

ACTUATE – Presentation

Advanced training for safe ecodriving of
electrically powered vehicles
- Hybrid bus -



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ACTUATE

“Advanced training for safe ecodriving of electrically powered vehicles”



For more information go to <http://www.actuate-ecodriving.eu/>

- Project for the **optimisation of driving behaviour to reduce energy consumption**

- Development of training programmes and general training measures for ecodriving electrically powered vehicles in local public transport.
- The focus is on the driver as the core operator for ecodriving.
- Accompanying motivation campaigns will ensure that drivers continue to apply what they learn in training courses.



ACTUATE Consortium

- The ACTUATE Consortium comprises
 - five local public transport companies from **Salzburg** (Salzburg AG, Austria), **Brno** (DPMB, Czech Republic), **Parma** (TEP S.p.A., Italy), **Leipzig** (LVB) and **Eberswalde** (BBG, both Germany) who are already operating electrically powered vehicles,
 - as well as the Leipziger Aus- und Weiterbildungsbetriebe (**LAB** - Leipzig Training Institute),
 - the Belgian bus manufacturer **Van Hool** and
 - **trolley:motion**, the international association to promote e-bus systems with zero emissions (Austria).
 - **Rupprecht Consult** (Germany) is responsible for project coordination.



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Introduction



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Ecodriving in scheduled passenger services

- Ecodriving in scheduled passenger services means:
 - energy-efficient
 - low-wear and
 - eco-friendly driving.

- ecodriving helps
 - to preserve the environment
 - to provide a less stressful journey for passengers and drivers
 - to reduce energy and maintenance costs



3 rules of ecodriving

- **Rule of safety**

All other rules are subordinate to the rule of safety

- **Rule of punctuality**

Punctuality is essential for scheduled passenger services and means leaving a stop neither too soon nor too late

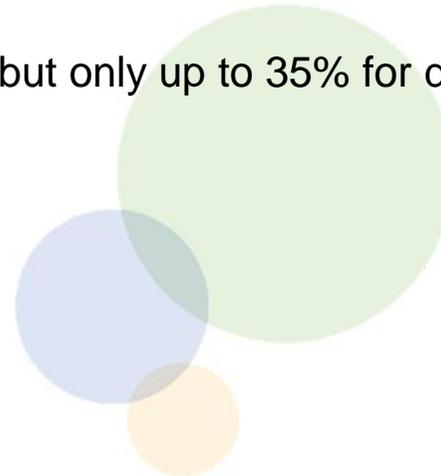
- **Rule of cost-effectiveness**

Ecodriving means minimising energy consumption and lessening wear on the vehicle while complying with the rules of safety and punctuality



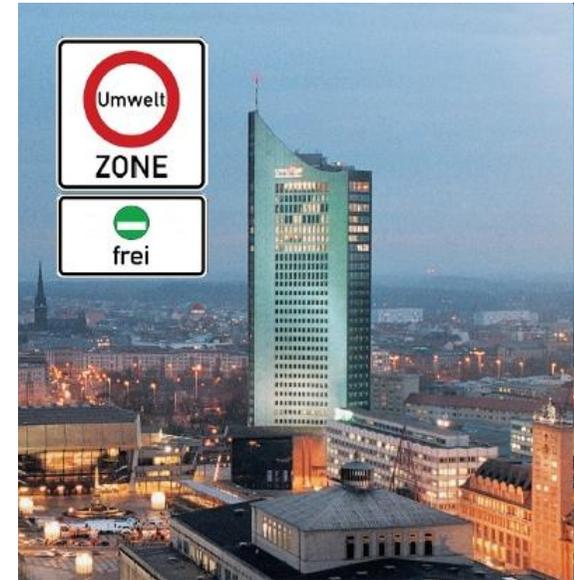
Energy source - e-mobility

- Utilisation of electric energy from renewable energy sources
- No loss during conversion in the production of renewable energy sources
(in contrast to the refining process for petrol and diesel)
- Zero emissions locally
- Possibility of energy recovery during braking
- Efficiency factor of up to 99% for electric motors, but only up to 35% for diesel engines
(lower for petrol and gas engines)
- **Electric drives are environmentally friendly!**



When does a hybrid vehicle run “clean”

1. Charged electricity storage device
2. As few electrical components as possible
3. Combustion engine switched off
4. Combustion engine with low RPMs
5. Combustion engine with operating temperature
6. Driver adapts operation of vehicle



Conclusion: driver's knowledge

- Introduction of modified hybrid plan
- Appropriate operation of hybrid vehicles is essential



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Who benefits from ecodriving?

Ecodriving does not only mean actual savings in fuel.

- **The vehicle**

- There is less wear, the drive systems are treated with more care.



Who benefits from ecodriving?

■ The environment

- Less emissions and particulate matter are produced.

■ The company

- Ecodriving with hybrid technology can realistically lead to an (additional and not technology-based) reduction in fuel consumption of c. 5 per cent, based on the experience of the ACTUATE partner company Leipziger Verkehrsbetriebe (LVB, Germany). The ecodriving approach can be applied to diesel buses because trained drivers are also deployed on diesel buses.

A model calculation for the LVB: With an annual consumption of around 4.5 million litres of fuel, savings of c. 225,000 litres of diesel fuel can be expected for the Leipzig bus fleet. In financial terms this would mean savings of around € 280,000 per annum for the LVB.



