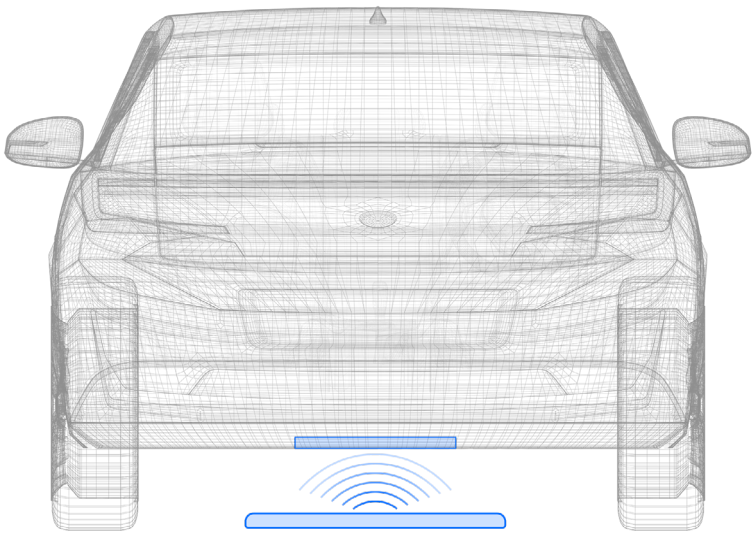
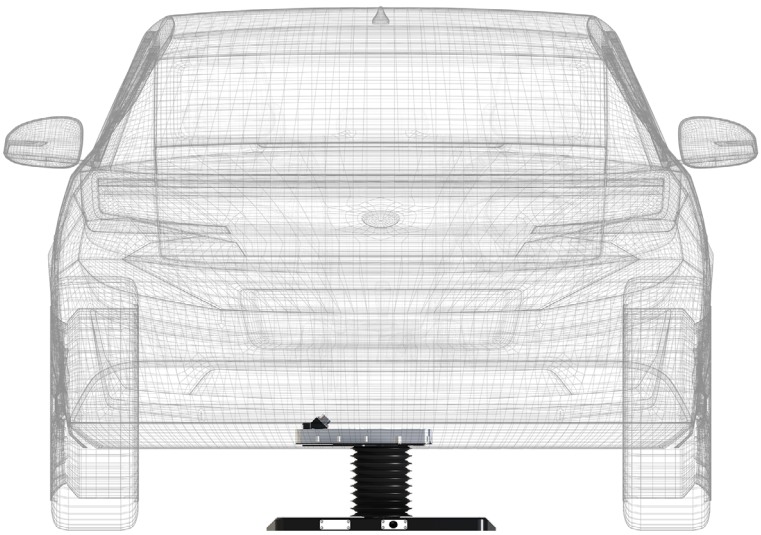
Easelink

Version 1.0 Headquarter Graz 2024

What is the winning EV charging technology?

Automated Charging: Inductive vs. Conductive



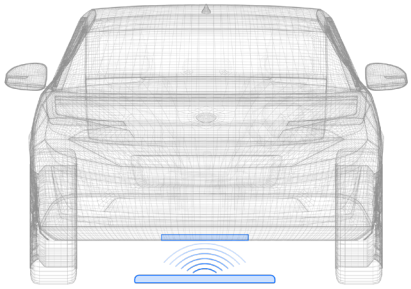


Automated Charging

What is the winning EV charging technology?

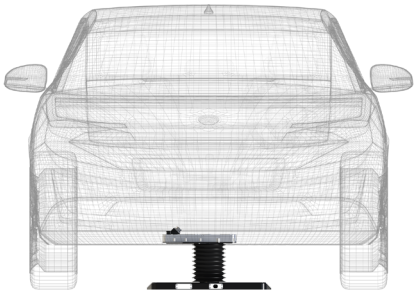
The automotive industry is currently going through a massive transformation, triggered by electrification, autonomous driving, user-centric design and the challenge to connect the mobility and energy sector. A key technology in this transformation is automated (or hands-free) charging. It allows a non-invasive charging infrastructure for electric vehicles, especially in densely populated areas, represents a prerequisite for the advance of autonomous driving functionality, enables a truly user-centric car and is key for a smart and sustainable energy grid, that can cope with fluctuations of increasingly used renewable energy sources like solar and wind.

