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News & Highlights

Electric Car Market Poised to Accelerate

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In October 2020, China announced plans to stop manufacturing and selling non-hybrid gas-powered vehicles by 2035 [1]. Proposed bans on sales of all new gas-powered cars were also recently announced by California in the United States (by 2035) [2], India (by 2030) [3], and many countries in the European Union (various dates) [3].

Enacted to curb climate change, such restrictions seem likely to boost the prospects for electric vehicles (EVs), which are increasingly seen as the most viable alternative to gas-powered vehicles. One major obstacle of more widespread adoption of electric cars, however, is so-called range anxiety, the concern that the car's battery will drain before the driver can make it to the next charging station, despite 90% of daily driving—an average of 40 mi (~64 km)—being within the range of most current electric cars. Now, bigger batteries, more efficient drive trains, and other advances in some new models are bringing electric car ranges more in line with those of their gas-powered competition. In addition, wireless charging technology now starting to be piloted could also make it easier for consumers to consider purchasing an EV.

The three primary low-emission car options now available to consumers are battery-powered EV, hydrogen-fuel-cell vehicles, and plug-in hybrids. Several large manufacturers have recently abandoned the slow-to-evolve market for hydrogen fuel-cell cars [4], which has lagged due to difficulties in bringing costs down and building a broad network of fueling stations. Sales of plug-in hybrids, which operate primarily as battery-powered EV but have gas engine backups to either take over when the battery drains or charge the battery, have also failed to take off, possibly due to misunderstanding among consumers of their benefits [5]. These challenges point to EV dominating an accelerating market for low-emission cars, at least in the near-term [4].

"A lot of car companies in the last couple of years have been trying to decide if they need to make this huge investment to change to electric cars, or if they can delay it and wait for some miracle to save them from making the shift," said Gil Tal, director of the Plug-in Hybrid and Electric Vehicle Center at the University of California, Davis. "What the European Union, and now California and China, are telling them is, 'It is not going to disappear, it is happening, and it is not going to be a 10% or 15% shift but a major change in your industry.'"

As governments help to convince manufacturers to make this shift, consumers will also need to be convinced. EV have been around for decades now, but still make up only a fraction of vehicles on the road—just 3% of the market as of 2019 [6]. This proportion could quickly increase, however, with several large auto manufacturers currently planning to significantly boost their EV portfolios, including General Motors, which recently announced plans to introduce 30 new EV models by 2025 [7].

Although price and concerns about charging and range remain obstacles for many potential buyers, charging has become less of an issue as collaborations between manufacturers and electricity providers have expanded the number of charging stations and made them interoperable, able to charge any electric car [8]. But even with improvements in charging, concerns about range remain a significant deterrent to buyers. The world's three best-selling EV models have considerably less range, on average, than the three highest-selling gas-powered models, 394 km versus 850 km [9,10]. "The market remains limited by the challenges of recharging and anxiety about range," said Scott Samuelsen, professor emeritus of mechanical and aerospace engineering and founding director of the Advanced Power and Energy Program at the University of California, Irvine.

Potentially removing range anxiety from the equation, a small handful of manufacturers are developing electric cars with ranges of 800 km and longer. Lucid Motors (Newark, CA, USA) recently announced it will begin production in spring 2021 of its Air model that will drive 800 km on a single charge (Fig. 1) [11]. The increased range comes not only from improvements to the car's battery pack—which operates at more than 900 V and fast charges at 350 kW, compared to 350 V and 80 kW for the Tesla Model 3 [12]—but also from design changes to the car that reduce air resistance and mechanical friction as well as efficiency upgrades in nearly every facet of its electric drive chain. Meanwhile, Mercedes is working on a new model called the Vision EQXX with a 1200 km range, also largely resulting from efficiency improvements [13]. Cost of these long-range electric cars will probably remain a deterrent for many potential buyers, however, with the base price of the Lucid Air running about 70 000 USD, including government incentives.

How much such improved range will move the market remains to be seen, Tal said, especially given studies of US driving habits suggesting that 98% of gas-powered cars could be replaced with current EV and still get people where they need to go on a daily basis [14]. "Range anxiety is only important for the consumer who has not yet really considered an EV—it is kind of a

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Fig. 1. The battery of Lucid Motor's Air model will power a range of more than 800 km on a single charge, thanks to design features that reduce air resistance and mechanical friction and upgrades in the efficiency of nearly every aspect of the electric drive chain. Credit: Lucid Motors (public domain).

boogeyman," said Tal. You would need to sit in your car for 10 h nonstop to drive 1200 km, he added. "To be honest, it is way overkill." Nonetheless, having long-range electric cars in the market could prove helpful, he said. "It could drive consumers in the same way that 1000-horsepower cars once drove consumers."