Working principle of the “hybrid bus” system

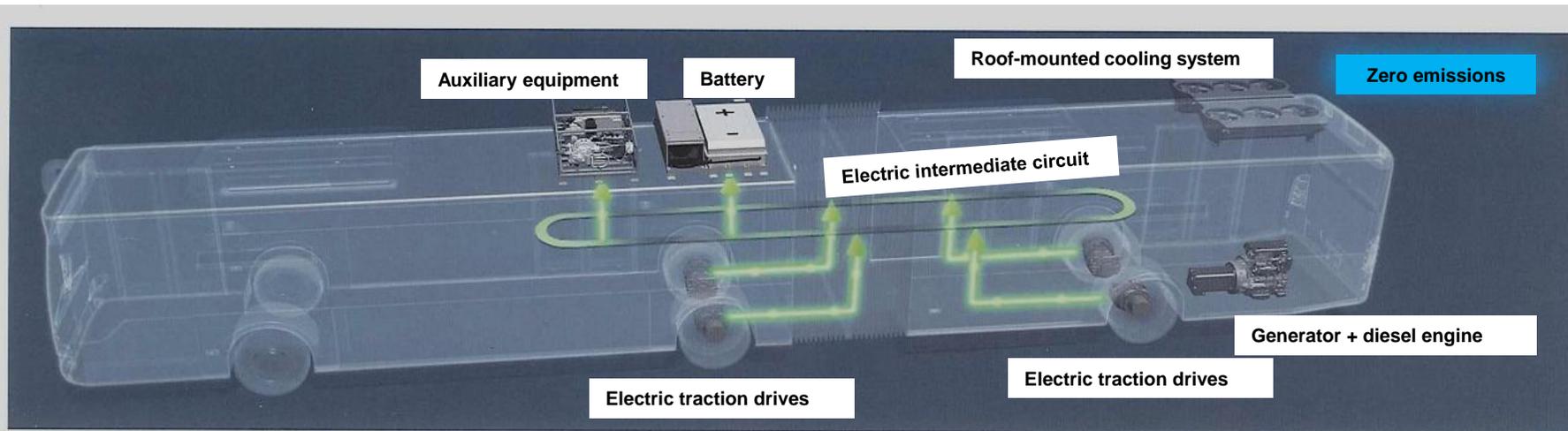


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Basic knowledge



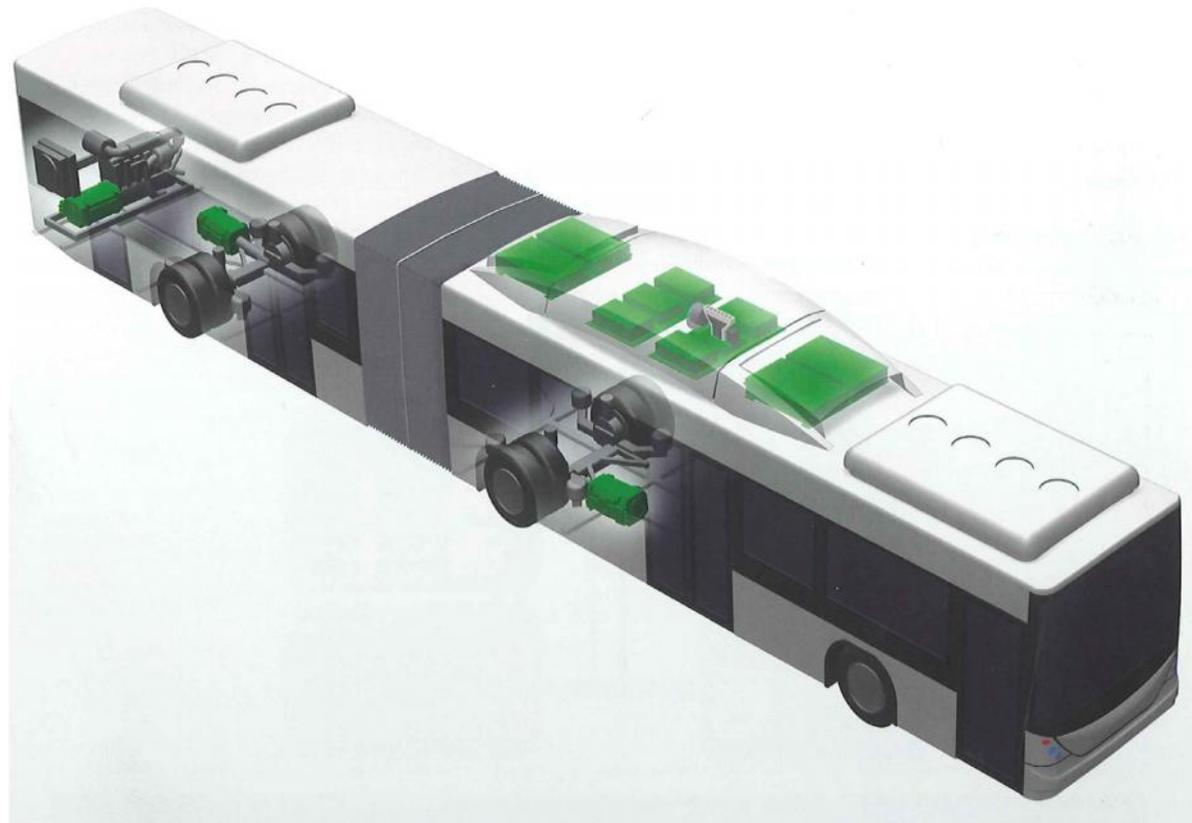
The components of the Citaro G BlueTec®-Hybrid



- 4 electric motors 4x80 kW
- Diesel engine 160 kW
- Electricity stored in lithium-ion batteries

