules or the entire battery replaced. The same applies to damage caused to the body resulting from an accident, as ease of repair was high on the list of technical specifications for the BMW i3 even during its design phase. BMW therefore developed time-saving repair methods specially for the plastic panelling and CFRP components of the BMW i3. As a result, all of the accident repair costs are similar to those of a BMW 1-Series.

2. BMW i Innovation Days 2013. (Long version)

2.1 Beginning of a new era – automotive manufacture with CFRP.

Consistent lightweight construction is especially important for electrically powered vehicles, as, alongside battery capacity, the vehicle weight is the limiting factor for the range. The lighter a vehicle, the greater the range, because the electric motor has less mass to move when accelerating. And in cities in particular, braking and acceleration phases alternate frequently. In addition to greater ranges, a lower vehicle weight also means lower power consumption and increased driving dynamics, and the battery can then be smaller.

Industrialisation of CFRP production.
In order to compensate for the extra weight of the electrical components, BMW i consistently uses lightweight construction and innovative materials in its vehicles. The concept and production of the car were also completely redefined at the outset. The Life module – the passenger cell of the future BMW i3 – is made primarily of carbon fibre-reinforced plastic, i.e. CFRP. The use of this light and crash-resistant high-tech material on such a scale is unique in the mass production of a vehicle, as the large-scale use of CFRP was previously deemed too expensive, and the processing and manufacture too complex and insufficiently flexible. But BMW recognised the potential of the material early on, and after over ten years of intensive research and process optimisation, materials, systems and tools, the BMW Group is the only automobile manufacturer to possess the necessary expertise for industrialised CFRP mass production. The advanced level of the production process today is discernible above all in the process safety achieved, the fast cycle times, and the high standard of quality in the CFRP components produced.

Lightweight construction materials such as aluminium or carbon fibre nevertheless require greater energy expenditure for their manufacture than steel, for example. This is why BMW attaches maximum importance to sparing resources and extensively CO_2-free power supply in manufacturing and processing. Energy and water consumption, process wastewater, solvent emissions and waste are the main focus here, with the savings a direct result of the new production concept. Together with the affiliated joint venture SGL Automotive Carbon Fibers (ACF), the BMW Group holds a unique position in the industry as the “owner” of all process steps, from fibre

production through to the recycling of fibres and composites (see Chapter 2.4).

Moses Lake: carbon fibre manufacture with hydroelectric power.
A precursor, a thermoplastic textile fibre made of polyacrylonitrile, is used to create the carbon fibre at SGL ACF in Moses Lake, U.S.A. All elements of the fibre are split off in gaseous form in a complex, multi-stage process until only one fibre is left consisting of virtually pure carbon with a stable graphite structure. This is only seven micrometres (0.007 millimetres) thick, compared to a human hair, which measures around 50 micrometres. For use in the automotive sector, around 50,000 of these individual filaments are combined into “rovings” or “heavy tows” and wound for further processing. In addition to the automotive applications, fibre composites of this thickness are also used in large turbine blades of wind power systems, for example.

To manufacture the carbon fibres in Moses Lake, all of the energy for production is obtained renewably from locally available hydroelectric power, making it 100 per cent CO_2-free. The ultramodern works in Washington State also sets standards in energy efficiency. In comparison to conventional CFRP production, the CO_{2e} (global warming potential) saving is around 50 per cent. In order for the BMW i3 to roll off the assembly line in Leipzig on schedule at the end of 2013, the ultralight high-tech fibres have been in production since the end of 2011. Two production lines each with a current capacity of 1,500 tonnes per year ensure the necessary supply. This constitutes a supply of around ten per cent of global CFRP production today.

The two parent companies BMW Group and SGL Group have invested around US $100 million in the production facility in Moses Lake to date and have created 80 new jobs.

Wackersdorf: processing into textile fabrics.
At the second site of the joint venture, in Wackersdorf Innovation Park, the fibre bundles produced in Moses Lake are further processed into light textile fabrics on an industrial scale. Unlike woven fabrics, the fibres are arranged side by side on one level rather than interlaced or interwoven with each other. A woven structure would bend the fibres and reduce the excellent properties somewhat, because it is the fibre alignment itself in the fabric that guarantees the optimal characteristics of the eventually produced component.

