

Press Release
November 2012

40 years of electric mobility at the BMW Group. From the BMW 1602 to the BMW i3.

When the first production version of the BMW i3 rolls off the assembly line in Leipzig in late 2013, it will mark the provisional culmination of 40 years of development work at BMW. It all began at the 1972 Olympic Games in Munich, where the BMW starting line-up included two electrically powered test vehicles. The converted BMW 1602 models served as a means of transport for the members of the organising committee, and were also deployed as support and camera cars in various long-distance events. However, there could be no questioning that lead batteries weighing 350 kilograms and with a range of around 60 kilometres (37 miles) were hardly ideal for a production car. BMW therefore launched a series of research and development projects with the aim of bringing an improved and, above all, more efficient technology for electric drive systems onto the road.

From late 1975, an experimental vehicle built on the platform of the BMW LS and fitted with new batteries and a new electric motor started to deliver the first findings. Then, in the 1980s, a research project was launched entitled “Electric car with high-energy battery”, which provided valuable experience in the use of sodium-sulphur energy storage devices. BMW furthermore constructed a special test rig for electric drives with a built-in output calculator. Besides the batteries, testing here focused primarily on the drive system and drive control. To trial the concept, eight vehicles based on the BMW 325iX were converted and subsequently proved their merit in inner-city use, for example as delivery vehicles for the German postal service.

The promising results of the research project prompted BMW to start work on designing a pure electric vehicle. Whereas previous experimental vehicles had been merely converted versions of standard production models, providing little scope for tailoring them to the specific requirements of an electric drive, this was all about to change. BMW’s work was underpinned by the realisation that the limited range of electric cars made them of interest for city use first and foremost. The first purpose-built solution was unveiled at the 1991 Frankfurt Motor Show: the BMW E1, an electrically propelled “citymobile” for use in cities and conurbations. Even back then, this prototype stood out for its low weight and high safety levels thanks to its consistent lightweight design and high-strength bodyshell.

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Its performance capabilities also made impressive reading: with an output of 32 kW, a peak torque of 150 Nm (111 lb-ft) and a range of around 160 kilometres (100 miles) its attractive key figures made it a viable possibility for day-to-day use, too.

In addition to the five E1 prototype vehicles, the project also featured 25 converted production models based on the BMW 3 Series. Between 1992 and 1996, eight BMW 325 models were in service on the island of Rügen off Germany's Baltic coast to test out various motors, transmissions and batteries under everyday conditions. The field trial produced large quantities of detailed data, which provided valuable insights for the further development of electric mobility. The project came to a conclusion with the BMW electric in 1997.

In 2008, a fleet of around 600 all-electric MINI E models designed for private, everyday use took to the roads. The findings gleaned by the BMW Group from its pilot project were channelled straight into the development process for a production car. The potential of lithium-ion batteries in particular was taken to new heights in the MINI E. Just one year later, the world premiere of the BMW Concept ActiveE in early 2010 saw the BMW Group push even further ahead with its research and development activities. Practical trials of over 1,000 units of this model got under way in 2011. As with the MINI E, the overriding objective was the creation of a Megacity Vehicle (MCV), which is now on the verge of being launched as the BMW i3. The electric drive system in the BMW i3 Concept is a perfect example of what ongoing, systematic development can achieve: it takes up around 40 per cent less space than the drive in the MINI E while generating the same output.

BMW 1602 Electric (1972)

Starting in 1969, BMW constructed two experimental vehicles on the basis of the BMW 02 Series with the aim of investigating the suitability of an electric drive unit for practical driving. The place of the manual gearbox was taken by a DC shunt-wound motor with a peak output of 32 kW that had been developed by Bosch and whose power was directed to the rear wheels via the intermediate gearing and prop shaft. A thermostat-controlled 140W radial fan took care of cooling. The 85-kilogram electric motor drew its power from 12 standard 12V lead-acid batteries from Varta, which were positioned on a pallet in the engine bay.

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The battery pack weighed in at a hefty 350 kilograms, although it could be removed as a single unit and replaced with a freshly charged pack. The BMW 1602 Electric accelerated from standstill to 50 km/h (31 mph) in eight seconds and achieved a top speed of 100 km/h (62 mph). It had a range of around 30 kilometres (19 miles) in city driving and double that when driving at a constant 50 km/h (31 mph). For test purposes, BMW decided to deploy the prototype vehicles at the 1972 Olympic Games in Munich, where they were used as support vehicles for the marathon, amongst other tasks. Even back then the electric motor doubled as a generator, allowing the energy produced during braking to be stored in the battery (regenerative brake). It nevertheless quickly became apparent that the specific drawbacks of the electric drive could only be resolved by advances in the field of battery technology. In light of this, the BMW 1602 Electric was seen as just a first attempt at development rather than a viable solution.