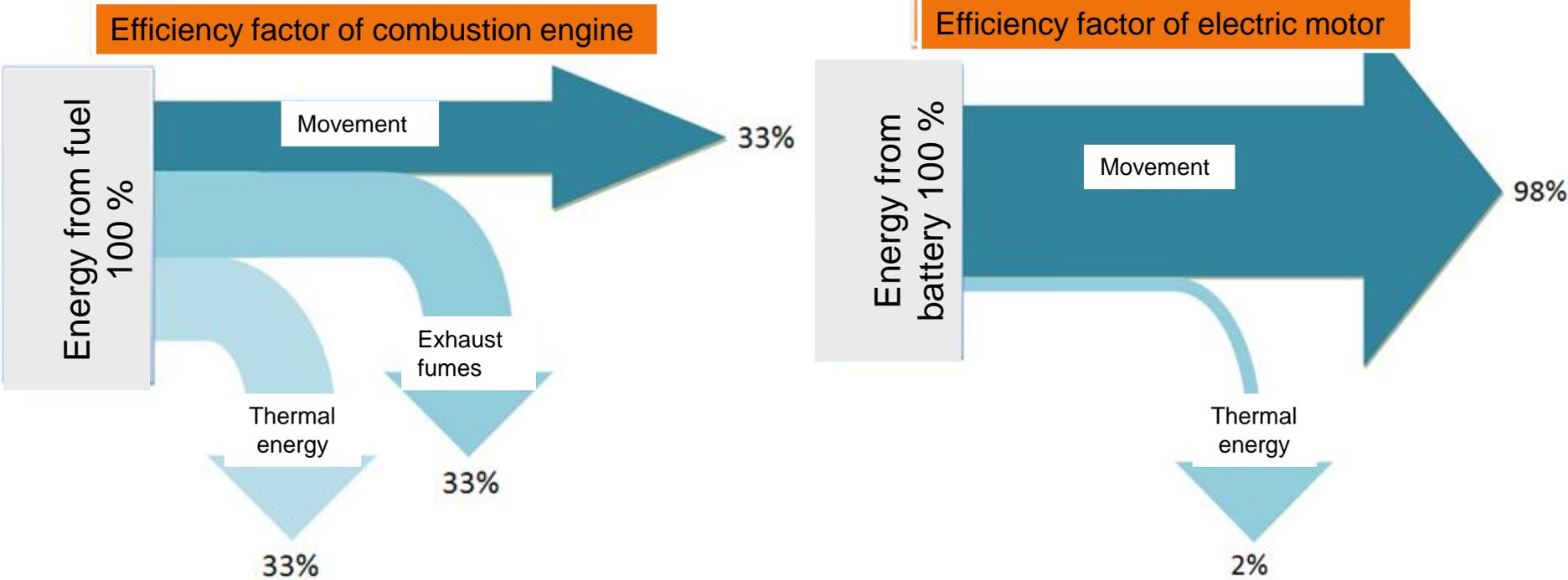


- 2 electric motors 160 kW each
- Diesel engine 190 kW
- Electricity stored in supercapacitors
- Energy management



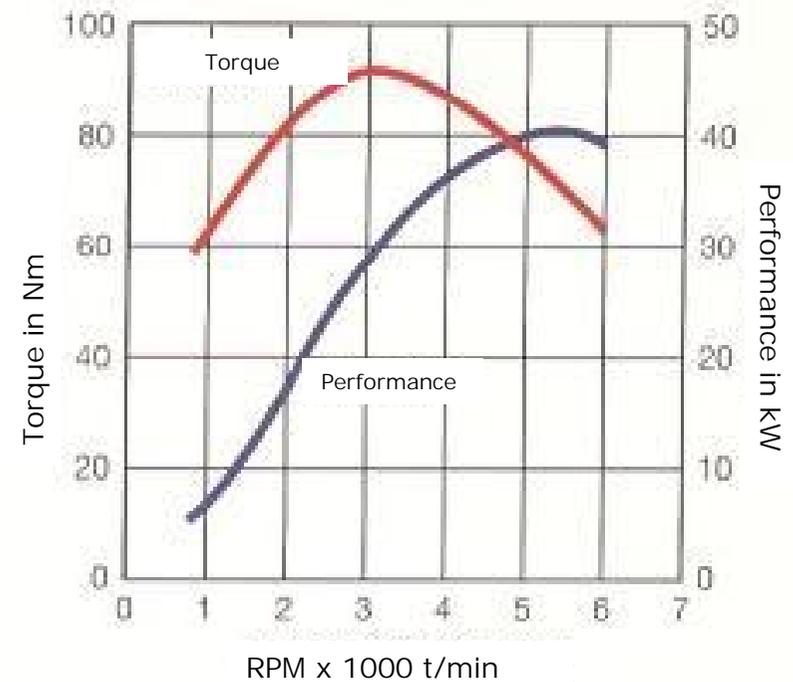
Source Vossloh-Kiepe





- In vehicles with combustion engines the traction force on the wheels must be adapted to the required performance and speed of the vehicle via the transmission.
- Practically no usable torque is available below idle speed.

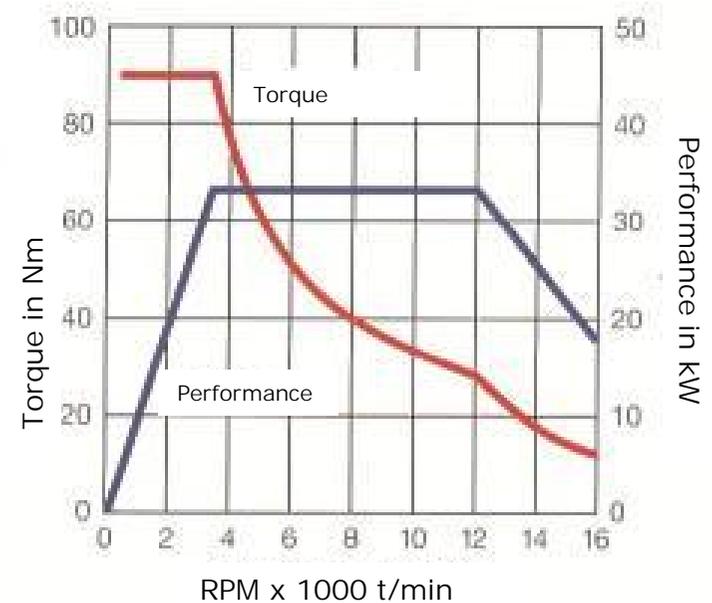
Otto engine



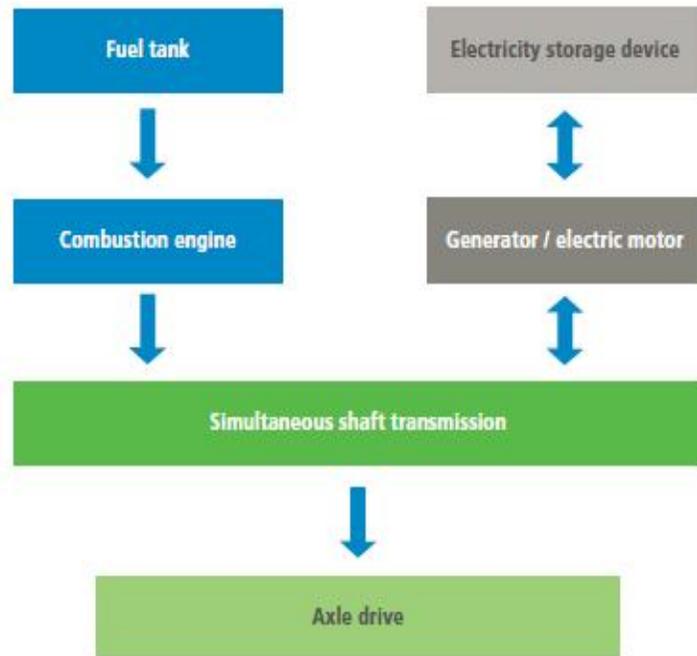
Electric motors offer several advantages over combustion engines:

- they are very low on wear and hence have low thermal discharge
- efficiency factor of 80 to 90 per cent depending on RPMs and load.
- very good torque characteristics,
- the maximum possible torque is reached almost from the first RPM.
- This means transmission and clutch are not needed.
- Furthermore integration in wheel hubs is possible.

Electric motor



Parallel hybrid

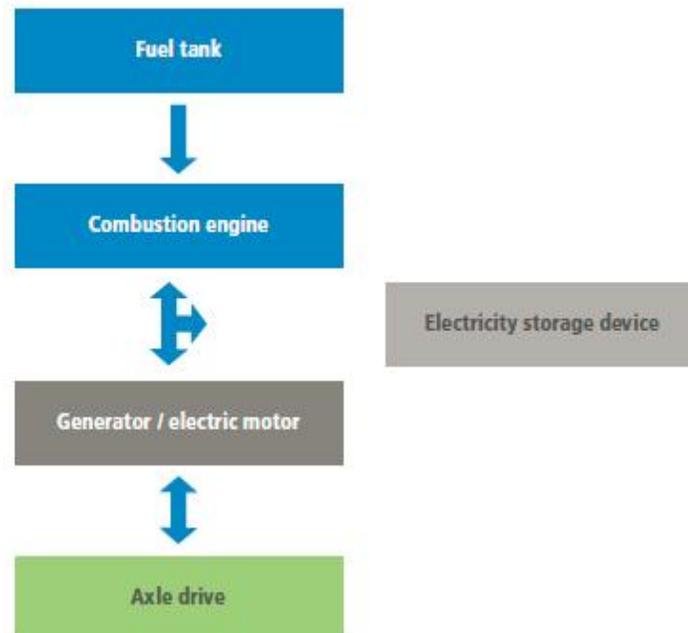


The advantages of parallel hybrid systems are:

Firstly lower consumption typical of hybrid drives as well as more or less significantly lower CO₂ emissions. However, fuel savings and a reduction in CO₂ emissions vary depending on the type of parallel hybrid – micro hybrid, mild hybrid or full hybrid.



Serial hybrid

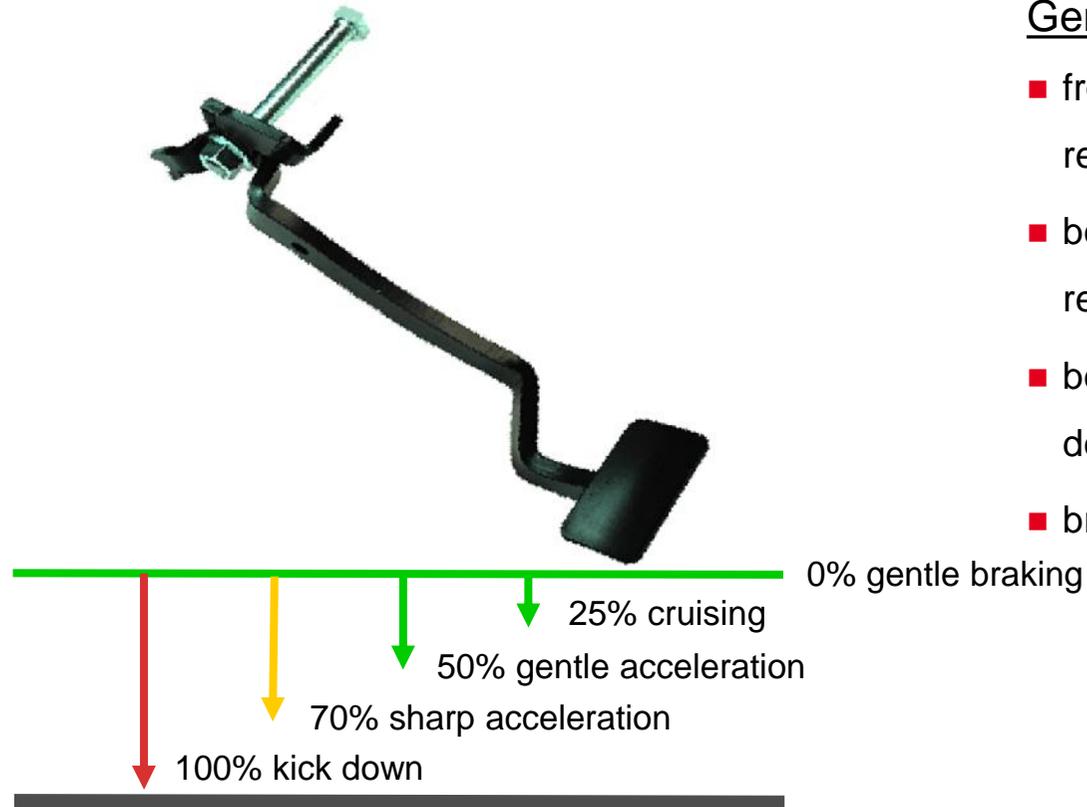


The main advantage of a serial hybrid system is that the combustion engine can be operated in an optimum window with regard to RPMs and hence torque. This results in the “trend” of downsizing and above all minimised fuel consumption as well as minimised CO₂ emissions.