After an investment of EUR 20 million and the creation of around 100 new jobs, today several thousand tonnes of carbon fibre fabrics can be manufactured per year at the Wackersdorf site. These form the starting

material for the manufacture of CFRP parts and components in the BMW works in Landshut and Leipzig.

Landshut: further processing into CFRP components.
The carbon fibre fabrics supplied from Wackersdorf are further processed into CFRP body parts at the pressing plants in Landshut and Leipzig. In Landshut, the BMW Group specialists have succeeded in further developing and automating the manufacturing process for CFRP components in the last ten years to such a point that today, economical and high-quality mass production with high process safety is possible. The roofs for the BMW M3 and M6 models and the bumper supports for the M6 have already been in industrialised CFRP production in Landshut for some time.

After an investment of EUR 40 million and the start of carbon production with around 100 employees in March 2012, the Landshut site is considered the definitive innovation and production centre for CFRP components. Landshut relies on its own junior staff to secure the high level of technical expertise needed for processing innovative lightweight construction materials, increasing the number of trainees to 40 young employees per year.

Leipzig: proprietary material manufacturing with variable formulation.
The newly established pressing plant in Leipzig is equipped with state-of-the-art technology for CFRP in automotive manufacture. BMW now manufactures its own carbon fibre composite materials at this facility designed for industrial mass production. The formulation, i.e. the composition, strength and geometry of the CFRP parts, can be individually modified or adapted in the pressing plant at any time during the manufacturing process depending on the design specifications. The tailor-made carbon fibre fabric supplied from Wackersdorf is first formed into its eventual shape in the preforming process. A heating tool gives the laminate a stable, three-dimensional form. Several of these preformed workpieces can then be assembled into a larger component. This makes it possible to manufacture large body components, which are difficult to produce in aluminium or sheet steel. After finishing and preforming, the next process step is resination under high pressure using the RTM process (**R**esin **T**ransfer **M**oulding). The RTM resin injection procedure used in the aerospace industry and in boat and wind turbine construction involves injecting liquid resin into preformed workpieces under high pressure. The bonding of the fibres with the resin and the subsequent hardening lends the material its stiffness and thereby its excellent properties.

CFRP industrialisation has begun.
With a closing force of up to 4,500 tonnes, the pressing plant works in

accordance with precisely defined time, pressure and temperature parameters developed in-house until the resin has bonded with the hardening agent completely and is cured. This special proprietary BMW manufacturing process eliminates the need for an additional time-consuming curing process in a separate oven, which usually follows a CFRP pressing step.
This new pressing plant specially designed for CFRP does not resemble a conventional sheet steel manufacturing facility. The production-specific investments have a much more streamlined investment structure, significantly reducing construction costs through the elimination of a classic paintshop and cathodic immersion bath coating, for example.
The production process is trend setting, saves a huge amount of time and makes the industrialisation of large CFRP composite components realistic for the first time. This is the only way to obtain preformed parts from the pressing plant in a matter of single-digit minutes.

Even complex assemblies such as an entire side door frame of the BMW i3 Life module leave the facility with many structural elements already integrated, optimal product quality, flawless functionality and very high fitting accuracy. The only remaining tasks are refinements such as precision cutting of the component contour and the insertion of any missing openings. For this, the parts are processed with a special waterjet cutting system, sandblasted, and the adhesive surfaces roughened for further processing.
Unlike the CFRP preformed part, it would be necessary to assemble several internal and external components in succession for a traditional sheet steel side frame. A normal sheet steel architecture requires significantly more body parts overall and so would be heavier than the LifeDrive module of the BMW i3 because of its design.

Revolution in car body construction with new precision tools.
The newly produced CFRP composite components from the new Leipzig pressing plant and supplied CFRP parts from the Landshut pressing plant are assembled in the new car body construction hall. Around 150 parts, one third fewer than in the conventional sheet steel construction, make up the basic form of the Life module of a BMW i3. There is no noise pollution from screwing or riveting, no sparks flying during welding, and only the latest adhesive technology is used, which is 100 per cent automated. A technology mastered by BMW alone. In the unique joining process developed by BMW, the individual components are assembled without touching to an adhesive gap of 1.5 millimetres in order to ensure optimal strength after the adhesive procedure. In the newly developed manufacturing process, all connecting components in the Life module are always separated by the same gap and so receive the same amount of adhesive. Only this precision guarantees perfect power transmission between the individual CFRP components and therefore

the highest standard of quality in the mass production series. In total, there is a precisely defined bonded range per car of 160 metres in length and 20 millimetres in width.

