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VIAVISION

VOLKSWAGEN  SHAPING THE FUTURE OF MOBILITY



THE GOLF GTE

The best of both worlds

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THE OPTIMAL SOLUTION TOWARDS ELECTRO-MOBILITY

Dr. Heinz-Jakob Neußer on the new Golf GTE



Dr. Heinz-Jakob Neußer, Board Member of Management for the Volkswagen Brand and Head of Powertrain Development.

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Why are there so many different types of engine for the Golf?

Because our customers want them. We can fulfil those wishes using our modular transverse matrix (MQB). With this technical innovation, we are able to offer our customers all the different types of engine that are available today; from TSI, TDI and CNG drives, to plug-in hybrids and pure electric drives. The Golf is one of our most popular cars in Europe. With this extensive offering, Volkswagen can now meet the individual mobility requirements of customers all over the world. At the same time, we are in an excellent position to react to changes in emission standards or the need for emission-free mobility in mega-cities. This has been our goal right from

the start. Even during our first strategic deliberations about modular and drive strategy, we primarily wanted to keep as many operational options available to Volkswagen Group as possible – in order to react quickly and flexibly to change. This plan has come to fruition. We can, to give an example, install alternative drives in up to 40 different car models using our modular transverse matrix.

With it our customers are given the option to configure their favourite car with their favourite engine. In order to make this possible during car manufacturing, we have taken this flexibility into consideration in the development of our factories, and have optimised and adapted manufacturing processes with

regard to it. This allows us to produce vehicles with different drives on the same production line.

Most of all, alternative drives are about reducing fuel consumption and consequently CO₂ emissions. Why has Volkswagen decided to equip the Golf GTE with such a sporty engine concept nonetheless?

It is not quite right to think that a sporty, dynamic vehicle necessarily has high consumption. Our plug-in hybrid is an alternative drive that enables very low consumption and dynamic driving. We have combined these qualities in the Golf GTE. The fun of driving does not fall by the wayside with this car. The Golf GTE has a standardised consumption of 1.5 litres per 100 kilometres and CO₂ emissions of 35 grams per kilometre. These numbers show that we have created a very economical car. A total range of 939 kilometres more than fulfils the need for long-range mobility. The car really offers perfect stats in every way.

The Golf GTE can drive electrically, but still needs the combustion engine for long distances. Does the Golf GTE herald a new kind of mobility?

The Golf GTE is an optimal solution on the way towards pure electro-mobility. In this car, we have combined the best of both worlds: a highly efficient combustion engine and a modern electric engine that represents the emission-free mobility of the future. Currently, combustion engines are indispensable for long-distance vehicles while electric

engines offer a highly efficient, economical and environmentally-friendly transport option for short journeys. With its highly efficient TSI-1.4 litre engine and its newly developed dual-clutch transmission in combination with an electric engine installed between the combustion engine and the transmission, the Golf GTE fulfils the requirements of a modern drive concept.

Why is Volkswagen constructing the Golf GTE as a plug-in hybrid and not as a full hybrid?

The decision to build the Golf as a plug-in hybrid has really added a new concept to our portfolio that answers the requirements of urban, emission-free mobility as well as our customers' demands concerning long-distance mobility.

Shorter distances can be driven purely electrically with our plug-in hybrid, just as in an e-car. This is why we have kept a pure electrical range of 50 kilometres in the Golf GTE. This would not be possible with a full hybrid. The driving profile of the majority of our customers is covered by this range. During weekend trips, the efficient TSI engine provides the necessary range.

Does it make sense to develop the Golf GTE in addition to the e-Golf?

Due to different emission standards around the world, it is absolutely vital to keep both drive concepts in the portfolio. Although both e-Golf and Golf GTE have an electric engine on board, they are nevertheless very different concepts. The e-Golf is a purely electric car with a

maximum range of up to 190 kilometres and is thus more suited to emission-free use in urban and nearby areas. The Golf GTE on the other hand has an electrical range of 50 kilometres and thus, for example, enables emission-free driving in areas where this is required by law. Combining the two types of drive, the Golf GTE becomes an environmentally-friendly car that answers every wish.