The ability to charge cars wirelessly through electromagnetic induction could also reduce the range anxiety of EV drivers. Electromagnetic induction involves two electromagnetic coils, usually made out of copper, that have oscillating electric currents running through them. To charge a vehicle wirelessly, one coil acts as a transmitter, embedded in a charging pad that sits under the car. The second coil is mounted to the car's undercarriage and serves as a receiver. As electricity passes through the transmitter coil, it generates a magnetic field that transfers energy to the receiver coil, which then charges the car's battery (Fig. 2). Invented more than 100 years ago [15], induction technology is currently used for wirelessly recharging a wide range of consumer devices, such as smartphones, electric toothbrushes, and other electronic products.

Significant innovations over the past 15 years are now making wireless charging practical for EV, said Morris Kesler, chief technology officer of WiTricity (Watertown, MA, USA), one of a handful of companies developing the technology. "Now that the market is growing, in terms of numbers of EV on the road, there is more of a pull for this technology to be deployed," Kesler said. WiTricity currently offers a wireless system that charges at 11 kW—enough to deliver 30 $mi \cdot h^{-1}$(~48.28 $km \cdot h^{-1}$), equivalent to a typical plug-in charger—and has deals with Chinese automakers to include its system in select models [16]. "Wireless charging is another way to increase adoption where users do not have to worry about changing their behavior with their vehicles," Kesler said. "They do not have to think about plugging the car in every time they get out of it at home—the charging happens automatically."

In October 2020, the Society of Automotive Engineers (SAE) International, a US-based organization (with world headquarters in Warrendale, near Pittsburgh, PA, USA) that develops standards for engineering professionals around the globe, helped to move the technology closer to market. Its new SAE J2954 wireless charging standard is designed to achieve up to 94% grid-to-vehicle efficiency under optimal conditions, enabling charging up to 11 kW over an air gap of 250 mm and interoperability among different vehicles [17].

Fig. 2. In wireless charging, electricity passes through a transmitter pad placed under the car to a receiving pad mounted to the car's undercarriage through electromagnetic induction. Credit: WiTricity (public domain).

In addition to homes, WiTricity and other wireless charger manufacturers are developing systems for places where vehicles often remain still for intermediate amounts of time, including parking lots, on-street parking spaces, taxi stands, and bus yards. In Oslo, Norway, for example, Momentum Dynamics (Malvern, PA, USA) will equip Jaguar I-Pace taxis with inductive charging pads so the vehicles can recharge wirelessly as they queue up for passengers; the technology adds 80 km of range for every 15 min the vehicles spend idling over inductive coils embedded in the pavement [18].

Autonomous vehicles will also benefit from wireless charging, Kesler said. "You really need wireless charging for autonomous vehicles because there is nobody around to plug those in." In the future, having transmitter coils embedded in roads to charge cars on the move—a concept called dynamic charging—could revolutionize the experience of driving an EV, allowing drivers to never again worry about charging up. It could also allow manufacturers to build cars with smaller batteries, reducing both vehicle cost and weight. Anticipating this future, in early 2019 WiTricity acquired San Diego-based Qualcomm's "Halo" wireless charging technology that had demonstrated dynamic charging at 20 kW with a vehicle driving 96 $km \cdot h^{-1}$ on a test track in France [19].

Despite its potential promise, Tal and Samuelsen agreed that economic factors, including the cost to build the necessary infrastructure and the falling price of batteries, may prevent widespread use of dynamic charging for personal vehicles. However, the technology may prove more viable for public transit, Tal said, where around-the-clock operation is often desired and routes are fixed, limiting the need for installing new infrastructure. Eyeing such public transit markets, the Israeli company ElectReon (Neurim, Israel) is building a dynamic charging system along a section of a bus route in Tel Aviv, as well as an 18 km shuttle route connecting the city of Eilat and Ramon International Airport [19]. And in May 2020, Sweden enlisted the company to establish a wireless system for an airport shuttle route on the Baltic Sea island of Gotland, which will act as an initial foray for the country's plan to outfit more than 1600 km of highways with dynamic charging [20].

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