



Mercedes-Benz

Press Information

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## VISION EQXX – taking electric range and efficiency to an entirely new level

### The road trip reimagined with a new technology blueprint for series production

Stuttgart. Range and efficiency are set to define the electric era. Exceptional range will make electric cars suitable for every journey and help to increase overall adoption. Reduced battery size and weight will improve efficiency, allowing us to go further with less. Mercedes-Benz is determined to lead the way. We are already leading the way in terms of real-world range with the EQS with 245 kW, as evidenced by the recent Edmunds test where an EQS 450+ travelled 422 miles on one charge, 77 miles further than any other car previously tested.

However, Mercedes-Benz is not stopping there. Driven by the idea of zero impact on our planet and a highly responsible use of green energy, we encouraged our engineers to go above and beyond. They are working intensively to take range and efficiency to a completely new level. The VISION EQXX is the result of a mission we set to break through technological barriers and lift energy efficiency to new heights. It demonstrates the gains that are possible through rethinking the fundamentals from the ground up. This includes advances across all elements of its cutting-edge electric drivetrain as well as the use of lightweight engineering and sustainable materials. Complete with a barrage of innovative and intelligent efficiency measures, including advanced software, the VISION EQXX allows us to explore new frontiers of efficiency.

*“The Mercedes-Benz VISION EQXX is how we imagine the future of electric cars. Just one-and-a-half years ago, we started this project leading to the most efficient Mercedes-Benz ever built – with an outstanding energy consumption of less than 10 kWh per 100 kilometers. It has a range of more than 1,000 kilometers<sup>2</sup> (620 miles) on a single charge using a battery that would fit even into a compact vehicle. The VISION EQXX is an advanced car in so many dimensions – and it even looks stunning and futuristic. With that, it underlines where our entire company is headed: We will build the world’s most desirable electric cars.”* Ola Källenius, Chairman of the Board of Management of Daimler AG and Mercedes-Benz AG.

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<sup>1</sup> Electrical consumption has been determined on the basis of Commission Regulation (EU) 2017/1151 according to WLTP

<sup>2</sup> Range figures preliminary and based on digital simulations in real-life traffic conditions. The VISION EQXX has not undergone type approval or homologation.

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The figures are provided in accordance with the German regulation 'PKW-EnVKV' and apply to the German market only. Further information on official fuel consumption figures and the official specific CO<sub>2</sub> emissions of new passenger cars can be found in the EU guide 'Information on the fuel consumption, CO<sub>2</sub> emissions and energy consumption of new cars', which is available free of charge at all sales dealerships, from DAT Deutsche Automobil Treuhand GmbH and at [www.dat.de](http://www.dat.de).



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## VISION EQXX – designed for the road trip to electromobility

There's a reason why road trips have been a cultural benchmark for at least 70 years, telling stories from the highway in books, movies and music. The road trip defines freedom, individuality, the very spirit of the automobile and the passing world. Stick a pin in the map – and drive. Be in tune with the road, and with the car. This urge to explore, discover and revel in the world beyond our horizon is part of what it is to be human. It's the pioneering spirit that pairs vision with the tenacity to make it happen.

The journey to electric mobility is a road trip; as exhilarating as it is challenging, as unknown as it is certain. The Mercedes-Benz VISION EQXX is a vehicle designed for that road trip. It answers the progressive demands of a modern generation of customers for and emotionality through innovation. Part of an advanced technology program, this software-defined research prototype was engineered by women and men with the creativity, ingenuity and determination to deliver one of the planet's most efficient cars – in every respect. They did so using the latest digital technology, the agility of a start-up and the speed of Formula 1.

The result is an efficiency masterpiece that, based on internal digital simulations in real-life traffic conditions, will be capable of exceeding 1,000 kilometers<sup>3</sup> (620 miles) on a single charge with an outstanding energy consumption of less than 10 kWh per 100 kilometers (efficiency of more than 6 miles per kWh).

By ripping up the automotive engineering rulebook, Mercedes-Benz has built a software-driven electric car that re-imagines the road trip for the electric era. At the same time, it presents a highly progressive interpretation of the fundamental Mercedes-Benz principles of modern luxury and Sensual Purity. Rather than simply increasing the size of the battery, the cross-functional, international team focused on maximizing long-distance efficiency. They pulled out all the stops in drivetrain efficiency, energy density, aerodynamics and lightweight design.

*“The technology program behind the VISION EQXX will define and enable future Mercedes-Benz models and features,”* says Markus Schäfer, Member of the Board of Management of Daimler AG and Mercedes-Benz AG, Chief Technology Officer responsible for Development and Procurement. *“As a halo car, the VISION EQXX firmly establishes Mercedes-Benz as the brand that pairs luxury with technology in the automotive world and beyond. And the way we developed it is as revolutionary as the vehicle itself. VISION EQXX has seen the best minds from our R&D centers work together with engineers from our Formula 1 and Formula E programs. They are proving that innovations from motorsport – where powertrains are already highly electrified – have immediate relevance for road car development. We are challenging current development processes with innovative spirit and outside-the-box thinking. This truly is the way forward.”*

The VISION EQXX is an exciting, inspirational, yet completely realistic way forward for electric vehicle technology. In addition to its groundbreaking energy efficiency, it offers meaningful answers to pressing issues. For instance, sustainable materials throughout decreases the carbon footprint considerably. Its UI/UX features a radical new one-piece display that comes to life with responsive real-time graphics and spans the entire width of the vehicle. Other elements of the UI/UX help the car and driver work together as one, and even use technology that mimics the workings of the human brain. And the software-led development process that delivered it revolutionizes the way electric cars are designed.

This car is one outcome of an ongoing program that is delivering a blueprint for the future of automotive engineering. Many of its features and developments are already being integrated into production, including the next generation of the MMA – the Mercedes-Benz Modular Architecture for compact and medium-sized cars.

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<sup>3</sup> Range figures preliminary and based on digital simulations in real-life traffic conditions. The VISION EQXX has not undergone type approval or homologation.