The two main technological concepts for hands-free charging currently pursued in the mobility industry are inductive and automated conductive charging. Within the latter category, Matrix Charging® is the leading concept currently considered by various OEMs all over the globe. In the following paragraphs, both technologies will be briefly explained and compared in detail along the most critical parameters for the mobility and energy industry – cost, efficiency and system complexity & weight.



Inductive Charging

Sometimes referred to as Wireless Charging, inductive charging transfers electrical energy via an airgap. It converts the grid frequency to a very high frequency (e.g., 85kHz) which allows a transmitter coil in the ground unit to produce a magnetic field which then induces current in a receiver coil in the vehicle unit. This technology is mostly known from charging mobile devices or the electrical toothbrush.



Matrix Charging®

In contrast to Inductive charging, a physical connection is established for the energy transfer – the same as for manual charging cables for electric cars, as found in charging stations today. The only difference is that the charging process is fully automated and does not require any user interaction whatsoever. As soon as the vehicle is parked above a charging Pad, a connector is lowered from the vehicle's underbody and physically connects to the charging pad to charge the battery.

1 Costs

Competitive cost is one of the most important criteria for the automotive industry, especially if the technology needs to address the volume segment in the long term. Various benchmarks by automotive OEMs and suppliers show that Matrix Charging® costs roughly 30% compared to inductive charging.

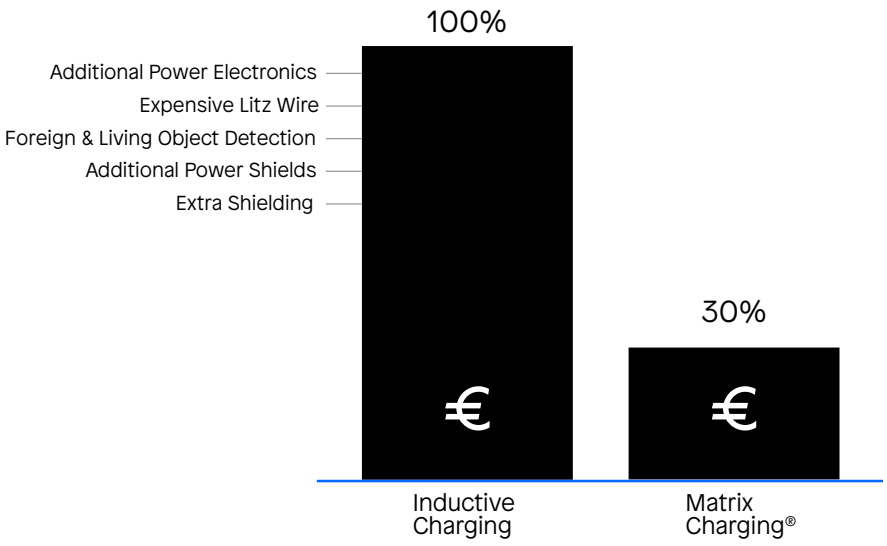
The significantly higher cost of inductive charging are caused by various factors. First, additional power electronics on the infrastructure and vehicle side are needed to transform from the grid frequency to 85kHz to allow energy transfer via the air gap.

Matrix Charging® is just transferring from the grid directly to the anyway existing Onboard Charger (OBC) of the car, without any additional transformation process. Since all electric cars, have OBC´s, Matrix Charging® is indirectly benefiting from massive investments currently poured into developments to make OBCs cheaper and more efficient.

Second, inductive charging requires two big and heavy coils using very expensive litz wire to optimize the power transfer efficiency.

