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Creating An On-Demand Electrified Mobility Ecosystem: What Will It Take?

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In September, Audi launched the Audi e-tron with a splashy media event in San Francisco. The SUV is the first all-electric series production model from the brand. Despite the U.S. launch event, the first models will be delivered in Europe later this year, Audi said. With a range of 400 kilometers (248.5 miles), private car owners will likely be able to simply charge at home at night.

Even with that range, Audi aims to alleviate range anxiety with the Audi e-tron Charging Service, a proprietary charging card that lets owners use over 72,000 charging points operated by 220 providers in the EU, thanks to partnerships with various operators including VW's Electrify America. An advanced app and the onboard navigation system both can plan longer routes for the car, taking into consideration the battery's current charge as well as traffic conditions and prevailing conditions of charging stations.

Charging availability was key to the launch, according to Peter Mertens, member of the board of management of AUDI AG for Technical Development. In the press release, he said, "The e-tron Charging Service builds confidence in our electric initiative. … We already have the right answers to many of the questions and concerns regarding charging."

Audi's announcement illustrates one of the major issues in e-mobility: Consumers are still anxious about electric driving ranges.

Driving consumer adoption of EVs

While transit agencies and transportation networking companies have their eyes on all-electric fleets, the consumer fleet is still part of the overall electrification landscape. Audi's attempt to address the availability of charging infrastructure and range anxiety is the kind of initiative that must pervade the auto industry before we see a higher consumer uptake on a national scale.

With Audi's high-voltage electric battery and compatibility with fast-charging stations, the e-tron Charging Service is icing on the cake, according to Harsha Nanjundaswamy, e-mobility director at FEV.

"They're trying to do more than what is needed to attract customers. Charging is the key to EV adoption," Nanjundaswamy says.

He thinks Tesla's model of providing a proprietary super-charging network, along with a longer-range vehicle, was key to its market success.

Porsche also is moving to provide charging stations with its ChargeBox. In advance of its all-electric Taycan, with a (300-mile) range, Porsche announced that the ChargeBox will be able to provide a 200 km (124 miles) range to 800-volt car batteries in just 20 minutes. It will also automatically accommodate lower-voltage batteries. The system includes a buffer storage battery system for times when the grid connection itself isn't powerful enough to provide that extra-fast charge.

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In a similar deal to Audi's, Lucid said it would let customers of its luxury EV, slated for production in 2020, access the Volkswagen-funded Electrify America network.

Although its charging network may have given Tesla a boost, Nanjundaswamy doesn't think every OEM needs to go this route. With a variety of privately-owned level-2 and DC fast-charging networks growing across the United States, he says, "Charging stations become less of a headache for OEMs."

According to the California Energy Commission, there were approximately 5,700 non-residential PEV chargers installed in California in August 2014; this more than doubled to over 11,500 by August 2017.

But California is a big place. According to the Plug-in Hybrid & Electric Vehicle Research Center of the UC Davis Institute of Transportation Studies (ITS), there was no measurable increase from 2014 to 2017 in the number of consumers who said they had seen a charging station.

How many are enough? There's not yet enough data to make a call on this; and the answer depends a lot on whether people living in a city or region have driveways or garages in which they can install chargers, as well as the prevalence of workplace charging.

A review of studies led by Scott Hardman, a researcher with ITS, looked at the number of plug-in vehicles compared to the number of public slow and fast chargers in the ten nations with the highest penetration of PEVS. It found the global average is 153 public chargers per 1000 PEVs. 97 slow chargers per 1000 PEVs, and 56 fast chargers.

The ITS concluded that, according to existing evidence, the home is the most frequently used charging location, and the ability to charge at home is the most important piece of infrastructure for convincing consumers to buy plug-in electric car. Workplace charging will be the second most-frequently used location. However, while public charging stations will be the least frequently used, they will still be important in alleviating range anxiety and thereby encouraging adoption.

After a very slow start, global electric car sales grew by 57 percent in 2017, according to the International Energy Agency, with China alone accounting for more than half of all EVs sold in 2017, while Norway leads in market share.

With Norway's very generous incentives and early start, EVs now make up almost half of all vehicles on the road, with the goal of all new cars being sold there to be electric by 2025.

Sales are poised for hockey-stick growth—at least, as to IEA sales targets, if not as an overall percentage of all car sales. The IEA says EV sales should reach the target in its Sustainable Development Scenario (SDS).