## VISION EQXX: main points at a glance

### A car with a mission – the most efficient Mercedes-Benz ever built

Efficiency means achieving more from less. The VISION EQXX is packed with efficiency improvements that push the envelope with a mixture of advanced technology and talented teamwork. The outcome will be a road-legal research prototype that delivers more range from less energy, more tangible luxury and convenience with less impact on the environment, and more electric mobility with less waste. A raft of digital tools and a software-led approach also delivered more car in less time.

**#EnergyWizard:** Across the board, efficiency engineering achievements delivered an astounding energy consumption of less than 10 kWh per 100 km (efficiency of more than 6 miles per kWh)

**#ElectricDrive:** Radical new system designed and built in-house – it achieves benchmark efficiency of 95% from battery to wheels

**#RangeBuster:** More than 1,000 km (over 620 miles)<sup>4</sup> on a single charge on public roads puts an end to range anxiety

**#EnergyDensity:** With expert engineering and Formula 1 thinking, our battery chemists squeezed the energy of the EQS into the dimensions of a compact car. The battery pack in the VISION EQXX holds almost 100 kWh of energy, yet has 50% less volume and is 30% lighter than the already benchmark pack in EQS.

**#AeroChamp:** Exterior designers and aerodynamicists delivered a benchmark drag coefficient of  $c_d$  0.17<sup>5</sup>

**#SustainableMaterials:** Innovative recycled and plant-based materials remove waste from landfill and lower carbon footprint

**#UpliftMindset:** A pioneering team of Mercedes-Benz engineers worked with the world's fastest race lab at High Performance Powertrains (HPP) and Mercedes-Benz Grand Prix (MGP) to engineer a highly efficient and compact electric drivetrain and lightweight battery case

**#BionicEngineering:** Inspired by natural forms and in partnership with innovative start-ups, engineers used advanced digital tools to lower weight and reduce waste by removing excess material assisted by 3D printing

**#RollingEfficiency:** Ultra-low-rolling-resistance tires with optimized aerodynamic geometry combine with lightweight magnesium wheels for increased range

**#BrakingLightly:** Lightweight brake discs made from aluminum alloy are a great fit for the VISION EQXX and help keep weight down

**#EfficiencyOnTheRoad:** Electric-only chassis with lightweight F1 subframe brings racing efficiency to the road

**#SolarPower:** Ultra-thin roof panels feed the battery system for up to 25 km of extra range

**#HumanMachineMerge:** Intuitive and intelligent user interface and user experience with guidance and assistance for efficient driving brings even closer harmony for the electric age

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<sup>4</sup> Range figures preliminary and based on digital simulations in real-life traffic conditions. The VISION EQXX has not undergone type approval or homologation.

<sup>5</sup>  $c_d$  figure measured in the Daimler aero-acoustic wind tunnel at a wind speed of 140 km/h

**#SensualPurity:** Totally focused EV exterior/interior design ethos underlines role as halo car for the all-electric future. Mercedes-Benz will build the most desirable cars

**#FastTechProg:** From clean sheet to on the road in just 18 months. The VISION EQXX is part of a technology program that can adapt innovative technologies for series production faster than ever before

**#Transformation:** VISION EQXX demonstrates Mercedes-Benz transformation into an all-electric and software-driven company

**#SoftwareDriven:** Software-driven approach key to success in achieving efficiency goals and a rapid development process, including groundbreaking battery management system.

**#GlobalResponsibleLeadership:** VISION EQXX accelerates Mercedes-Benz goal to “Lead in Electric” and set benchmarks in sustainable mobility.

## VISION EQXX: key technical data at a glance<sup>6</sup>

|                                |                           |                   |
|--------------------------------|---------------------------|-------------------|
| Battery energy content, usable | kWh                       | <100              |
| Max. system voltage            | Volts                     | >900              |
| Energy consumption             | kWh/100 km<br>(miles/kWh) | <10<br>(>6)       |
| c <sub>d</sub> value           |                           | 0.17 <sup>7</sup> |
| Max. power output              | kW                        | ~150              |
| Wheelbase                      | in                        | 110               |
| Gross vehicle weight           | lbs                       | ~3,858            |

<sup>6</sup> Range figures preliminary and based on digital simulations in real-life traffic conditions. The VISION EQXX has not undergone type approval or homologation.

<sup>7</sup> c<sub>d</sub> figure measured in the Daimler aero-acoustic wind tunnel at a wind speed of 140 km/h

## Efficiency is the new currency

At its heart, efficiency means achieving more from less. For Mercedes-Benz, this is nothing new – Mercedes-Benz has always strived for efficiency in its vehicles, achieving massive technological strides over the decades. These have benefitted consumers through consistent improvements in fuel consumption, comfort and convenience. However, the imperatives of electric mobility and sustainability have shifted the framework for efficiency.

The most familiar expression of automotive efficiency is that of fuel consumption or fuel economy. This is expressed in different ways depending on where we are in the world (i.e. liters per 100 kilometers, miles per gallon or kilometers per liter). Regardless of convention, they all relate units of fuel (energy) with units of distance. Electric mobility is no different in that respect.

By making efficiency the new currency, Mercedes-Benz has created a common denominator for quantifying technological development across the board – beyond fuel efficiency alone. Meaning, more range from less energy, it also means more tangible luxury and convenience with less impact on nature, and more electric mobility with less waste.

The VISION EQXX demonstrates that this is all within reach in a real-world vehicle that pushes the envelope on all fronts. It gives Mercedes-Benz customers a clear insight into what premium efficiency for the electric and digital era looks like and feels like. Beautiful design and intuitive operation enhanced by advanced digital technologies deliver sustainable, long-haul electric mobility that has Mercedes-Benz written all over it.

*“The XX suffix augments the Mercedes-Benz brand with the X-factor of electric mobility that thinks beyond limitations, and an agile, X-divisional collaborative development approach,”* explains Markus Schäfer, *“This enhances the breadth and depth of development skills within Mercedes-Benz AG with highly advanced digital tools as well as industry-leading expertise from a diverse array of partner companies, start-ups and institutions around the world.”*

From its innovative drivetrain to its lightweight “bionic” structure, and from its ingenious thermal management to its serenely slipstreaming exterior, the efficiency engineering in every single detail adds up to the remarkable energy consumption and real-world range of the VISION EQXX.

