Mercedes-Benz

Mercedes-Benz Citaro with full-electric drive system

Press Information

eWorkshop: the Mercedes-Benz Citaro goes electric

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Mercedes-Benz – A Daimler Brand

Locally emission-free and almost silent through the city

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Stuttgart - The full-electric Mercedes-Benz Citaro runs locally emission-free and almost silently, taking electric mobility using city buses to a new level. The 12-metre variant will celebrate its world premiere in September at the IAA Commercial Vehicles show, with the start of series production also taking place this year. The new Citaro offers an impressive and hitherto unknown standard of energy efficiency. The intelligent modular concept for its battery and charging technology is similarly compelling.

Citaro: from low-emission bus to zero-emission bus

With its range of low-emission and, going forward, locally emission-free city buses, Mercedes-Benz provides the answers in the quest for environmentally friendly local public transport. All of them are based on the best-selling Citaro, which in 2012 became the first city bus in the world to meet what is currently the most stringent emissions standard, Euro VI. The Citaro hybrid, with even further reduced fuel consumption, is formally classified as a low-emission bus. The gas-powered Citaro NGT is practically CO_2-neutral when run on bio natural gas. The full-electric Citaro is now taking the next step from low-emission bus to locally emission-free bus.

Electric portal axle, modular battery concept, flexible charging technology

The basis of its drive system is provided by an electric portal axle with electric motors at the wheel hubs. The peak output of the motors is 2 x 125 kW, while torque is 2 x 485 Nm. It is an inherent feature of such motors that this is fully

available right from the start, so ensuring appropriate dynamic performance even with a full complement of passengers.

Lithium-ion batteries with a total capacity of up to about 243 kWh are responsible for providing the power. These are split between up to a maximum of ten modules. As well as two battery modules on the roof, the standard equipment includes four modules in the rear of the bus. Depending upon customer requirements, a further two or four battery modules may be mounted on the roof.

The charging technology used is similarly flexible. For the start of series production, charging via a Combo 2 connector is envisaged. If, in order to extend the range of the vehicle, there is a requirement for opportunity charging, there will in future also be an option to charge the Citaro via a pantograph. The Citaro thus allows for all variants currently in use.

This intelligent modular concept for the battery and charging technology means that Mercedes-Benz is able to offer transport operators the opportunity to configure the Citaro precisely to the individual requirements of the company, or even of each separate route.

Thermal management: new approaches for heating and climate control

The energy consumption of a full-electric city bus is significantly impacted by the cooling and, above all, heating requirements of the spacious interior. Its thermal management system is therefore one of the key features of the Citaro: its exceptional energy efficiency provides the basis for the Citaro's very viable operating range.

The passenger compartment of the Citaro is heated in an energy-efficient manner by a heat pump, backed up by the usual side-wall fan heaters and the front heater. All components that give off heat are linked together, so keeping the amount of energy required for their cooling to a minimum. During the colder months, the roof-mounted air-conditioning system is used in addition as a heat pump. The use of CO_2 as a coolant brings further benefits. Its very efficient use of the heat pump, even at very low temperatures, is impressive.

Another boon: the interior can be conditioned up to and even beyond the desired temperature while the batteries are still being charged at the depot. The bus will therefore have been heated or cooled before it sets off.

Viable range under difficult conditions

When it comes to giving figures for the vehicle's range, Mercedes-Benz prefers to consider a "worst-case scenario", taking its direction from the challenging 'Standardised On-Road Test cycle', SORT2. According to this, the Citaro with a full complement of batteries can achieve an operating range of around 150 kilometres in the summer. In other words, it is already possible to serve some sub-networks within the daily coverage of a city bus without opportunity charging.

Rethinking urban mobility: the integrated eMobility system

Electric mobility means rethinking the way buses are used for urban mobility. The full-electric Citaro forms part of Daimler Buses' integrated eMobility system. This encompasses the expert advice service eConsulting, even before any purchase is made. Experts analyse the various routes, evaluating the runs and establishing links between them. A simulation programme then calculates the energy needs. This work produces detailed recommendations and calculations relating to charging infrastructure, energy consumption, load capability of the power supply at the depot and charging management.

