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FUTURE OF TRANSPORTATION

Could Roads Recharge Electric Cars? The Technology May Be Close.

But challenges await, including technical issues, regulatory barriers and many miles of highway.

By Kerry Hannon
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This article is part of our series on the Future of Transportation, which is exploring innovations and challenges that affect how we move about the world.

Electric vehicles are getting a lot of buzz. Yet sales of electric vehicles, or EVs, are expected to amount to less than 4 percent of passenger vehicle sales in the United States in 2021.

One reason: the inability to easily recharge on long trips, known as range anxiety. And the concern is valid: Range, charging time and availability of charging stations all still have a long way to go.

EVs are getting a boost, though: They are prominently featured in a $7.5 billion initiative from the Biden Administration, signed by the president earlier this month, with the goal of building a nationwide network of a 500,000 high-speed electric vehicle charging stations by 2030. (Currently, there are about 43,000 charging stations, according to the U.S. Department of Energy.)

But that would solve only part of the problem, in part because charging times are still lengthy. The real sweeping change in the next decade may address that: roadways that electrically power cars as they travel, using a technology known as inductive charging.

In July, the Indiana Department of Transportation and Purdue University announced plans to develop the world's first contactless wireless-charging concrete pavement highway segment.

The project is being undertaken by an engineering research center called Advancing Sustainability Through Powered Infrastructure for Roadway Electrification (ASPIRE). It is funded by the National Science Foundation.

“One of the major barriers to electrification is the range anxiety. This technology is intended to solve the problem,” said Nadia Gkritza, a professor at the Lyles School of Civil Engineering and ASPIRE campus director at Purdue University. “In simple terms, the vision is to bring the charge to the vehicles, rather than having the vehicle stop at charging stations to recharge.”

The multiyear project will use a magnetizable concrete technology — developed by the German company Magment — enabling wireless charging of electric vehicles as they drive.

The technology works by adding small particles of recycled ferrite — a ceramic made by mixing iron oxide blended with slivers of metallic elements, such as nickel and zinc — to a concrete mixture which is magnetized by running an electrical current. This creates a magnetic field that transmits power wirelessly to the vehicle.

A plate or box made of the patented material, roughly 12-feet long by 4-feet wide, is buried inside the roadway at a depth of a few inches. The box contains coils of wire that connect to the power grid through specialized electronic equipment — that’s the transmitter, explained Dionysios Aliprantis, a professor at the Elmore Family School of Electrical and Computer Engineering at Purdue.

Surrounding the transmitter is normal roadway material — concrete or asphalt. The transmitters would be embedded in the roadway one after the other, allowing for a continuous power transfer. The receiver is a similar, but smaller box with coils that is attached to the underside of a car.

(Another product from the company is MagPad, a wireless power transmitter pad which can be installed either on-ground or in-ground. The transmitters could be installed at public parking lots or private garages.)

The project will test the electrified pavement through analysis and research conducted at the Indiana Department of Transportation Accelerated Pavement Testing facility in West Lafayette. The first test will apply pressure on the roadway segment as if trucks are driving on it to see if the pavement will last, Mr. Aliprantis said.

The second test will assess the capability of the system to transfer high-levels of power wirelessly. While the idea is similar to cellphones that charge wirelessly, there is a significant difference: charging with a 10-to-15-inch gap between the transmitter and receiver.

“The cellphone touches the surface to charge, so it’s pretty strongly coupled,” he said. “Whereas now, if we increase the so-called air gap, the coupling weakens, and so does the power transfer.”

Within the next two years, once the technology is validated in the lab tests, the Indiana Department of Transportation will build a quarter mile-long test bed where engineers will examine the electrified roadway's capacity to deliver high power to trucks.

"We want to take it slowly, to do those test beds and pilots," Ms. Gkritza said. "Our goal is within four to five years to have a longer test on one of the interstates, most likely I-70."

Cost estimates to electrify roads in both directions vary widely, from $1.1 million to $2.8 million per kilometer, according to projections made in the last three years.

Indiana isn't the only state getting into the race. In September, Gov. Gretchen Whitmer of Michigan announced a new initiative to develop the nation's first wireless charging infrastructure on a public road and said the state is looking for partners to help develop and deploy the technology.

The Inductive Vehicle Charging Pilot is a partnership between the Michigan Department of Transportation and the Office of Future Mobility and Electrification, according to the Michigan Economic Development Corporation. The pilot will cover a one-mile stretch of road in Wayne, Oakland or Macomb county. Utah State University is also developing inroad wireless charging, with induction coils in the pavement transmitting energy to coils in outfitted EVs.

"Magnetized cement? Crazy, man," said Chris Nelder, an energy analyst and consultant, and former manager of the EV grid integration group at the Rocky Mountain Institute. "I would love to see it work. But this would be very early-stage technology, needing cars to be redesigned to use it as well as the actual implementation of the charging capability. But the need to redesign the cars is non-trivial."

A big challenge is clearly on the vehicle side, agreed Mauricio Esguerra, chief executive and co-founder of Magment. "The automotive industry is so busy with making batteries, making software, so that confronting them right now with inductive charging is a priority which is far away. The spirit of this project is to concentrate first on the technical challenges of demonstrating that it works."

Other challenges may slow the electric road of the future. "To put this in context, inroad charging while driving is not likely to be a broad solution for all electric vehicles, but it could play an important role for some applications," said Jeremy J. Michalek, professor of engineering and public policy and director of the vehicle electrification group at Carnegie Mellon University.

"For passenger cars, most drivers will leave home on most days with a full tank of electricity, and EV range is growing large enough that most drivers won't need public charging except on rare long-distance travel days," he said.

But there is a bigger problem that these kinds of roadways can solve. “For long-haul trucking, inroad charging aims to address a real problem with electrifying trucks,” Mr. Michalek said. Electric trailer trucks require large battery packs that reduce payload; inroad charging could help, though that amount of long-distance travel would require a huge investment in infrastructure.

Inroad charging will also need to “withstand all of the weight and weather abuse that tears up our roads today. There may be particular applications where inroad charging infrastructure could be targeted to select locations, such as bus stops or fleets with fixed routes and known stops,” he said.

The Purdue team is mindful of these challenges, but optimistic. “The technical obstacles that we need to overcome are not insurmountable,” Mr. Aliprantis said. “Those can be overcome with proper design.”

There are, however, regulatory barriers, he said. “For example, in Indiana if you’re not a utility, you cannot resell electricity. So, if you’re the roadway operator, you cannot charge the vehicles for the electricity they consume. Also, there are obstacles to using the interstate right of way right now to install this infrastructure. There are certain regulations that need to change before this becomes a reality, at least in this country.”

Moreover, electric grids will need to increase capacity to guarantee they can cover the demand that will be created. “Especially if we want to implement this technology at scale, because we’re not charging cellphones, we’re charging big vehicles moving at freeway speeds, which require a significant amount of power,” he said.

For the Purdue project, it’s the start of the road trip.

“We see this technology as a great opportunity to align with the vision from the U.S. Department of Transportation and the Federal Highway Administration of alternative fuel corridors along major national roadways that support plug-in electric vehicle charging, hydrogen, propane, and natural gas refueling with existing or planned infrastructure,” Ms. Gkritza said. “We are not proposing that all roads will be 100 percent electrified.”