Why has Volkswagen decided to mass produce the plug-in hybrid Golf instead of the Twin up!?

The Twin up! was a study that we presented at the car show in Tokyo in order to test the response to such a car. With this car, we have shown that the drive of the XL1 can be installed in other vehicles too. One of the goals that we kept our eyes on during the development of the XL1 technology carrier was the subsequent transfer from this to projects for mass production. This is why today we do not want to rule anything out for the future. For now, the Twin up! remains an interesting study that has caused a lot of interest from the public.

In March 2008, we introduced a Golf study of a hybrid at the Geneva Motor Show and this year the Golf GTE is coming to market. It is not impossible for a study to become a mass produced vehicle.

STRONG DUO

These drives power the Golf GTE

The powertrain of the Golf GTE is a parallel hybrid: with its electric motor and its internal combustion engine, the GTE features two sources of drive that are connected to each other in the hybrid mode. With a system output of 150 kilowatts, the GTE is not only very economical but also very dynamic. In addition, its maximum range is 939 kilometres.

E-MACHINE



Motion in the electric motor is caused by the alternating attraction and repulsion of opposing and same polarity magnets. The Golf GTE is equipped with a permanently excited synchronous machine with a maximum output of 75 kilowatts. The permanent magnets in the rotor, the movable part of the motor, are alternating south and north poled magnets. The stator, the fixed part of the motor, generates a rotating magnetic field, created by applying current to the three-phase copper coils. As a result of the interaction with the permanent magnets, the rotor turns at a speed synchronous to the rotating magnetic field of the stator. The compact e-machine in the Golf GTE is installed between the engine clutch and the drive clutches.



POWER ELECTRONICS



The power electronics are responsible for the conversion of electric current. To do this, it is connected to the electric motor and the battery. In electric motor mode, six high-power transistors convert the direct current of the high-voltage battery into a three-phase alternating current that powers the electric motor. In generator mode, the power electronics rectify the alternating current generated. This supplies the electrical system and charges the high-voltage battery.

COMBUSTION ENGINE

A 1.4-litre four-cylinder TSI engine with an output of 110 kilowatts is part of the drivetrain. The power is transmitted via a six-speed dual clutch transmission. The unit is part of the modular transverse matrix. When the Golf GTE is driven purely electrically, the engine remains switched off. It was constructed specifically in order to provide full power instantly.



Parallel hybrid: two fully-fledged drives are available in the GTE.



TECHNICAL DATA	
Combustion engine:	110 kilowatts/150 hp
Electric motor:	75 kilowatts/102 hp
System:	150 kilowatts/204 hp
Maximum torque, combustion engine:	250 newton metres
Maximum torque, electric motor:	330 newton metres
Maximum torque, system:	350 newton metres
Electric range:	50 kilometres
Electric consumption:	11.4 kilowatt hours per 100 kilometres
Acceleration 0-100 km per hour:	7.6 seconds
Maximum speed:	217 km per hour 222 km per hour with boost function
Fuel consumption (NEDC):	1.5 litres per 100 kilometres
CO ₂ emissions:	35 grams per kilometre
Unladen weight:	1,540 kg

DUAL CLUTCH GEARBOX

The newly developed six-speed dual-clutch transmission facilitates the combination of a transversely mounted internal combustion engine with an e-machine. The power flow is transferred over the input shaft into two separate transmissions, each with an upstream drive clutch. Except for the mechanical parking lock, this is controlled by an electro-hydraulic control module.