Service, maintenance and repair requirements change with electric mobility. The eMobility service provided by the Omniplus service brand therefore offers tailored service concepts. Options range from the classic supervision of the customer's workshop through to workshop services allied to service contracts, completed in Daimler-based competence centres and, at the top end of the scale, BusDepot Management: in this case Omniplus employees undertake a defined scope of work, which may extend to full full-round service management of the vehicles, directly at the customer's workshop.

The electrically powered Mercedes-Benz Citaro

- **Citaro: from low-emission bus to zero-emission bus**
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- **Intensive summer and winter testing**

It emits zero local emissions and runs almost silently. It combines the platform of the world's best-selling city bus with new technological solutions. The full-electric Mercedes-Benz Citaro takes electric mobility using city buses to a new level altogether. The 12-metre variant will celebrate its world premiere in September at the IAA Commercial Vehicles, with the start of series production coming before the end of the year. The new Citaro offers an impressive and hitherto unknown standard of energy efficiency, courtesy of its innovative thermal management system. The intelligent modular concept for its battery and charging technology is a similarly compelling proposition. The electric Citaro is also more than simply a city bus: Mercedes-Benz takes a holistic view of electric mobility, embedding the Citaro firmly within its overall eMobility system. This comprises services that range from individual and very practically oriented advice ahead of any purchase and recommendations relating to charging infrastructure through to taking on servicing work at the customer's own workshop.

Urbanisation demands low-emission and locally emission-free mobility

The process of urbanisation marches on: for the last ten years, for the first time in the history of the earth, more people have been living in cities than in the country. According to forecasts from the United Nations organisation (UN), this proportion is set to grow to two thirds of the world's population by 2050. Whether we are talking about a megacity, a large city or a small town, the challenges and problems are similar: a growing population means a growing

need for mobility, for both work and recreational purposes. And thereby both an opportunity and a risk for already overburdened traffic systems, along with potentially greater environmental pollution from exhaust emissions and noise. Both the populace and politicians are, however, becoming more and more acutely aware of the associated disadvantages and limitations.

One possible solution in this respect is a well-developed local public transport infrastructure, with low-emission and locally emission-free buses. The current buzzword, therefore, is electric mobility. The new full-electrically powered Mercedes-Benz Citaro is an important element here, running as it does both locally emission-free and almost silently.

Thanks to new technological solutions, the Citaro is able to demonstrate outstanding performance capability. At the same time, its variability means that it is perfectly suited to meet the stringent demands of the transport operating companies with their complex systems of route networks and timetables. It also brings the advantage of being based on a tried and tested vehicle: with more than 50 000 units sold, the Citaro is the world's best-selling city bus.

Citaro: from low-emission bus to zero-emission bus

With a wide range of low-emission and, going forward, emission-free city buses, Mercedes-Benz has the appropriate answers to questions about environmentally friendly local public transport. All variants are based on the global best-seller, the Citaro. Back in 2012, this became the first city bus in the world to meet what is currently the most stringent emissions standard, Euro VI.

The Citaro hybrid variant then became a fully recognised low-emission bus. Launched last autumn, it features a hybrid module that further optimises the performance of the combustion engine and reduces the already low fuel consumption by as much as 8.5 percent. Compared with a city bus meeting the Euro V standard, the CO_2 emissions have thus fallen by almost 20 percent and the nitrogen oxide emissions by as much as 98 percent in just a few years, while particulate emissions have even reached the limits of detection. The

Citaro hybrid, featuring innovative 48-volt technology, dispenses with the need for a high-voltage network and is available as an option for the majority of Citaro variants, including for the natural gas-powered Citaro NGT. This model is particularly quiet-running and its emissions low, while when fuelled by biogas it is virtually CO_2-neutral.