Time saved with instant adhesive.
Nowadays, CFRP car body compartments are generally only manufactured for special vehicles, in racing and for extravagant individual sports cars. The production costs are of comparatively minor importance for these small production quantities. The curing time for the adhesive bonds can be more than one day. To minimise this time for mass production of the BMW i3, BMW has greatly accelerated this curing process.

A newly developed adhesive can now be processed for only 90 seconds before developing adhesion following application to a component. Half an hour later it is hard. This property represents a ten-fold acceleration of a traditional bonding process. In order to further reduce the curing time to the single-digit minute range, BMW has developed an additional thermal process. This involves additional heating of specific adhesion points on the CFRP parts to be bonded to further accelerate the curing process by a factor of 32.

Colour concepts can be chosen up to six days before final assembly.
The high-strength CFRP passenger cell (Life module) manufactured in Leipzig passes from body construction to the new assembly hall where it is bonded with the aluminium Drive module. The basic Drive module supplied from Dingolfing is completed in Leipzig before being screwed and glued inseparably to the Life module. Only then does the internal CFRP Life module cell receive its final external plastic housing. For the painted multi-part outer skin, thermoplastic injection moulded plastics are primarily used, as is also the case in traditional vehicle construction (front/rear apron, side sill etc.). The coloured plastic preformed parts are screwed inconspicuously to the interior Life module cell during final assembly using special mounts.

CFRP recycling and the BMW i: a closed loop.
In the course of developing the BMW i, the BMW Group devised the first recycling concept of its kind worldwide for CFRP components, body components and sorted production waste which was suitable for series production. In different procedures, the valuable recyclable materials from production and even from damaged/scrapped vehicles are reused in automotive construction and channelled back to the production process or used in other applications.

In the recycling process, carbon fibre recycling with “dry”, unresinated material is differentiated from composite material recycling (CFRP), in which “wet”,

resinated plastics are used. The dry carbon offcuts created during production can be reprocessed into valuable non-woven textiles and reused in the manufacturing cycle. Around ten per cent of the carbon fibre used in the BMW i3 now is recycled material, a process unique in the automotive industry worldwide.

In composite material recycling – the processing of resinated carbon fibres – CFRP is first separated industrially from the mixture with other plastics and, for example, processed in a pyrolisis facility. The heat from the resin breakdown process is used to separate the undamaged carbon fibres. These fibres can then be used to manufacture components and reduce the new fibre requirement. For example, the rear seat pan is made from this recycled carbon fibre. It meets the BMW quality standard 100 per cent and weights 30 per cent less than the conventional glass fibre matt construction. Ground or cut into short fibres, the recycled CFRP or carbon fibres are also used in many areas outside the automotive industry, for example, in the textile and electronics industries (housing material for control units). The use of "secondary CFRP fibres" is part of a sustainable material cycle that spares resources and secures raw materials for future uses.

2.2 Consistency in sustainability: BMW i3 production in Leipzig with 100 per cent CO_2-free power supply.

The expansion of the BMW works in Leipzig is right on schedule. Production of the electrically powered BMW i3 begins in autumn 2013 using a CO_2-free power supply. The BMW i8 will follow at the start of 2014 – a plug-in hybrid-sports cars with an electric motor as well as a combustion engine.

The production of the BMW i models will set new standards in environmental conservation and require around 50 per cent less power consumption and 70 per cent less water consumption – in comparison with the already extremely efficient BMW production average. All of the electricity used to produce the BMW i models in the Leipzig works is generated from wind power and therefore 100 per cent renewable energy sources.

For the first time in Germany, wind power systems are being installed on the plant grounds of an automobile manufacturer to directly power production on-site. The building works to erect four wind turbines with an output of 2.5 MW each will be completed in spring. The electricity these generate will then meet all power requirements for the future production of the BMW i models at the Leipzig site.

Wind turbines produce more electricity than required for production in Leipzig.
At around 26 GWh per year, the four Nordex N100/2500 wind power systems will even generate more electricity in the future than is needed to produce the BMW i models. An annual surplus of up to two GWh is anticipated, which can then be used elsewhere in the Leipzig works.
The operator of the wind power system will be Germany's leading company in the development of wind power projects, wpd AG from Bremen. The BMW works in Leipzig has concluded a long-term agreement with wpd for direct use of the electricity produced on the plant grounds.