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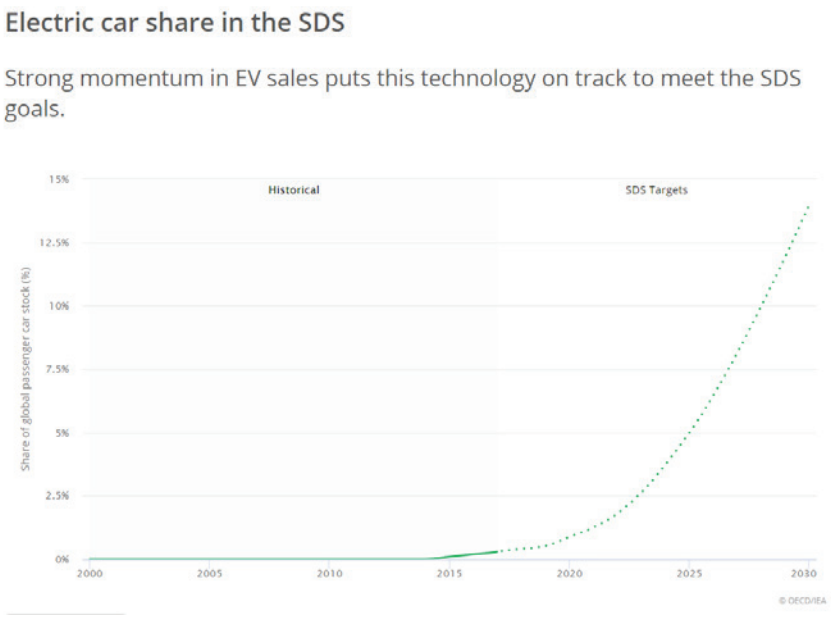

Source: International Energy Agency; SDS = Sustainable Development Scenario

The transition is driven by global governments setting emissions goals and offering incentives to consumers.

OEMs rise to the challenge

EVs are key to the future strategies of many OEMs, which have either already introduced or announced a transition to electric vehicles.

Most recently:

- BMW said it will extend the range of the i3 EV to 260 km (160 miles).
- Peugeot unveiled a concept electric coupe, the e-LEGEND.
- Faraday Futures began taking orders for its FF 91 luxury EV, with delivery expected in the first half of 2019.
- Ford will stop producing cars, including the electrified Focus, but it aims to produce hybrid and all-electric SUVs and trucks.

While planning to build EVs, OEMs in the United States are still pushing gas-guzzlers instead. A 2018 study commissioned by the Northeast States for Coordinated Air Use Management found that OEMs are spending "almost nothing" to promote their electric models. What advertising they did do was concentrated in the Northeast and California, two regions where clean-air mandates are in place.

This shows that market factors may not be enough to increase EV adoption. In the United States, state regulations may be the strongest impetus, pressuring OEMs to do more to move these vehicles.

In the most recent example, California's Air Resources Board implemented a stick and a carrot. It tightened its Low Carbon Fuel Standard to require

a 20 percent reduction in lifetime carbon emissions for all fuels sold in California by 2030. It also gives utility companies credits for charging zero-emission vehicles that they can sell, using the proceeds to offer consumer incentives for EV purchases.

Investing in Charging Infrastructure

The age-old question for the e-mobility space is, who will pay the significant infrastructure costs of installing enough EV charging stations that drivers feel confident they'll find one if they need it?

Should it be the automakers, the charging infrastructure providers or even the government? The answer lies somewhere in the middle with a healthy mix of public private partnership and investment.

But all this could change rapidly. EV ranges are increasing, and many people who buy cars that can travel 200 miles between charges will simply charge them at home.

In the United States, utility companies are not significantly participating in the development of charging infrastructure. A 2017 survey of U.S. utility companies by the Deloitte Center for Energy Solutions found that 70.6 percent of them expected EVs to account for no more than 5 percent of the total passenger car fleet in the company's service area.

On the other hand, a survey of businesses this spring by Deloitte found that the companies expected gas or diesel vehicles to make up less than half their fleets by 2020.

Nevertheless, 64.7 percent had conducted research or a pilot program related to EV charging.

At that point, 67.6 percent of utilities neither installed nor incentivized the installation of home charging systems, but 39.1 percent were interested in doing so.

Andrew Slaughter, executive director of the Deloitte Center for Energy Solutions, says, "There's a great level of interest among utility companies, but there are very few that could yet see the business case for putting real money into this."

Utilities are still trying to understand logistics, rate plans, transmission and how local distribution of systems might affect them. In the Deloitte survey, the majority of them were unsure whether such infrastructure investments could be recoverable from their rate payers. Plus, it's a small market so far.