Third, inductive charging also needs a lot of extras, like a specific cooling system, sophisticated sensors like foreign object detection (FOD) and living object detection (LOD) for safe operation and extra shielding to reduce power loss caused by eddy currents induced in steel parts in the vicinity of the receiver coil and to protect other electronic components in the vehicle from electromagnetic interference.

In the case of bidirectional charging, additional components for power electronics on the infrastructure and vehicle side are needed to allow the energy transfer in the opposite direction and increase the cost of inductive charging even further, widening the gap to Matrix Charging® to a factor of 4x.



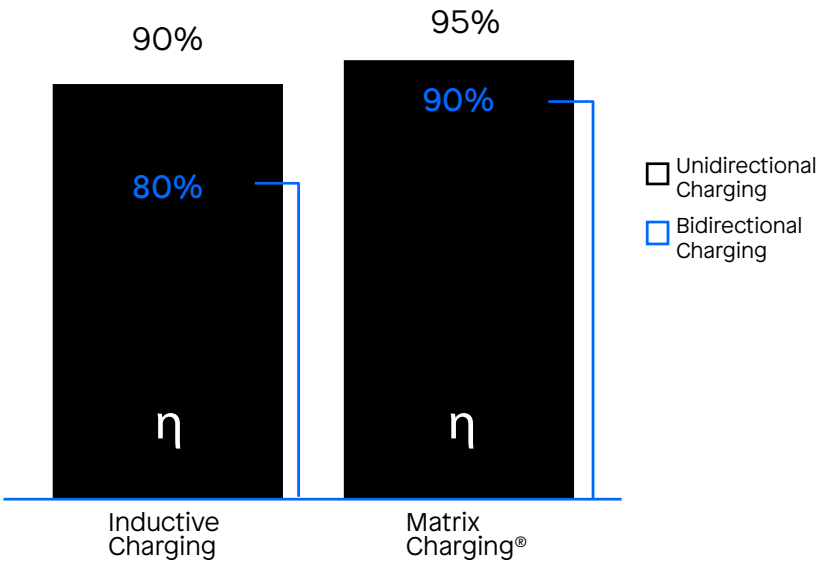
2 Efficiency

The efficiency of conductive systems is between 5 to 10 absolute percentage points higher than inductive charging. While inductive charging can reach 90% only in ideal conditions (a German OEM launched a limited series of vehicles available with inductive charging in 2018 - an overall charging efficiency of only 85% was published), conductive systems reach 95% and higher. The primary losses in conductive systems stem predominantly from the OBC, highlighting the potential for further enhancements through ongoing investments in development. The Matrix Charging® system itself has an efficiency of >99%.

The root cause for this drastic efficiency penalty is the weak magnetic coupling between the transmitter and receiver coil. Additionally, when the vehicle gets parked the coils are usually not perfectly aligned. The lateral misalignment further reduces the magnetic coupling and thus the efficiency of Inductive Charging.

In case of bidirectional charging, the efficiency penalty needs to be counted twice (for charging the battery and feeding back the energy to the grid), which increases the efficiency penalty of inductive charging even more.