BMW 1602 Electric (1972): Specifications	
Motor	DC shunt-wound motor (Bosch)
Continuous/peak output	12 kW / 32 kW
Energy storage	12 lead-acid starter batteries (Varta)
Capacity	12.6 kWh
Weight	350 kg
Performance (approx.)	
Top speed	100 km/h (62 mph)
Acceleration 0-50 km/h (31 mph)	8 sec
Range in city traffic	30 km (19 miles)

BMW LS Electric (1975)

In June 1975, BMW launched a new project that was kept under wraps at the time. A discarded BMW LS served as the basis for an experimental vehicle, which began driving trials in December 1976. The DC shunt-wound motor used on the BMW 1602 now gave way to a new DC series motor from Bosch, while 10 Varta lead-acid batteries with Aquamatic (centralised water topping up and degassing) were also meant to provide new findings.

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This was the first time that the vehicle included a charger complete with charging leads and automatic shut-off mechanism, which allowed the batteries to be connected to a standard mains socket and recharged in 14 hours. Although the production vehicle's drum brakes were retained, priority was always given to using the electric regenerative brake first. The reduction and differential gears were combined into a compact block and bolted together with the electric motor. The heated windscreen and rear window together with an electric storage heater from Bauknecht assumed the task of interior climate control.

BMW LS Electric (1975): Specifications	
Motor	DC series motor (Bosch)
Continuous/peak output	8 kW / 17 kW
Energy storage	10 lead-acid traction batteries (Varta)
Capacity	10.8 kWh
Weight	318 kg
Performance (approx.)	
Top speed	65 km/h (40 mph)
Acceleration 0-50 km/h (31 mph)	11.4 sec
Range in city traffic	30 km (19 miles)

BMW 325iX (1987–1990)

The “Electric car with high-energy battery” research project first launched in 1981 eventually led to eight BMW 325iX models being converted from all-wheel to front-wheel drive from 1987 onwards ready for testing. They served as experimental vehicles for trialling a brand-new, maintenance-free sodium-sulphur (NaS) battery, which had been purpose-developed by Asea Brown Boveri (ABB) for use in an electric vehicle. With an energy density three times greater than that of conventional lead-acid batteries it represented a great leap forward: for the first time there was a realistic prospect of mitigating the specific disadvantages of electric drive systems, such as battery weight and the space required. Beyond this, all of the electric drive components were to be tested out and further improved. BMW constructed a special test rig for this purpose with a built-in output calculator. Another new feature was the electronic drive management, which regulated and monitored charging from the mains socket, the energy flow between motor and battery, as well as the system's thermal circuit.

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The entire control electronics were housed in a compact component carrier next to the motor. The project management team resolved to conduct the first ever external trials under everyday conditions with the electrically powered BMW 3 Series. A BMW 3 Series Touring proved its suitability for daily use as a delivery vehicle for the German postal service, for instance, while other prototype models demonstrated their merit as city cars operated by state and local authorities. It was not least because of this that the test vehicles were equipped with a diesel-fuelled hot water system for heating the vehicle interior.

BMW 325iX (1987-1990): Specifications	
Motor	DC shunt-wound motor (ABB)
Continuous/peak output	17 kW / 22 kW
Energy storage	Sodium-sulphur high-energy battery
Capacity	22 kWh
Weight	265 kg
Performance (approx.)	
Top speed	100 km/h (62 mph)
Acceleration 0-50 km/h (31 mph)	9 sec
Range in city traffic	150 km (93 miles)

BMW E1 and E2 (1991-1993)

Encouraged by the positive results with the new NaS battery, BMW Technik GmbH was commissioned to develop an electric vehicle from scratch, with the objective of investigating the electric drive's advantages and disadvantages in practical operation. The target specifications included performance suitable for everyday motoring, a reasonable driving range, enough room for four adults plus luggage, and achieving high standards of safety while keeping weight to a minimum. After just 10 months in development, the result received its public premiere at the 1991 Frankfurt Motor Show: the BMW E1, a citymobile with a compact exterior measuring 3,460x1,648x1,500 mm (lxbxh), a long wheelbase (2,325 mm) and a versatile interior. Even now, 20 years on, many of its technical features still have a sophisticated ring to them.