The Citaro and the large-capacity CapaCity bus, as well as the Citaro hybrid and the Citaro NGT, provide practical evidence, thousands of time every day, of the highly sophisticated level of development of drive systems with combustion engines. They are characterised by both their efficiency of operation and their low emissions. The full-electric Citaro is now taking the next step from low-emission bus to locally emission-free bus. In doing so, it adds to the range a variant that sets new standards in terms of electric mobility.

Proven electric axle, new modular battery concept

The drive system of the new full-electric Citaro is based on the tried and tested ZF AVE 130 electric portal axle with electric motors at the wheel hubs, as previously deployed in other variants of the Citaro. Their peak output of the motors is 2 x 125 kW, while torque is 2 x 485 Nm. It is an inherent feature of such motors that this is fully available right from the start, so ensuring appropriate dynamic performance even with a full complement of passengers.

Lithium-ion batteries with a total capacity of up to about 243 kWh are responsible for providing the power. These are modular in design: the batteries are split between up to ten modules, each supplying around 25 kWh. As well as two battery modules on the roof, the standard equipment includes four battery modules in the rear of the bus. In the Citaro these are located on the left-hand side in the direction of travel, in the place of the current drive system combination of combustion engine and transmission. Depending upon customer requirements, a further two or four battery modules may be mounted on the roof of the Citaro.

Each battery module is made up of 15 cell modules, together with a control unit for monitoring purposes and as a means of balancing the charge of the battery cells. Each separate cell module houses twelve battery cells.

Mercedes-Benz uses easily manageable prismatic cells with a capacity of 37 Ah each. With a minimum of six and up to a maximum of ten battery modules possible, transport operators can adapt their usage and charging strategy very precisely to individual needs. Opting for the largest number maximises the range of the buses, while a smaller number reduces the weight as well as the cost of purchase and allows more space for passengers - but potentially makes time-consuming interim, or 'opportunity', charging necessary.

With the maximum complement of ten battery modules, the full-electric Citaro with standard equipment weighs around 13.7 tonnes. In conjunction with a permissible gross vehicle weight of 19.5 tonnes, this corresponds to a payload of 5.8 tonnes or around 80 passengers – even in the rush hour, as is commonly necessary.

The Citaro's engineering has been future-proofed. Since the development of battery technology is progressing at a rapid pace, provision has already been made for the transition to the next generation.

Flexible charging technology: charging at the depot as standard, via current collector as an option

The Citaro's charging technology also allows it to adjust to the individual wishes and requirements of the transport operators. For the start of series production, charging via connector is envisaged. The city bus features as standard a socket for a Combo 2 connector above the front wheel arch on the right-hand side of the vehicle in the direction of travel. This corresponds to the usual position for the tank filler neck on a Citaro with diesel engine.

If, in order to extend the range of the vehicle, there is a requirement for opportunity charging, the full-electric Citaro can also be charged via a current collector. This option will be gradually phased once series production has started. There will be two possible variants: in phase 1 an integrated vehicle collector on the vehicle roof; in phase 2 the fitting of charging rails that will allow charging via a fixed-installation current collector at a charging station. In both cases the equipment will be mounted in line with the front axle.

The Citaro will thus allow for all charging variants currently in use. This intelligent modular concept for the battery and charging technology means that Mercedes-Benz is able to offer transport operators the opportunity to configure the Citaro precisely to the individual requirements of the company, or even of each separate route.

The Citaro is also able to generate electrical energy through a process of recuperation. In this case the two electric motors at the wheel hubs of the drive axle act as alternators during braking, transforming the kinetic energy of the vehicle into electricity.

Thermal management: new approaches for heating and climate control

The battery capacity on its own, however, provides little indication of the actual performance capability and, above all, the range of a full-electrically powered city bus - the true measure is that of energy consumption. In the case of a city bus, this is impacted significantly by climatic conditions, through the need to cool and, above all, heat the interior.

