EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRIC TRANSPORTATION UPDATE

May 2018

IN THE NEWS

Light-duty Sales – Data, Consumer Surveys, and Opinion

With more plug-in models available in the U.S. and Europe, sales continue to rise. This month we also report on an optimistic consumer survey from an unlikely source, and deviate from usual individual critique to offer EPRI perspective on a particularly pessimistic opinion piece.

April Sales Update

Here in the U.S., the 19,396 plug-in vehicles (BEV and PHEV) sold in April reflect a 49% increase over the same month last year. January to April sales this year, 73,139, are up 36% over the same period last year. Hybridcars.com

The California New Car Dealers Association reports 3,723 Tesla Model 3 registrations in the state during the first quarter. That number tops the sales of competing "Near Luxury" segment models, including the Mercedes C-Class, BMW 3-Series, Lexus ES, and Infiniti Q50. San Jose Mercury News.

In Europe, EV sales jumped 41% in the first quarter, with battery EVs up 35% and plug-in hybrids up 47%. Germany, meanwhile, has surpassed Norway as Europe's biggest market for "electrified" cars. Plug-in sales in Germany jumped 70% in first quarter 2018 compared to first quarter 2017. With a total of 17,574 plug-in cars sold in first quarter, Germany nudged ahead of Norway, which had 16,200 sales, according to data from the European Automobile Manufacturers Association. Bloomberg. In on-the-road numbers, though, Norway still leads with 142,490 all-electric cars and vans to date, accounting for 5.1% of all vehicles. Electrive.com. Also, EV sales are up 40% in Ireland. Irish Times.

AAA Study: Americans Warming to EVs

Twenty percent of Americans say their next car will be an EV, according to a new AAA survey published in early May. That number is up from 15% last year, and the auto club says it's primarily because consumers' range anxiety fears are diminishing. A telephone survey was conducted March 8-11, 2018. A total of 1,003 interviews were completed among adults, 18 years of age or older. AAA, USA Today, The Detroit Bureau.

Another View: The Impending EV Fiasco

Detroit auto industry insider John McElroy asks, "Where are all the EV buyers going to come from?" in this critical Ward's Auto opinion piece. He writes:

> "Here's what's likely to happen, at least in the U.S. Over the next three to four years more than 100 BEV models could go on sale, up from 12 today. They will attract some attention, but once

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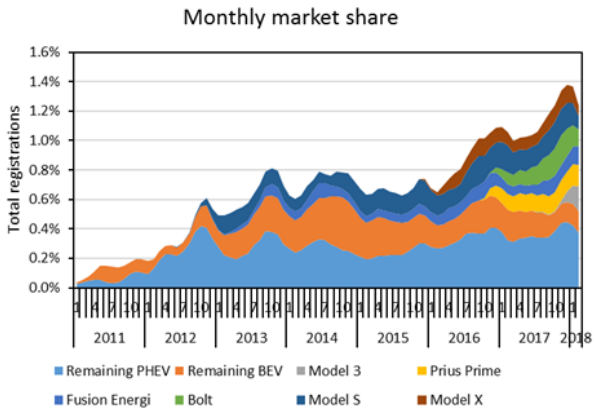
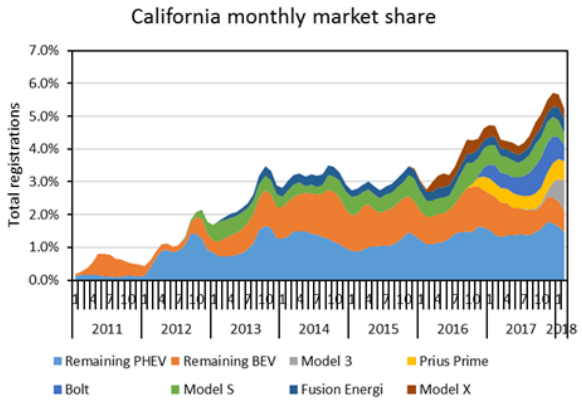
most shoppers look at the sticker prices or discover the monthly lease payments, they'll move on to something more affordable.