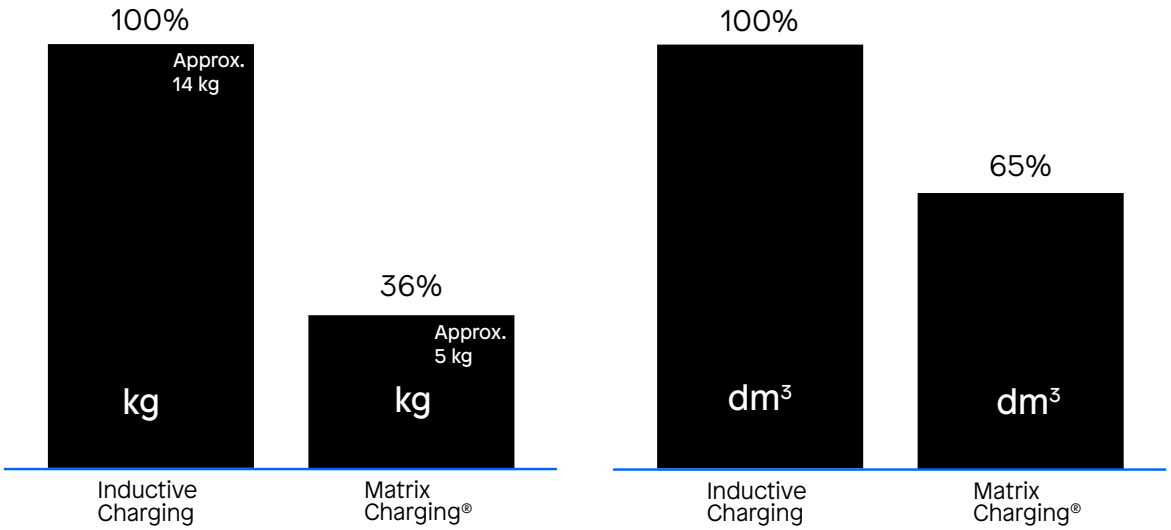
Considering the massive investments of the automotive industry over the last decades to increase powertrain efficiency and optimize for every tenth of a percentage point, the big efficiency difference between inductive and conductive charging seems very hard to overlook, especially after the anonymously progressive claims from automotive players for a sustainable future of the industry.



3 System Complexity & Weight Vehicle Unit

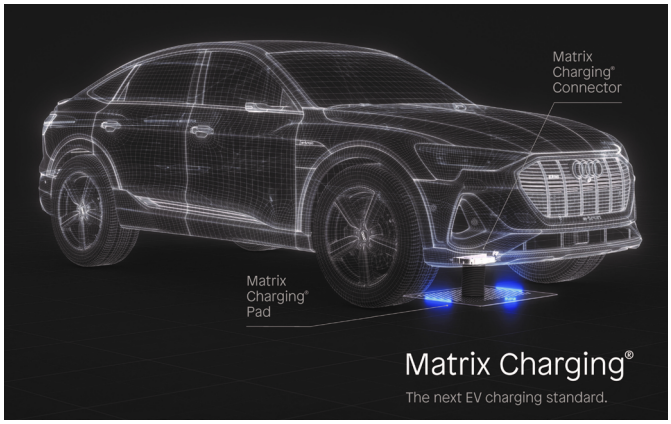
Also important from an OEM-perspective is how simple the system can be integrated into the vehicle architecture considering limited space and light-weight requirements. While inductive charging systems weigh around 14kg on the vehicle side, Matrix Charging® weighs only 5kg, meaning less than the half. This is mainly caused by the copper and ferrite content of the coils and all the extra parts already mentioned.

Furthermore, Matrix Charging® can be easily integrated in the vehicle's E/E architecture as it does neither require cooling, additional space for aluminum shields to increase efficiency and mitigate electromagnetic interference (EMI) and electromagnetic field (EMF) issues, nor complex sensors to ensure safe operation.



Best-in class. Technology conclusions.

Matrix Charging® provides outstanding advantages in cost, efficiency, system simplicity, and reduced vehicle weight, making it the leading technology for automated, hands-free charging in the mobility and energy sectors.



About the Authors

Gregor Eckhard
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Gregor Eckhard brings over 12 years of automotive industry experience. He holds a Master's in Automotive Engineering & Business Economics and an MBA. At McKinsey & Company, Gregor led technology and strategy projects with automotive manufacturers across Europe, the USA, and Asia. He later managed the automotive start-up MultiMaterial-Welding AG, securing major investments and serving on its supervisory board. Currently, Gregor co-leads the Easelink team with Hermann Stockinger, focusing on pioneering the next generation of electric vehicle charging standards.

Peter Wambsganß
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Peter Wambsganß, with a professional background in electrical engineering, has been working in the field of EV charging for over 15 years. Before joining Easelink, he served as Director of Business Development Europe at WiTricity, a US-based company specializing in inductive charging for EVs. His extensive experience in developing and promoting advanced charging technologies has been instrumental in shaping the future of electric mobility.

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