At an outside temperature of minus ten degrees Celsius, the energy consumption of a city bus doubles by comparison with journeys where no heating is required - thereby halving the range. The cause: the extreme efficiency of an electric motor means that, compared with a combustion engine, the amount of usable waste heat is negligible. The heating system must therefore be fed from the vehicle's own energy supply. An added factor is the sheer volume of the interior space, particularly when up to three double-width doors are opening regularly and letting outside air in every 400 metres or so, assuming normal bus-stop intervals.

The engineers have therefore put a considerable amount of thought into the issue of thermal management. It is one of the outstanding features of the Citaro and has been honed and refined in every detail: compared with the current Citaro with combustion engine, the energy requirement for heating, ventilation and climate control has fallen by about 40 percent. Achieving this exceptional level of energy efficiency has been a complex process, but it provides the basis

for the Citaro's very viable operational range, even under unfavourable conditions.

Batteries at the ideal temperature: maximum performance and service life

Here too, thermal management is important. Mercedes-Benz, for example, cools the batteries to ensure that they remain at the ideal temperature, thereby ensuring maximum performance capability and service life. This cooling is undertaken by a separate battery cooling device mounted on the roof. At extreme outside temperatures, the standard passenger-compartment climate control system is used to boost the cooling of the batteries.

Further flexibility is possible by exploiting the discharge depth of the batteries. This can be extended, although at the expense of range and service life.

Heating: even the passengers help with heating

The passenger compartment of the Citaro is heated in an energy-efficient manner by a heat pump. An even distribution of temperature is ensured by use of the familiar side-wall fan heaters. The conventional heater at the front is boosted by the addition of a double heat exchanger. For use in extreme weather conditions, or to extend the vehicle's range, a fuel-powered auxiliary heater can also be used as an option.

A series of examples makes clear the care and detailed attention that have gone into the thermal management system. All components that give off heat are linked together, so keeping the amount of energy required for their cooling while in operation to a minimum. Since the human body likewise gives off heat, the heating on a bus carrying a full complement of passengers can be turned down earlier. Furthermore, Mercedes-Benz varies the output of the heating and climate control systems according to the number of passengers on board: the intake of fresh air in the bus is matched to the current number of passengers. The capacity utilisation of the bus is measured via its axle load sensors.

Air conditioning system and heat pump: high efficiency through using CO_2 as a coolant

During the colder months, the roof-mounted air conditioning system is used in addition as a heat pump, so ensuring effective and efficient climate control for the passenger compartment. The use of CO_2 as a coolant brings further benefits. Its very efficient use of the heat pump, even at temperatures as low as minus 10 degrees Celsius, is particularly impressive. And, should there be a release of coolant, unlike some other materials it is environmentally harmless, non-toxic and non-flammable. Mercedes-Benz uses CO_2 as a coolant as standard in the Citaro, making it one of the first bus manufacturers to do so.

Climate comfort tailored to the needs of passengers

Another boon: the interior can be conditioned up to and even beyond the desired temperature while the batteries are still being charged at the depot. The bus will therefore have been heated or cooled to reflect the season before it sets off.

The heating and climate control systems are configured in accordance with the requirements of the Association of German Transport Companies (Verband Deutscher Verkehrsbetriebe: VDV). If the temperature outside is extreme, comfort levels at either end of the scale are reduced somewhat in favour of energy consumption and thus range. Instead of the interior temperature being set to a consistent level all year round, it is adjusted according to situation to ensure the comfort of passengers. As passengers generally spend only a short time in the vehicle and are normally dressed in accordance with the time of year, the inside temperature is set higher on hot summer days and lower on cold winter days, without at any point compromising passengers' sense of comfort.

When it comes to the driver's workplace, Mercedes-Benz pursues a somewhat different strategy: since the driver spends all his or her working hours in the city bus, the expectations here are greater, while the physiological safety of the driver must be ensured at all times. The climate control system for the driver's

workplace is therefore controlled separately, with an ambient temperature of 24 degrees the aspiration at all times, whatever the extremes outside.