- The driver can use the accelerator not only to determine the RPMs of the diesel engine but also the output of the traction motor.
- The CCU (central control unit) controls output and determines whether the supercapacitors, the generator or both should be used to provide output.
- The generator provides power according to the characteristic curve of the diesel engine in order to demand maximum power at the best point of the diesel engine (basis for saving fuel).
- When braking (brake pedal actuated or the accelerator in neutral or “0”) the generator applies coast mode to the diesel engine. The diesel engine is moved via the generator and diesel injection is blocked.

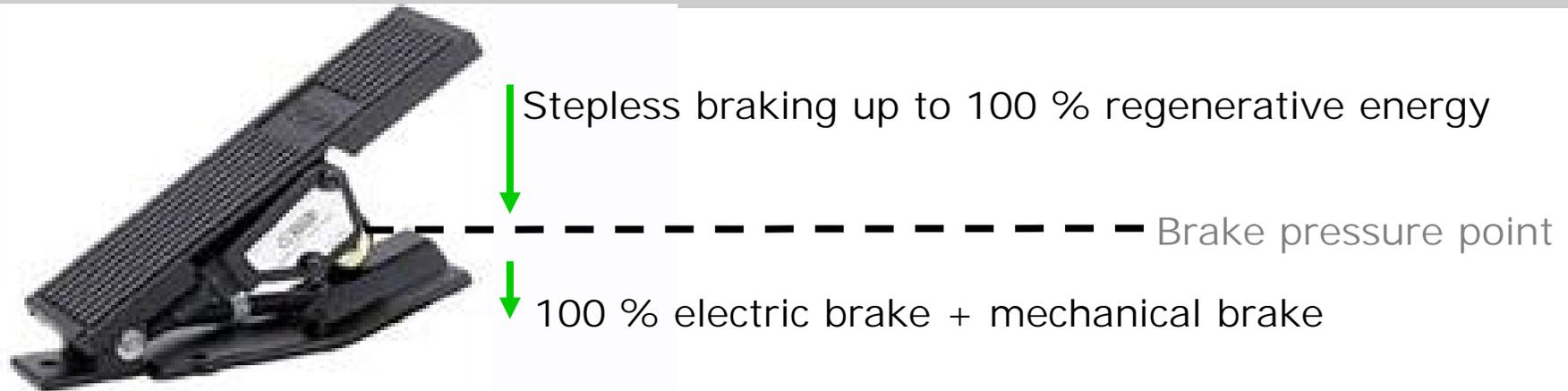




Gentle braking

- from 35 km/h with 20% of maximum recovery rate
- below 25 km/h with 10% of maximum recovery rate
- between 35 and 25 km/h gentle linear decrease of recovery rate
- braking sensation similar to engine brake





Braking

- Vehicle can be braked up to 3 km/h with the electric brake; it is brought to a standstill with the mechanical brake.
- The vehicle is kept motionless by applying the parking or hand brake
- The vehicle is prevented from rolling backwards



Using the retarder

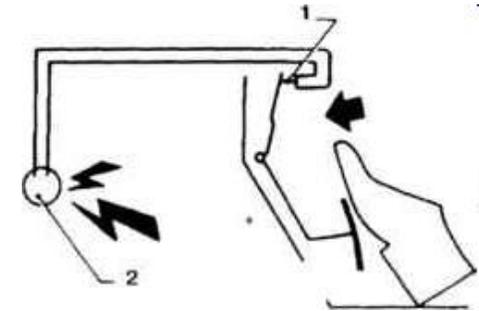
- The retarder provides greater energy output through the retarding effort.
- Note the retarder level with regard to passenger-friendly driving
- Don't "rip" the retarder
- Use as long a braking distance as possible



Starting diesel engine Zero emission operation

- Bus drives off using power from the supercapacitors
- When accelerator is applied to kickdown, starting mode is activated via the generator at min. 20 % stored energy in the supercapacitors
- A delay of 1 second occurs until the diesel engine starts up
- The distance for zero emissions is determined by the energy stored in the supercapacitors and the load requirements for moving (select small accelerator position for longer distances on flat surfaces)





Starting diesel engine Kickdown

- Bus drives off using power from the supercapacitors
- When the accelerator is applied to the kickdown position, start-up mode is activated via the generator at a speed of 10 km/h
- A delay of 1 second occurs until the diesel engine starts up

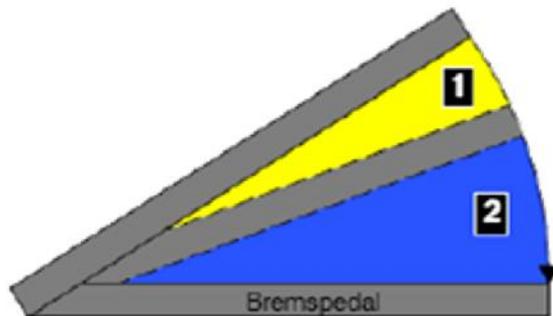
Application of fallback level

- If the generator cannot start the diesel engine, engine start-up is interrupted and the starter is applied automatically after a time lag of 5 seconds



Brake pedal

1. Only controls electric brake (actuated max. 25%)



2. Additional use of mechanical brake (25% - 100 %)





Activating an event

- when a defined GPS point stored in event management is reached

Deactivating an event

- when a newly defined GPS point is reached or a new event is activated, when they are stored in event management

Deselection of an event

- when the mode selector switch is set to “0” and “manual”

Applying events

- individual events can be applied or several events combined in sequence via event management



■ MAN hybrid - city bus



Overview of the advantages of the MAN Lion's City Hybrid:

- Up to 30 per cent less fuel consumption
- Optimum air conduction through new Efficiency-Design (cw value of 0.31)
- No noise or emissions at stops
- Saving resources
- Maintenance-free braking energy storage system designed for the service life of the vehicle
- Suitable for second generation bio fuels



■ MAN hybrid - city bus

The stop-start system functions fully automatically and independently of the driver

if the following conditions are met:

- Speed less than 1.5 km/h
- Charge in energy storage unit is sufficient (60 %)
- Discharge output of energy storage unit is less than 10 kW (speed up to c. 18 km/h)

