Media Workshop:

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Press kit

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Fuel consumption and emissions

Taycan models

NEDC: Electrical consumption combined: 29.4 – 26.2 kWh/100 km
CO_2 emissions combined: 0 g/km

WLTP: Electrical consumption combined: 26.6 – 20.4 kWh/100 km
CO_2 emissions combined: 0 g/km

Consumption and emission data determined in accordance with the measurement procedure required by law. As all new cars offered by Porsche are type-approved in accordance with the WLTP, the NEDC values are therefore derived from the WLTP values.

Further information on the official fuel consumption and official, specific CO_2 emissions of new passenger cars is available in the publication entitled “Guidelines on fuel consumption, CO_2 emissions and power consumption of new passenger cars”, which is available free of charge from all sales outlets and from DAT, Hellmuth-Hirth-Strasse 1, D-73760 Ostfildern.

Introduction

Turbocharged ideas – innovation management at Porsche

"An innovation programme does not invest in patents or inventions. It invests in people." Oliver Blume's two guiding principles from 2016 have become a formula for success. Today, the innovation management programme initiated by the Chairman of the Executive Board of Porsche AG is a key element in securing the company's future. The aim of the programme is to support Porsche's transformation as it heads towards a digital, electrified future, and to resolve the contradiction between offering premium, high-performance and luxury vehicles, and being a sustainable company.

Ideas are in demand; ideas with a future. No matter where they come from, every idea is not only welcome, but also actively encouraged. Organisational structures have been changed and requirements for working together across roles and departments have been created for this very reason. These changes have given employees the freedom they need to work creatively, providing the foundation from which innovations can emerge. The concept has been well received: 80 to 100 teams and individual employees contribute ideas every year. Their creative proposals include ideas for improving products, enhancing the manufacturing process and even developing innovative digital services that would have been unthinkable just a few years ago.

Employees can submit proposals either to their own department's innovation manager or via a dedicated IT tool. The innovation manager then sets a time for the employee to present their idea in person and receive immediate feedback. For an idea to be considered an innovation at Porsche, whether it relates to a vehicle, production or another field, the idea must meet three basic requirements: it must be new and unique, it must be economically viable for the company to implement and it must have a relevant benefit for customers.

If the feedback is positive, the project work begins more or less immediately. The employee who submitted the idea is encouraged to proactively develop the concept and to manage the project, albeit with help. Meanwhile, the innovation manager’s role is to provide methodological support, assign money for investment when needed and contact potential

development partners within or even outside the company as appropriate. This division of labour helps innovation managers ensure that innovative project ideas are validated in a structured way and, if successful, that they can be developed to a point that allows them to become standard practice.

To ensure that ideas can be implemented as soon as possible, the seven corporate departments of Porsche AG and Porsche Digital GmbH have appointed up to two innovation managers each. The team follows a set innovation agenda to focus its activities on the topics most relevant to the future of Porsche. The sports car manufacturer has already outlined some clear objectives for its future: by 2025, the company intends to invest 15 billion euros in electric mobility and digital transformation, of which more than 800 million euros will be spent on digitalisation every year.

Porsche knows it is not the only company with ideas about innovation, which is why cooperation with start-ups and universities is another key element of the company's strategy. In some cases, Porsche even buys shares in emerging companies or launches initiatives to promote digitalisation. More than 150 million euros is available annually for investments in start-ups and venture capital companies. The Porsche Ventures business unit is part of an ecosystem that can support any type of start-up, whether it’s at the idea stage or at a point where funding rounds have already begun. This ecosystem also includes the company builder Forward 31 and the early-stage investor APX, which is a 50:50 joint venture with Axel Springer. Both organisations are based in Berlin. The Porsche Ventures venture capital unit and Porsche Digital GmbH actively seek out new start-ups that will strategically advance the Porsche brand.

The sports car manufacturer is also not afraid to explore completely new fields: for example, Porsche has spurred on the production of fuels that are almost CO_2-neutral by initiating a large-scale eFuels project. The company is also looking for new business areas away from its core automotive sector via its Beyond Mobility project, which covers topics such as smart living in networked smart cities as well as vertical mobility concepts.

