MAGMENT

Wireless Power Transmission for Electromobility

In order to accelerate the acceptance of electromobility, best performing technologies for recharging electric energy storage (batteries) are necessary. To this end it is important to consider factors such as convenience, transferable power range, efficiency, electromagnetic compatibility and health risks.

The contactless (inductive) transmission of electric energy is a convenient and secure way to load batteries, which combines performance with efficiency and flexibility. The inductive energy transfer requires a stationary primary coil (source) and at least one mobile secondary or pick-up coil, as a component of the vehicle (sink). Both coils should be arranged (aligned) in such a way that transmissible power and efficiency are maximized. With power ranging up to 500 kW, efficiencies in excess of 90% have been implemented. Charging of electric vehicles can only be considered from an economic perspective thanks to a high enough efficiency. This is the more important, the higher the transmitted power and will be achieved if the distance between the coils is small (in the range of a few centimeters if possible from a design perspective) and/or the permeability of the coil substrate for focusing the magnetic field is large enough. For structural reasons, a large distance between primary and secondary coils is inevitable in large vehicles, which increases the need for a large permeability of the coil substrate. To comply with the prescribed magnetic field limits [ICNIRP 2010] inside the vehicle, anyway soft ferrites are used as a carrier material of the secondary coil. For the primary coils that are installed in the ground the use of ferrites is often avoided for cost reasons. This is however only possible if no **dynamic charging** is intended and there are no **shielding requirements against network cables**.

Since the primary coil is a large-sized part (up to several meters), conventional ceramic ferrite components can only be integrated at high cost. Plastoferrites are not an option either because they are also way expensive as compared to cement-bonded components, have lower permeabilities and would not be dimensionally stable at high temperatures. All other soft magnetic materials (metal powder or amorphous metals) do not come into consideration due to high costs and limitations with respect to the size of the component. This also applies to composite materials based on these materials.

Magnetizable concrete

The technological basis of a cement or asphalt bonded magnetizable concrete therefore offers the optimal solution in every respect. It allows to shape component geometries to optimize the field focusing with a casting process performed **under no pressure** by using **inexpensive** raw materials enabling **full integration** into the road structure. The ferrite particles used as magnetic filler of the concrete are obtained from **recycled** materials from the ferrite production and from the electronic waste cycle.

For greater practicality and availability, the field generated by the primary coil should be focused by the highest possible permeability compared to air. Calculations of an exemplary arrangement in which the primary coil was backed by magnetic concrete (coil width 80 cm, coil spacing 15 cm, concrete thickness 5 cm) on the basis of finite element modeling show on the one hand, an increase in the efficiency and on the other hand an increase in the coil spacing at constant efficiency. This effect can be reached with permeabilities around μ = 40, which can be realized with magnetic concretes. The use of ceramic ferrites (μ = 2000) would yield only a small further increase (see Figure 1).