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The body, for instance, was systematically engineered to keep weight down, and featured a high-strength bodyshell built from extruded aluminium sections and an outer skin predominantly made from recyclable plastic. Aluminium was used for the bonnet and boot lid. Weighing 200 kilograms, the high-energy battery was secured in a safety frame underneath the rear seats, while the in-house developed electric motor was integrated in the rear axle together with the transmission. A new electronics concept featuring two main modules ensured intelligent control of all electrical components, whose dissipated heat was furthermore utilised for heating the interior. The batteries were fully recharged after just six hours when plugged into the mains and a mere two hours when connected to a special charging station. And with a range of up to 160 kilometres (100 miles) in city driving, the BMW E1 also covered the catchment zone of major metropolitan areas.

A second, more advanced version of the BMW E1 was presented at the 1993 Frankfurt Motor Show. It was equipped with a new means of energy storage based on sodium-nickel chloride (NaNiCl₂). The "ZEBRA" battery, as it was known, was another significant leap forward, as it helped to improve not just service life, but driving range and performance, too. The drive system in the BMW E1 was furthermore designed so efficiently that the energy generated during vehicle deceleration was automatically fed back into the battery. One year prior to this, BMW had already taken the wraps off the E2 at the Los Angeles Auto Show. Derived from the first-generation BMW E1, this study's dimensions and power output had been specially adapted to the US market.

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BMW E1, 1st/2nd generation (1991-1993): Specifications	
Motor	Permanently excited rotating-field AC motor
Continuous output	32 kW
Energy storage	Sodium-sulphur high-energy battery / sodium-nickel chloride high-energy battery
Capacity	19.2 kWh / 19 kWh
Weight	200 kg
Performance (approx.)	
Top speed	120 km/h (75 mph) / 125 km/h (78 mph)
Acceleration 0-50 km/h (31 mph)	6 sec / 5.6 sec
Range in city traffic	150 km (93 miles)

BMW 325 / BMW electric (1992–1997)

Starting in the early 1990s, the third generation of the BMW 3 Series provided the basis for some 25 experimental vehicles, which were used for testing and honing new components in order to gradually bring electric drive technology up to production standard. The first generation of these prototype vehicles included eight models that took part in the world's largest ever public field trial staged on the German island of Rügen. A number of manufacturers collaborated on this joint research project, which had the backing of the German Federal Ministry of Research and Technology. A further six test vehicles were incorporated into the fleet of the Bavarian State Government. Following problems related to the sodium-sulphur batteries, in 1993 the energy storage devices were switched to the sodium-nickel chloride batteries already familiar from the BMW E1. One BMW 325 model from the Rügen fleet was fitted with a nickel-cadmium (NiCd) battery. Over the course of development, electric motors with outputs of up to 45 kW were used, which now weighed just 65 kilograms including transmission. Notable progress was also made with regard to the energy storage technology, with quick charging now enabling the batteries to attain 75 per cent of capacity in just 40 minutes. Finally, the engineers also succeeded in recuperating as much as 20 per cent of the electrical energy during driving.

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The testing of the various engines, transmissions and batteries between 1992 and 1996 produced a mass of detailed data that provided valuable clues for further development. Consequently, a second generation of 10 more experimental vehicles was built between 1995 and 1997 that boasted major improvements in terms of both performance and driving range. Sporting a striking yellow paint finish, the “BMW electric” models were mainly used by the technical departments at BMW.

BMW 325 / BMW electric (1992-1997): Specifications	
Motor	Permanently excited rotating-field AC motor
Continuous output	32 kW / 45 kW
Energy storage	Sodium-nickel chloride high-energy
Capacity	21.7 kWh / 29 kWh
Weight	260 kg / 350 kg
Performance (approx.)	
Top speed	128 km/h (80 mph) / 135 km/h (84 mph)
Acceleration 0-50 km/h (31 mph)	8 sec / 6 sec
Range in city traffic	120 km (75 miles) / 150 km (93 miles)

MINI E (since 2008)

When the BMW Group first presented the MINI E in 2008, it brought out a fleet of over 600 purely electrically powered cars designed for private, everyday use. A broad-based pilot project was launched which saw the electric car being supplied to selected private and corporate customers, first in the USA and then in Europe as well. The evolution of lithium-ion batteries for automotive applications reached a whole new level in the MINI E, with power capabilities, storage capacity and dimensions all making impressive reading. For the first time, customers were provided with a special charging station known as a wall box, which allowed the energy storage devices to be fully recharged in the space of two-and-a-half hours. The performance, range and everyday practicality of the MINI E helped to further boost interest in electric drive concepts and acceptance of them in the years that followed.