Synthetic fuels

eFuels to supplement electric mobility on the road to becoming CO_2 neutral

Using electricity to create fuel: just a few weeks ago, construction started on a plant initiated by Porsche for producing virtually CO_2-neutral fuel. The Haru Oni joint project, involving Porsche, Siemens Energy and various other international partners, will be the world's first integrated, large-scale commercial plant to manufacture synthetic, carbon-neutral fuels. Located in the Magallanes Province of southern Chile, the plant takes advantage of the region's ideal conditions for generating wind energy, which will be used as a sustainable source of electricity to produce synthetic petrol.

The pilot plant in Chile is scheduled to start production by mid-2022. Joining Siemens Energy and Porsche in working on the Haru Oni project are various other partners, including Italian energy company Enel, ExxonMobil and the Chilean energy companies Gasco, ENAP and AME – the main developer and owner of Highly Innovative Fuels (HIF), the company running the project.

Given its status as a sports car manufacturer, Porsche plans to use the eFuels in its own combustion-engined models. The huge number of vehicles on the world's roads – some 1.3 billion according to the latest figures – means that the transition to electric mobility is not happening fast enough to achieve the goals set out in the Paris Agreement. In addition, different regions of the world are adopting electric mobility at varying speeds, meaning vehicles with combustion engines will remain on the road for decades to come.

eFuels produced via a virtually CO_2-neutral process will mean that these vehicles can still help to rapidly reduce carbon emissions. "We urgently need a solution for operating existing fleets of vehicles in a sustainable way," explains Michael Steiner, Member of the Executive Board for Research and Development at Porsche AG. "This goal can be achieved with green fuels, which are a sensible complement to electric vehicles." These fuels also represent a solution for other traffic sectors in which electrification is either very difficult or impossible, such as air travel and shipping.

Obtaining cheap renewable energy for the production process is vital for ensuring that eFuels can quickly develop into a competitive product. A wind turbine located next to the pilot plant in Chile operates at full load for an average of 270 days per year. The same equipment in Germany would only do so for around 80 days per year, due to the country's geographical and meteorological conditions. This means that the Chilean wind power plant’s 74 per cent utilisation ratio for full-load hours is three and a half times higher than could be achieved in Germany, where the utilisation ratio is 22 per cent from all onshore wind turbines.

The low cost of energy for manufacturing eFuels in Chile is not the only important factor: taxes and charges will also have an impact on the price, and therefore the financial success, of the product. eFuels will become competitive faster as fossil fuels become more expensive in the years ahead due to regulatory measures such as energy taxes and carbon pricing, as well as measures that make eFuels exempt from such charges, i.e. charges relevant to CO_2 emissions.

The methanol-to-gasoline (MtG) process being pioneered by the Haru Oni project group will initially focus on fuel for petrol engines. eFuels are produced from just two raw materials: water and carbon dioxide. Hydrogen is generated via electrolysis, which involves passing a direct current through water. The hydrogen is split off and collected at the negative pole (cathode). Carbon dioxide, the other essential component for producing eFuels, is drawn straight from the ambient air using a process called direct air capture. Large fans blow air through filters in which the carbon dioxide contained in the atmosphere is deposited. Methanol synthesis causes the H_2 and CO_2 to react and produce eMethanol (CH_3OH), which then goes through MtG synthesis and is converted into synthetic, straight-run petrol.

This virtually CO_2-neutral fuel is then blended and refined to the point that it complies with the current DIN EN 228 fuel standard, allowing it to be used directly in petrol vehicles or added to fossil fuels. Some comparatively minor modifications to the plant would enable the partners to convert the eMethanol into products such as eKerosene for aircraft, as well.

As early as the end of 2022, the pilot plant will have produced around 130,000 litres of eFuels. Porsche will purchase this volume in full – and will initially use the green fuel

primarily in its motorsports activities. Chile has also set itself some ambitious targets as part of its National Green Hydrogen Strategy. One of its goals is to produce the world's cheapest hydrogen and develop the country into a leading exporter of green hydrogen and its derivatives.

