

BMW Group Innovation Days 2014: New drive technologies. Contents.



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1. BMW Group Innovation Days 2014: New drive technologies. (Introduction)

The recently launched BMW i3 and BMW i8 are the first zero-emission vehicles in the premium segment, being designed respectively as dedicated all-electric and plug-in hybrid models. Their BMW eDrive technology promotes hallmark brand driving pleasure, while at the same time delivering major reductions in fuel consumption and CO₂ emissions – all the way to zero tailpipe emissions when operating in all-electric mode. This is BMW Efficient Dynamics taken to its logical conclusion.

For more than 15 years, the Efficient Dynamics strategy has inspired and shaped the development of new models across all the BMW Group brands, resulting in the development of highly efficient vehicles that combine dynamic performance with intelligent energy management. Today, thanks to Efficient Dynamics, the BMW and MINI brands offer premium models that set benchmarks in their respective segments in terms of their exceptional balance of performance and fuel economy. No other manufacturer has reduced its vehicles' CO₂ emissions faster and on such a broad front as the BMW Group.

Efficient Dynamics: flexible portfolio and continuous optimisation.

The BMW Group favours a flexible approach based on a broad portfolio of vehicles and drive technologies. This ensures that the Group is always prepared to meet the challenges of the future in all their various forms – including the changing mobility requirements of its customers and evolving legal requirements and social priorities. The spectrum of tailored solutions includes:

- highly efficient vehicles incorporating the latest advances in combustion engine design,
- all-electric models for everyday city use,
- low-emission plug-in hybrid models for longer distances.

Continuous optimisation, incorporating the latest advances from the Efficient Dynamics programme, is a hallmark not only of the Group's TwinPower Turbo internal combustion engines but also of the BMW eDrive electric motors, batteries and energy management systems used in the electric and plug-in hybrid models. Within a longer-term horizon, the BMW Group is also working on the development of hydrogen-based fuel cell technology.

eDrive technology to be integrated in BMW-brand models.

The BMW i8 combines sports car performance with compact-car fuel consumption. Its plug-in hybrid system, developed in-house by the BMW Group, offers highest standards of performance, efficiency, everyday practicality and quality, and once again confirms the Group's position as a technology leader in the field of powertrain engineering. Over the longer term, the BMW Group is planning to transfer this eDrive technology to all models of its core brands.

The outstanding qualities of the plug-in hybrid powertrain of the BMW i8 are based on a mating of eDrive and TwinPower Turbo technology. Precise synchronisation between the internal combustion engine and the electric motor results in trademark BMW power and performance, an intensive driving experience and excellent fuel efficiency in everyday driving. BMW Group know-how is also reflected in the adaptive powertrain control and intelligent energy management. For example, the BMW i8 features road-coupled all-wheel drive and an electric boost function to assist the internal combustion engine when accelerating. The high-voltage battery is recharged by braking. Highlights also include an additional high-voltage generator at the rear axle, which supplies further energy to the battery when travelling at constant speed or accelerating. This is achieved by operating the engine at higher load, and ensures the vehicle has plenty of power in reserve to travel in all-electric mode at a later stage of the journey.

Last year, at the Frankfurt International Motor Show (IAA) 2013, this plug-in hybrid technology was also presented in a model of the BMW core brand – the BMW Concept X5 eDrive. It was also the first time the plug-in hybrid system had been combined with the BMW xDrive intelligent all-wheel-drive system. The result is a Sports Activity Vehicle that combines sportiness with fuel efficiency, superior traction and versatility, and has a 0 to 100 km/h (62 mph) sprint time of less than seven seconds. The BMW Concept X5 eDrive also has an all-electric range of up to 30 kilometres (approx. 18 miles). Its EU average fuel consumption of approximately 3.8 litres/100 km (74 mpg imp), with emissions of approx. 90 g CO₂/km, sets new standards in this vehicle class.

Further information on official fuel consumption figures, specific CO₂ emission values and the electric power consumption of new passenger cars is included in the following guideline: "Leitfaden über Kraftstoffverbrauch, die CO₂-Emissionen und den Stromverbrauch neuer Personenkraftwagen" (Guideline for fuel consumption, CO₂ emissions and electric power consumption of new passenger cars), which can be obtained from all dealerships, from the Deutsche Automobil Treuhand GmbH (DAT), Hellmuth-Hirth-Str. 1, 73760 Ostfildern-Scharnhausen and at <http://www.dat.de/en/offers/publications/guideline-for-fuel-consumption.html>. LeitfadenCO₂ (GuidelineCO₂) (PDF – 2.7 MB)

2. The world's most successful premium sedan – now with plug-in hybrid drive: The BMW 3 Series plug-in hybrid prototype.

Outstanding flexibility, which means it can be integrated in a wide range of different vehicle concepts, makes rapid deployment of this plug-in hybrid drive technology in the BMW model range a feasible and realistic proposition. The BMW 3 Series plug-in hybrid prototype provides a first taste of the extra-efficient driving pleasure which the world's most successful premium sedan will offer.