High efficiency means viable range under difficult conditions

Indications of operating range for full-electric-powered city buses are often difficult to compare and caution is advised, since reference values can be missing and the figures have often been calculated under ideal conditions. Things are different with the Citaro: in the interests of reliable data, Mercedes-Benz prefers to consider a "worst-case scenario" and therefore takes its direction from the challenging 'Standardised On-Road Test cycle', known as SORT2. To make things even trickier, Mercedes-Benz also adds the energy requirements of the ancillary consumers into the equation. According to SORT2, the Citaro with a full complement of batteries can achieve an operating range of around 150 kilometres in the summer. In other words, it is already possible to serve some sub-networks within the daily coverage of a city bus without opportunity charging.

More space for passengers thanks to careful weight distribution

The downside of full-electric city buses is the extra weight added by their batteries. Even the intrinsically lightweight Citaro is unable to offset completely the 2.5 tonnes of the maximum battery set. However, with a carefully considered distribution of weight, the Citaro is able to exploit the permissible axle loads to secure the highest possible payload - and thus number of passenger places.

The engineers managed to balance the bus by installing four battery modules within the rear overhang and up to six further battery modules on the roof, on a line with the front axle. This axle is also characterised by a maximum load-carrying capacity of eight tonnes and thus, depending on the variant, space for a realistic complement of around 80 passengers.

Since the developers have adopted the tried and tested layout of the Citaro, the configuration of the passenger compartment remains unchanged compared with the conventional Citaro with vertically mounted engine. Passengers will find everything familiar. The vehicle is available with either two or three doors.

Another advantage of the Citaro platform: transport operators are able, as ever, to individualise the bus by selecting from a wide range of optional extras. Whether it's the passenger seats, flooring, grab rails, communication systems or unseen details such as the door controls - the Citaro is, and remains, a fully customisable city bus, whatever its drive system.

Intensive summer and winter testing

The technology of the full-electric Citaro as it goes to the start is well proven. Its superb quality is guaranteed by the tried and tested Citaro that is already in such regular use. This is backed up by the fact that it is manufactured at the company's bus plant in Mannheim, on the production line for the conventionally powered Citaro - where the test vehicles were also built. Key components such as the drive axle and the electrohydraulic steering system have already proved their worth in the challenging world of city bus transport. The design of the roof, with integrated heavy-duty rails for the batteries, is derived from the system used for the gas tanks on the Citaro NGT.

What is more, by the time of the series-production start-up, the full-electric Citaro will already have been through a comprehensive programme of testing. This bus has to pass all the same tests as any other bus that bears the three-pointed star, for the Citaro with full-electric drive system will offer the same high level of availability and the proverbial reliability of its stablemates with combustion engine.

All components are tested individually as well as in interaction with others, on test benches and in practice in the bus. Mercedes-Benz has tested the Citaro at temperatures below minus 15 degrees Celsius at the Arctic Circle and at more than 30 degrees Celsius in the searing summer heat of Spain. Winter testing

also includes road tests on a slippery surface to test dynamic handling control systems and recuperation. Summer testing takes place in challenging urban traffic conditions and on steep up- and downhill gradients in the Sierra Nevada. The test programme also includes rough-road and endurance testing. All in all, a dozen or so prototypes are being very thoroughly put through their paces.

Far more than just a city bus: the full-electric Mercedes-Benz Citaro as a key element of eMobility

- **The challenge of electric mobility: rethinking urban bus travel**
- **eMobility Consulting: detailed practical advice for transport operators**
- **Omniplus Service: new concepts for the challenges of high-voltage technology**

The new full-electric Mercedes-Benz Citaro is far more than just a city bus: it is a key part of Daimler Buses' integrated eMobility system. This encompasses the pre-purchase advisory service eMobility Consulting, including an in-depth analysis of the transport operating company and its various routes. Omniplus Service offers companies tailor-made service concepts designed for electric mobility, right through to services provided in the customer's own workshop.

The challenge of electric mobility: rethinking urban bus travel

Electric mobility presents a challenge, as experienced by buyers of private passenger cars thinking about their route to work or their plans for a weekend outing. And it is one that is all the more tricky for transport operators, who have to work with a tight and intricate nexus of route networks and timetables. In an ideal world, they would like to see a straightforward 1:1 replacement of city buses with combustion engine by fully electric-powered buses. This is, however, not normally possibly without some intervention, making meticulous preparation indispensable – electric mobility means rethinking the way buses are used for urban mobility.