New development and testing methods

Using digital processes to safeguard automated driving functions

Combining dynamic performance and automated driving in the same car: across China, the US and Germany – the three largest markets for Porsche – almost a quarter of Porsche customers would consider buying a car that can take control of driving manoeuvres in specific situations. This is why the sports car manufacturer is working hard to develop technology and concepts that provide automated driving functions.

However, the associated sensor technology and data processing requirements are so complex that they far exceed the possibilities of conventional development and testing methods that use physical test cycles. Scientists at the US think tank RAND Corporation believe that a fully autonomous vehicle would need to drive hundreds of millions – and sometimes hundreds of billions – of miles to reliably test the individual systems and the way that they interact. According to the RAND Corporation, these vehicles would need to drive around 11 billion miles to reduce the risk of a fatal accident caused by an autonomous vehicle by 20 per cent, compared to a vehicle driven by a human. Driving 100 test vehicles at an average speed of 40 km/h for 24 hours per day, seven days per week, would take approximately 500 years. Clearly this is not a practical scenario.

To make the testing process more manageable, many of the test kilometres can be driven in a laboratory using digital solutions and extensive computer simulations. Because of this, Porsche Engineering – an engineering service provider and subsidiary fully owned by Porsche AG – has started work on the Porsche Engineering Virtual ADAS Testing Centre (PEVATeC). ADAS stands for advanced driver assistance systems. In the future, this laboratory will be used to create virtual worlds that cover all relevant situations on the road. These situations will then be used as test cases for the algorithms and sensors in driver assistance systems.

Test drives performed within a simulated environment save money and time, and can be organised more easily, but they also allow critical situations taken from genuine road traffic

scenarios to be reproduced and modified as needed during virtual testing. The simulations also help explore new, critical scenarios that are not perceived as dangerous by human drivers, but which are crucial when combined with a sensor algorithm and automated driving functions.

In addition to the fact that the simulations can be experienced in real time, it is just as important, if not more so, for the virtual worlds created with a computer to produce physically realistic effects. Digitally reproduced objects such as roads, pavements, house walls and vehicles must have precisely the same characteristics as those that apply in genuine road traffic situations – only then can they provide the camera, lidar, radar and ultrasound systems with realistic input.

Porsche Engineering uses game engines from the video game industry for this purpose. These game frameworks generate photo-realistic images and ensure that objects in computer and video games behave in ways that are physically correct. Porsche Engineering uses these software packages to virtually develop and test automated driving functions. In addition to artificial intelligence, game engines play a key role here: the game engines use synthetic sensor data to train driver assistance systems, allowing the technicians to play out all scenarios and outcomes in detail.

Simulated test drives using game engines have the advantage that they can be repeated as many times as necessary, they can be controlled and they take less time than conventional tests. Simulations are also used at the vehicle design stage to reduce the number of physical prototypes and therefore save on time and costs. Porsche Engineering uses a visual engineering tool developed in-house for this purpose. For example, questions about how best to arrange components can be answered quickly and cost-effectively using augmented reality (AR) or virtual reality (VR) glasses in combination with CAD data.

In the future, game engines will also be used to enhance the customer's purchasing experience: Porsche is currently testing a VR car configurator. Porsche Centres will also soon be able to show customers an incredibly lifelike, three-dimensional simulation of their configured vehicle via a gaming PC with connected VR glasses.

Multi-stage service concept

High-voltage battery repairs at Porsche Centres

Porsche thinks ahead: since the introduction of its first generation of hybrid models back in 2013, the sports car manufacturer has been taking a holistic approach to its electric vehicles with high-voltage batteries. The Porsche concept covers sourcing and manufacturing, consulting, sales and servicing, and logistics and recycling.

Having a repair concept for high-voltage batteries makes an important contribution to sustainability and the conservation of resources. At the start of its battery development process, Porsche looks beyond the traditional considerations linked to whether or not the component is feasible to produce. The development teams also make sure that the construction of the energy carrier is as simple as possible, so that it can be repaired at qualified Porsche Centres later in its life cycle. For example, 28 or 33 modules are installed in the various Taycan derivatives, depending on the battery capacity. The battery housing can be opened to allow the replacement of cell modules and other components. Enabling such detailed repairs is also an advantage for customers from a price perspective.

