Wireless power could revolutionize highway transportation, researchers say

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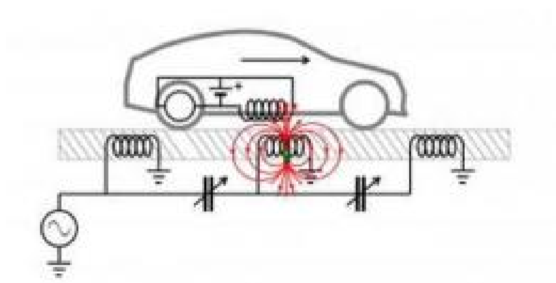

Stanford University researchers are developing a technology that uses magnetic fields (shown in red) to wirelessly charge electric vehicles cruising at highway speeds. Credit: Sven Beiker, CARS/Stanford University

A Stanford University research team has designed a high-efficiency charging system that uses magnetic fields to wirelessly transmit large electric currents between metal coils placed several feet apart. The long-term goal of the research is to develop an all-electric highway that wirelessly charges cars and trucks as they cruise down the road.

The new technology has the potential to dramatically increase the driving range of electric vehicles and eventually transform highway travel, according to the researchers. Their results are published in the journal Applied Physics Letters (APL).

"Our vision is that you'll be able to drive onto any highway and charge your car," said Shanhui Fan, an associate professor of electrical engineering. "Large-scale deployment would involve revamping the entire highway system and could even have applications beyond transportation."

Driving range

A wireless charging system would address a major drawback of plug-in electric cars – their limited driving range. The all-electric Nissan Leaf, for example, gets less than 100 miles on a single charge, and the battery takes several hours to fully recharge.

A charge-as-you-drive system would overcome these limitations. "What makes this concept exciting is that you could potentially drive for an unlimited amount of time without having to recharge," said APL study co-author Richard Sassoon, the managing director of the Stanford Global Climate and Energy Project (GCEP), which funded the research. "You could actually have more energy stored in your battery at the end of your trip than you started with."

The wireless power transfer is based on a technology called magnetic resonance coupling. Two copper coils are tuned to resonate at the same natural frequency – like two wine glasses that vibrate when a specific note is sung. The coils are placed a few feet apart. One coil is connected to an electric current, which generates a magnetic field that causes the second coil to resonate. This magnetic resonance results in the invisible transfer of electric energy through the air from the first coil to the receiving coil.

"Wireless power transfer will only occur if the two resonators are in tune," Fan noted. "Objects tuned at different frequencies will not be affected."

In 2007, researchers at the Massachusetts Institute of Technology used magnetic resonance to light a 60-watt bulb. The experiment demonstrated that power could be transferred between two stationary coils about six feet apart, even when humans and other obstacles are placed in between.

"In the MIT experiment, the magnetic field appeared to have no impact on people who stood between the coils," Fan said. "That's very important in terms of safety. "

Wireless charging

The MIT researchers have created a spinoff company that's developing a stationary charging system capable of wirelessly transferring about 3 kilowatts of electric power to a vehicle parked in a garage or on the street.

Fan and his colleagues wondered if the MIT system could be modified to transfer 10 kilowatts of electric power over a distance of 6.5 feet – enough to charge a car moving at highway speeds. The car battery would provide an additional boost for acceleration or uphill driving.

Here's how the system would work: A series of coils connected to an electric current would be embedded in the highway. Receiving coils attached to the bottom of the car would resonate as the vehicle speeds along, creating magnetic fields that continuously transfer electricity to charge the battery.

To determine the most efficient way to transmit 10 kilowatts of power to a real car, the Stanford team created computer models of systems with metal plates added to the basic coil design.

"Asphalt in the road would probably have little effect, but metallic elements in the body of the car can drastically disturb electromagnetic fields," Fan explained. "That's why we did the APL study – to figure out the optimum transfer scheme if large metal objects are present."

Using mathematical simulations, postdoctoral scholars Xiaofang Yu and Sunil Sandhu found the answer: A coil bent at a 90-degree angle and attached to a metal plate can transfer 10 kilowatts of electrical energy to an identical coil 6.5 feet away.

"That's fast enough to maintain a constant speed," Fan said. "To actually charge the car battery would require arrays of coils embedded in the road. This wireless transfer scheme has an efficiency of 97 percent."

Wireless future

Fan and his colleagues recently filed a patent application for their wireless system. The next step is to test it in the laboratory and eventually try it out in real driving conditions. "You can very reliably use these computer simulations to predict how a real device would behave," Fan said.

The researchers also want to make sure that the system won't affect drivers, passengers or the dozens of microcomputers that control steering, navigation, air conditioning and other vehicle operations.

"We need to determine very early on that no harm is done to people, animals, the electronics of the car or to credit cards in your wallet," said Sven Beiker, executive director of the Center for Automotive Research at Stanford (CARS). Although a power transfer efficiency of 97 percent is extremely high, Beiker and his colleagues want to be sure that the remaining 3 percent is lost as heat and not as potentially harmful radiation.

Some transportation experts envision an automated highway system where driverless electric vehicles are wirelessly charged by solar power or other renewable energy sources. The goal would be to reduce accidents and dramatically improve the flow of traffic while lowering greenhouse gas emissions.

Beiker, who co-authored the APL study, said that wireless technology might one day assist GPS navigation of driverless cars. "GPS has a basic accuracy of 30-40 feet," he said. "It tells you where you are on the planet, but for safety, you want to make sure that your car is in the center of the lane." In the proposed system, the magnetic fields could also be used to control steering, he explained. Since the coils would be in the center of the lane, they could provide very precise positioning at no extra cost.

The researchers also have begun discussions with Michael Lepech, an assistant professor of civil and environmental engineering, to study the optimal layout of roadbed transmitters and determine if rebar and other metals in the pavement will reduce efficiency.

"We have the opportunity to rethink how electric power is delivered to our cars, homes and work," Fan said. "We're used to thinking about power delivery in terms of wires and plugging things into the wall. Imagine that instead of wires and plugs, you could transfer power through a vacuum. Our work is a step in that direction."

Provided by Stanford University