Since automakers are mandated to sell specific percentages of BEVs or face stiff fines, they'll be forced to offer big discounts. They will lose a lot of money. Dealers will be reluctant to order more BEVs because they don't want to get stuck with slow-selling models that need massive support from the factory."

EPRI's Take: John McElroy echoes what may be labeled the 'Detroit mentality.' If you extended his logic to the Model T era, people would still be driving horse-buggies. Car companies are in the EV business because they are very afraid of missing a transformational change that could wipe them out – from the highest-profit margin vehicles on down. We are past the first decade of this period, and one can argue over growth rates, but this tide cannot be turned back. Granted, there will be some individual misses as OEMs compete for segments of customers, but the sheer force of a variety of factors—China, vehicle and charging station investments, Mobility-as-a-Service (MaaS) models, and rapid proliferation of infrastructure—will work together to keep moving the industry forward with momentum.

He talks about residual values. I'd argue that once infrastructure is in place and range anxiety is no longer a factor, people would find these vehicles with subsidized residual values to be huge bargains. The trick is going to be to ensure that the depreciation is recovered less and less through tax incentives and more through cost reductions and residuals climbing. I believe both are likely to happen. The only unknown is how quickly. I believe MaaS has a very important role to play here, but that will require vehicle designs to evolve to become more like mass transit type interiors and simplicity for ease of maintenance, longevity and abuse-tolerance.





The "low/no demand" argument is frustrating, since many market segments don't offer a plug-in option yet. This is why the metric (currently 30+) of plug-in crossovers by 2023 is so important. Want a minivan? You have one choice, and have only had that for a couple of months. This is what all those announcements are about, though: in the early 2020s, PEVs will finally be a real option for most people. You will be able to choose the vehicle you want and then choose the powertrain you want instead of having to compromise on a compact sedan in order to get the powertrain you want.

It seems to me that this is type of knee-jerk reaction piece is not so much anti-EVs per se, as against innovation of any kind. Engadget made fun of this type of screed a few years ago by pointing out that doom-and-gloom predictions came before every model of the iPhone, and in most cases the arguments were laughable.

Light-duty Product Updates and OEM News

Tesla has taken a PR beating in recent weeks, with more Model 3 production delays announced followed by a tense quarterly earnings call on which it was revealed the company has continued to burn through cash at a higher rate than expected. Still, Elon Musk insisted the company is on track to make 5,000 Model 3s in a single week by the end

of the second quarter. Wall Street Journal. Per Bloomberg's Tesla Model 3 tracker, Tesla is somewhere around making 2,800 Model 3s per week as of May 23. Musk garnered headlines by referring to analysts' questions as "boring" and "bonehead." Forbes. Musk has also responded defensively to negative media attention to several recent crashes which have injured or killed drivers and occupants, and reportedly occurred when the autopilot function was on.

Meanwhile, this piece from Clean Technica argues Tesla's PR woes are opponents' smoke and mirrors – because Tesla's Model 3 ramp-up is 10 times Chevy Bolt's. Clean Technica.

EPRI's Take: If you look beyond the gloom and doom, you'll see that there is a steady uptick in Tesla's weekly Model 3 production numbers. That said, Elon Musk intentionally sets what Jeff Bezos used to call BHAGs, or Big Hairy Audacious Goals. So, ultimately it results in transformative products and companies. Only here, capital intensity is very high so the question is how quickly can the revenues be ramped up to outrun the costs. It's mystifying why they can't figure out how to make what is essentially the Toyota Camry of EVs. That said, the market has gone full Mark Twain ('The reports of my death are greatly exaggerated') on the only OEM that can sell every EV it makes.

Toyota has shifted a lot of Prius sales to Prius Prime sales. Prius Prime is Toyota's plug-in hybrid model of the Prius. This is interesting in context of the company's past approach, which favored conventional hybrids without a plug. Inside EVs.