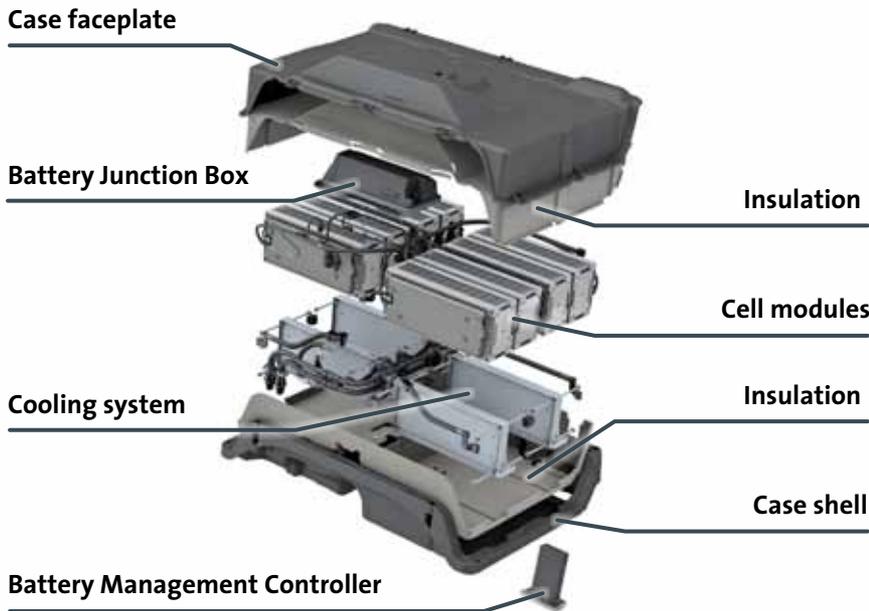


ENERGY SOURCE

The battery in the Golf GTE

The hybrid vehicle is mainly characterised by the fact that it has two types of engine. Next to the traditional internal combustion engine, the electric motor enables zero-emission driving. The energy for the electric motor comes from a 120 kilogram battery that needs to meet very high requirements concerning crash safety or extreme temperature in the vehicle. A lithium-ion high-voltage battery is installed in the Golf GTE. A conventional 12 volt starter battery is installed in the Golf GTE for the conventional electrical system.

Storage medium



DATA SHEET	
Size:	710 x 948 x 267 millimetres
Weight:	120 kilograms
Cell modules:	8, each with 12 cells
Energy content:	8.8 kilowatt hours
Voltage:	352 volts

The lithium-ion high-voltage battery is installed in the underbody of the car and connected to the power electronics. The battery management system, consisting of Battery Junction Box and Battery Management Controller, monitors and controls the battery and its energy flow.

Energy Boost

The battery must be charged in advance in order to provide energy for the drive. The high-voltage battery in the Golf GTE is fully charged within 3,5 hours, using a normal domestic 230 volt outlet with a charging power of 2,3 kilowatts. This only takes 2,5 hours if a Wallbox or a public charging station with a charging power of 3,6 kilowatts is used. The battery charges using alternating current in both cases; the plug employed is standardised. It is planned to equip all electric cars in Europe with these in the future.



The Wallbox increases the charging power in a domestic garage to 3,6 kilowatts, reducing charging time by up to one hour.

Recuperation

Recuperation in a car means the recovery of motion energy, also called kinetic energy. Electric energy is generated, as a side effect, during the propulsion and braking phases. Therefore, when the car is meant to decelerate anyway, the car's battery is charged using this energy. The drive motor in an electric car functions temporarily as a generator to charge the battery of the hybrid system. This way, the energy already invested into driving can be used as fully as possible thanks to recuperation.

GRAN TURISMO

The Golf's GT philosophy

GT is short for Gran Turismo and synonymous with sportiness. The Golf GTE expands Volkswagen's product range by a third GT model.

GTI



The first Golf GTI was became available in 1976, here the "I" stands for "injection". This refers to the engine's electronic fuel injection. Since market launch, the GTI has constantly been improved upon. The current version was presented in 2013 and produces up to 169 kilowatts from a displacement of 2.0 litres. However, the consumption is only 6.4 litres per 100 kilometres.

GTD



A sporty type of Golf with diesel injection was introduced in 1982 with the GTD. This car too was brought up to the latest standards of design and technology in 2013. The 2.0 litre TDI of the GTD produces 135 kilowatts and the average consumption is just 4.2 litres per 100 kilometres.

GTE



The GTE is the newest GT extension of the Golf range – a hybrid car of the sporty kind. Here, the "E" stands for the additional electric drive. The GTE is the logical development of sportiness and economy.

HYBRID VARIETY

The different types of hybrid

A hybrid vehicle combines the advantages of an internal combustion engine with those of an electric drive. This solves the system related problems of electromobility, such as range or the capacity of the battery systems. However, hybrid does not equal hybrid – there are differences both in the range of possible functions as well as in the construction.

