

GOOD PRACTICE MANUAL

Project MESA-

Mechatronics in energy saving applications,
project Leonardo da Vinci, Transfer of innovation

When converting a car with gasoline or diesel engine into an electric car, we have to take into consideration some important factors, which enable bigger range and smaller electric energy consumption. The vehicle should be light, because the electric motor can then be more efficient. Some of the appropriate models are Renault Twingo, Smart, Audi A2, Fiat Panda and Cinquecento, Volkswagen Polo and Dacia Sandero. The aerodynamics of the vehicle must be below 0.33 CW. The rolling resistance should be as small as possible, because this enables the electric motor to achieve the optimal number of revolutions. The speed of the vehicle is also influenced by the wheel rim and tyre efficiency. Energy saving tyres are recommended, because the tyre design enables small rolling resistance. When converting a vehicle, we must not forget the controller system, namely the steering rack. It is recommended to have a steering system with the servo mechanism, because it does not need electric energy. The electronics in the vehicle should be simple and without any electric particularities. Besides the electric motor, LiFePO₄ batteries are installed, because they have high energy density and smaller decrease with high charge. In place, where batteries are kept, heating must be installed, because when the outside temperature drops below zero, they need longer to recharge. Apart from that cell lifespan can get significantly shorter. When buying a car with gasoline or diesel engine, the quality and condition of the engine is not important, because it will be dismantled from the vehicle and replaced by an electric motor. Important is the good condition of body-shell, because then we can avoid any extra costs. A lighter colour of the car is recommended. Apart from that air-conditioning is not installed in the vehicle, which keeps vehicle light and its range long.



Internal combustion engine, fuel tank and other pipes for fossil fuel were dismantled from Smart. Only the Tiptronic transmission stayed in the car and later an electric motor was installed. All the textile and plastic covers were removed from the cabin. Standard Smart electronics was removed and replaced by electronics with silicone cables, which enables steering of electric motor, information transfer and fire safety.

The engine on the back part of Smart was dismantled. In its place an electric motor was installed with the help of special adapter plate. This adapter plate is made from special kind of aluminium. The plate was made by special CNC tool, which enable precise manufacturing of the product.



Picture 2: Adapter plate

When we join the electric motor and the adapter plate, we have to be careful that the axis from the transmission has a bearing in the transmission and not in the motor shaft. Now we can install the system or if necessary first balance it on the special tool for shaft balancing. In the back side of Smart, where the throttle, regulating the amount of air entering the engine, was located, all the electronics beside the existing ECU computer are installed. This enables ABS braking system to function constantly and air bags to release. With the help of diagnostics computer, connected to the ECU computer in the car, we deleted or hid the reported errors. The vehicle will therefore function without problems and it will not endanger us or other road users. Three-phase alternating motor with power of 15 KW is connected directly to the motor controller. To connect the motor with the controller, three copper conductors with the diameter of at least 50 mm² must be used, which are then attached to the assigned connectors on the controller. They are marked with letters U, V and W. To the section, marked with B+, a positive pole from LiFePO₄ batteries is led. In electrical junction box, made from PVC casing, there are main fuse, potentiometer, pre-charger, main power relay and BMS (battery management system) power supply. BMS enables control of LiFePO₄ batteries consumption and ensures symmetric charging of battery cells. Under the vehicle, where the fuel tank was, we have installed special heated aluminium case, which enables perfect functioning of LiFePO₄ batteries even in cold days. When we install the batteries, we have to place them evenly across the whole aluminium case. Otherwise the position of the vehicle on the road is not optimal. Since there is a BMS power supply in the car, the battery cells are connected in series. Each cell is connected to BMS separately and BMS also provides symmetric charging of battery cells. The negative pole of LiFePO₄ batteries is connected only to the controller of electric motor. The body-shell is namely connected to the negative pole of the 12 V battery. The primary voltage in Smart is 48 V, or up to 60 V, because Lektrika's motor of 15 KW and controller both require this voltage to operate. The decisive factor was the safety regulation, because the voltage up to 60 V is regarded as class A low-voltage electric system. There is also a secondary voltage, which enables functioning of electric systems that require 12 V voltage. These are lights, cabin heating system, window control and windscreen wiper.

Because of that an additional 12 V battery was installed in the cabin of the car, which is powered by DC/DC converter.

The car is now propelled by electric energy and not fossil fuel, so we added a special potentiometer to the gas pedal, which is required for the functioning of electric motor. Besides that it ensures an easier drive-off and also a more comfortable and safe drive. Car model Smart uses for steering an ordinary mechanical mechanism for steering wheels, which does not need electric motor or hydraulic system to steer front wheels. For the braking system to work we have installed new electric vacuum pump, which is turned on by controller, when we push the brake pedal. The brake pedal is therefore always flexible, as in gasoline or diesel-powered cars. For charging of both batteries we have installed ordinary three-pole industrial socket to charge LiFePO₄ batteries. We installed it on the position, where the fuel pipe was before. With a special carrier, made from stainless metal, we mounted everything to the body-shell and glued a sticker 220V to the lid, which marks that this car needs electric energy and not fossil fuel.



Picture 3: Charging of the car

On the front part of the electric car we have fixed a charger for LiFePO₄ batteries, which is directly connected to the three-pole socket. When charging the LiFePO₄ batteries, the voltage proceeds through the socket to the charger. The charger has a power of 3kW, so a good cooling is needed.

Cooling and heating of the cabin is needed in electric cars. We have installed an electric heater, which boils water, on the existing pipes. The heater has a power of 800W and is connected to the 12 V voltage. For cooling we use the existing ventilator for air flow. We did not install additional AC compressor, because it would use too much electric energy and decrease the range by quite some kilometres.

When the conversion was completed, we took the car for a test run and checked if the car reacted normally or as we expected. After the test run we checked all the electric components, controllers and silicone cables to see if any unwanted errors occurred. In that case we would have to immediately solve the errors and ensure safety and uninterrupted functioning of the car. Conduits are placed correspondingly in the cabin and if necessary we can group more cables with a tie. Cables are then firmer and there is less possibility that some metal part in the

car would pierce the silicone insulation. Then we can cover the floor with textile to hide the conduits, connected to the dash board, charger of LiFePO4 batteries and back boxes. This also additionally protects the silicone cables in the cabin. When we are done with covering the floor, we can install the interior PVC covers, so the electric car Smart looks like before, except that it is now propelled by electric energy and not fossil fuel.