To ensure the seamless market launch of the BMW i3 in 2013, a new carbon-pressing plant, plastic part manufacturing facility, car body construction facility and an assembly hall/logistics hall for the new models have been erected on the extended works grounds at the Leipzig site. The total investment amounts to EUR 400 million.

Sustainability throughout the entire added value chain.
Sustainability has been very important for BMW i from the start, and continues throughout the entire added value chain. For the BMW i3 as the first vehicle project, binding sustainability objectives were therefore defined in the early design phase, which range from purchasing, development and production through to sales. And these objectives were met. Apart from the global warming potential, there were also targets for other environmentally related fields of influence and social sustainability. This is achieved using many innovative individual measures in the development, production and recycling process, with the incorporation of solutions from the supplier network, so BMW i sets new standards in sustainability.

Exemplary environmental profile of the BMW i3.
The environmental profile of the entire vehicle is characterised definitively by the usage phase, where the lightweight construction in particular demonstrates its potential for savings. Although manufacturing costs (battery, lightweight CFRP construction) are less economical energetically compared to conventional materials, it is the lightweight construction itself that makes the BMW i3 more energy-efficient in daily use. As a result, the energy savings compensate for the higher energy expenditure in the manufacture early in the usage phase.

The goal is CO_2-free production.
From the very start, the BMW Group controls the CO_2 emissions generated through power consumption from the manufacturing process. The BMW i3 demonstrates the success of these efforts particularly impressively: across the entire production and life cycle including power generation in Europe (EU-25 electricity mix), the electric car exhibits at least one-third less global warming potential (CO_{2e}) than a similar, high-efficiency vehicle with a combustion engine. If the power for driving the vehicle is obtained from renewable sources such as wind or hydroelectric power, the global warming potential can even be reduced by significantly more than 50 per cent.

BMW i changes automotive manufacture.
The production of the BMW i range sets standards in the use of innovative materials, the conservation of resources and the industrialisation of electromobility. However the production concept is also revolutionary. The vehicle architecture, with its LifeDrive module and the carbon fibre passenger cell of the Life module, make an innovative production process possible without the classic production stages in the pressing plant and paintshop. Even the manufacturing processes are unique: instead of classic production methods, high-tech bonding is used.

This makes the work significantly easier for the employees. The new vehicle architecture means that jobs are more ergonomic and assembly is much quieter. The production halls are also filled with natural light.

“Leed Gold Standard” for sustainable building planning.
The world-renowned U.S. Green Building Council has already awarded the new buildings in Leipzig the LEED Gold Certificate (**L**eadership in **E**nergy and **E**nvironmental **D**esign) for buildings designed with sustainability in mind.

Technical measures were used to significantly reduce power consumption in the halls. Using intelligent ventilation control, all of the air in the production facilities is replaced several times a day via the overhead and side lighting in the hall ceiling. The natural ventilation reduces the odour and dust levels in the car body construction plant and assembly hall, and provides the cooling required to counter the heating generated in the pressing plant by the production process. No additional fans or air-conditioning systems are needed anywhere in the ventilation system. In addition, white foils on the strip lights in the hall ceiling reflect sunlight and reduce the use of artificial lighting. The new buildings in Leipzig also set ecological standards in the automotive industry.

2.3 E-mobility: the road is clear.

The power supply for the BMW i3 is provided by a specially developed high-performance lithium ion battery with eight modules and 96 cells, which is integrated compactly into the subfloor, where it is optimally protected. The battery was optimised continually in the course of development in order to optimally balance performance, range, weight and durability. The storage cells last as long as the entire life of a vehicle. When fully charged, the BMW i3 can travel up to 160 kilometres under everyday conditions before needing to be reconnected to a power source. The BMW i3 is used primarily in cities and as a commuter vehicle between work and home, but is also suitable for rural areas, as our MINI E trials have shown. And after evaluating over 20 million kilometres driven by over 1,000 test customers with MINI E and BMW ActiveE in ten countries, a clear picture emerges: around 90 per cent of daily journeys are around 45 kilometres on average, so a fully charged BMW i3 meets the everyday needs of its uses in urban areas to the maximum extent possible. While greater distances can be driven electrically with larger batteries, this currently entails extra weight, higher costs and reduced driving dynamics.

