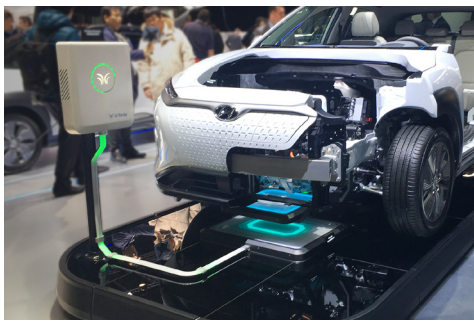
WiTricity®
Powering life, wirelessly.

The Next Wireless Revolution: Electric Vehicle Wireless Charging

Power and Efficiency





WiTricity Corporation

The Next Wireless Revolution: Electric Vehicle Wireless Charging

The power and efficiency of wireless electric vehicle (EV) charging — and the future of electrified, shared, and autonomous transportation

Imagine never having to think about fueling your car. That day is close at hand.

In such a world, cars charge themselves. The vehicle just gets the power it needs on its own, delivered wirelessly. There are no plugs or power cords, let alone trips to a gas or charging station.

Fast, safe, and efficient wireless EV charging — an essential component of electric and autonomous transportation — is a technology that's proven and ready to be deployed.

Top off your battery by "power snacking" during the day – at work or running errands.

EV charging levels

According to SAE International, there are three basic levels of EV charging:

Level 1 ("slow") charging consists of standard 120 V household wall plug charging, requiring 8 to 20 hours to charge a typical EV battery pack.

- *Simple AC plug charger often included for free in the purchase of an EV.*
- *Typically 4 miles of range per hour charging*

Level 2 ("fast") charging units use 240 V electricity, are rated from 3.3 kW up to 22 kW and can charge an EV in 3-4 hours.

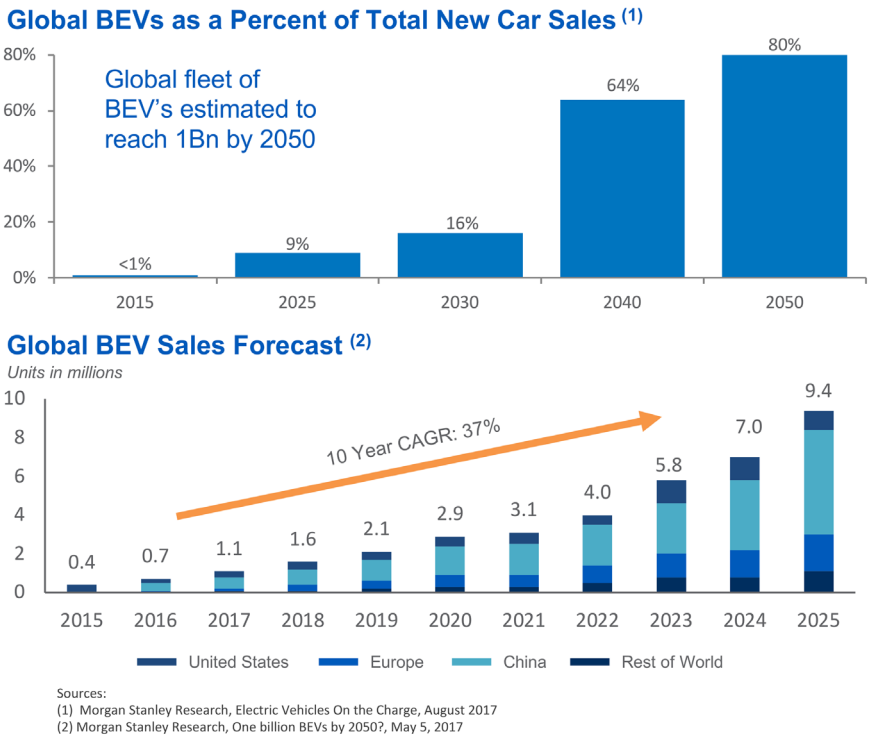
- *Typically installed at home or in public parking spots with the same wiring one needs for an electric clothes dryer.*
- *Typically 35 miles of range per hour charging at 11kW*

Level 3 ("rapid") charging (AC or DC) are rated between 43 kW and 120 kW and require 20-30 minutes to charge an EV.

- *Expensive equipment and installation requiring planning by local utility company to meet extreme power requirements.*
- *Can charge at speeds over 200 miles of range per hour (depends on vehicle, charging equipment and battery level)*

The speed and efficiency of wireless EV charging

Electric vehicles are extending their range and market penetration every year. According to the U.S. Department of Energy, EV range has increased by 56% from 2011 to 2017. Meanwhile, regulations are helping drive EV adoption — along with a rapidly increasing consumer demand. In California, whose regulations set the standard for U.S. automakers, the state's Zero Emission Vehicle program mandates 8% of new cars sold by 2025 to be EVs. By at least one estimate, the state is already nearly halfway to this goal. Moreover, Norway (2025), Germany (2030), India (2030), France (2040), and Britain (2040) have all mandated the complete transition from fossil fuel combustion vehicles to electrified vehicles.