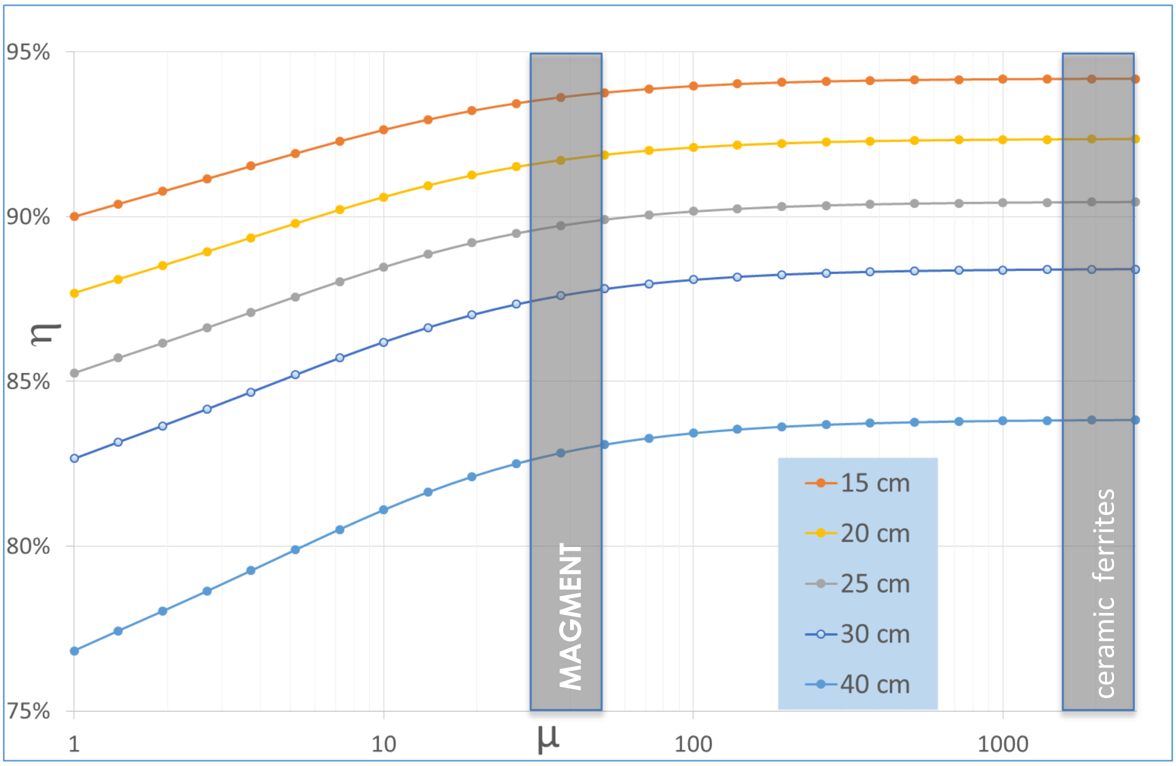

Figure 1: efficiency depending on the distance between the primary and secondary coil at different permeability of the primary coil substrate

Figure 2 shows the corresponding field distribution for different permeabilities and distances between primary and secondary coils. The desired field focusing effect thanks to the magnetizable concrete layer can be clearly seen. Figure 3 shows a schematic of a dynamic wireless power transmission system (DWPT) and Figure 4 its application for battery charging at stops of Bus Rapid Transportation (BRT) systems.

Conclusion

The use of a magnetizable concrete for coupling coils with high coupling factor is a versatile applicable concept with high potential for contactless energy transfer in wide power ranges. The combination of two very sophisticated groups of substances in a material offers a broad and innovative range of application possibilities for future technologies.

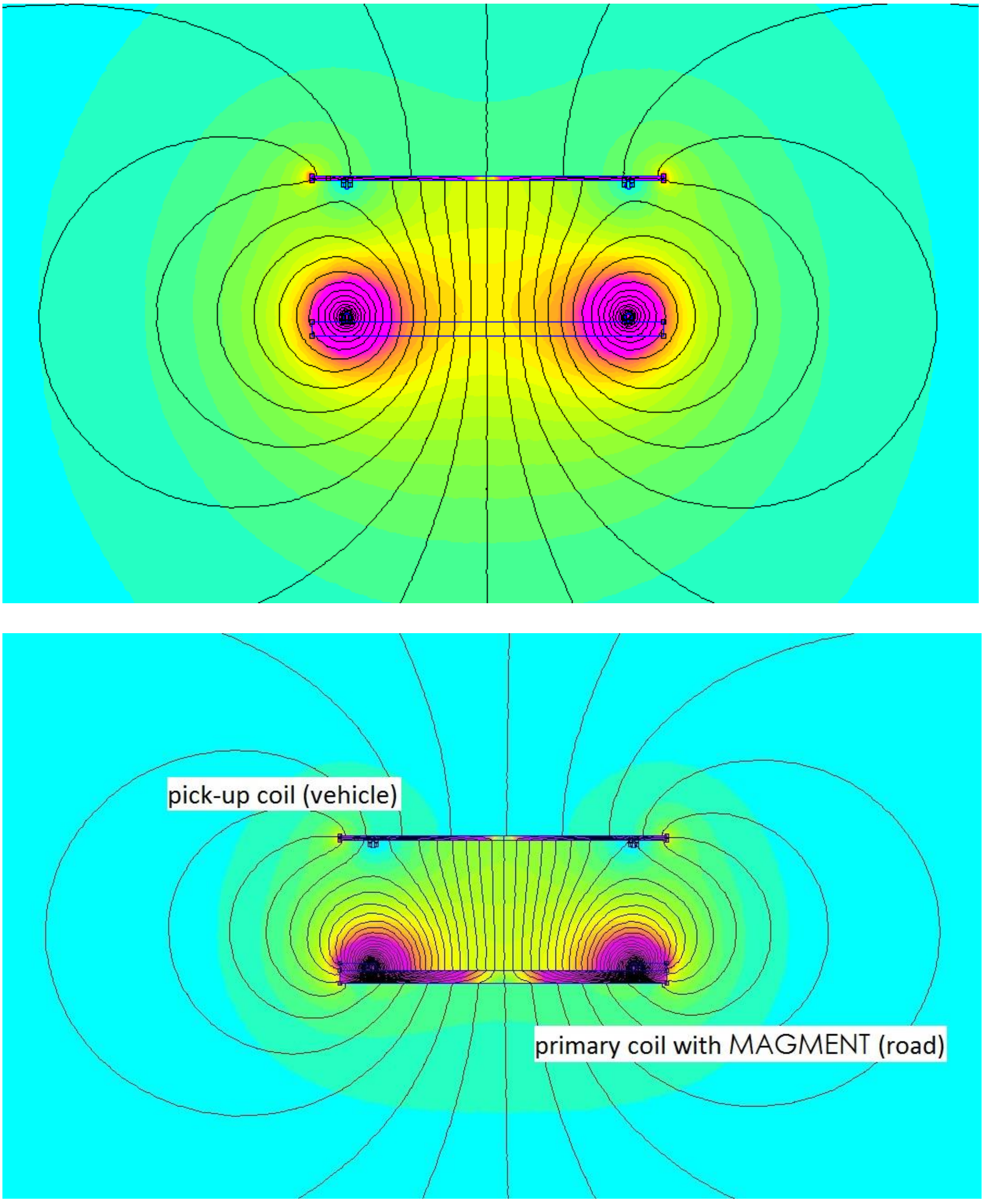

Figure 2: magnetic field distribution for a coil distance of 20 cm and different permeability μ of the primary coil substrate (a) μ = 1 (air) (b) μ = 40 (magnetizable concrete)