Functions

MICRO HYBRID

Micro hybrids are start-stop systems which are operated in the range of 12 to a maximum of 48 volts and have a purely recuperative function. Due to the low voltage level and the generator technology used, the performance of the system is limited.

Functions:

- *Start-Stop*
- *Recuperation*

MILD HYBRIDS

Mild hybrids have a higher performance and voltage level, and can recover significantly more energy during braking, through recuperation, compared to a micro hybrid. The internal combustion engine and e-motor are seated on the same shaft. Additional power (Boost function) can be provided by the simultaneous use of electric and combustion engine during acceleration.

Functions:

- *Start-Stop*
- *Recuperation*
- *Boostfunction*

FULL HYBRID

Full hybrids, with a system voltage greater than 100 volts, have better performance than mild hybrids. Pure electric driving is possible over a limited range and with limited speed. In order to reduce consumption, and to avoid drag losses, the combustion engine is disconnected by a decoupler, or its speed is set to zero with an electronic, continuously variable transmission when driving electrically and during recuperation.

Functions:

- *Start-Stop*
- *Recuperation*
- *Boostfunction*
- *Pure electric drive*

PLUG-IN HYBRID

The plug-in hybrid electric drive has a higher performance and range during pure electric driving than a full hybrid. A special feature of these systems is their ability to recharge the battery via the power grid. Their electric range depends on the energy content of the battery systems used.

Functions:

- *Start-Stop*
- *Recuperation*
- *Boostfunction*
- *Pure electric drive*
- *External charging*

Construction

PARALLEL HYBRID

The electric motor creates additional torque for the boost function on the same shaft as the internal combustion engine. The same applies to the recuperation for battery charging. The engine can be decoupled from the drive for electric driving or recuperation, and be started again during electric driving. The performance of the internal combustion engine and electric motor is introduced directly into the transmission. This requires a downstream automated multi-speed transmission, such as Volkswagen's dual clutch gearbox.

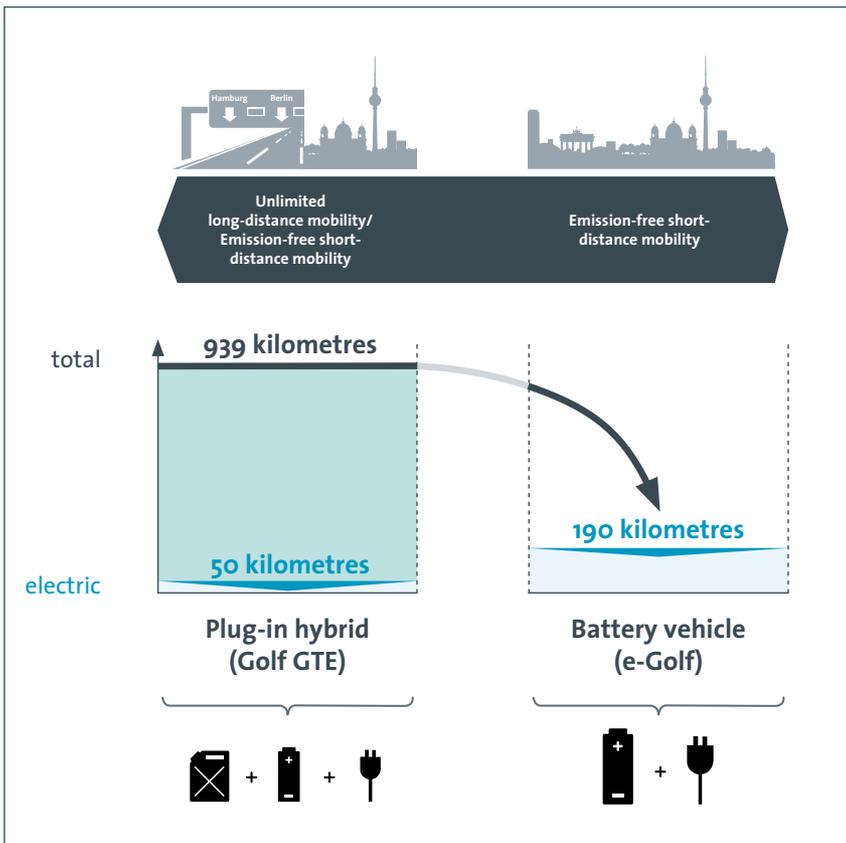
SERIES HYBRID

Series hybrids have two electric motors, with one electric motor operating on the same shaft as the internal combustion engine and converting mechanical energy into electric power. The second electric motor is supplied with the energy generated and propels the vehicle. Due to the performance and torque characteristics of electric motors, a multistage transmission is not required for a drive that is in continuous operation.