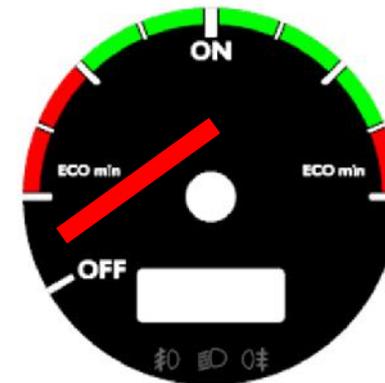
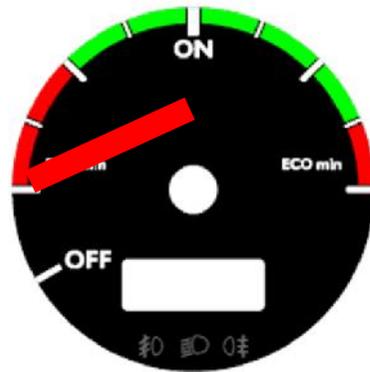


MAN hybrid - city bus



Start-up:

Once the ignition is turned on, the onboard computer is booted.

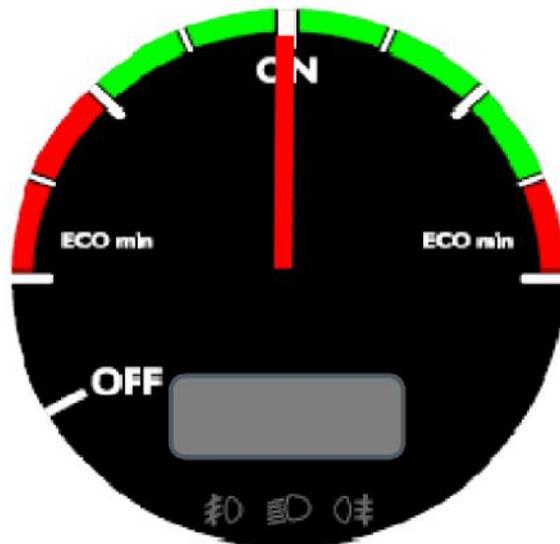


The indicator moves from the “OFF” position.



■ MAN hybrid - city bus

When the system is ready for use, the indicator moves to the “ON” position.



The vehicle is ready for operation (position of indicator: ON)

The engine can now be started up.

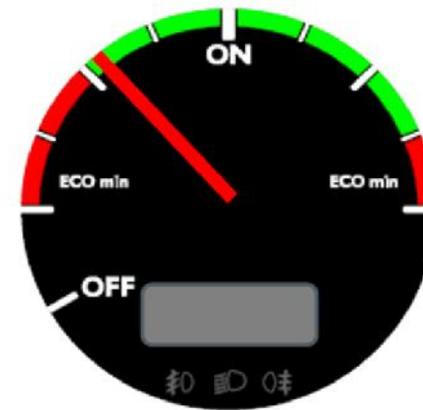


Example

MAN hybrid - city bus



It has economic acceleration
(right, ECO min = red range)



It has economic braking
(left, ECO min = red range)



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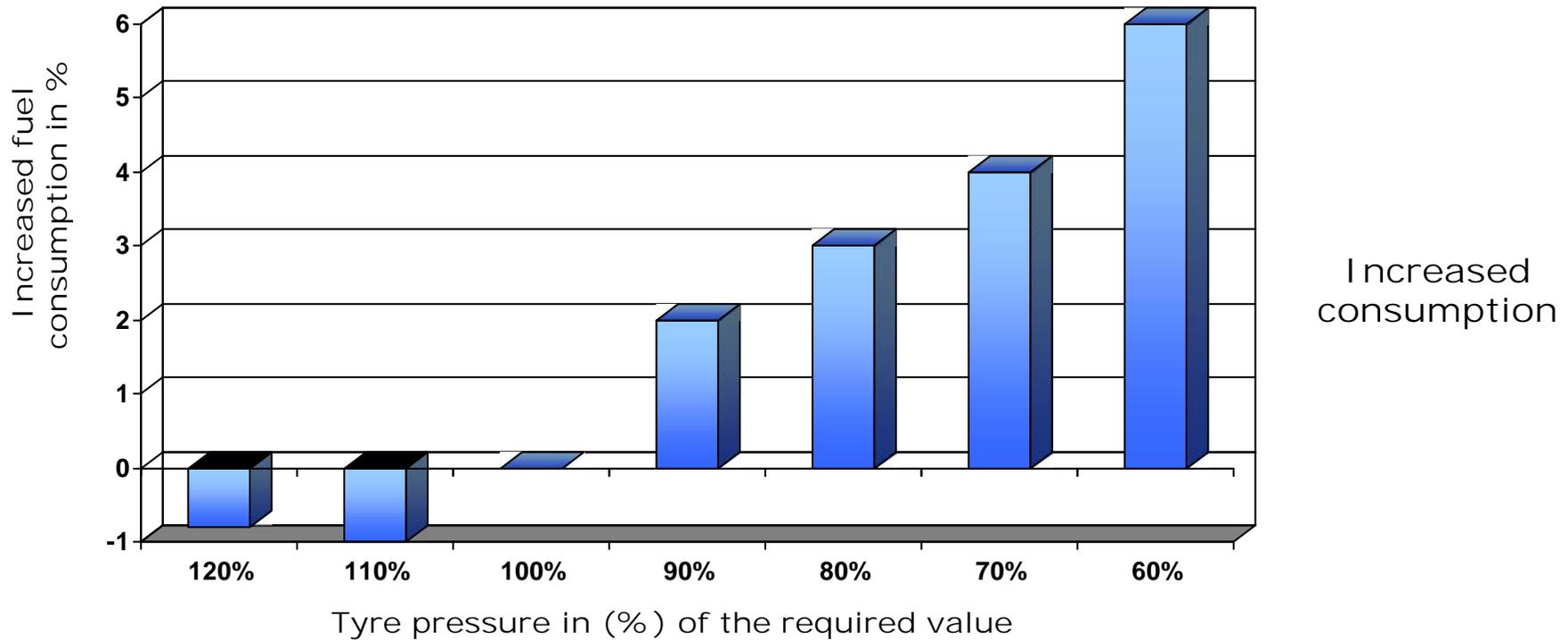
Controllable factors

- since traffic volume, routing and occupancy (weight) cannot be influenced for scheduled services, the factors
 - driving behaviour
 - anticipatory driving behaviour
 - adjustment of HVAC systembecome more important

- Tyre pressure and condition of the (hybrid) bus can be checked visually



Fuel consumption dependent on tyre pressure



110% air pressure in the tyres means fuel consumption is lowered by c. 1 %.