*“Electric range sounds easy but is a complex technical challenge. The easiest way is to put a bigger battery in the car. However, this leads to diminishing returns due to size and weight. This is definitely not the smartest route and it’s also not the best use of scarce resources. With the VISION EQXX, we’re presenting the results of an extraordinary challenge: we pushed efficiency to a totally new level. And we explored new ways to increase the range of an electric car.”* Joerg Bartels, Vice President for Vehicle Engineering and Overall Vehicle Functions.

This remarkable project went from white paper to completed vehicle in just 18 months. It drew talent not only from Stuttgart but also from Formula 1 and a diverse array of start-ups, partners and institutions from around the world into a cross-functional, multi-disciplinary team. Sparring with one another, they applied the latest technologies and thinking to develop advanced, high-efficiency solutions with real-world potential for the near future.

## Pioneering drivetrain for the electric era – waste not, want not

On any road trip, it's the car that does the work – soaking up the miles and leaving the driver and passengers to experience the journey. In the long-haul mindset that makes the VISION EQXX so special, efficiency is king.

With output of around 150 kW, the super-efficient **electric drivetrain** (encompassing everything from battery to electric drive unit to wheels) in the VISION EQXX provides the power and stamina underpinning this exceptional long-distance runner. More than a composition of individual parts, it is a work of engineering art in its own right. Tasked with a very clear and specific set of targets, the team set out to create an electric drivetrain with a world-beating combination of efficiency, energy density and lightweight engineering. So, let's throw in a figure here – 95% efficiency. That means up to 95% of the energy from the battery ends up at the wheels – pure and simple. Compare that to just 30% from even the most efficient ICE drivetrain or around 50% from an average human long-distance runner.

The Formula 1 experts at Mercedes-AMG High Performance Powertrains (HPP) in Brixworth (United Kingdom) know a thing or two about making every kilojoule of energy count. In an intense collaboration, Mercedes-Benz R&D worked with them hand-in-hand to redesign the drivetrain and slash the system losses.

*“One of the best ways to improve efficiency is to reduce losses,”* explains Eva Greiner, chief engineer of the electric drive system at Mercedes-Benz. *“We worked on every part of the system to reduce energy consumption and losses through system design, material selection, lubrication and heat management. And our fantastic simulation tools helped us find out quickly what works and what doesn't.”*

The **electric drive unit** in the VISION EQXX is a dedicated unit consisting of the electric motor, transmission and power electronics featuring a new generation of silicon carbides. The power electronics unit is based on the upcoming Mercedes-AMG Project ONE hypercar.

## Battery development at its best in collaboration with HPP

Rather than simply increasing the size of the battery, Mercedes-Benz and the HPP team developed a completely new **battery pack** for the VISION EQXX, achieving a remarkable energy density of close to 400 Wh/l. This benchmark figure is what made it possible to fit a battery pack with just under 100 kWh of usable energy into the compact dimensions of the VISION EQXX.

*“In effect, we fitted the energy of the EQS into the vehicle dimensions of a compact car,”* says Adam Allsopp, Advanced Technology Director from HPP. *“The battery has almost the same amount of energy but is half the size and 30% lighter. The battery management system and power electronics have been designed with an absolute focus on reducing losses. In achieving this efficiency milestone, we learned a lot that will flow into future development programs.”*

The substantial increase in energy density comes in part from significant progress in the chemistry of the anodes. Their higher silicon content and advanced composition mean they can hold considerably more energy than commonly used anodes. Another feature that contributed to the impressive energy density is the high level of integration in the battery pack. This platform, developed jointly by Mercedes-Benz R&D and HPP, created more room for cells and helped reduce the overall weight. The separate compartment for the electrical and electronic (EE) components, called the OneBox, likewise made more room for cells, with added benefits for installation and removal. The OneBox also incorporates novel safety devices with energy efficient operations that consume significantly less energy than the equivalent component in a production EV.

Tasked with pushing the envelope of technical feasibility on all levels, the battery development team also decided to experiment with an unusually high voltage. Increasing the voltage to more than 900 volts proved an extremely useful research tool for the development of the power electronics. The team was able to gather

a great deal of valuable data and is currently assessing the potential benefits and implications for future series production.

Several more aspects of the battery design add to its exceptional efficiency. For instance, its lightweight lid was engineered jointly by Mercedes-AMG HPP and their chassis partners at Mercedes-Grand Prix. The lid is made from a unique, sustainable composite material derived from sugar-cane waste, reinforced with carbon fiber, as used in Formula 1. The battery also features active cell balancing, which means drawing the energy evenly from the cells while the car is driving – in effect, giving it greater stamina. Overall, the battery weighs around 1,091 lbs, including the OneBox.

### **Taking the heat – the innovative thermal management system**

Those who paid attention in physics class will know that heat is an energy form in a new guise. The VISION EQXX has an advanced thermal-management system that preserves the thermal energy and, significantly reduces cooling drag. Both contribute to maximum efficiency.

How? The Mercedes-Benz “cooling-on-demand” concept has been further developed for the VISION EQXX not only for optimal cooling based on the prevailing circumstances. The exceptional efficiency of the electric drive unit means it generates only minimal waste heat. This helped keep the thermal management system extremely small and lightweight. The carefully engineered interaction of aero-shutters, coolant valves and water pumps ensures the electric drive unit, comprising the power electronics, electric motor and transmission, maintains the most efficient temperature balance at minimum energy cost. Technically, this system is a combination of an innovative air-flow management system and a cooling plate.

The cooling plate is installed in the vehicle floor, enabling it to take advantage of the air flowing along the underside of the VISION EQXX. This is the most aerodynamically efficient way of keeping the electric drive unit cool under normal conditions, allowing the vehicle to gain about 20 kilometers (12 miles) of range in the most aerodynamic mode.