Alongside the higher costs and possible subsidies for electric-powered buses, key factors when changing over to electric mobility include detailed consideration of energy consumption and the resultant range, passenger capacity, charging capacity including the energy supply source and, finally, service - from equipping the customer's workshop through to differentiated training of their staff.

This is where eMobility Consulting from Daimler Buses comes in. Experienced advisors begin by demonstrating to transport operators the performance capability of the full-electric Citaro, moving on to sound out the companies' hopes and expectations. In the next stage, each route is individually analysed, producing a plethora of data that ranges from the length of the route to passenger numbers and average speed. Even the outside temperature plays a role here, for the increased energy consumption required for heating and climate control means that this can have a significant impact on the range of electric city buses. A simulation programme developed in-house then calculates the energy needs.

The experts evaluate the individual scenarios and link them to one another. A series of different variants are the outcome, from a standard capture of data with a calculation of range, through to the issue of charge management and even the organisation of the bus depot. The experts' detailed knowledge of their own company's buses, their close contacts to the engineers in the development area and their professional relationship, based on trust, with the transport operators prove advantageous here – and result in a unique level of expertise relating to buses as a transport system.

At the end of all this, the experts are able to provide precise recommendations and calculations covering the charging infrastructure, energy consumption, the load capability of the power supply at the depot and charge management. The recommendations go into very practically relevant detail and might, for example, suggest split services or opportunity charging at the depot as an alternative to the use of external charging stations in cases where daily mileages are high.

Omniplus Service: new concepts for the challenges of high-voltage technology

Service, maintenance and repair are also significantly different with electric mobility. Tasks relating to the combustion engine and automatic transmission are no longer relevant; the focus now is on high-voltage technology.

The 'Omniplus' service brand of Daimler Buses has therefore prepared a special eMobility service concept. Transport operators can select appropriate modules from within this to suit their individual needs. Options range from the classic supervision of the customer's workshop through to workshop services allied to service contracts, completed in Daimler-based competence centres and, at the top end of the scale, BusDepot Management: in this case Omniplus employees undertake a defined scope of work, which may extend to full full-round service management of the vehicles, directly at the customer's workshop. This approach has already been proven to work effectively at several locations across Europe.

Terms and components from the world of electric mobility explained in brief

Battery cells

The cells of lithium-ion batteries can take different forms: cylindrical cells, pouch cells or prismatic cells. Mercedes-Benz has opted to use batteries with prismatic cells. These are of the approximate shape and size of a paperback book, each in its own housing, and are sturdy and easy to work with.

Electric motor

Whereas a combustion engine uses a process of combustion to convert liquid or gaseous fuel into mechanical power (conventionally in the form of a stroke), an electric motor converts electrical energy into mechanical power. Energised coils generate magnetic fields with opposing forces that attract and repel to create rotational movement. Mercedes-Benz uses water-cooled asynchronous motors in the Citaro. These are robust and speed-resistant, extremely efficient to run and do not require brushes, which are subject to operational wear.

Emission-free driving

Full-electric vehicles are locally emission-free, which is to say they emit no exhaust gases while in use. Depending upon how the electricity they use is produced, however, emissions may still be generated further upstream, for example in coal or gas-fired power stations. Even an full-electric city bus is therefore not classified as emission-free, but as locally emission-free.

Depth of discharge (DoD)

This describes the extent to which a battery is emptied relative to its total capacity. A very deep discharge will increase range, but has a negative impact on battery service life. In the case of the Citaro it is therefore possible to select a different depth of discharge for specific application profiles.

High-voltage technology

'High-voltage' relates to a DC voltage of more than 60 volts. High-voltage components are specifically identified as such, while high-voltage cables are recognisable by their orange sheathing. Full-electric-powered commercial vehicles will commonly feature voltages of 600 volts or more. Depending on their precise role, service technicians must therefore attend mandatory familiarisation and training sessions of varying scope.