"There ought to be a role for utilities, given their expertise in building local infrastructure and their access to capital, but they're not ready yet to make the leap," Slaughter says.

One exception is Pacific Power, serving the State of Oregon. (Oregon has a goal of 50,00 electric cars on the road by 2020.) It will develop up to

seven utility-owned charging stations throughout the state, with the first one slated for Klamath Falls, a small city with a median household income below the state average. The stations will feature fast-charging docks that can charge vehicles in 30 minutes.

Pacific Power also will provide $1.45 million in quarterly grants for business and civic customers to develop their own charging stations.

Slaughter thinks cities could also play a role in developing public charging infrastructure, as more and more cities brand themselves as sustainable or smart. "This could be one thing they could point to as going beyond branding to action."

Energy and the grid

As more plug-in cars penetrate the market and regularly charge, this could seriously impact the electrical grid. Eventually, EVs may act as ancillary storage batteries and even return power to the grid when necessary. But in the short term, if the majority of EV owners drive home from work in the evening and plug their cars in, at the same time everyone is turning on lights, running electronics, cooking and doing laundry, it could impact the grid at the local level.

The ITS/UC study identifies two important tactics for managing loads: time-of-use (TOU) rates to incentivize charging during off-peak hours, and smart charging.

Because it's automatic, smart charging may be able to shift more charging events to off-peak times than TOU rates, ITS concluded. The Netherlands, which is implementing smart charging, expects it to allow the existing electricity grids to support ten times more plug-in vehicles. However, some consumers may be reluctant to give up control of when they charge.

This peak-time load on local grids becomes even more impactful as more electrical generation moves to renewable sources.

Patrick Kelly, program manager (Electric Vehicles), EDF Renewables, points out that for solar power, peak availability is during the middle of the day.

"Instead of charging your car at home, you should be charging during the day to be aligned with solar production. This is why workplace charging is so important," Kelly says.

EDF Renewables develops, operates and maintains wind, solar, biomass, and biogas projects in the United States, Canada, and Mexico. Kelly says his company incentivizes daytime charging by offering workplace charging packages that include solar power, battery storage and EV charging stations, along with a smart-charging system.

If EDF is already implementing a solar power project, Kelly says it can cost very little less to add charging stations. It can calculate the cost per kilowatt, facilitate chargebacks to employees and provide reporting.

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These solutions are more appropriate to suburban areas, according to Kelly, especially office parks. And he points out that if workplace charging in suburban office parks becomes ubiquitous, people commuting from downtown areas won't need as much charging infrastructure in the urban center.

Kelly sees the fast chargers being promulgated by Tesla, Porsche et. al. as a necessary evil. They negatively impact the grid with their random high demands. He says, "There are a handful of road trips during the year where you need the fast-charging infrastructure. But it's infrastructure that will never pay for itself."

EVs on the streets

"The future is not about the next new product, it's about capturing efficiencies wherever we find them—and the most glaring need is public transportation," says Kris Bailey, COO of Electric Cab of North America.

Electric Cab provides first- and last-mile transport using electric shuttles, with both on-demand service and regular routes. It typically creates "mobility zones" where its research shows usage would be high. And, in an example of the kind of public/private partnerships that can be used to test EVs for public transport, it's piloted microtransit services in Dallas and Austin, Texas; St. Louis and Kirkwood, Missouri; and Chandler, Arizona.

In Austin, Electric Cab service was funded by a $1 million grant from the U.S. Department of Energy, in partnership with Capital Metro, the local transit agency, and Pecan Street, an Austin company focused on water and energy research. The free shuttles provided point-to-point service from a light rail station to The Domain, a multi-block, mixed-use development.

In St Louis, its $135,000 pilot was funded by the Downtown St. Louis Community Improvement District, a voluntary taxing district composed of local merchants. It moved roughly 14,000 people over the life of the pilot.

The pilots aim to show that providing free transit offers indirect economic benefits to an area. While the economic impact analyses of Electric Cab's pilots are not complete, Bailey says, "When you make it super-easy to get anywhere in a district, people do go more places and spend more money."

The next market Electric Cab wants to crack is dense new housing developments. Bailey sees free shuttles as an amenity developers can provide residents while avoiding the need to add huge parking garages.

He says, "Developers can provide it as turnkey solution for everyone who moves into that complex for less cost than the parking garage."