Only when the weather is hot or the driving style is “lively” does the cooling system ramp up a notch. Shutters that are normally closed at the front of the VISION EQXX open when things heat up, and send extra cooling air along a system of air guides. The inlets for these air guides are cleverly located along the front bumper’s highest-pressure zone. Conversely, the outlets are in low-pressure zones along the top of the hood.

The beauty of this “cooling-on-demand” approach is that when the shutters are open, it adds only seven points (0.007) to the drag coefficient. If cooling is required when the vehicle is at a standstill, a backup cooling fan kicks in (thermal-efficiency mode).

### **Keeping the heat – a heat pump makes the most of ambient and waste heat**

The innovative heat pump in the VISION EQXX sucks up heat generated by the drive system and from the ambient air outside to keep the cabin cozy. Its impressive efficiency is a major boost for battery range in colder parts of the world.

This multi-source heat pump recovers waste heat from the drivetrain, and has an external heat exchanger that draws heat from the ambient air. Not available in previous Mercedes-Benz heat pumps, this feature increases the operating temperature range. This is especially handy for heating up the cabin quickly and is highly effective at lower temperatures. And to squeeze out every last bit of heat, it even uses the “evaporator enthalpy” when dehumidifying moist ambient air. Enthalpy is the latent energy released as heat when water vapor in the air changes state from gas to water.

## Let the sun shine in – more range thanks to solar power

The sun is the original source of all energy on Earth, but it can take a very circuitous path. So, it made perfect sense for the Mercedes-Benz development engineers to cut out the “middleman” and go straight to the big boiler in the sky for some extra oomph.

The electric system that powers many of the ancillaries in the VISION EQXX draws additional energy from 117 solar cells on the roof. It was developed in collaboration with the Fraunhofer Institute for Solar Energy Systems ISE – Europe's largest solar energy research institute. The net result of reducing the energy drain on the high-voltage system is an increase in range. On a single day and under ideal conditions, this can add up to 25 km (15 miles) of range on long-distance journeys.

The solar energy is stored in a lightweight lithium-iron-phosphate battery, which supplies a climate blower, the lights, the infotainment system and other ancillaries. Mercedes-Benz and its partners are working towards using solar power to charge the high-voltage system, too.

## Design and aerodynamics – a masterclass in conflict resolution

Over long distances on the open road, one of the biggest obstacles to efficiency is staring us in the face – yet we can't see it. The air may be fresh and inviting, but it wants to hold us in its grasp. Aerodynamic drag can have a big impact on range. On a regular long-distance drive, a typical electric vehicle dedicates almost two-thirds of its battery capacity to cutting its way through the air ahead, which is why the VISION EQXX has an ultra-sleek and slippery drag coefficient of 0.17<sup>8</sup>.

However, the disciplines of aerodynamics and design often have opposing interests as Gorden Wagener, Chief Design Officer Daimler AG and Mercedes-Benz AG explains: „*The VISION EQXX is a vision of the future that embodies the desire for the next level of luxury from Mercedes. As designers, we always think in terms of technology and aesthetics. The aerodynamics of the VISION EQXX embody this fusion of tech and aesthetic for us as designers. In line with our philosophy of Sensual Purity, we created spectacular proportions that combine beauty with efficiency. The resulting body flow delivers revolutionary aerodynamics. The fact that the end result is as beautiful as it bears testament to the skill of our design team working in close collaboration with the aerodynamics experts.*”

The team at Mercedes-Benz has a long tradition of working closely together to achieve stunning design with class-leading aerodynamics, from the W 125<sup>9</sup> in 1937 and the 1938 540K Streamliner to the Concept C111<sup>10</sup> from the 1970s to the current EQS. Another prime example is the Concept IAA of 2015<sup>11</sup>, which provided significant inspiration for the VISION EQXX. It was, for instance, the first Mercedes-Benz vehicle to make extensive use of active aerodynamic features to achieve notable improvements in drag coefficient paired with the distinctively elegant lines of Mercedes-Benz design.

A huge amount of work went into integrating the painstaking passive and active aerodynamic features into the external form of the VISION EQXX. The remarkable result was achieved on an impressively short timescale. The inter-disciplinary team used advanced digital modeling techniques to reach a compromise that reduces drag while retaining the sensual purity of the Mercedes-Benz design language and the practicalities of a road car.

*“It usually takes around a year to finalize the form,”* says head of aerodynamics at Mercedes-Benz Teddy Woll. *“We had less than half of that for the VISION EQXX. Lean, agile processes and mature digital*

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<sup>8</sup>  $c_d$  figure measured in the Daimler aero-acoustic wind tunnel at a wind speed of 140 km/h

<sup>9</sup> On January 28, 1938, the Mercedes-Benz W 125 record-breaking car set the world speed record on public roads, which is still valid today, with its  $c_d$  value of 0.17: Rudolf Caracciola reached a speed of 432.7 km/h on the A5 motorway between Darmstadt and Frankfurt at that time.

<sup>10</sup> The record-breaking C111-III had a drag coefficient of 0.183

<sup>11</sup> First non-sports car from Mercedes-Benz to feature active aerodynamics for a drag coefficient of 0.19

*tools make collaborative work far easier, with faster decision-making and more nimble compromises. We also needed fewer models and less time in the wind tunnel.”*

Despite the practical challenges and the compressed timescale, the success of the collaboration is evident in the sophistication and poise of the exterior design. The surfaces of the VISION EQXX run smoothly from the front, developing powerful yet sensual shoulders above the rear wheel arches. This natural flow concludes with a cleanly defined, aerodynamically effective tear-off edge accentuated by a gloss-black end trim, punctuated by the rear light clusters.

Painted in a striking Mercedes-Benz alubeam silver appearance, the body of the VISION EQXX cradles the smooth dome of the greenhouse as it flows elegantly like a water droplet towards the rear. The retractable rear diffuser is a powerful example of the collaboration between design, aerodynamics and engineering – deploying only at higher speeds when the air becomes a considerably tougher opponent. When retracted, it fits seamlessly into the bodywork, preserving the balance, proportions and lightweight aesthetic of the rear end.

