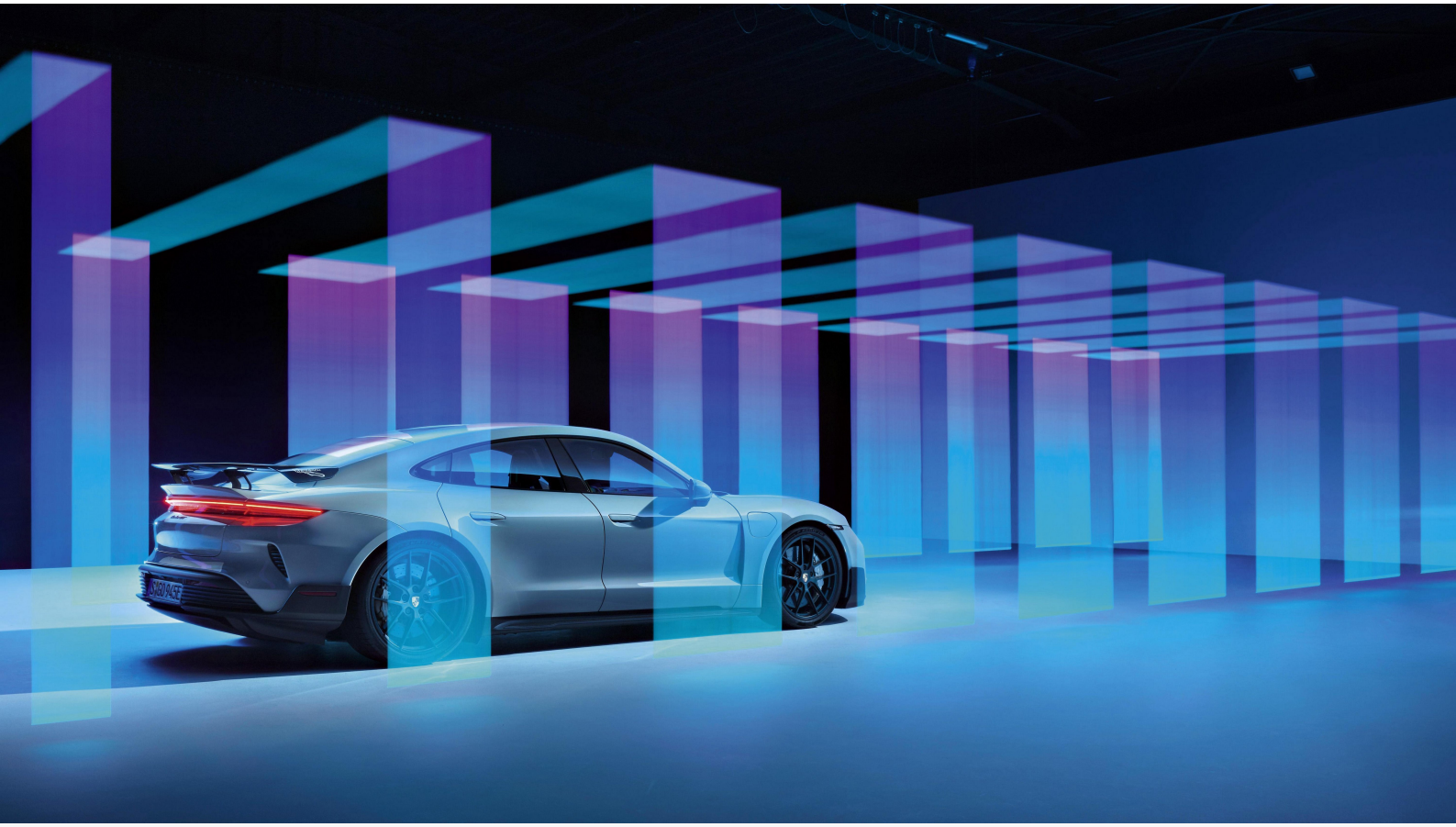

Porsche E-Performance: The ‘E’ is for Emotion

19/08/2025 From the hairpin stator to the two-speed transmission on the rear axle, Porsche uses every component of the electric drive system to elevate efficiency and driving dynamics to a new level. The result is electric propulsion that sets new standards.