Charging: conveniently at home, at work or on the road.
In practice, charging the BMW i3 is extremely easy, and even today, many people can use electromobility comfortably on a daily basis. This is because at a home charging station – whether a standard electrical socket or the BMW i wallbox – the BMW i3 battery is completely full after a minimum of six hours, and with a modern public quick-charging device 80 per cent of the battery is charged after 30 minutes. In the time it takes to have a spot of lunch or do some shopping in the city centre, the battery can be recharged for a further 120 kilometres.

360° ELECTRIC.
To facilitate optimal use of the BMW i3, BMW i provides a comprehensive range of products and services that covers the individual needs of customers beyond the vehicle. With the full 360° ELECTRIC package, the advantages of electromobiilty can be experienced very reliably, comfortably and flexibly on a daily basis. Customers choose the products and services they want themselves. The 360° ELECTRIC portfolio is based on four main pillars: Charging at home, Charging at public charging stations, Securing mobility and Integration into innovative mobility concepts for overcoming range restrictions.

Home charging: convenient charging at home.
For customers with their own garage or private parking space, BMW i offers tailored solutions for charging at home safely, comfortably and very quickly. BMW i concluded a far-reaching partnership with Schneider Electric and The Mobility House (TMH) for this purpose in January 2013. The aim of this cooperation is to offer customer-friendly and efficient charging options that permit easy charging in your own garage when the BMW i3 is launched on the market. The agreement encompasses services such as testing of the residential installation at customers' homes, delivery and assembly of the charging station (the BMW i wallbox), and maintenance, consulting and other services.

BMW i also supports the use of electricity from renewable sources and offers different green electricity products in cooperation with selected partners. As part of a strategic cooperation between BMW AG and Naturstrom AG, in future customers in Germany will have the option of purchasing an eco-electricity package for running their BMW i3. As Naturstrom AG supplies all of its electricity from renewable energy sources, including a very high percentage from wind power, CO_2-free operation of the electric vehicle is guaranteed. And BMW i is also helpful if customers opt for a carport with solar panels, for example.

Outlook: inductive charging.
While charging with a charging cable and wallbox has now developed to become a standard series feature, the BMW Group is already working on possible additional options for the future. One example is inductive charging, which works without cables or electrical sockets. With this technology, the electrically powered vehicle drives onto a charging plate on the ground, and power is transferred without contact via an electromagnetic field. Such a solution is theoretically possible for home garages, but could also eventually be made available in public areas – such as plates embedded in the ground on roads and public car parks.

When development of the BMW i3 began, the available vehicle-side charging units were too big and heavy, and would have reduced the range of the vehicles unnecessarily. However the researchers in the BMW Group have now succeeded in reducing the size and weight of the charging plate integrated into the vehicle by a factor of ten. Much smaller systems that are highly efficient and safe are now feasible through the use of ultramodern resonator technology. In order for inductive charging technology to be compatible with vehicles from different manufacturers, an – ideally international – standard is needed. The BMW Group has founded an official workgroup for this purpose with other German manufacturers under the auspices of the German

Commission for Electrical, Electronic & Information Technologies (DKE/VDE), and various manufacturers are in communication at an international level.

Public charging: charging on the go.
Users who cannot charge their BMW i3 at home or at work will also find custom solutions at 360° ELECTRIC. In cooperation with car park operators and providers of public charging stations, BMW i offers customers reliable access to the public charging infrastructure. Together with its partners, BMW i supports interconnection with smartphones and navigation systems to provide users with convenient features such as displaying available charging stations and simple, transparent payment methods with the ChargeNow card. The ChargeNow card permits comprehensive access to charging stations and cashless payment. The ChargeNow card bundles the maximum possible number of public charging infrastructure providers in all BMW i markets, so that customers can access the charging stations of different providers with just one card and receive one standardised bill from BMW i.

In Germany alone there are over 70 different providers of public charging facilities currently using different payment and service concepts. Harmonisation of this situation is essential. The ChargeNow card is the proprietary BMW i product providing customers with an intelligent solution. The challenge is to continue further expanding the comprehensive products and services together with all participating partners.

A current example of the interconnection of the public charging infrastructure is the recently presented solution portfolio of Hubject GmbH, a joint venture of the BMW Group, Bosch, Daimler, EnBW, RWE and Siemens. The company enables providers of electromobility services to expand their offering to include e-roaming. With just one provider agreement, drivers of electric vehicles have access to each public charging point in an existing European network – which BMW i customers can use with the ChargeNow card. This will make charging electric vehicles as easy as withdrawing money from a cash machine in future. Access to the charging station occurs via a standardised QR code, which starts and ends the charging process by scan function and smartphone app.