However, it presented a significant engineering challenge. Standing toe-to-toe with the laws of physics, the development engineers working on it had to ensure this seemingly simple mechanism ticked a number of boxes. As well as functioning in all conditions, it also had to weigh next-to-nothing and instantly retract in event of a rear-ender.

The VISION EQXX has a number of less visually obvious, but equally important, active and passive aerodynamic details, such as its small frontal area. It is actually less than that of today’s CLA or even the vehicles from smart. And how many would notice that the rear track is 2 inches less than at the front? Another is the air curtain at the front bumper. This ingenious layout pairs with the wheel covers to remove almost every last whisper of aerodynamic separation from the front wheels. And while all that is going on, air pathways guide additional cooling air over the hood, opening the cooling shutters if necessary. This reduces the interference drag around the mirrors and lowers overall drag compared with a conventional outlet into the underbody.

Despite its small frontal area, the front of the VISION EQXX packs a big design punch. A band of light above the gloss-black grille with rose-gold highlights flows effortlessly into the energy-efficient headlights, reminiscent of those from the EQS. Each headlight consists of two star-shaped elements, the larger one housing both the low-beam and high-beam light arrays behind a glossy center lens. This arrangement, paired with the 2D star pattern on the front bumper, offers a preview of front-end design detailing that will feature in future Mercedes-Benz models.

#### **Efficient wheels and tires – optimized for rolling resistance and aerodynamics**

On every car, it is the tires that form the all-important interface with the road. For the VISION EQXX Mercedes-Benz engineers worked in cooperation with Bridgestone. Together, they took advantage of Bridgestone’s Turanza Eco tire combined with lightweight and environmentally friendly ENLITEN and ologic technology enabling ultra-low-rolling-resistance.

The tire design also features aerodynamically optimized sidewalls to match the covers mounted on the 20-inch, lightweight, forged-magnesium wheels. The semi-transparent double-spoke design of these covers meets all aerodynamic requirements while at the same time retaining a view of the rose-gold accents adorning the wheels.

#### **The beautiful simplicity of lightweight interior design**

Marking the launch of a new, super-purist design style, the VISION EQXX represents a new expression of efficiency in interior design. In a departure from the conventional design approach, the interior layout focuses

on just a few modules and the beautiful simplicity of lightweight design. This is expressed through the absence of complex shapes and the integration of lightweight structures into the interior aesthetic in a wholly organic way, making traditional trim elements unnecessary.

From mushrooms to vegan silk, nature's influence continues when we step inside the VISION EQXX. The lightweight luxury feel of the interior comes from extensive use of lightweight, sustainable materials and organic-inspired design detailing. The basic principle is maximum comfort and style with minimum weight – and absolutely no animal-derived products.

The interior features a large number of innovative materials sourced from start-ups around the world. For example, the door pulls are made from **AMsilk's Biosteel fiber**. This **high-strength, biotechnology-based and certified-vegan silk-like fabric** comes from the inventor of biofabricated (nature-identical) fiber. Combining revolutionary science with true environmental integrity, its use here marks a first in the automotive sector.

Another sustainable material gracing the interior of the VISION EQXX is **Mylo™**, a **verified vegan leather alternative made from mycelium**, which is the underground rootlike structure of mushrooms. It is certified bio-based, which means it is made predominantly from renewable ingredients found in nature. This completely new material category created by the power of biotechnology is designed to be less harmful to the environment and is used for details of the seat cushions in the VISION EQXX.

The animal-free leather alternative called **Deserttex®** is a **sustainable cactus-based biomaterial** made from cactus fibers combined with a sustainable bio-based polyurethane matrix. In this combination, the leather alternative has an exceptionally supple finish that is extremely soft to the touch. Forthcoming versions have a higher cactus content, giving this material the potential to halve the ecological footprint associated with conventional artificial leathers.

On the floor, the carpets in the VISION EQXX are made from **100% bamboo fiber**. In addition to being fast-growing and renewable, this natural raw material offers an extremely luxurious look and feel. Mercedes-Benz chose these sustainable, innovative, high-performance materials because they, and others like them, have the potential to replace all sorts of petroleum- and animal-based products currently used in automotive applications. Together, they show a way forward for luxury design that conserves resources and is in balance with nature.

Elsewhere, the VISION EQXX makes extensive use of recycled waste materials, such as the recycled PET bottles used in a shimmering textile to enhance the floor area and door trim. Higher up in the interior, the designers used **Dinamica** made from 38% recycled PET to create a wrap-around effect linking the upper edge of the screen with the doors and headliner. The interior also features **UBQ material**, a sustainable plastic substitute made from household and municipal landfill waste.

*“Working with these innovative, sustainable materials to design the interior of the VISION EQXX was a hugely liberating and exhilarating experience,” says Gorden Wagener, Chief Design Officer Mercedes-Benz AG. “They open up completely new avenues of creativity, and the visual and tactile finishes are exquisite. The upscale feel of the interior through the use of ambient lighting as well as silver, rose-gold and gloss black accents is a highly progressive interpretation of modern luxury for the all-electric era.”*

### **Body-in-white – intelligent, efficient and sustainable through bionic engineering and advanced materials**

When it comes to lightweight engineering, the best on Earth is Mother Nature. No one else comes close. Over millions of years, she has honed the finest examples of high-efficiency long-distance travelers – from the Monarch butterfly to the Arctic Tern.

With a considerably shorter timescale for the VISION EQXX, Mercedes-Benz engineers drew inspiration from her creations and pulled in some lateral-thinking external expertise to assist. The result is a weight efficient design derived from engineering excellence paired with a sustainable combination.

This intelligent use of sustainable advanced materials and methods inspired by nature is dubbed bionic engineering and was facilitated by a digital process called bionic mesh design. Mercedes-Benz has a long history of applying bionic engineering techniques dating back to its “bionic car” concept study from 2005.