There is enormous potential in the use of electric motors in cars. Porsche's engineers and developers not only consistently harness this but also take it to a whole other level. To put it simply, this means exploring the possibilities of the technology down to the smallest detail – and extracting everything possible.

The mindset at Porsche has not changed since the era of Ferdinand Porsche, but the technological requirements have. Ferdinand Porsche had relatively simple direct current motors at his disposal. Today, highly developed electric motors are used that extract the maximum from every watt supplied – because Porsche is fully commited to performance, whatever the drive system.

At the heart of it all is the operating principle of an electric motor: there are permanent magnet

synchronous motors (PSM) and asynchronous motors (ASM). The most noticeable difference is that PSMs offer higher continuous power and are less prone to overheating. Because of the many advantages it offers, Porsche chooses to use PSM technology despite the higher costs involved.

How E-Performance feels

We put the Taycan GTS through a little stress test on the race track. Sustained power, extremely hard braking and rapid acceleration out of corners were all on the agenda. The Taycan not only impresses with its excellent handling, thanks to the suspension and damping setup, but also with its incredible technology. The thrust on the exit of every corner is simply phenomenal and remains consistent even after the 10th, 11th, or 12th hard acceleration. Even under racing conditions over 20 kilometres at full load, the Taycan's performance doesn't diminish in the slightest. And despite the enormous strain, the brakes provide consistent deceleration.

Of course, such manoeuvres are not required in everyday driving. However, good brakes and, when needed, really fast acceleration contribute to safety and confidence in real-world driving scenarios. Overtaking manoeuvres on country roads are executed with ease, and when it matters, the brakes quickly bring the Taycan GTS to a halt. Everything is just as one would expect from a Porsche. But also, everything is new, and everything is electric. What's the technology behind it?

How E-Performance works

Porsche's PSM is supplied and controlled by power electronics with three-phase alternating current. The motor speed is determined by the frequency of the alternating current, which oscillates from positive to negative, centred about zero. In the motors of both the Taycan and Macan, the frequency of the rotating magnetic field in the stator is controlled by a pulse inverter, thereby regulating the rotor speed.

The rotor, meanwhile, is fitted with high-quality permanent magnets made from neodymium-iron-boron alloys, which are permanently magnetised during manufacturing by a strong directional magnetic field. These permanent magnets also enable extremely high energy recovery through regenerative braking. In coasting mode, the electric motor switches to generator mode, allowing the magnets to send voltage and current into the stator winding. The regenerative power of the Porsche electric motor is among the highest on the market.

But that's not all. The winding of the motors and the pulse inverter also contribute to achieving maximum performance. A key component is what is known as the hairpin winding, used by Porsche on the front axle of the Taycan. In this design, the stator coils consist of wires that are not round but rectangular. Unlike traditional winding methods, which use copper wire from an endless spool, hairpin technology is a forming-based assembly process. The rectangular copper wire is cut into individual sections and bent into a U-shape – similar to a hairpin.

Compact power

These individual hairpin wires are inserted into the stator laminations, where the winding is housed, so that the flat surfaces of the rectangular cross-section lie against each other. This is the key advantage of hairpin technology; it allows the wires to be packed more densely, thereby increasing the amount of copper in the stator. While conventional winding methods achieve a copper fill factor of about 50 per cent, the technology used by Porsche reaches nearly 70 per cent. This increases power and torque within the same installation space – making it a compact powerhouse. These technical advantages also apply to Porsche's I-pin technology, used in the Macan and on the Taycan's rear axle. Unlike hairpins (or U-pins), I-pins are not bent but welded on both sides.

The ends of the wire clips are laser welded to form the coil. Another important advantage is that the homogeneous contact between adjacent copper wires improves heat transfer, allowing a hairpin stator to be cooled much more efficiently. Although electric motors convert more than 90 per cent of energy into propulsion, they still generate waste heat, albeit significantly less than combustion engines, which must be dissipated. Therefore, the electric motors are equipped with a cooling water jacket.