Eventually, he'd like to see small-capacity, on-demand electric shuttles such as his replace some public transit bus routes. Instead of huge, noisy buses running half-empty along what sometimes are inconvenient routes, Bailey says, "We are trying to prove out that transit agencies can save money if they provide door-to-door service."

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Lewis Fulton, who directs the Sustainable Transportation Energy Pathways program within the Institute of Transportation Studies at UC Davis, adds, "There's a lot of awareness within transit agencies that they have to evolve quickly. A lot of pilot programs are testing the use of ride-sharing vans to transit stops. In the case of bus companies, they are certainly looking at options to work with TNCs to give preferential rates to get to and from station, as well as minivan service in places that don't have good transit."

Unfortunately, city and regional transit agencies face several barriers to making switching to on-demand service, or even to making routes more efficient. While many already have shifted to hydrogen- or electric-powered buses, labour rules for drivers could hinder eliminating routes or changing schedules. Cities also would have to make sure that all citizens understood and were able to access the revamped rides.

For example, on-demand bus services such as Chariot require riders to make reservations and pay via a mobile app, precluding those who don't have a smartphone or are unable to use the app from riding.

EVs in shared mobility solutions

Car sharing and ride hailing have unique constraints that make it more difficult to provide all-electric fleets. But it is being done already.

- Groupe Renault and ADA launched Moov'In.Paris application, a free-floating car-sharing service with 100 Renault ZOEs and 20 Renault Twizy.
- In Montreal, Car2Go added 20 smart fortwo EVs to the local fleet. They'll rely on the city's existing charging infrastructure. It tells drivers the EVs are best for short trips and gives them a chart to evaluate whether a vehicle's current state of charge will be enough for their needs.
- GM's Maven Gig lets ride-hailing drivers rent Chevy Bolts.
- EkoRent, a Finnish company, launched Nopia Ride in Nairobi. The ride-hailing service launched this summer with a few vehicles and branded charging stations. According to an FAQ on its website, drivers are required to provide their own EVs and charge on their own time. The company didn't respond to an interview request for more information.
- EkoRent operates an EV car-sharing service in Helsinki. Renters there are informed about the vehicles range and public charging options. They're expected to plug in the car when they return it.

More are in the works:

- In California, AAA plans to add 260 EVs to its Sacramento Gig free-floating car share service.
- Volkswagen says it will launch We Share, an all-electric carsharing service, in 2019, beginning in Berlin with 2,000 e-Golf and 500 e-up! Vehicles.

Says UC Davis' Fulton, "If you end up in a world where the mobility-as-a-service providers are creating fleets of vehicles and looking to optimize those, we'll probably see them being electric." That's because such vehicles will be in use most of the time, and EVs in that situation will be much cheaper to operate.

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Fulton notes that if TNCs, car shares and other service providers use electrics, it will speed up the rate in which EVs penetrate the overall transportation system: They'll turn over in two or three years, with these companies continuing to buy new ones.

For fleet operators, both car-sharing services and TNCs that own their own vehicles, charging is fairly straightforward, according to Deloitte's Slaughter. Instead of worrying about the availability of public charging stations in the urban core, they're likely to maintain their own charging facilities at the edge of town.

"Their vehicles can shuttle back and forth to the charging station, or stay overnight when they need to be charged," Slaughter says. "It's more efficient and reliable, and more economical, as well."

One popular theory is that, as mobility services become more prevalent, efficient and affordable, people in the city will get rid of their cars, while suburbanites will use transit to commute into town. Urban parking lots can then be converted to charging stations and mobility hubs.

Slaughter thinks this unlikely. While there might be less need for those parking spaces, he sees higher and more valuable uses for that space. Most likely, they'd be converted to offices or apartments.

Will AVs be EVs?

Electrification is a good fit for autonomous vehicles. Just, not yet.

With the heavy load of sensors and processors necessary for autonomy, drawing on the heavy-duty electric battery in an EV makes more sense than adding the battery to an internal combustion vehicle.

And Tesla has shown that semi-autonomous features can co-exist with a driving range of up to 500 km (310 miles) for the Model S3 with long-range battery.

In a co-evolutionary path toward autonomous electric driving, OEMs including BMW, Volvo and Daimler are adding more-advanced driver-assistance features to their EVs and concept cars.

According to Jada Smith, vice president-advanced engineering and external relations for Aptiv, "The future of mobility requires the complete overhaul and re-engineering of vehicle architecture; one that will deliver a fast, safe and reliable distribution of data and power. "EVs and AVs have separate but complimentary technology."

As well, the electrical loads of autonomous systems will need to come down while batteries continue not only store more electricity but also become cheaper.