Combining a four-cylinder TwinPower Turbo petrol engine from the new Efficient Dynamics engine family with an electric motor, the BMW 3 Series plug-in hybrid prototype offers standards of sporty performance on a par with a conventionally powered BMW 3 Series six-cylinder model, combined with a significant reduction in fuel consumption. Its plug-in hybrid drive system has a combined output of approximately 245 hp and maximum combined torque of approximately 400 Newton metres (295 lb-ft). These figures, together with the substantial extra acceleration provided by the electric motor's boost function, bring a sharp and intensely dynamic dimension to everyday motoring. Average fuel consumption and CO₂ emissions are approximately 2 litres/100 km (140 mpg imp) and 50 g/km respectively. In all-electric mode, the prototype is capable of a top speed of 120 km/h (74.5 mph), and has a driving range of approximately 35 kilometres (22 miles).

Plug-in hybrid system in the BMW 3 Series Sedan: ideal platform, superior drive components, maximum efficiency.

The BMW 3 Series Sedan provides the ideal starting point for developing an exceptionally dynamic and fuel-efficient plug-in hybrid model. The conventional combustion-powered models already set standards in the mid-sized premium segment with their blend of sportiness and frugal fuel consumption. This is down to factors such as intelligent lightweight design, best-in-class aerodynamics and an extensive range of standard-specification BMW EfficientDynamics technologies.

The internal combustion engine used in the BMW 3 Series plug-in hybrid prototype is based on a TwinPower Turbo four-cylinder petrol engine that has already twice been voted "International Engine of the Year". Its hallmarks are sporty performance, smooth and refined running and exceptional efficiency. The plug-in hybrid prototype also features an electric motor and power

electronics which are directly based on the BMW eDrive technology of the BMW i3 and BMW i8 models. The motor is powered by a lithium-ion battery which, together with the battery management system and high-efficiency direct cooling system, are likewise rooted in the experience and know-how amassed during development of the BMW i models. The battery can be recharged at any household power socket and is mounted in a particularly crash-safe position underneath the load compartment.

The power electronics form a single integrated system that drives the electric motor, via a liquid-cooled inverter, manages the energy flow from the high-voltage battery to the onboard electrical systems and provides centralised control of hybrid-specific functions. The drive torque from engine and electric motor is supplied to the rear wheels of the BMW 3 Series plug-in hybrid prototype via an 8-speed Steptronic transmission which – as on conventionally powered BMW models – makes its own additional contribution to the efficiency of the overall drive system.

Nowadays, the potential integration of a plug-in hybrid system is taken into account at all stages in the development of new models of the BMW and MINI brands. Amongst other things, this ensures that future hybrid versions offer the same level of practicality as the base models. For example, there is only a minimal reduction in boot space in the BMW 3 Series plug-in hybrid prototype compared with a conventionally powered BMW 3 Series Sedan, while the interior configuration possibilities – e.g. with the folding rear seatback – are unchanged. The simplicity with which the 8-speed Steptronic transmission can be integrated into the plug-in hybrid system is a further benefit of this flexible, forward-looking development strategy.

Intelligent energy management with adaptive powertrain control.

Like the current production models, the BMW 3 Series plug-in hybrid prototype is fitted with a Driving Experience Control switch, which is mounted on the centre console. This can be used to select different vehicle settings to suit varying requirements and situations. Three different modes are available: COMFORT, SPORT and ECO PRO mode. Each features different suspension settings, different shift characteristics for the 8-speed Steptronic transmission, and a different hybrid operating strategy.

In COMFORT mode, which perfectly balances comfort and efficiency on the one hand with typical BMW dynamic performance on the other, the electric motor's control strategy is geared to relaxed, fuel-efficient driving. In tandem, the electric motor and internal combustion engine can also deliver high levels of power and performance when required. SPORT mode, meanwhile, is aimed at maximised performance, harnessing the full combined output of the

engine and the electric motor. In this mode, engine and motor are both on stream at all times, ensuring instantaneous response to all accelerator commands. Finally, in ECO PRO mode, the accent is on harnessing the full efficiency potential of electrification. Intelligent hybrid functionality allows the electric motor and internal combustion engine to work in tandem to maximise overall system efficiency. Efficient energy management is enhanced by variable control of the electric comfort functions such as air conditioning, seat heating and exterior mirror heating, which always operate at the most appropriate power level. This likewise helps to maximise the vehicle's range.