Power electronics are crucial for precisely controlling the permanently excited synchronous motor. This is where the pulse inverter comes into play. Porsche has invested extensive know-how into this device. It converts the 800-volt DC from the battery into AC and supplies it to the two electric motors. Originally developed for the Porsche 919 Hybrid race car, the 800-volt technology, first used in a production model with the Taycan, reduces weight and installation space through thinner cables while also enabling shorter charging times. The electric motors reach up to 16,000 revolutions per minute.

In order to make optimal use of this speed range for the typical Porsche balance between driving dynamics, efficiency, and top speed, the front and rear drive units each have their own transmission. The Taycan was the first electric sports car to feature a two-speed transmission on the rear axle, with the first gear having a very short ratio. The front axle uses a single planetary gear to transfer power from the electric motor to the wheels. The longer-ratio second gear on the rear axle ensures efficiency and optimal power delivery at higher speeds. This combination allows the Taycan Turbo S to unleash its enormous power of up to 700 kW (952 PS, **Taycan Turbo S (WLTP)*:** Electrical consumption combined: 20.0 – 17.8 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A).

Booster for the Turbo

But Porsche and its developers have never been content to settle with what they have accomplished so far. It's no surprise, then, that achieving even higher performance was near the top of the to-do list. Christian Müller, Porsche's Technical Project Manager for Taycan special vehicles, and his team were the ones responsible for this. "An increase in power is an essential element for a model designed for all-out performance," says Müller. "That's why we addressed it very early on in development." Compared to the Taycan Turbo S, the top-of-the-range Turbo GT can deliver up to 120 kW (163 PS; **Taycan Turbo**

GT (WLTP)*: Electrical consumption combined: 21.2 – 20.5 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A) of additional power for a maximum of 10 seconds – like a booster for the Turbo.

Here, again, the pulse inverter plays a crucial role. The Taycan Turbo S uses a 600-amp (A; **Taycan Turbo S (WLTP)*:** Electrical consumption combined: 20.0 – 17.8 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A) inverter to control the electric motor and to convert the 105 kWh high-voltage battery's direct current into alternating current. The Taycan Turbo GT's inverter, however, operates at a current of up to 900 A (**Taycan Turbo GT (WLTP)*:** Electrical consumption combined: 21.2 – 20.5 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A), pushing more electrical energy toward the motor. Additionally, the Turbo GT's inverter uses silicon carbide instead of silicon as the semiconductor material, reducing switching losses and enabling a faster switching frequency.

"This results in significantly improved efficiency, and combined with optimal tuning of the electric motor, it also achieves higher continuous power," explains Müller. Whereas in the past, engine displacement, cylinders, or horsepower were the key factors in car specifications, today it's more about the strength of the pulse inverter, charging times, or range – categories where Porsche is once again at the forefront.

As well as changes to the inverter, the permanent magnet synchronous motor and the two-speed transmission on the rear axle had to be retuned. The increased load, due to the higher input torque, required a revision of the transmission components. The surfaces of the gear pairs were treated accordingly, bearings modified, and the clutch reinforced. To achieve the higher top speed of 305 km/h (**Taycan Turbo GT (WLTP)*:** Electrical consumption combined: 21.2 – 20.5 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A), the second gear was given a longer ratio. Overall, the Taycan Turbo GT offers a power output of 580 kW (789 PS). With Launch Control (LC) active, a power output of 760 kW (1,034 PS) is available – or 815 kW (1,108 PS) when Launch Control with Overboost is active, for a maximum of two seconds. There's no time to catch your breath on launch. Pure excitement is guaranteed.

How big should a BEV battery be?

Much has been said about the power and enormous importance of the pulse inverter. But at least as important for the acceptance and sustainability of an electric vehicle is the drive battery. How large must the energy storage be to enable an appropriate range? Which cells should be used to achieve both power and efficiency?

As expected, Porsche takes its own path here as well. To find a battery size that meets the needs of sports car customers, priorities and actual everyday use were considered and analysed. It goes without saying that driving dynamics are high on the list of priorities for sports car customers. On the other hand, shorter range is tolerated on long-distance trips if fast recharging is possible. Large batteries are often associated with longer range, shorter travel times, and superior driving dynamics. However, virtual simulations of laps on the Nürburgring Nordschleife have shown that the weight of batteries that are

either too large or too small negatively affects performance.