SERIES-PARALLEL HYBRID

The series-parallel hybrid, also called a power-split hybrid, is a combination of parallel hybrid and serial hybrid with two electric motors. The electric motors and the combustion engine are connected to each other with a planetary gear unit (see Glossary). The engine output is split through the transmission. A part of the power flows directly to the wheels. Another, larger proportion is transformed into electric energy in the electric motor. This is in turn fed to the second electric motor and, depending on driving conditions and load requirements, to the high-voltage battery.

**Range Comparison:
Golf GTE versus e-Golf**



The plug-in hybrid combines the advantages of emission-free short-distance mobility with unlimited long-distance mobility.

Glossary

Planetary gear:

The planetary gear mechanism consists of an outer ring gear, a centre wheel – the so-called sun gear – and a group of planetary gears. The planet gears mesh between the ring gear and sun gear. The planetary gear facilitates the transmission of high torques in a compact design, because the load is distributed to multiple planet gears.

Boost function:

The boost function combines the internal combustion engine's, and electric motor's, power on the wheels, achieving higher torque and performance values than a single motor. This noticeably increases the acceleration capability of the vehicle.

Permanently excited synchronous machine:

A permanently excited three-phase synchronous machine is an electric motor, which is called synchronous because its rotor rotates at a speed synchronous to the circular moving magnetic field of the stator and therefore runs smoothly even at low speed. The magnets of the rotor are permanently of north or south polarity. A current consisting of the individual alternating currents, called a three-phase alternating current, flows through the coils of the stator.

SMART HIGHLIGHTS

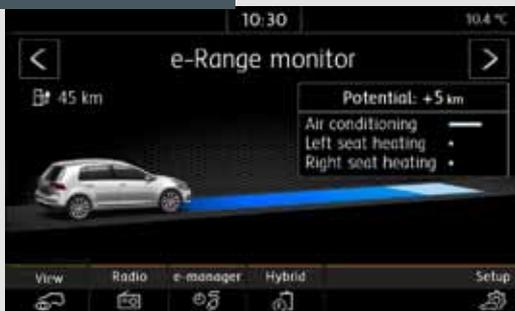
The GTE has even more to offer

It is also the little features that make the Golf GTE an innovative vehicle. Innovations from the fields of information technology and user friendliness allow for comfortable and economic driving. The solid-borne sound sensor that triggers the airbag even faster in an accident provides additional safety.

Technology in the field of view

Given the large number of technical innovations, one thing is essential to the driver: maintaining an overview of the vehicle's technology. To ensure this happens intuitively, the Golf GTE is equipped with a touch screen, which always keeps the driver up-to-date during driving. In addition, owners can access a range of information from a distance on their smartphone using a special app.

RANGE MONITOR



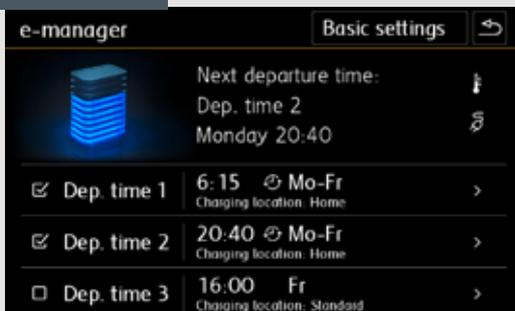
The range monitor shows the driver how far he can drive purely electrically. This function also explains how to increase the range by switching off auxiliary energy consumers, such as climate control or heated seats.

POWER METER



The power meter supplements the rev counter on the left side of the instrument panel. It indicates if the high-voltage battery is currently charging via recuperation or if energy is being discharged.