Cell modules that are still functional but no longer suitable for powering a vehicle can be used for stationary tasks. As part of its second-life strategy, Porsche is working on a pilot project that will allow high-voltage batteries to be re-used. These batteries are dismantled down to the module level and installed in stationary energy carriers. Having a standard solution is essential for enabling the long-term, sustainable re-use of old batteries.

Working with the Volkswagen Group and other professional partners, Porsche has been making ongoing improvements to its existing recycling processes in order to increase the proportion of raw materials in circulation and to re-use these materials in new batteries.

A holistic concept for servicing all-electric Porsche vehicles has also been developed. As the sports car manufacturer's first all-electric model, the Taycan has some very different service and repair needs compared to vehicles with combustion engines. For example, the electric sports car has a service interval of two years or 30,000 kilometres but tasks such as

replacing spark plugs and oil changes are no longer necessary, meaning up to 30 per cent less maintenance work is required. In addition, the electric powertrain, including the high-voltage battery, is completely maintenance free. However, repair work on electric vehicles requires expert training and specialist tools that Porsche Centres must obtain before they can offer these services.

The service concept for electric vehicles therefore comprises several stages: the first point of contact is a high-voltage base, set up within a qualified Porsche Centre. The sports car manufacturer is also establishing cross-regional hubs at certain qualified centres, which will handle repairs on high-voltage vehicles in areas where there is no high-voltage base close by. The Porsche Centre that originally accepts the vehicle for repairs will take it to the high-voltage hub, where the work will be carried out along with a final quality inspection, before it is returned to the original Porsche Centre.

If transporting the vehicle to a dedicated repair centre is not possible, a ‘flying doctor’-style repair technician is deployed. These mobile high-voltage experts can repair defective high-voltage batteries on site. Ahead of this, the relevant Porsche Centre receives all the high-voltage tools and replacement parts required for the work. These different options allow Porsche to offer a seamless service network for high-voltage battery repairs.

The final part of the concept for work on the Taycan as the first series production car with a system voltage of 800 volts is recognising the need for a clear division of tasks and responsibilities. With this in mind, Porsche has defined three qualification levels: qualified electricians, high-voltage technicians and high-voltage experts. Qualified electricians have a basic qualification that allows them to perform standard repairs to high-voltage vehicles, such as changing the tyres or wiper blades. They must be briefed and supervised by a high-voltage technician when working on a high-voltage vehicle.

High-voltage technicians are trained to work on vehicles that have been disconnected from the voltage supply, and are familiar with classifying and storing lithium batteries. They are also qualified to remove and pack high-voltage batteries classified as ‘Normal’ and ‘Warning’. High-voltage experts have the highest qualification level at the Porsche Centre. They are

the only people allowed to perform work inside high-voltage batteries, handle high-voltage batteries with insulation faults and prepare and pack these types of batteries for transportation.

The expertise required for service work on high-voltage vehicles is extensive, particularly for the two more specialised roles. As a result, Porsche has developed a specialised training concept for all three roles, which comprises web-based learning, instruction materials and in-person training sessions.

The optimal balance

A battery's role in balancing range, performance and sustainability

Porsche has a clear goal: by 2030, the sports car manufacturer plans to have a carbon-neutral balance sheet across the entire value chain. The company's timeline for changes to production and logistics has been updated accordingly, although it is the progress of electric mobility that will play the pivotal role.

Almost half of all the CO_2 emissions generated during the lifecycle of an electric vehicle are produced at the manufacturing stage, which includes the extraction and processing of raw materials. The second-largest source of emissions is operation of the vehicle, which is determined by the energy mix used to charge it, charging efficiency, vehicle efficiency and driving style. Recycling procedures and further processing of materials at the end of a vehicle's life cycle generate the lowest proportion of CO_2 emissions.