In the balance between range, performance, and sustainability, Porsche focused on journey times. A battery size of around 100 kWh offers the optimal balance. The current Taycan has a capacity of 105 kWh (gross) and 97 kWh net – and, under optimal conditions, can be charged at DC charging stations at up to 320 kW (**Taycan (WLTP)*:** Electrical consumption combined: 19.1 – 16.7 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A). That's 50 kW higher than before. Due to increased charging robustness, high charging power of more than 300 kW can be sustained for up to five minutes. This reduces the time needed to charge from 10 to 80 per cent state of charge (SoC) by nearly four minutes to 18 minutes, despite the larger battery capacity. The higher charging power and improved efficiency makes it possible to add up to 315 km of range in just 10 minutes of charging. This equates to a 40 per cent increase compared to the first-generation Taycan. It's performance data like this that remains a hallmark of the sports car manufacturer.

Porsche has also increased the battery's energy density by about 10 per cent, with new cell chemistry. Additionally, a modified pulse inverter with optimised software, a modified thermal management system, and a next-generation heat pump have also been used. All this results in a WLTP range of nearly 680 km for the new Taycan – 175 km more than its predecessor. This makes longer journeys even more effortless than before.

Another important factor in maximising time between charging stops is regenerative braking. As soon as the driver presses the brake pedal, the electric motors switch to generator mode. Instead of driving the wheels, the motors slow the vehicle down and simultaneously generate electricity that can be used to charge the battery. In both the Taycan and Macan, up to 90 per cent of all braking in everyday driving can be done purely electrically, without involving the hydraulic braking system. With the Taycan, the engineers were able to increase the maximum rate of recuperation from 290 to up to 400 kW (**Taycan (WLTP)*:** Electrical consumption combined: 19.1 – 16.7 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A) – a 30 per cent jump.

The Macan, also equipped with 800-volt technology and the first Porsche model built on the jointly developed PPE (Premium Platform Electric) with Audi, can achieve a substantial recuperation power of up to 240 kW (**Macan (WLTP)*:** Electrical consumption combined: 19.4 – 16.8 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A). Under optimal conditions, the high-voltage battery can be charged at up to 270 kW using a suitable charging point. It takes just 21 minutes to charge the battery from 10 to 80 per cent, and just four minutes to add enough energy for 100 km of range.

The vehicle's thermal management system not only ensures comfortable interior temperatures but also ensures optimal conditioning of the high-voltage battery. Depending on the charging station and the expected SoC at arrival, the battery is brought to the optimal operating temperature. The Macan is equipped with a six kW high-voltage heater that ensures the cells are kept at the right temperature, especially in cold weather. In the Taycan, the combination of a high-voltage heater and a heat pump can even achieve a heating output of up to 17 kW.

BEV development continues to advance

Shorter charging times and even further improved driving dynamics are expected in the coming years, thanks in part to advances in battery technology.

When it comes to electric drive in general, it may seem surprising that Porsche continues to use designations like Turbo, Turbo S, or Turbo GT, as well as the GTS badge. However, the sports car manufacturer wants to clearly indicate the performance level of each model version, just as it does with combustion-engined cars.

Performance and emotion have always been at the heart of Porsche's passion. This hasn't changed since the first models developed by Ferdinand Porsche – whether electric or combustion-powered. Achieving this requires new ideas, meticulous development work, and sheer dedication. Porsche remains as committed to this goal today as it was in the early days of producing sports cars.

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Consumption data

Taycan Turbo Cross Turismo (WLTP)*: Electrical consumption combined: 21.5 – 18.9 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Macan Turbo (WLTP)*: Electrical consumption combined: 20.7 – 18.4 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Taycan Turbo S (WLTP)*: Electrical consumption combined: 20.0 – 17.8 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Taycan (WLTP)*: Electrical consumption combined: 19.1 – 16.7 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Taycan 4 (WLTP)*: Electrical consumption combined: 20.0 – 17.6 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Panamera Turbo E-Hybrid (WLTP, preliminary values)*: Fuel consumption weighted combined: 4.3 – 3.5 l/100 km; Fuel consumption with depleted battery combined: 11,0 – 10,0 l/100 km; Electrical consumption weighted combined: 19.8 – 18.8 kWh/100 km; CO_2 emissions weighted combined: 99 – 81 g/km; CO_2 class weighted combined: C – B; CO_2 class with depleted battery: G