E-MANAGER



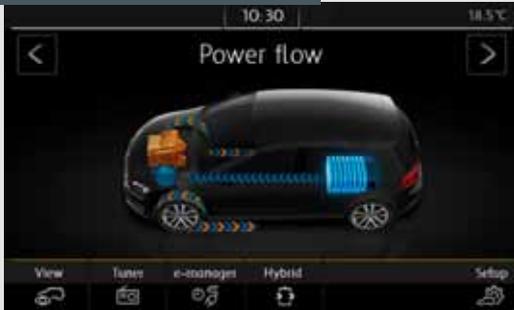
Thanks to the E-Manager, three different departure and charging times can be pre-set. The Golf GTE sets the required interior temperature as well as the battery's state of charge ready for these times.

360° RANGE



A map of the environment shows the current possible radius of action when driving purely electrically. Nearby charging stations as well as the remaining range can be displayed.

ENERGY FLOW DISPLAY



The energy flow display shows the flow of power during acceleration and braking, or rather recuperation, in animated form. The energy of the electric motor is illustrated with blue arrows, that of the internal combustion engine with yellow arrows.

CAR-NET E-REMOTE



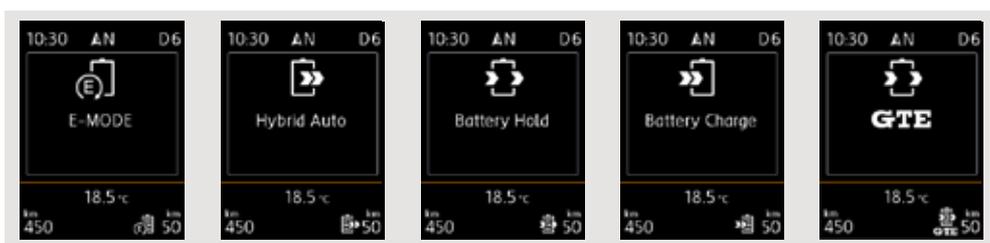
The “Volkswagen Car-Net e-remote” smartphone app can pre-set the climate control, the departure time and control battery charging. In addition, parking spaces can be located remotely and it also checks if the doors are closed. Vehicle data and statistics, such as kilometres driven, driving time and fuel consumption data are available on demand.

Safety on call

The Golf GTE is also up-to-date in terms of safety. The so-called solid-borne sound sensor facilitates an earlier and more accurate deployment of the airbag. Airbags and other restraint systems such as seat belt pretensioners must be triggered within a few milliseconds to protect the vehicle occupants in the event of a severe frontal collision. However, if it is a lighter accident, for example, a parking bump, triggering the restraint systems should be avoided. The protective effect is not required in this case, and repair costs can be saved. Conventionally, the deceleration of the car is detected by the vehicle’s sensor system. Whether the airbag needs deploying is calculated using this data. Additional acoustic deceleration signals are measured and evaluated by the solid-borne sound sensor. These signals originate from structure-borne sounds during the rapid deformation of the supporting structures in the front of the vehicle. The signals propagate rapidly in the vehicle structure and very quickly supply accurate information about the severity of an accident.

Driving fun at the push of a button

The Golf GTE can be driven in three different modes – pure electric, with the combustion engine or as a hybrid. If the driver activates the “E-mode” button, the Golf GTE drives purely electrically. The maximum range in this mode is 50 kilometres, the maximum speed is limited to 130 kilometres per hour. If the driver pushes the GTE button, the GTE mode is activated. Now the driver can reach a top speed of 217 kilometres per hour. A top speed of 222 kilometres per hour can be reached for a short time using the boost function. The car now accelerates from standstill to 100 kilometres per hour in 7.6 seconds.



If the driver changes from one mode to another, a pop-up in the display indicates the current mode. In hybrid mode, the driver can also choose if the battery should be charged, kept in its current state of charge, or be in operation until it is discharged.

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THE GOLF GTE

The best of both worlds



THE GOLF GTE ACCELERATES TO
100 KILOMETRES PER HOUR IN 7.6
SECONDS

THE PURE ELECTRIC RANGE OF THE
GOLF GTE IS 50 KILOMETRES