### **BIONEQXX™ casting**

Currently the largest aluminum structural casting at Mercedes-Benz, BIONEQXX is the major structural component at the rear end of the VISION EQXX – the rear floor. It was developed in-house by Mercedes-Benz using entirely digital techniques and a software approach that is utterly unique within the automotive sector. The result is optimum functionality packaged within the compact dimensions of the available space. Furthermore, the team created this impressive and manufacturable one-part casting in just four months.

Taking their cues from organic forms, the development engineers sought to use material only where necessary for structural function, i.e. where loads are exerted. In line with the laws of nature, where there is no load there is no need for material.

The most important of the structural criteria is the need for very high rigidity and excellent crash performance. The beauty of the one-part BIONEQXX casting is the ability to pair this with functional integration within an extremely lightweight single component rather than an assembly of multiple parts joined together.

### **Bionic simulation with a touch of Hollywood magic**

So, how did they achieve this in such a short time? By applying a completely digital vertical process that provides a blueprint for the future development of production vehicles. In addition to classic optimization techniques, the team also applied a unique collaboration model that included graphics and polygonal modeling tools used in the 3D gaming industry and Hollywood animations.

Used by Mercedes-Benz engineers in the automotive context, these tools help identify stresses and load paths in a component. All of this happens digitally, before anything is cast in metal, speeding up the development process considerably, and enabling a bionic shell structure to be created in half the time.

The resulting one-part casting has a web-like appearance with gaps where there is no need for structural elements. However, the rear floor of a vehicle is subject to more than just physical loads in everyday use. It has to withstand attempts by nature to get inside the car in the form of water and dirt. To address this, Mercedes-Benz engineers turned once more to external partner UBX Materials. The sustainable plastic substitute developed by the Israel-based start-up is made from the kind of waste that typically ends up in landfill. This includes food and garden waste as well as mixed plastics, cardboard and even baby diapers. Two pounds of UBX removes 3 lbs of trash from landfill, of which around 0.6 lbs is water. The cooperation between Mercedes and UBX won the Sustainability Award in Automotive 2021 in the "best start-up"<sup>12</sup> category. UBX is not just suitable for prototype applications; it also offers very strong potential for transfer into series production in the near future.

The openings in the BIONEQXX rear-floor casting were closed using patches made from UBX produced on a 3D printer. A total of 42 UBX patches were designed using shape optimization to achieve extremely high stiffness and sound-dampening qualities. Once inserted into the BIONEQXX casting using a special bonding process, the final unit is fully sealed against the effects of water and dirt. The resulting part

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<sup>12</sup> Sustainability Award in Automotive 2021 | Roland Berger

indicates that this innovative engineering approach has the potential to achieve weight savings of between 15 and 20% compared to a conventionally produced component. It marks a milestone in lightweight design that meets the exacting Mercedes-Benz quality requirements.

### **BIONICAST™ damper dome**

BIONICAST is a Mercedes-Benz registered trademark applied to structural castings engineered according to the principles of nature. In addition to the BIONEQXX rear-floor casting, another BIONICAST component that features in the VISION EQXX is the damper domes which accommodate the suspension components at the front of the car. Like the BIONEQXX casting, they too contribute significantly to keeping weight to a minimum, saving around 9 lbs compared with conventional pressed domes. The bracket carrying the windshield wipers and motor on the VISION EQXX was likewise designed using principles of bionic engineering. Here, too, the pioneering technique proved invaluable in keeping weight to a minimum while maximizing functionality within the tight packaging constraints.

This technology has already been transferred to Mercedes-Benz production models. For instance, the chassis components in the new EQS have been modified to reduce weight by increasing stiffness.

### **Advanced bodyshell materials deliver progress in lightweight design, safety and sustainability**

The VISION EQXX features a raft of advanced materials that deliver practical functionality and safety to exacting Mercedes-Benz standards. Several of these materials are currently being used in the development of future production models.

The MS1500 ultra-high strength martensitic steel used in the VISION EQXX marks a first for a Mercedes-Benz body-in-white application. The exceptional strength of this material offers excellent occupant protection in the event of a crash, while keeping weight to a minimum.

The body-in-white of the VISION EQXX is one of the first Mercedes-Benz applications of low-CO<sub>2</sub> flat steel produced with 100% scrap using an electric-arc furnace technique. These low-CO<sub>2</sub> steel grades have been introduced recently in Mercedes-Benz production vehicles and represent a blueprint for future models. In fact, the cooperation between Mercedes-Benz AG and **Salzgitter Flachstahl GmbH** won the MATERIALICA Design + Technology Gold-Award 2021<sup>13</sup> in the category "CO<sub>2</sub>-Efficiency".

The doors of the VISION EQXX are made from a hybrid of CFRP and GFRP (carbon- and glass-fiber reinforced plastics) components with aluminum reinforcements. As well as the weight benefits, this design also achieves a careful balance of stiffness and ductility in the event of a crash. Meanwhile, a new polyamide foam reinforces the lower edge of the door and optimizes energy absorption in a side-on collision.

Lightweight design thinking was applied throughout the VISION EQXX. On the chassis, aluminum brake discs reduce the mass significantly compared with cast steel discs. As well as being completely corrosion-free, this brake system designed by Mercedes-Benz Advanced Engineering also reduces brake dust emissions by up to 90% thanks to an innovative coating. Meanwhile, new advanced glass-fiber-reinforced plastic springs developed in partnership with **Rheinmetall Automotive** remove further weight compared with conventional coil springs.

### **Neuromorphic computing – a car that thinks like you**

Another key efficiency feature of the VISION EQXX that takes its cue from nature is the way it thinks. It uses an innovative form of information processing called neuromorphic computing. The hardware runs **spiking neural networks**. Information is coded in discrete spikes and energy is only consumed when a spike occurs, which reduces energy consumption by orders of magnitude.