Sources:
(1) Morgan Stanley Research, Electric Vehicles On the Charge, August 2017
(2) Morgan Stanley Research, One billion BEVs by 2050?, May 5, 2017

In all, the future of personal transportation will increasingly be built around the EV, which means being more and more reliant on EV charging.

Consumers who buy EVs today typically buy plug-in charging stations for their home or office. Most, however, do not realize that the time it takes to fully recharge will be the same with either a wired or wireless charger.

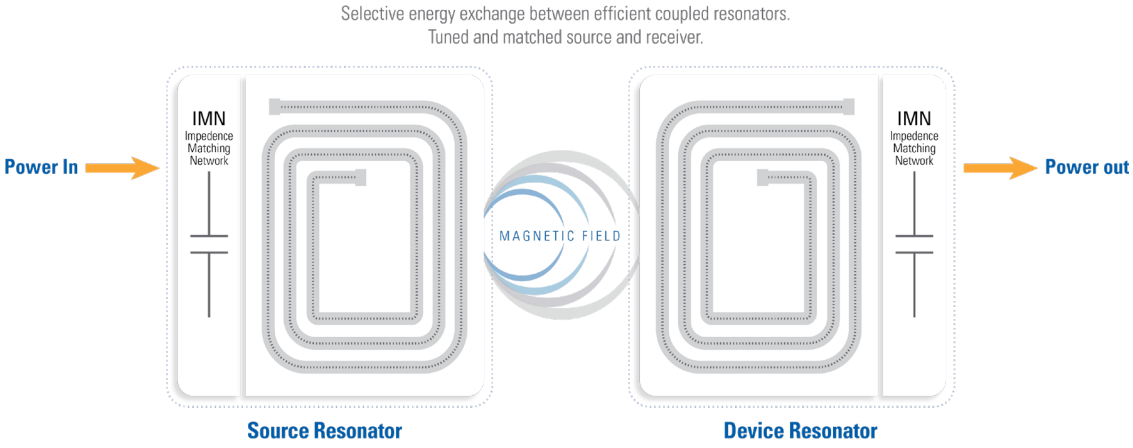
Most consumer plug-in EV chargers — whether Level 1 or Level 2 (see sidebar) — operate in the 88% to 95% efficiency range. Leading wireless EV charging technologies today operate in the upper end of that same range — at between 90% to 93% efficiency.

WiTricity wireless charging is based on an improvement upon the physical principle of electromagnetic induction. Induction has long been used in household appliances like induction cooktops, charging electric toothbrushes, and even some smartphones.

Yet, the remarkable fact that Electric Vehicle wireless charging can be as efficient as plugging in stems not from induction alone. One additional technological layer is needed: the innovation of magnetic resonance.

In 2007 a group from MIT published the results of an experiment demonstrating that the use of magnetic resonance enables efficient wireless power transfer across mid-range distances. Using coupled magnetic resonators they powered a 60 Watt lightbulb over a distance of 2 meters, a result that received worldwide attention.

By tuning both the transmitter and receiver to an equivalent resonant frequency, the system becomes significantly more efficient while also allowing for transmission distances that are far more practical than traditional induction permits.



WiTricity technology provides a unique solution for medium and high power requirements.

Today the commercial outgrowth of that technology — known as magnetic resonance or, equivalently, highly resonant wireless power transfer — represents the core of WiTricity's EV wireless charging system. Independent testing at the US Department of Energy's Idaho National Laboratory, as part of the J2954 standard being developed by SAE International, proved the superior performance and interoperability of WiTricity's system. The efficient design and architecture is also being considered for use in other global standardization efforts led by IEC/ISO (International) and CATARC (China).

Moreover, WiTricity's wireless charging technology is safe. EV charging using WiTricity technology at even 11 kW meets all regulatory guidelines for human safety. Designed after years of rigorous and detailed electromagnetic analysis, WiTricity EV charging technology keeps stray magnetic and electric fields below the well-established and longstanding safety limits used in all electromagnetic consumer devices — including cellphones, wireless routers, Bluetooth headsets, and radio transmitters.

Economic and practical considerations of wireless EV charging

It's easy to forget how much time and effort people spend throughout their lives keeping their cars' gas tank filled. Yet imagine a hassle-free technology that filled your car every night while you slept, and you didn't even need to plug it in. How much of a premium would you be willing to pay never to have to worry about filling or charging your car?

The question is not merely one of convenience either. Wireless EV charging also represents a step forward in safety. In a torrential downpour or severe thunderstorm, would you prefer to wirelessly charge your car without a second thought, or would you rather get soaked as you fumble around with a 480-Volt DC Fast Charging cable?