Taycan Turbo GT (WLTP)*: Electrical consumption combined: 21.2 – 20.5 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Taycan Turbo GT with Weissach package (WLTP)*: Electrical consumption combined: 20.8 – 20.7 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Macan 4S (WLTP)*: Electrical consumption combined: 20.5 – 17.7 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Macan (WLTP)*: Electrical consumption combined: 19.4 – 16.8 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

Taycan GTS (WLTP)*: Electrical consumption combined: 20.2 – 17.8 kWh/100 km; CO_2 emissions combined: 0 g/km; CO_2 class: A

*Further information on the official fuel consumption and the official specific CO_2 emissions of new passenger cars can be found in the "Leitfaden über den Kraftstoffverbrauch, die CO_2-Emissionen und den Stromverbrauch neuer Personenkraftwagen" (Fuel Consumption, CO_2Emissions and Electricity Consumption Guide for New Passenger Cars), which is available free of charge at all sales outlets and from DAT (Deutsche Automobil Treuhand GmbH, Helmuth-Hirth-Str. 1, 73760 Ostfildern-Scharnhausen, www.dat.de).

Image Sublines

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_1.jpg
Title: Taycan GTS, Spirit of E, 2025, Porsche AG
Subline: Ready for the Guinness Book of Records: in January, a Porsche Taycan GTS completed 132 laps on ice in a controlled drift, lasting 46 minutes and covering 15.503 kilometres. World record!

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_2.jpg
Title: Macan Electric model, Spirit of E, 2025, Porsche AG
Subline: The electric Macan repeatedly demonstrates its excellent handling, as seen here at the e-Performance Days at the Porsche Driving Centre Silesia Ring in Poland.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_3.jpg
Title: Taycan GTS, Spirit of E, 2025, Porsche AG
Subline: A stunning installation: the Taycan GTS at the 2025 Shanghai Auto Show. The stand design is reminiscent of the hall in Zuffenhausen where Porsche stores its historic treasures.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_4.jpg
Title: Lohner-Porsche Mixte racing car (1902), Spirit of E, 2025, Porsche AG
Subline: As early as 1902, the Lohner-Porsche ‘Mixte’ developed by Ferdinand Porsche was racing around corners at high speed.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_5.jpg
Title: Taycan 4, Spirit of E, 2025, Porsche AG
Subline: At the Arctic Circle: Charging works even in the depths of winter. And the Northern Lights shine unrealistically brightly.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_6.jpg
Title: Macan 4S, 9XX, Spirit of E, 2025, Porsche AG
Subline: Racing and series production go hand in hand: Formula E provides important insights for series production, and vice versa, developments such as those in the current Macan contribute to progress on the race track.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_7.jpg
Title: Battery module, Spirit of E, 2025, Porsche AG
Subline: Porsche puts a great deal of engineering effort into the crash safety of its batteries. With success, as tests prove.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_8.jpg
Title: Macan 4S, Taycan Turbo Cross Turismo, Spirit of E, 2025, Porsche AG
Subline: Ever better: More and more Porsche Charging Lounges, Inonity stations and many other charging points are turning a patchwork quilt into a respectable charging network.

Path: Porsche E-Performance: The ‘E’ is for Emotion/Images/img_9.jpg
Title: Taycan Turbo GT, Spirit of E, 2025, Porsche AG
Subline: James May and Richard Hammond pitted the Taycan Turbo GT against the Pipistrel Velis Electro. 129 kilometres as the crow flies with one stop to recharge versus 174 kilometres on English roads. The result: the Porsche won the race.

Path: Porsche E-Performance: The 'E' is for Emotion/Images/img_10.jpg
Title: Panamera Turbo E-Hybrid, Childhood home of Ferdinand Porsche in Vratislavice, Czech Republic, Spirit of E, 2025, Porsche AG
Subline: Roots in Maffersdorf, now Vratislavice: the place where Ferdinand Porsche first demonstrated his technical skills (in the field of electric vehicles, incidentally) is now occasionally visited by an electric Porsche.

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