Charging standard ISO 15118

This safeguards the communication between the charging station and the on-board charge control device. It therefore provides the basis for an active and intelligent charge control system – important for the avoidance of excessive and expensive charging peaks within a fleet – and for billing systems.

Charging connector

The industry in Europe favours the Combo 2 connector as standard. This is suitable for high charging loads and quick charging (CCS = Combined Charging System). It allows a charging power of up to 150 kW, and currents of up to 200 A.

Battery balancing

Battery balancing, as it is called, maintains all the cells of a battery at the same level of voltage, so ensuring its efficient operation and long service life.

Power electronics

Several components are contained within a single housing. The inverter, also known as an AC-DC converter, converts direct current into alternating current. It is necessary because, while the batteries supply direct current to the HV network, electric motors run on alternating current. The converter, or voltage transformer, also known as a DC-DC converter, converts incoming DC voltage into a higher or lower DC voltage.

Lithium-ion battery

A lithium-ion battery is a rechargeable energy storage device that converts electrical energy into chemical energy, which it then stores ready to release once again when needed in the form of electrical energy. When the battery is charged, the lithium ions move from the cathode to the anode; during discharge from the anode to the cathode. Lithium-ion batteries are renowned for their high energy density and are therefore the cutting-edge requirement for full-electric-powered vehicles.

Current collector

The current collector, or pantograph, is used to pass electrical current from a charging station to a vehicle. In the case of battery-electric city buses it is used to supply a stationary vehicle during so-called opportunity charging, and occasionally for charging at the depot. The device may be fitted as an integral feature on the roof of the bus or as a fixed installation at charging stations. In either case the current collector is extended at the beginning of the charging process to connect the vehicle with the charging station.

Peak output

The peak output of an electric motor is comparable with the figure given for the rated output of a combustion engine and corresponds to the maximum possible output that is briefly achievable. Another quoted figure is that for continuous output, representing the maximum output that can be called upon for an extended period.

Power meter

A display in the instrument panel that replaces the rev counter commonly found in vehicles with a combustion engine. The power meter shows the level of output currently being drawn by the drive systems. During braking or coasting, it shows the level of recuperation, i.e. of braking energy being recovered.

Wheel hub motor

Unlike a combustion engine, the position of the electric motor within the vehicle is largely immaterial. Various configurations are possible for city buses. Mercedes-Benz has opted for a compact form of installation - the tried and tested ZF AVE 130 drive axle with electric motors mounted at the wheel hubs, as previously deployed in other Citaro models. This electric portal axle features a water-cooled asynchronous motor at each wheel, each delivering 125 kW, in other words together 250 kW. From standstill, the motors therefore deliver torque of 2 x 485 newton metres, which the gearing ratio turns into a drive torque of approx. 2 x 11 000 newton metres. The space freed up by the absence of the combustion engine and transmission on the left-hand side at the rear is used by Mercedes-Benz to accommodate battery modules.

Recuperation

Recuperation is also known as braking energy recovery or regenerative braking and is a process whereby kinetic energy is converted into electrical energy. The wheel hub-mounted electric motors in this case function as alternators, leading to the creation of braking torque. The electrical energy generated in this way is stored in the batteries, thereby becoming available again for use by the vehicle's drive system.

SORT

A reproducible on-road test cycle used to calculate comparable fuel consumption figures for city buses. SORT (Standardised On-Road Test cycles) is based on a series of agreements between trade associations, transport operators and leading European bus manufacturers. SORT replicates a range of challenging urban traffic scenarios (SORT1, SORT2, SORT3). SORT figures may, for instance, be used as a criterion in calls for tender.

Heat pump

A heat pump exploits the physical effects of the transition of liquids to a gaseous phase, or vice versa. It is a process that is already familiar from modern stationary heating systems in buildings. In full-electric vehicles, heat pumps are used as an alternative source of energy-efficient heating or cooling for the vehicle.

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