70 % air pressure in the tyres means increased consumption of c. 4 %.



Driving practice



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Tips on the practical part of training

- Selection of a “real” route/line for the practical part (ensure conditions are as realistic as possible, e.g. driving behind a scheduled bus) in order to simulate approaching, stopping and moving off from bus stops as close to reality as possible
- Determination of a certain sequence of drivers
- Prepare the energy measurement for the journey
- Application of “normal driving behaviour” (“before” run)
- If possible the same route and sequence of drivers should be retained for the “after” run
- Teach driving behaviour, including information provided during the theory part, during the “after” run
- Repeat energy measurements for a comparison of possible reductions in energy compared to the “before” run



Safety aspects of hybrid buses



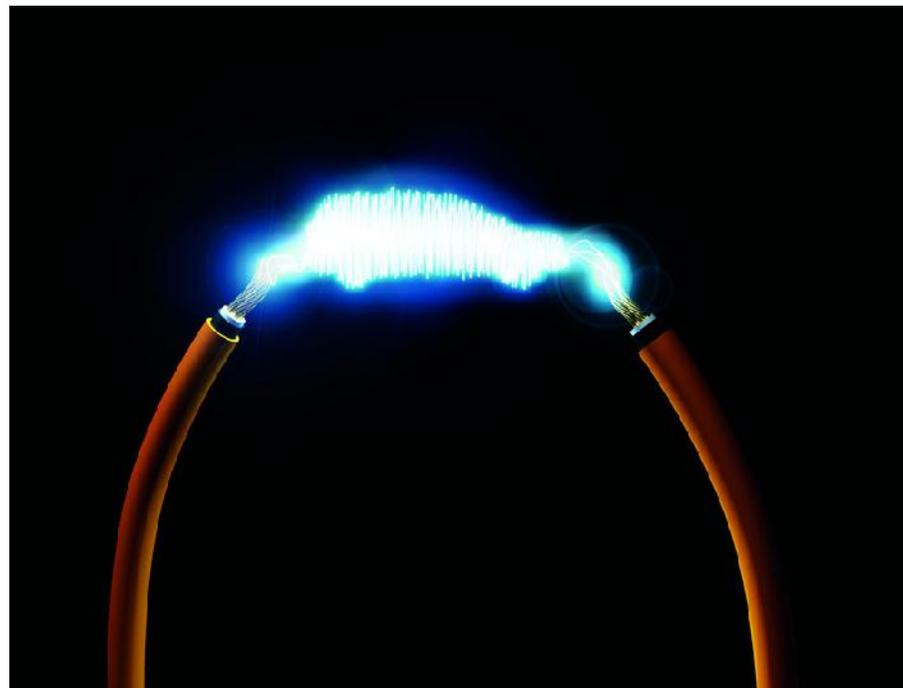
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■ Citaro G BlueTec Hybrid

Voltage for the KOM Citaro G BlueTec Hybrid is 600 V.



©http://www.amz.de/files/smthumbnaildata/lightboxdetail/4/1/9/7/0/6/Hochvolt.jr1405_29.1.jpg



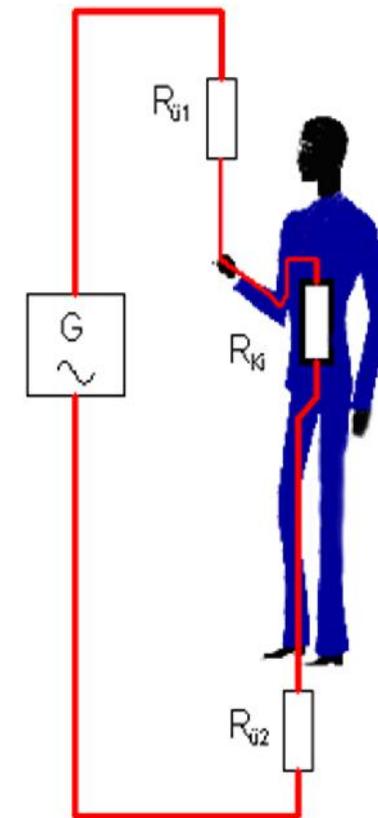
Effect of an electric current

The electricity flowing through a body depends on the voltage and resistance of the body:

- Resistance of body R_B = internal resistance of body I_{RB} and transfer resistances TR_1 and TR_2 at power intake and outlet point

The transfer resistances depend on external conditions:

- dry skin/clothing: high resistance
- humidity, e.g. sweat or moisture

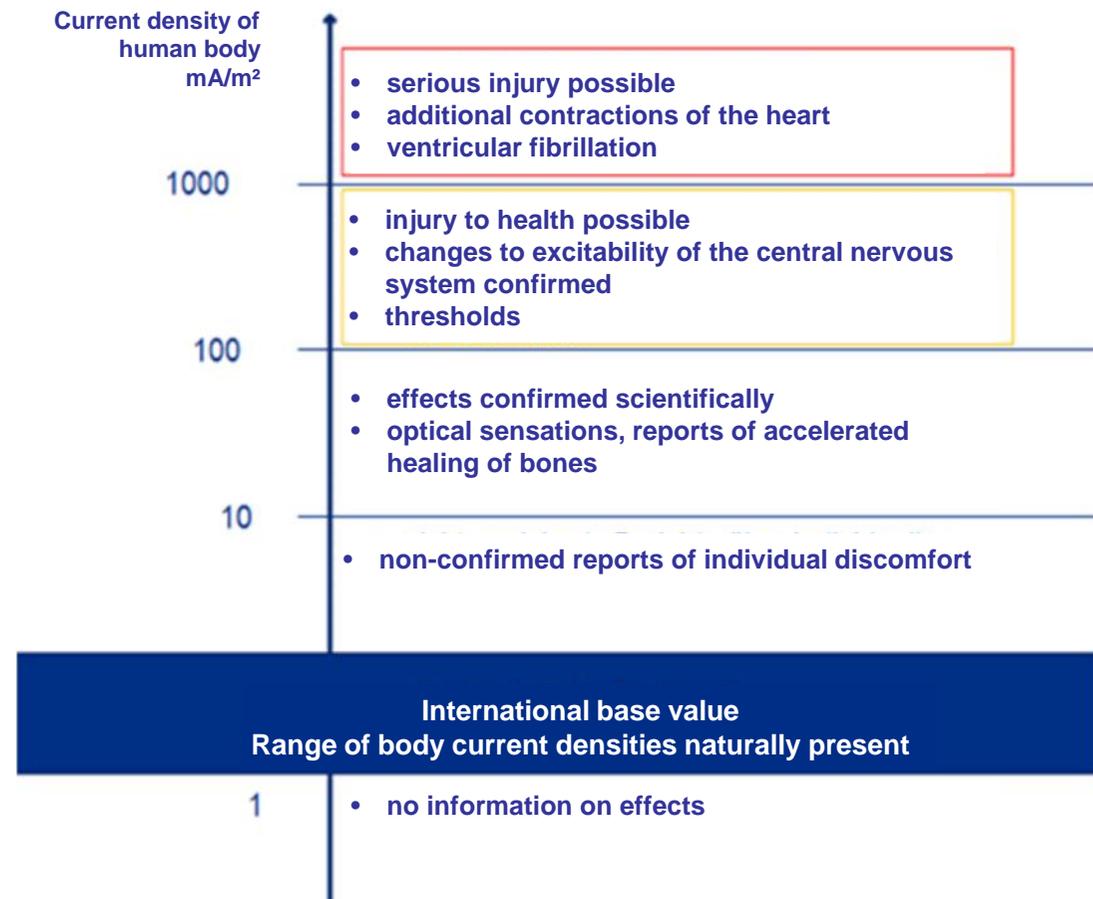


©<http://www.elektro-wissen.de/Tipps/wirkung-des-stroms-auf-den-Menschen.html>



Effect of an electric current

Effects of electricity on the human body



©http://www.tennet.eu/de/fileadmin/_migrated/pics/auswirkungen-korperstromdichten_01.png



Steps to take in the case of accidents

■ Steps regarding the chain of survival:

Think of your own safety
first!

- Immediate action: cut off electricity.
- Caution: risk of death on contact with live parts!
- Switch off, remove plug.
- Remove fuse.
- Ensure you are isolated.
- Separate injured persons from the power source using a non-conductive object or pull on dry clothing.



Steps to take in the case of accidents

- Cardiac arrhythmia or cardiac arrest are life-threatening
- Seconds can mean the difference between life and death
- Call the emergency services as quickly as possible, following the “W” procedure:

WHERE
did it happen?

WHAT
happened?

WHAT NUMBER
of people have
been injured?

WHAT TYPE
of injuries?

WAIT
for further questions!

- See if the injured respond when you speak to them, check breathing and pulse
- Depending on the injuries sustained, give first aid or call for first aiders
- Do not leave the injured alone



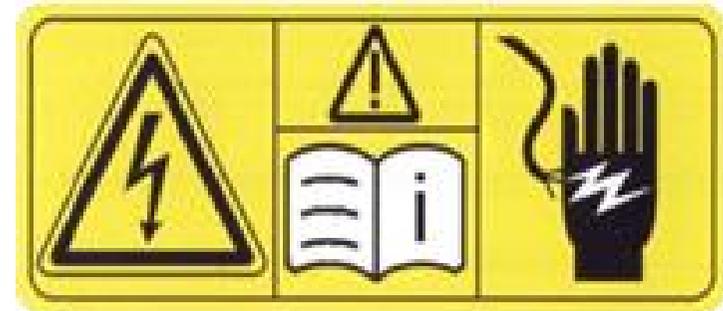
Accident prevention

Do not work on live parts

DGUV (Statutory Accident Insurance) Regulation 3 - Section 6 (1).

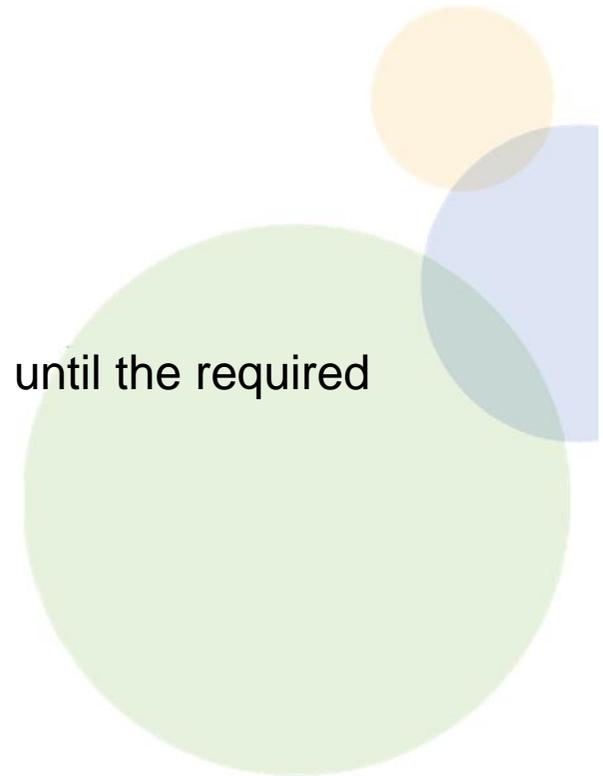
Before working on live parts:

- Check/confirm they are disconnected
- Ensure they remain disconnected while working



6 golden rules for ecodriving:

- Always stay calm!
- Never accelerate to the maximum but accelerate evenly until the required speed is reached-
- Make the best use of rolling.
- Brake evenly, remembering passengers, using the electric regenerative brakes.
- Make sensible use of auxiliary equipment such as heating and air-conditioning
- Concentrate and be aware when driving.



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Thank you for your attention!



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