An imminent reality: from Munich to Leipzig by electric vehicle alone.
In a German government-funded joint venture of the BMW Group with ABB, Deutsche Bahn, EIGHT, RWE, the University of Bamberg, the University of the German Armed Forces Munich and Dresden University of Technology, a quick-charging station for electric vehicles is being erected at BMW World in Munich, which will be ready by the summer. It offers users two charging

points in the Combined Charging System CCS (Combo), which the European automobile manufacturers have agreed upon as a common standard. In addition to the known charging method using alternating current, CCS permits ultrafast charging with direct current and is suitable for the new BMW i3 as well as electric vehicles from other manufacturers.

The new charging station creates an intersection between electric vehicles, local public transport and electric bicycle traffic in the immediate vicinity of Olympiapark underground train station.

As part of another promotional project, a consortium consisting of the BMW Group, Siemens and E.ON is installing quick-charging stations along the A9. From the start of 2014 this will enable 100% electrically powered travel from Munich to Berlin – interspersed with short charging stops. And it will not end there: a similar plan by other companies will bridge the distances from Munich to Salzburg and Vienna and further on to Bratislava – paving the way for a transnational network of quick-charging stations.

These examples show that the publically accessible charging infrastructure is growing continually and the charging options at home or work currently still in predominant use are continually being improved, giving users of electric vehicles even greater flexibility and the option of travelling even longer distances without difficulty. The large-scale field trial by the BMW Group also produced interesting results here: users who had their own and secured public charging facilities were able to make up to 90 per cent of their journeys with the MINI E, and achieved this with less than 10 per cent public charging on average.

Flexible mobility: adept use of alternatives.
Where the range of a BMW i3 is insufficient, customers can avail of supplementary mobility modules, which can be used to handle even greater distances – the temporary use of a BMW with a combustion engine or hybrid engine, for example. Individual annual quotas can be added using 360° ELECTRIC for this purpose. BMW i customers also have access to the DriveNow car-sharing service.

The focus with the BMW i3 is on the 100% electrically powered option. For customers who regularly want to drive distances exceeding 160 kilometres, however, we offer an optional range extender that increases the range of the BMW i3 to around 300 kilometres.

Assistance services.
In order for the BMW i3 to always function reliably in daily use, the battery and

other electric systems are continually monitored while driving. In the rare event of a fault, the BMW Service Mobiles or workshops are able to identify defective components through diagnosis.

However, if the battery is actually damaged, BMW i offers a fully modular and reparable high-voltage battery for the first time in the automotive industry with the introduction of the BMW i3. Any defect does not therefore necessarily require a full replacement, as it may be possible to correct the problem by replacing individual modules at selected BMW i dealers. The design measures and replacement part approach contribute significantly to long-term product acceptance, economical operating costs and reduced warranty costs. This concept also therefore contributes very significantly to the conservation of resources and the sustainability strategy.

BMW developed the battery itself.

The high-voltage batteries for the BMW i3 are manufactured on an ultramodern assembly line in the BMW works in Dingolfing. Apart from the cells, which are bought from a supplier, the batteries are a proprietary development of BMW. This made it possible to build on development experiences from previous batteries developed in-house, such as the BMW ActiveHybrid 3 and 5 and the BMW ActiveE, and make further optimisations.
The modular structure of the battery comprises individual blocks which each have their own safety systems. The decision to build the energy store itself does more than just secure the future for the site in Germany. It also offers BMW and its customers many advantages. It guarantees that the potentials of the power storage technology are further exploited, while also guaranteeing typical BMW performance and maximum safety. And as developer and manufacturer, BMW can respond very flexibly to future requirements and needs.

Battery lasts the life of a vehicle.

The lifespan of a lithium ion battery depends on different factors. Two effects cause it to age: firstly, calendrical, i.e. performance and storage ability decline with advancing age; this effect is highly dependent on the temperature of the battery. Secondly, charging and discharging affect the ageing behaviour. Exhaustive tests by developers have shown that the cells as used in the BMW i3 meet the strict BMW requirements regarding both lifespan and cycle stability for the entire life of the vehicle. This is achieved using a suitable selection of chemical components in the cells and intelligent battery management, which operates the storage device in the optimal usage range (e.g. adjustment of temperature by cooling or heating).