EPRI's Take: In the past, Toyota seemed able to generate ZEV credits whenever they wanted, wherever they wanted, by shifting sales from the Prius to the Prius Plug-in. For example, if they needed credits in New York, there would be a spike for two months where they would (apparently) generate the credits they needed, then they would shut the spigot. Now that one-third of Prius sales are consistently for Prime, I wonder what their calculus is. This is about what I'd think you could do for a premium trim (which Prime essentially is), so it seems likely that they are chasing ZEV credits however they can get them, without really having another option. Keep in mind that they get many fewer ZEV credits per Prime than others get per medium or long-range BEV. -- Marcus

Hyundai's Kona EV, set for U.S. market release in the fourth quarter, has received an EPA range rating of 250 miles. That beats the Chevy Bolt (238 miles). Kona will have a 64kWh liquid-cooled battery. Autoblog. Green Car Reports.

Nissan's Leaf crossover is said to be based on the IMx concept. Electrek.
EPRI's Take: We like to think this newer, bigger version of the Leaf will show up sooner rather than later. The styling seems to be a step in the right direction (and logical). It would be interesting to guess the size of the battery pack in one of the pictures. We're taking bets: 100kWh+ for a 350+ mile range?

Tesla has started a new 12-week education program to train the next generation of electric car technicians. The programs are at Rio Hondo College in Whitter, Calif., and Central Piedmont Community College in Charlotte, NC. Those graduating through 'Tesla Start' can hope for a job at Tesla within 30 days after graduation but need to be willing to relocate. Electrive.com.

EPRI's Take: ***This is a big deal. A few community colleges around the San Francisco Bay Area are spooling up EV tech programs, but they are few and far between. Automotive News recently lamented the dearth of car mechanics, in general. It's a real problem, not just in the automotive space. Back in 1999, machining suppliers in Silicon Valley were having trouble finding CNC machinists. It seems, OEMs are nervous about how a different technology (and one that needs way less maintenance) will impact their business models. Having trained EV mechanics will be key.***

Commercial Vehicles

Electric Buses in the News

Across the country local governments are stepping up to electrify their bus fleets. San Francisco has committed to an all-electric bus fleet by 2035. SFMTA. New York City says it is aiming for all-electric by 2040. Inside Climate News. Meanwhile, New Flyer is working to deliver another 100 hybrid buses for the Southeastern Pennsylvania

Transportation Authority, the third installment of a five-year contract that will see the provider's fleet 95% electrified when complete. Electrive.com. SamTrans, the transit provider in San Mateo County south of San Francisco, has ordered 10 all-electric buses from Proterra; they will replace diesel models. San Mateo Daily Journal.

China is still the leader in electric bus deployment (as it is in total vehicle sales, including EV deployments). China adds to its roads an electric bus fleet equal to the city of London's fleet every five weeks. Oil companies are likely taking note. Bloomberg.

Fleet Electrification – Where it Makes Sense

Electric vehicle technologies took a high profile at the recent ACT Expo fleet industry conference. A new analysis by the North American Council for Freight Efficiency (NACFE) examines the point at which commercial EVs reach parity with diesel-powered vehicles in terms of attributes like cost, weight and maintenance needs. NACFE worked with Rocky Mountain Institute on the research, which looked at Class 3 to Class 8 commercial vehicles. NACFE Guidance Report. Greenbiz.com.

Delivery giant UPS has announced another EV deployment project, this one with ARRIVAL, a U.K-based electric van developer. By the end of this year 35 electric delivery vans, with a reported 150-mile range, will hit the road in London and Paris. Hybridcars.com.

Volvo has released a second all-electric truck. The FE electric will serve as a refuse hauler. It is said to have a range of 200 miles and twice the power of the FL urban delivery model released in April. Electrive.com on the FL. Electrive.com on the FE.

Batteries and Components

Battery Improvements Coming

Coming improvements in lithium ion batteries could increase storage capacity by as much as 30%, according to a detailed article in the Wall Street Journal. Aside from the advances in the science, however, the article notes the biggest stumbling block is getting these new technologies to market. Wall Street Journal.