In terms of individual factors, the powertrain battery has the greatest influence on CO_2 emissions during a vehicle's lifecycle: The battery accounts for around 40 per cent of the carbon dioxide produced when a single Taycan is manufactured. In other words, the size of the energy carrier is fundamentally responsible for the carbon footprint of an electric vehicle. Yet it is also this component that determines an electric vehicle's success on the market: After all, the size of the battery must be right to ensure that these vehicles meet customers' expectations and requirements.

According to a study conducted by a vehicle manufacturer in the US, worries about being left stranded with an empty battery are the main barrier to customers buying an electric vehicle. An increase in battery capacity and battery efficiency mean that electric vehicles are evolving to better suit customer requirements. Some manufacturers are now in a position to launch models with a range of well over 600 kilometres, but smaller vehicles for shorter journeys and a smaller operating range are also becoming more popular with customers.

Porsche is taking its usual pioneering approach in the way that it is tackling this challenge. The sports car manufacturer has analysed priorities and use cases to help it identify a battery size that strikes the right balance between what can often be described as conflicting requirements. For example, Porsche customers value a dynamic driving experience but at the same time expect their vehicles to cover long-distances quickly with short charging times. Statistics indicate that the majority of customers drive less than 80 km per day, and approximately 80 per cent of the journeys that take place within a week amount to less than 450 km.

It is generally believed that a large powertrain battery equates to dynamic performance. However, simulated lap times on the Nordschleife track at the Nürburgring suggest otherwise: Porsche has calculated that a virtual Taycan Turbo S featuring a 85.1 kWh battery and weighing 2,419 kg in total can complete a lap of the Nordschleife in 7:39.5 minutes.

When the battery capacity is reduced to 70 kWh, the total vehicle weight goes down to 2,310 kg. The reduction in battery power means that the Taycan takes an extra seven tenths of a second to complete the lap. The lower vehicle weight makes it possible to accelerate from 0 to 100 km/h in 2.90 seconds, which is 0.02 seconds faster than the reference vehicle but with this configuration the Taycan takes 9.51 seconds to reach 200 km/h, which is around eight tenths of a second slower. These calculations indicate that an overall weight saving does not compensate for the reduced power of the battery.

By contrast, a 100-kWh battery adds a very noticeable extra 107kg to the total vehicle weight. Despite the more powerful battery, the lap time increases to 7:42.4 minutes, accelerating from 0 to 100 km/h takes 3.04 seconds and 0 to 200 km/h takes 9.71 seconds. The influence of weight becomes even clearer with a 130-kWh battery, which increases the total vehicle weight to 2,743 kg. With this configuration, the lap time increases to 7:48.2 minutes, accelerating from 0 to 100 km/h takes 3.28 seconds and 0 to 200 km/h takes 20.48 seconds.

Porsche's findings indicate that, while a smaller battery is the better option for reducing CO_2 emissions during production, a medium-sized battery delivers the best driving dynamics. Large batteries are generally believed to offer a greater range plus shorter journey times.

However, thanks to its 800-volt technology and highly efficient direct current charging process, the Taycan takes just five minutes to store enough energy to cover an extra 100 km. Most studies recommend a ratio of two hours of driving to 15 minutes of charging, and the Taycan is already capable of covering long distances when driven in this way.

When looking at how to balance range, performance and sustainability, Porsche has focused on travel time. A battery size in the region of 100 kWh is the best option in this regard. Future battery developments will continue to enhance driving dynamics and charging times, and we can expect even greater progress in terms of reducing CO_2 emissions. The second-generation electric vehicles that have not yet been launched will generate around a quarter less carbon dioxide during their lifecycle than the first-generation models, but it is the battery technology itself that will make the largest contribution to reducing a vehicle's carbon footprint: New cell technology will reduce energy consumption, while higher charging capacities will improve efficiency. In addition, the expected increase in the proportion of recycled raw materials available from batteries promises a big improvement in sustainability, as well as giving Porsche a real chance of achieving its target by 2030: to have a carbon-neutral balance sheet across the entire value chain.