Cooling with refrigerants.
BMW i uses the air-conditioning system's refrigerant to cool the high-voltage battery directly. This coolant offers maximum refrigerating efficiency in comparison to water or air-cooling and no additional components such as fans or pumps are needed, reducing weight and installation space. The heat for preconditioning in cold temperatures is powered directly from the electricity network, if the vehicle is connected to the wallbox.

As a result, battery output is maintained evenly throughout most of the charging status and is generally independent of fluctuating temperatures, benefitting the suitability for daily use, long-term stability and lifespan of the battery.

In addition, particular importance was attached to low power consumption by the electrical consumers in the BMW i3. The passenger compartment heating system operates on the heat pump principle and saves up to 30 per cent electricity in urban traffic compared to conventional electric heating. Electricity-saving, light-emitting diodes are used for interior and exterior lighting. Both of these measures contribute substantially to the range of the BMW i3. And with the first ever use of laser light, the BMW i8 breaks into a whole new energy efficiency league.

Reliability is key.
The introduction of new technologies is always associated with caveats. However, when the BMW i3 is launched this year, drivers, passengers and other road users can rely on a completely safe vehicle that meets the high BMW Group standard. It exceeds statutory requirements in all safety-related areas.

Unlike a conventional on-board network, the electrical system of the BMW i3 has a bipolar design. Therefore the minus pole is not attached to an earth, i.e. the car body, but instead is wired as a separate, fully insulated line. A completely sealed battery housing also keeps all water out. Naturally, the suitability of the cells for automotive use was considered in addition to efficiency and durability, particularly with regard to safety, when selecting the chemical composition of the battery cells.

In addition, complex monitoring algorithms, sophisticated sensors and the cooling system described above ensure that the battery cannot be overcharged or excessively depleted and does not overheat in operation. Three safety levels including both software and hardware deactivation mechanisms secure the entire electrical system reliably.

Sustainability: repurposing after the life of the vehicle.
The battery of the BMW i3 is still highly efficient with good energy storage capability at the end of the vehicle's lifespan. After around 1,000 charging cycles, the battery retains most of its rated capacity. BMW i will therefore prepare the batteries and repurpose them. From a sustainability perspective, the batteries can be used as stationary energy storage devices for numerous new applications.

These include interim storage of solar energy in a solar power system for feeding electricity back into the home network during the night or poor weather or to recharge a BMW i3 – making it possible to power a BMW i using self-produced green electricity.

Connecting multiple batteries together also offers the possibility of storage systems on commercial scales. The two research centres of the BMW Group already use these systems: the BMW Group Technology Office USA in Mountain View, California, and since January 2013, the BMW ConnectedDrive Lab in Shanghai, China. MINI E batteries are also used in the Energy Efficiency House Plus of the German Ministry of Economy and Technology in Berlin to optimise and stabilise the local power supply.

Other commercial usage scenarios for large storage devices with several megawatts of storage capacity include supply stabilisation at electricity network level. BMW i is working on researching and implementing applications on this scale. As a global automobile manufacturer, BMW i pursues an integral strategy for covering the potential world markets in the area of repurposing batteries.

2.4 CFRP safety and repair.

Lightweight construction and safety are not a contradiction. Quite the opposite in fact: the combination of the materials aluminium and CFRP in the LifeDrive concept of the BMW i3 has even partially surpassed the previous steel designs in crash tests. The use of carbon fibre-reinforced plastic also makes it possible to build very light car bodies. CFRP possesses impressive energy absorption properties and is very damage-tolerant. CFRP is the lightest material that can be used in car body construction without impairing safety.

LifeDrive module offers optimal safety.
The crash requirements in automotive manufacture are very strict. Numerous impact criteria stipulated by the stringent guidelines of global consumer protection organisations and legislators must be taken into account. Even during the development of the BMW i3 concept, there was intensive communication with the international crash test institutes on the novel car body and safety concept of the BMW i models.

Dr Ulrich Veh, safety expert in BMW i Development, sums it up: “We are at BMW level with the BMW i vehicles also.” Overall, the highly resistant passenger cell together with the intelligent power distribution in the LifeDrive module create the prerequisite for optimum passenger protection. Even after the structurally debilitating offset front crash at 64 km/h, the extremely rigid material maintains an intact survival space for passengers. The crash-active aluminium structures at the front and read end of the Drive module provide additional safety, so less car body deformation occurs than in similar sheet steel car bodies. Furthermore, the “cocoon effect” of the CFRP car body ensures that the doors can be opened without any problem.