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The findings gleaned in day-to-day driving were evaluated and channelled directly into the development process for production vehicles, with the BMW Group having already committed itself to development of a Megacity Vehicle (MCV) for use in metropolitan areas.

MINI E (2008): Specifications	
Motor	Asynchronous motor
Output	150 kW
Energy storage	Lithium-ion battery
Capacity	35 kWh
Weight	260 kg
Performance (approx.)	
Top speed	152 km/h (94 mph)
Acceleration 0-100 km/h (62 mph)	8.5 sec
Range	250 km (155 miles)

BMW ActiveE (since 2010)

In early 2010, just a year or so after the debut of the MINI E, the BMW Group took another big step towards a zero-emission production vehicle with the world premiere of the BMW Concept ActiveE. This was because pre-production versions of the drive components and energy storage devices for the future Megacity Vehicle (MCV) were being trialled in the BMW ActiveE, which was built on the basis of the BMW 1 Series Coupé. To this end, a test fleet of over 1,000 models was dispatched into service in 2011. Delivering an output of 125 kW and maximum torque of 250 Newton metres (184 lb-ft), the BMW ActiveE sprints to 100 km/h (62 mph) from a standing start in just nine seconds, while the newly designed lithium-ion battery gives the vehicle a range of around 160 kilometres (100 miles) in everyday motoring. In the meantime, the BMW Group has announced it will be marketing the MCV via its new BMW i sub-brand from 2013. The electrical pre-production components incorporated into the BMW ActiveE have an identical or similar design without compromising space in the compact BMW 1 Series Coupé. The electric motor, transmission and power electronics have all been fully developed in house at the BMW Group.



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BMW ActiveE (2010): Specifications	
Motor	Permanently excited hybrid synchronous motor
Output	125 kW
Energy storage	Lithium-ion battery
Capacity	32 kWh
Weight	450 kg
Performance (approx.)	
Top speed	145 km/h (90 mph)
Acceleration 0-100 km/h (62 mph)	9 sec
Range in city traffic	160 km (100 miles)

A comparison with the MINI E clearly illustrates the technical progress made by the BMW Group in the space of just a few years: the electric drive system in the forthcoming BMW i3 takes up around 40 per cent less space than in the experimental vehicle from 2008 while generating the same output.



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BMW Group Classic

BMW Group Classic is responsible for all activities within the BMW Group associated with the history of the company and its three brands BMW, MINI and Rolls-Royce. This ranges from the Group Archives, which are available to anyone as a centre of expertise for all the facts and figures surrounding the history of the company, the brands and the products, through the BMW Museum, which receives more than 400,000 visitors each year, to the BMW Classic Centre where all the facilities are provided that drivers require to satisfy their passion for classic BMW vehicles from spare parts to full restoration. Another aspect is planning and implementation of participation in all the classic events attended, and administration and expansion of the vehicle collection with more than 1,000 exhibits.

The BMW Group

With its three brands – BMW, MINI, Husqvarna Motorcycles and Rolls-Royce – the BMW Group is one of the world's most successful premium manufacturers of cars and motorcycles. It operates internationally with 25 production and assembly plants in 14 countries and a global sales network with representation in more than 140 countries.

During the financial year 2011, the BMW Group sold approximately 1.67 million cars and more than 113,000 motorcycles worldwide. The profit before tax for 2011 was € 7.38 billion on revenues amounting to € 68.82 billion. At 31 December 2011, the BMW Group had a workforce of approximately 100,000 employees.

Long-term thinking and responsible action have long been the foundation of the BMW Group's success. Striving for ecological and social sustainability along the entire value-added chain, taking full responsibility for our products and giving an unequivocal commitment to preserving resources are prime objectives firmly embedded in our corporate strategies. For these reasons, the BMW Group has been sector leader in the Dow Jones Sustainability Indices for the last seven years.

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