At the press of a button, the driver can choose between different plug-in hybrid modes. The MAX eDrive mode provides all-electric, zero-local-emission propulsion. Selecting the SAVE Battery mode keeps the battery at a constant state of charge. If the battery is less than 50 percent charged, the charge level is increased. In this way drivers can ensure they have enough power in reserve to operate in all-electric mode on a later, urban section of the journey.

The BMW 3 Series plug-in hybrid prototype also features a special hybrid-adapted Proactive Driving Assistant. Integrated in the navigation system, this system manages the powertrain not only with reference to current battery capacity but also to upcoming route profile, speed restrictions and traffic conditions.

This function marks the most extensive and advanced integration to date of BMW EfficientDynamics and BMW ConnectedDrive. Whenever the navigation system is in operation, the hybrid Proactive Driving Assistant collates all the available information about the upcoming route and relays this to the powertrain controller. This information comprises both static data from the interactive map, for example about speed restrictions and gradients, and also real-time information on current traffic conditions (Real Time Traffic Information – RTTI). The proactive energy management system then breaks the route down into its component parts, including low-speed sections, last-lap sections and gradients, before computing a proactive, route-specific strategy for managing the electric drive power right through to the specified destination.

3. Growing focus on electric operation: Power eDrive plus TwinPower Turbo technology – the future of plug-in hybrid drive.

The overall efficiency of a plug-in hybrid vehicle is closely related to its all-electric driving range. The ongoing development and refinement of hybrid drive systems under the Efficient Dynamics programme is geared in particular to maximising the amount of time the vehicle spends in electric mode. In order to ensure that this shift to increased electric operation goes hand in hand with typical BMW dynamic performance, unimpaired everyday practicality and maximum long-distance capability, the BMW Group is developing a new generation of “highly electrified” hybrid concept models.

Highlights of the future models’ Power eDrive technology will include significantly higher-powered electric motors and batteries with twice the capacity of present versions. With this technology, the BMW Group is embarking on the next stage in powertrain electrification. The development of high-performance Power eDrive electric drive technology is aimed at increasing both the overall efficiency and the dynamism of future hybrid vehicles. Increasing focus will be placed on all-electric operation – i.e. operation with zero tailpipe emissions. Power eDrive technology for plug-in hybrid application will be a natural choice for use in upmarket vehicle segments too, where it will offer unrestricted everyday practicality plus good long-distance capability.

In these plug-in hybrid vehicles of the future, the Power eDrive electric drive system will contribute approximately two thirds of the vehicle’s combined output, with the TwinPower Turbo internal combustion engine accounting for the remaining third. The drive components used in these future hybrid systems will offer combined outputs in excess of 500 kW, while the capacity of the lithium-ion batteries – up to 20 kilowatt hours – will likewise be greatly in excess of current hybrid systems.

Zero local emissions in everyday operation, instant accelerating power, superior long-distance comfort.

These advances, coupled with an increased all-electric driving range of up to 100 kilometres (62 miles), will make it possible to operate in locally emission-free all-electric mode on virtually all day-to-day trips. The role of the internal combustion engine within this concept will be a supporting one that takes various forms. For example the engine can provide a boost function when extra-dynamic acceleration is required, and it can also serve to increase the overall driving range to levels typical of a conventionally powered vehicle.

At the same time, the performance of these future hybrid models will be on a par with that of a conventionally powered sports car. To add to the excitement the new, higher-powered motors will offer a further increase in the low-end responsiveness that has always been the hallmark of electric drive.

Flexible concept for typical BMW driving pleasure.

On future plug-in hybrid concepts the electric motor, which will be the main source of power for everyday driving, will continue to drive the rear wheels, while the addition of a second electric motor driving the front wheels will create an all-electric road-coupled all-wheel-drive system. At the same time, an internal combustion engine will also supply power to the front axle.

With its development work in the field of eDrive technology, the BMW Group is positioning itself to field the broadest possible range of high-overall-efficiency vehicle concepts. While the BMW i3 is the ideal solution for urban and suburban mobility, future plug-in hybrid drive systems will allow fuel consumption and emissions to be steadily reduced in long-distance operation as well. In other words, it will be possible to deliver a typical BMW driving experience across a whole range of scenarios, including zero-local-emission everyday driving, long-distance trips and sporty, dynamic driving situations.