Equally, fire brigade rescue crews find no rescue difficulties with the new vehicle concept in the event of an accident. Gerhard Schmöller, responsible for training Munich’s Municipal Fire Brigade, says: “Munich Municipal Fire Brigade has had the opportunity to confirm in standardised cutting tests that the rescue of passengers from a crashed BMW i3 is similar to a conventional vehicle. The development work in relation to accident rescue has already reached a very high level – despite the brand new vehicle concept and large-scale use of CFRP. We are impressed by the determination and foresight of

BMW engineers to write automotive history without compromising passenger safety."

Combination of aluminium and CFRP embeds the battery safely.
The high-voltage battery is housed in the underfloor of the aluminium Drive module for maximum protection, where statistically the vehicle absorbs the least amount of energy in crashes and so experiences the least deformation. In the Euro NCAP side impact test, in which a pole strikes the side of the vehicle dead centre at 32 km/h, the carbon fibre composite also demonstrates its extraordinary energy-absorbing capacity. The Life module absorbs the entire impact with minimal deformation, guaranteeing optimum passenger protection. Even when CFRP dissipates energy, there is no danger to passengers or other road users.
The high-voltage battery also benefits from the excellent deformation properties of the CFRP Life module. In the side crash test, the pole does not penetrate as far as the battery. The mix of materials used and the intelligent power distribution in the LifeDrive module ensures that the high-voltage battery is optimally protected even in the side sill area.

Lithium ion batteries are safe even in the event of a fire.
Safety is a key criterion in the development of the BMW i models. A range of systems and measures have been implemented in the vehicle that ensure safety in normal operation and in the event of accidental fires. The high-voltage system is designed to cope with accidents beyond legal requirements. The high-voltage battery includes features (e.g. venting unit) to ensure the controlled venting of fire gases from the battery. It is assumed that the fire gases and fire-extinguishing water do not cause greater harm to the environment than a fire in a conventional vehicle.

To quote the latest series of tests by the renowned DEKRA Competence Centre for Electromobility: "We have conducted extensive tests from inflammation behaviour, flame propagation and extinguishing requirements to the pollution of the fire-extinguishing water runoff. Our summary is that electrical and hybrid vehicles with lithium ion batteries are at least as safe as vehicles with a conventional engine in the event of a fire." (DEKRA press release dated 29 October 2012; DEKRA is one of the world's leading independent expert organisations focusing on safety, environmental protection and product analysis.)

To ensure maximum safety in such a crash scenario, the high-voltage battery is disconnected from the high-voltage system and the connected components discharged when the passenger restraint systems are triggered.

Target is to safely prevent the possibility of a short circuit, which could lead to electric shocks or cause a fire.

Repair costs for the BMW i models are at class level.
According to tests by vehicle insurers and BMW Accident Research, mainly minor damage results from most accidents. Comprising around 90 per cent of all recorded accidents of conventional vehicles, these involve damage to the outer skin. The BMW i3 takes account of this and is equipped with screw-/clip-on plastic plating all around. Small bumps are absorbed without leaving dents, as usually occurs with metal parts. Damage to the paint does not lead to rusting.
If a section of the external skin of the BMW i3 needs to be replaced, this can be carried out quickly and economically. Overall, the accident repair costs are similar to those of a BMW 1-Series. It can therefore be assumed that the first insurance classifications will be at the usual compact car class level.

“Cold” repair methods for aluminium components.
The aluminium Drive module structure welded in series production is repaired using the “cold” repair methods “bonding and riveting”. These methods have been in successful use in BMW workshops since 2003.

Time-saving repair methods with CFRP components.
The reparability of the CFRP structure of the Life module was top of the list of technical specifications during the development of the vehicle concept. For example, several repair sections were defined for the side frame. If a damaged side sill needs to be replaced after a side impact, the workshop performs a visual inspection and damage assessment, and then removes only the side sill repair section using a patented milling tool. The necessary side sill component is manufactured to fit, and then installed on the damaged vehicle. The new part is bonded to the separation points using repair elements.

Any authorised BMW i dealer can repair the outer skin. Due to the product-specific features of the LifeDrive module, there will be repair centres in which specialised employees repair vehicles with damage to the aluminium or CFRP structure.