Networking data

A digital chassis twin for predictive driving functions and component status updates

Every new generation of Porsche benefits from the improved performance of its integrated sensors, networking and data processing capabilities, which in turn uncovers new possibilities for effectively using these capabilities. One of these possibilities is known as a ‘digital twin’. This is a virtual copy of an existing object, which allows data-driven analysis, monitoring and diagnostics without the challenges and constraints of real-world tests.

The digital twin of a vehicle comprises not only the operating data it collects but also any related data, such as information collected during planned maintenance work and unexpected repairs. Elements of this digital twin already exist in control unit memories and in the databases maintained at Porsche Centres.

The main advantage of digital twins is the fact that they can be networked and the data combined with a centralised intelligence system. Conclusions that benefit every single vehicle and therefore every individual customer can be drawn from data relevant to an entire field. For example, an algorithm can compare big data against sensor data from a specific vehicle's powertrain and chassis to identify a customer's driving style. The algorithm can then recommend not only the optimal time for service work on the vehicle but also the required scope of that work. This data makes it possible to customise service intervals and allow servicing for specific components as needed, based on how the customer uses their vehicle. For instance, with this approach the hard-working suspension bushes of a sports car that spends most of its time on a race track could be replaced at exactly the right time. By contrast, service work on the engine is more important for vehicles predominantly driven for long distances on motorways. Another even more important benefit of this approach is the fact that potential component wear and even faults can be identified before they have actually occurred, which is a significant advantage from a safety perspective.

For the past three years or so, software specialists at Porsche have been working on a digital twin concept that focuses on the chassis, known as a ‘chassis twin’. This project is

now being managed by CARIAD, the standalone automotive software company within the Volkswagen Group. In addition to data from Porsche vehicles, the project now has access to data from all Volkswagen Group vehicles, which increases the data pool by a factor of 20.

The reason for focusing on chassis components is clear: on a Porsche, the chassis is subjected to the highest loads, particularly when the vehicle is used on racing circuits. Sensor technology in the vehicle and the intelligent neural algorithms used for centralised analysis allow the load on the chassis to be detected within the vehicle and conveyed to the driver. This intelligent use of data makes the vehicle safer for its passengers because any specific faults are identified immediately, even before the driver or the workshop notices a problem signified by noise or vibration.

The digital chassis is already being used for its first practical testing scenario: monitoring the components in the air suspension of the Porsche Taycan. This project is primarily for collecting data about body acceleration in this initial stage. The data is evaluated and transferred via Porsche Connect to the central backend system. This system continuously compares the data from each vehicle against the fleet data. The algorithm calculates thresholds based on this comparison and, if these are exceeded, the customer is notified via the onboard Porsche Communication Management system (PCM) that the chassis may need to be inspected at a Porsche Centre. While this approach ensures that wear does not got beyond specified limits, early repairs also help to prevent consequential damage.

Artificial intelligence within the vehicle and within the centralised intelligence system continuously improves contingency planning and the accuracy of the algorithms. Data privacy during the testing phase and after the series production launch is the top priority so customers are prompted via the PCM to provide their consent to data being collected anonymously. Around half of all Taycan customers have agreed to take part in this pilot project, which is an incredibly positive response to this application of the digital chassis.

The first version of the digital twin will be launched next year and only sensor data directly from mechatronic components will be evaluated. Other functionality will be added in the future, such as functions that allow wear on specific components to be calculated without

the need for physical gauges to be used. For example, if multiple vehicles require adjustments to their wheel alignment or a track rod replacement and multiple sensors have already detected corresponding deviations, this information can indicate a pattern. If the same data is then identified on a further vehicle, the driver will accordingly be told to visit a Porsche Centre. Early diagnostics in this format can prevent consequential damage, which in this example would be worn tyres caused by track misalignment. The fault-finding process at the workshop will be faster, because the specific components responsible for a fault can be replaced, thereby reducing throughput times in the workshop and lowering costs for customers.

The digital twin offers other benefits for customers beyond operation of their vehicle: Digital vehicle records can be used to show the residual value of a vehicle, making the process of buying and selling used vehicles more transparent. In addition, manufacturers could consider offering an extended approved warranty based on seamless documentation of component status updates, and even a certificate with a price recommendation for selling on the vehicle.