Thanks to technology improvements and economies of scale, Fulton of UC Davis concludes, "There is every reason to believe that the refinements that

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come to automated systems will include less energy-intensive systems. And the cost is coming down a lot."

He's seen estimates saying that, eventually, autonomous cars will use only around 10 percent more energy than manually driven EVs. "They have to get them into a zone of energy use that's acceptable."

In addition to economies of scale and improved tech, there are a variety of hardware and software tweaks that could reduce energy usage. For example, Jennova creates custom energy-harvesting devices that could be used to reduce energy usage by sensors in autonomous vehicles, according to Christian Pennisi, director of operations.

Pennisi says that many EVs and hybrids already employ some energy harvesting, which translates the kinetic energy of a component to electrical energy that's fed back into the battery. Offsetting the battery drain of additional sensors—or even taking some sensors off battery power altogether—could be valuable.

Pennisi notes that critical sensors will remain connected to a battery, but energy harvesting could be used for some layers of sensors. He foresees more uses: It could play a role in cars' 5G connections, perhaps acting as a signal booster when necessary. And it could be used to help power aftermarket, connected-car equipment. Finally, energy harvesting enhances modularity in sensors: Instead of installing one sensor for each thing to be monitored, the same sensor could monitor several things. "Energy harvesting enables modularity to happen quicker with simplified installation and at a lower lifetime cost. I imagine it will play a future role in automotive as well," Pennisi says.

Fulton doesn't think that private owners will necessarily want all-electric, self-driving cars.

"Households that would be buying driverless cars will not necessarily be as concerned about fuel costs," Fulton says. "But they may be concerned about the plug-in problem. If we are only at a 5 or 10 percent market for EVs by 2025, why would people who want an autonomous vehicle suddenly want an EV?"

Unless that's all they could get. Fulton posits there might be regulations at the state level that mandates autonomous cars had to be electric. He thinks that's most likely to happen in China and maybe Europe. "The Chinese will be very aggressive on pushing electrification along with autonomy," he says. "That could be a game changer."

When it comes to autonomous, shared mobility—car sharing and transportation networking companies, Deloitte's Slaughter differentiates between fleets and TNCs. He says, "If you're operating a fleet with a fairly predictable and circumscribed operating range, such as a city-based delivery vehicle or municipal bus fleets, it can work to have that fleet owner or operator maintain and run its own charging at certain locations. If you're talking about autonomous vehicles for ride share, with less predictable use

patterns, you'll still need a more publicly available charging infrastructure they can go to."

Then, the question becomes, how do those self-driving cars plug in?

One literally blue-sky solution comes from Amazon. It patented an idea for self-driving drones that would travel to EVs to recharge them. Um, but then how do the drones recharge themselves?

Wireless charging is the more likely solution for general use. BMW has already shipped its wireless charging system for the BMW 530e iPerformance.

Self-driving cars could easily locate the charging pad via cameras or sensors and navigate onto it. The problem then becomes similar to the plug-in charging-station dilemma: locating enough wireless charging units to satisfy demand.

Conclusion: Inevitable but not imminent

The electrification of private cars, commercial fleets and public transportation is inevitable. There's a global movement for a cleaner, more sustainable world, and EV transport is a crucial part of that vision.

It will take a combination of regulation and incentive to move the world in that direction. While the savings in energy and maintenance already can make the switch to electric cost-effective, sweetening the deal with an incentive makes it an easier decision for fleet operators and transit agencies.

The stick is still an important tool. Regulations such as London's Low Emission Zone and ever-tightening emission standards such as the Euro 6 and California's Advanced Clean Cars program encourage automakers to move faster and further along the path to full electrification. They also can impel fleet operators to buy EVs.

Consumer adoption remains the sticking point. Owning an EV requires a change in habit and outlook. Drivers are used to filling up the tank as needed, making use of ubiquitous petrol stations: Gas is always close and available at any time of the day or night. With an EV, they must be mindful of the length of the trip. If a charging dock isn't provided at work or within a housing complex, they must install a special device at significant cost.

As we've seen in California, even a serious investment in public charging infrastructure combined with rebates of up to $7,000 haven't moved the needle on EV purchases.

Maybe, like with so many things, it's up to style to make the difference. Tesla is the de rigueur choice for Silicon Valley tech executives, and it's a worldwide status symbol—not especially because it's electric.

As more of those electric concept cars move into production, maybe their glossy chassis and cockpit accoutrements will make it cool to have an EV. And then, they'll sell.

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