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<sup>13</sup> MATERIALICA Design + Technology Award 2021 | Salzgitter Flachstahl GmbH

Working with California-based artificial intelligence experts BrainChip, Mercedes-Benz engineers developed systems based on BrainChip's Akida hardware and software. The example in the VISION EQXX is the "Hey Mercedes" key-word detection. Structured along neuromorphic principles, it is five to ten times more efficient than conventional voice control.

Although neuromorphic computing is still in its infancy, systems like these will be available on the market in just a few years. When applied on scale throughout a vehicle, they have the potential to radically reduce the energy needed to run the latest AI technologies.

### **UI/UX in the VISION EQXX – the non-judgmental road trip sidekick**

On a road trip, it's good to have someone along for the ride. A road trip sidekick helps with the navigation. They might be in charge of the music selection. Or perhaps they're clutching the travel guide, pointing out places of interest and fascinating nuggets of information along the way. They might even offer the occasional "tip" on driving style. Admittedly, however, this kind of "help" can also be a source of friction. In the VISION EQXX, all of this and more is handled by the car, allowing the driver and passenger to relax and enjoy each other's company.

The VISION EQXX shows us the potential of game-engine-powered interfaces, with graphics as they've never been seen before and a highly adaptive design. The UI demonstrates how real-time graphics enables new digital worlds which instantly respond to the driver's needs and bring the real-world into the car.

The user interface and user experience inside the VISION EQXX catapults us into a highly responsive, intelligent and software-driven future. Stunning to look at, intuitive to work with and in tune with the human mind, the first ever completely seamless display in a Mercedes-Benz spans 47.5 inches from one A-pillar to the other. With an 8K (7680x660 pixels) resolution, the thin, lightweight mini-LED display acts as a portal connecting the driver and occupants with the car and the world outside. A star-cloud avatar, reminiscent of our name-sake Mercedes Jelinek, is the ethereal guide. Shape-shifting in response to the driver's needs and taking care of the passengers, she makes the journey into a luxury experience. The system manages information to ensure the driver has what they need when they need it – on their terms.

The Mercedes-Benz team worked with navigation experts NAVIS Automotive Systems, inc. (NAVIS-AMS) to develop the first real-time 3D navigation system on a screen of this size. It performs seamless zoom and scroll functions from satellite view down to a height of 33 feet in the 3D city representation. Executed on the one-piece display, it offers the user stunningly clear, accurate and intuitive route guidance.

The road trip sidekick in the VISION EQXX is also fun to talk to. The further development of the "Hey Mercedes" voice assistant is emotional and expressive thanks to a collaboration between Mercedes-Benz engineers and the voice synthesis experts from **Sonantic**. With the help of machine learning, the team has given "Hey Mercedes" its own distinctive character and personality. As well as sounding impressively real, the emotional expression places the conversation between driver and car on a completely new level that is more natural and intuitive, underscoring the progressive feel of the modern luxury conveyed by the UI/UX in the VISION EQXX.

### **Efficient use of energy and information**

The one-piece display is also highly energy efficient. Its mini-LED backlight consists of more than 3000 local dimming zones, meaning it consumes power only as and when needed in specific parts of the screen.

The 3D navigation screen adapts to the type of content being shown. For instance, if you're driving in an urban area, abstract visualization of the surrounding buildings helps provide orientation amid densely packed streets. However, if you are traveling on the highway or open road, the level of detail diminishes to provide

a clearer overview of the journey. This has the added efficiency benefit of reducing the energy consumption of the display.

As well as providing seamless navigation, the intelligence in the VISION EQXX can mine for data based on the car's route, with the avatar on hand to function as an intelligent tour guide. It can even help you manage your music library and offer local suggestions.

There is also a system to help you drive more efficiently. From energy flow to terrain, battery status and even the direction and intensity of the wind and sun, the efficiency assistant curates all the available information and suggests the most efficient driving style. This actually enhances the driver's own senses by providing input on external conditions that the driver themselves is unable to feel directly – in the way that, for instance, a cyclist can feel the force of the wind or the extra effort involved to pedal uphill. This sensorial support is further augmented by the ability of the VISION EQXX to use the map data to “see into the future”, anticipating what lies ahead to help the driver take advantage of it in a way that maximizes efficiency. A cool orb graphic in the display provides an instinctive overview, underpinned if desired by sound.

And if more detailed information is what you want, a series of screens will tell you all you need to know with easy-to-follow visuals and infographics. The influence of current acceleration, gradient, wind and rolling resistance on energy consumption are shown in real time. If it's a full analysis you want – you got it. Equally, if you're someone who prefers to travel on a “need to know” basis, the VISION EQXX will remain silent.

The simplicity of the interface is a further development of the Zero Layer concept first used in the EQS, which eases driver-vehicle interaction by removing submenus. The interface is efficient and effective, thanks to intelligence and personalization. Highly proactive, it shows you what you need when you need it, with an intuitive zoom feature providing access to all functions. Your human road trip sidekick has their own dedicated zoom feature and entertainment zone. And if you prefer to travel alone, this part of the display powers down to save energy.

### **Weaving sound into the equation**

Lastly, the sound system in the VISION EQXX is interwoven into the UI/UX to deliver an impressive 4D experience with exceptional energy efficiency. A typical sound system can be a significant energy consumer, so Mercedes-Benz engineers looked closely at how to optimize the sound experience while minimizing energy consumption. This can be done by reducing the degradation that sound waves experience when they are absorbed by or bounce off interior surfaces.

Reducing the overall number of speakers and positioning them very close to the individual occupants dramatically reduces the distance the sound travels. Two broadband speakers installed in each headrest are paired with a bass exciter in each seat. The VISION EQXX uses the exciters for regular audio output as well as for vehicle sounds, haptic feedback and auditory warning. The efficient pairing of sound and haptic feedback is a energy-efficient way of increasing perception and awareness through the use of more stimuli.

As well as reducing energy consumption, the layout of sound system in the VISION EQXX also facilitates multiple different sound zones. The efficiency assistant takes advantage of the sound system to communicate its recommendations to the driver via a series of intuitive audio “cues”. These were inspired by the cues used by Formula E motor racing to help the drivers perform more efficiently.