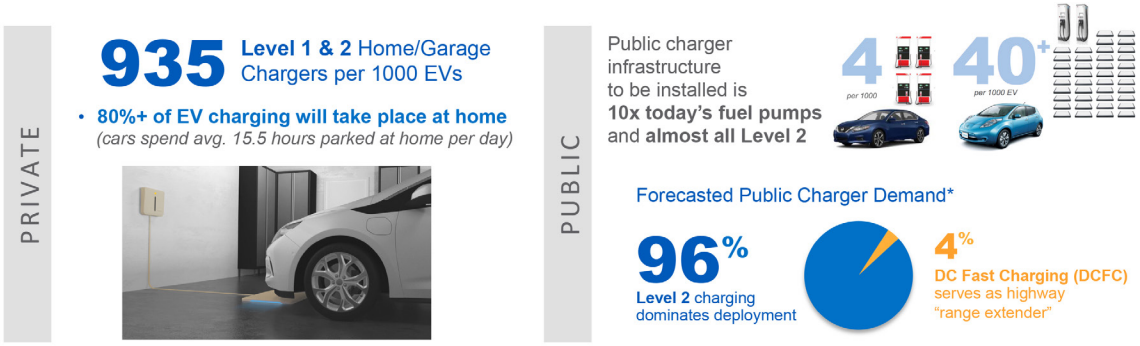
Park and charge wirelessly and autonomously.

Wireless charging, to be clear, is just as convenient and safe out in the elements as it is inside a garage.

Wireless EV charging ultimately represents a new way of thinking about transportation. People aren't used to putting their car in the same category as their household appliances — whose power sources are effectively invisible and out-of-mind. Unless there's a power outage, the refrigerator or dishwasher just run without any second thought paid to their power source. So too, with wireless EV charging, the car becomes a little bit more like a household appliance — at least in terms of its power sourcing.

In other words, wireless charging is something that happens in the background, when the car is parked over wireless charging pads. It just charges itself, and on a typical day's driving, one doesn't need to think about power sourcing and battery levels.

According to studies by the U.S. National Renewable Energy Laboratory, 80% of EV charging will take place at home, where on average cars spend 15.5 hours parked per day. These home charging units will in all likelihood be so-called Level 2 (see sidebar) charging stations. In fact, even when fully scaled out, 96% of the public charging stations will be Level 2, not Level 3 DC Fast Charging (DCFC) stations. Current systems are targeted at 11 kW, while the standard and roadmap continues easily to 22 kW. Some studies show that 99% of the anticipated global charging infrastructure will be 11 kW or below.



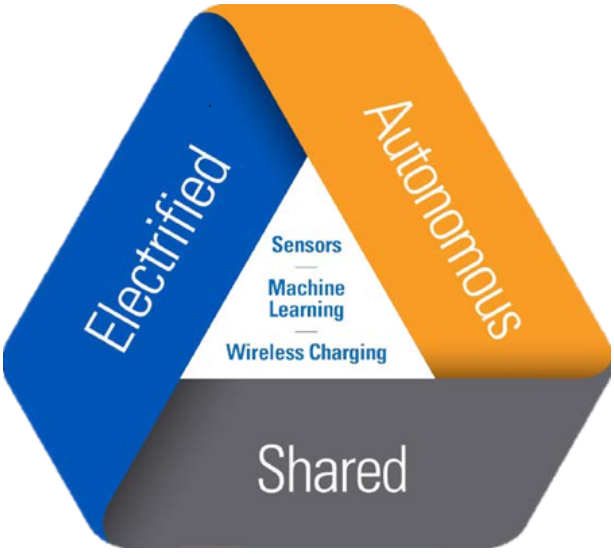
Reality of wireless charging infrastructure.

Those remaining 4% of the EV charging infrastructure, Level 3 DCFC, will serve primarily as a highway "range extender" for long trips. Installing DCFCs requires special safety considerations and special trunk wiring (for the 480 V and 43 to 120 kW power levels) and commands equipment price tags from $10,000 to $40,000, plus installation cost up to $50,000 per charger. DCFCs will not be widely deployed for everyday consumer use, just like no one has their own gas pump in the backyard for their internal combustion car.

Level 2 chargers, running at 3 kW to 22 kW and filling a car in 3-4 hours, will represent the baseline for EV charging around the world. Installed at a typical cost between $400 and $6500, Level 2 charging is how most cars in most driving situations will get their power.

WiTricity delivers scalable charging rates from 3.6 to 22 kW, to meet the needs of vehicles ranging from PHEV's with small capacity battery packs to EV's with high capacity, long range battery packs. WiTricity charging units charge vehicles ranging from low ground clearance sports cars to medium ground clearance sedans to high ground clearance SUV's, with a single system design and no moving parts. Moreover, WiTricity's units can be installed as an on-ground charging pad in a private residence and buried flush in the pavement of a parking lot as public charging infrastructure.

In a world where cars are electrified, shared, and autonomous, how, after all, could an autonomous car plug itself in? With the added demands of autonomous systems, autonomous robotaxis will need to opportunity charge or "power snack" through the day, without leaving their service area. The solution is wireless power. The wireless power revolution is shaping the future of transportation today. Contact WiTricity to find out how wireless EV charging could be in your EV future too.



Wireless charging enables the future of mobility.

References

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[3] "Regional Charging Infrastructure for Plug-In Electric Vehicles: A Case Study of Massachusetts" by Eric Wood et al, NREL. Jan. 2017 https://www.nrel.gov/docs/fy17osti/67436.pdf

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