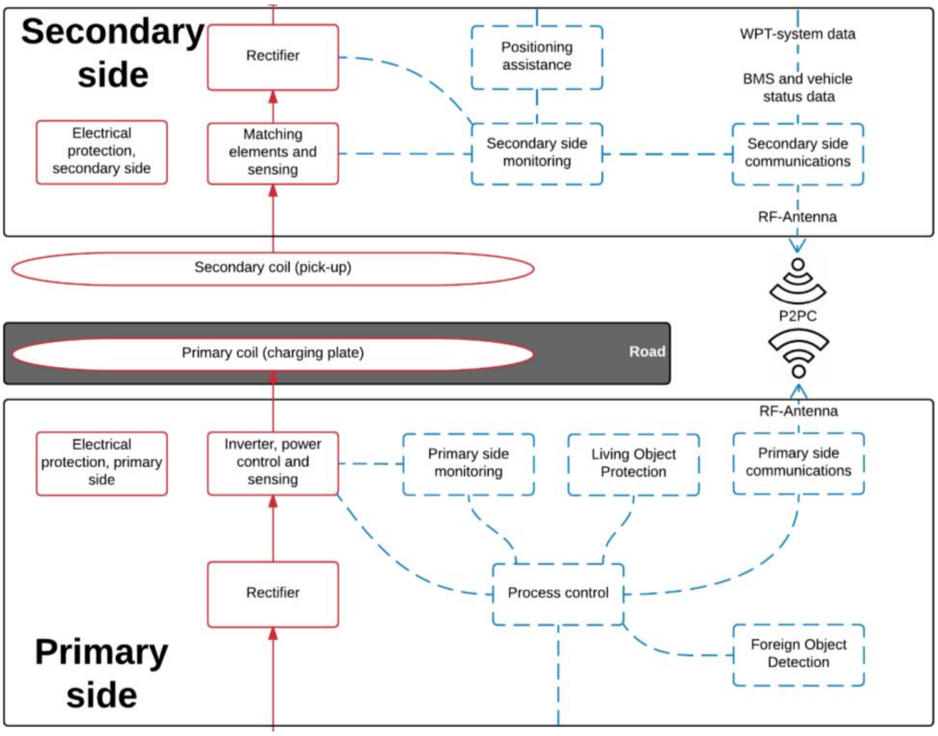

*Figure 3: wireless dynamic power transmission system**

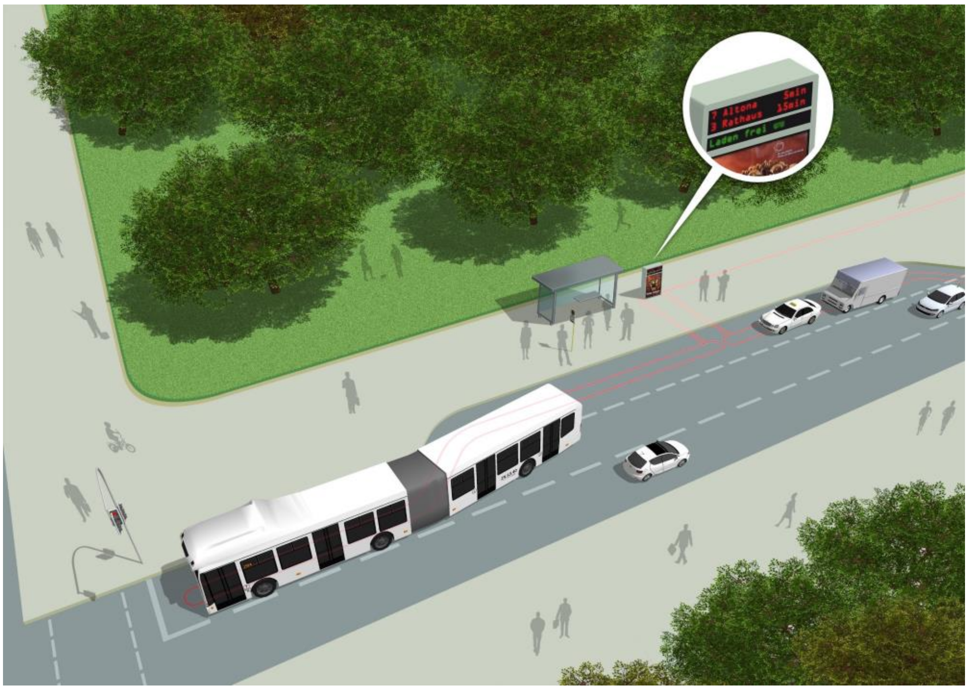

*Figure 4: Inductive energy supply for BRT Systems**

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