### **The development and testing process – a digital journey driven by software**

The global road trip to electric mobility is fueled by advanced software and digital processes. The highways and byways are many and varied, the attractions and connections along the way inspiring.

Pulling together such a diverse array of expertise and innovative ideas from around the world to create the VISION EQXX in half the time was a masterclass in software management. The team made extensive use of open-source technology, augmented by elements created in-house. Agile working practices and monthly release planning ensured a continuous flow of end-to-end functions and early integration of solutions.

The scale of the digital development work involved in designing and engineering the VISION EQXX is truly groundbreaking. Highly advanced digital tools such as augmented and virtual reality dispensed with the need for time-consuming physical mock-ups. It also facilitated simultaneous development work by remote teams working in different parts of the world – from Stuttgart (Germany) to Bangalore (India) and from Brixworth (UK) to Sunnyvale (California). This massive uplift in digital power slashed the time spent in the wind tunnel from more than 100 hours to just 32. It also meant more than 186,411 miles of test driving was covered virtually.

The digital development made extensive use of Software in the Loop (SiL) systems. This kept the commissioning phases with the real hardware extremely short and enabled us to drive large-scale tests early on in the project. Using this approach, the team was able to install the drive unit, flash the software and get the wheels turning on the VISION EQXX within the space of just two hours. This extremely nimble, efficient and responsive teamwork was made possible by a combination of a motorsport mindset and intelligent use of the comprehensive testing options at Mercedes-Benz.

This highly effective and efficient digital development approach means that many of the innovations in the VISION EQXX could be quickly adapted for production applications.

## DID YOU KNOW, THAT THE VISION EQXX...

### ...achieves more with less

Being efficient is all about cutting waste to an absolute minimum to make the most of what you have, be that energy, time or resources. In the Mercedes-Benz VISION EQXX, efficiency means more range from less energy, more tangible luxury and convenience with less impact on nature, and more electric mobility with less waste. It also means radically shorter development times through the application of advanced digital tools and cross-functional teamwork.

### ...can get from Berlin to Paris on a single charge

A single charge of the VISION EQXX would take you from Berlin to Paris, from New York City to Cincinnati, Ohio, or from Beijing to Nanjing. Not because it has a big battery, but because it's highly efficient. Based on average distances driven per year, a driver in the U.S. or China would have to fully recharge the VISION EQXX only twice per month and in Europe just once per month<sup>14</sup>.

### ...is the electric equivalent of a “1-litre car”

The VISION EQXX uses less than 10 kWh of electrical energy to travel 100 km<sup>15</sup>. That equates to traveling 6 miles on 1 kWh of electrical energy. But what does that mean? Translated into fossil-fuel consumption, this is around the golden figure of 1 liter per 100 kilometers (235 mpg).

Here are a few examples of what 10 kWh of energy delivers in other areas of life:

- Run a tumble dryer for just over 3 hours
- Run an average domestic air conditioner for around 3 hours
- Use an iron for 5 hours
- Watch a 50-inch LED TV for 100 hours
- Run the conventional (non-LED) floodlights at a major sports stadium for around 3 minutes

### ...is more aerodynamic than a football

On a long-distance journey, a typical EV uses around two-thirds of its energy just pushing its way through the air. At 0.17<sup>16</sup>, the ground-breaking cd figure of the VISION EQXX can make a big difference at highway cruising speeds. A reduction of just 0.01 adds around 2.5% to the range. Let's put that into context with a few other drag coefficients:

- Penguin – 0.05
- VISION EQXX – 0.17<sup>16</sup>
- EQS – 0.20
- Football – 0.18 to 0.2
- Cyclist – 0.6 to >0.8
- Person – 0.8 to 1.2
- Parachute – 1.1 to 1.3

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<sup>14</sup> The average American drives 21,600 km (13,500 miles) per year. In Europe, that figure is around 12,000 km (7,500 miles) and in China 20,000 km (12,500 miles). <https://www.fhwa.dot.gov/ohim/onh00/bar8.htm>  
[https://www.globalfueleconomy.org/transport/gfei/autotool/case\\_studies/apacific/china/cs\\_ap\\_china.asp](https://www.globalfueleconomy.org/transport/gfei/autotool/case_studies/apacific/china/cs_ap_china.asp) <https://www.odyssee-mure.eu/publications/efficiency-by-sector/transport/distance-travelled-by-car.html>

<sup>15</sup> Range figures preliminary and based on digital simulations in real-life traffic conditions. The VISION EQXX has not undergone type approval or homologation.

<sup>16</sup> c<sub>d</sub> figure measured in the Daimler aero-acoustic wind tunnel at a wind speed of 140 km/h

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**Mercedes-Benz AG at a glance**

Mercedes-Benz AG is responsible for the global business of Mercedes-Benz Cars and Mercedes-Benz Vans, with over 170,000 employees worldwide. Ola Källenius is Chairman of the Board of Management of Mercedes-Benz AG. The company focuses on the development, production and sales of passenger cars, vans and vehicle-related services. Furthermore, the company aspires to be the leader in the fields of electric mobility and vehicle software. The product portfolio comprises the Mercedes-Benz brand with the brands of Mercedes-AMG, Mercedes-Maybach, Mercedes-EQ, G-Class and the smart brand. The Mercedes me brand offers access to the digital services from Mercedes-Benz. Mercedes-Benz AG is one of the world's largest manufacturers of luxury passenger cars. In 2020 it sold around 2.1 million passenger cars and nearly 375,000 vans. In its two business segments, Mercedes-Benz AG is continually expanding its worldwide production network with around 35 production sites on four continents, while gearing itself to meet the requirements of electric mobility. At the same time, the company is constructing and extending its global battery production network on three continents. As sustainability is the guiding principle of the Mercedes-Benz strategy and for the company itself, this means creating lasting value for all stakeholders: for customers, employees, investors, business partners and society as a whole. The basis for this is Daimler's sustainable business strategy. The company thus takes responsibility for the economic, ecological and social effects of its business activities and looks at the entire value chain.