EPRI's Take: It's nice to see a pretty even-handed article without much hype, and discussion of the timeline as "a few years out" which is difficult to argue with. It's good to be cautious because people have been promising silicon anodes for a while. There are also different approaches – and some are coming close to working. Progress has definitely been made. Between silicon anodes, advanced cathodes, and high-voltage electrolytes, there are still good prospects for lithium ion. With increased research funding (most of it outside the U.S.) there have been faster developments, and I think we'll reach the 2x point from 2018 by 2025, and maybe go past 2x in the years beyond that.

Battery Degradation Study Draws Attention

A battery "state of health" (SOH) study involving the Nissan Leaf 30kWh pack has raised some eyebrows and prompted as many questions as it purports to answer. The study suggests that the rate of decline of the 30kWh pack is too rapid to be considered within normal parameters, while the rate of decline in the 24kWh Leaf is acceptable. In addition to EPRI's Take, below, there are more than 100 reader comments on the blog. Inside EVs. Original paper.

EPRI's Take: This paper relies on reporting by Leaf owners of the vehicles' SOH, which is calculated using a proprietary algorithm. That's problematic, but since SOH is what the warrantee is based on, either there will be a change in algorithm, a kink in the rate of degradation, or we're going to be hearing a lot more about this.

It's hard to know without seeing the data, but one reason for the findings could be different vehicle usage/driver behavior. Early Leaf owners may have suffered from range anxiety and may have insisted on traveling fewer miles between charges, whereas more mature owners may be willing to travel longer distances between charges (more DOD = more degradation) and more willing to use fast chargers. Vehicles that drive fewer miles are probably more likely to spend time at high states of charge waiting to drive. Sustained time at high SOC increases calendar degradation. More driving will of course increase cycle-based degradation, so the net effect depends on which the chemistry is more sensitive to. It looks like the

straight LMO chemistry was more sensitive to calendar degradation than the LMO-NMC chemistry. It's also worth noting that Nissan has chosen to air-cool its traction battery instead of using active cooling like nearly every other OEM.

We could speculate all day. Regardless, and even though it's a small sample, since Nissan provides virtually no data on the composition of their batteries or their own estimates of life (nor do other manufacturers) we really have no idea what is going on, but it looks like these batteries are degrading rapidly. Their warranty covers battery replacement if the life falls below 70% in five years, so even given a bit of squishiness in how capacity is defined, this will be keeping a lot of Nissan engineers and finance people up at night.

Battery Shortage Interrupts Sales

Reports of a global shortage of lithium ion batteries have popped up in recent months (we covered several angles in our March newsletter), prompting delayed deliveries of new EV models, such as Hyundai's Ioniq Electric. The news comes as Hyundai prepares to introduce an even longer-range version of the Ioniq as well as the new Kona EV. Green Car Reports.

EPRI's Take: We wonder if this is truly a global problem as reported or if Hyundai simply did not order enough from its battery supplier and now has to go to the back of the line?

Progress on Battery Recycling

Claiming a first, **Nissan** has opened a new battery recycling facility to provide refabricated batteries for older LEAFs, non-road EVs such as forklifts, and backup energy storage use. The recycling operation in Japan is run by 4R Energy, a joint venture between Nissan and Sumitomo Corp. Inside EVs, Electrive.com,

BYD also reportedly plans to open a battery recycling facility in Shanghai, although details of the stated plant have not been released. BYD is also said to be working to reduce rare earth materials in its power pack. Reuters.

EPRI's Take: The cost figures in the Nissan story offer a window into the replacement question.

How Much Is A Lot?

Volkswagen, which says it will sell as many as 3 million EVs by 2025, just awarded contracts worth $48 billion – that's with a B – for lithium batteries. This article notes that amount almost equals Tesla's entire market value. Fortune.

U.S. DOE Funds New Battery and Fast Charging Research

The U.S. Department of Energy (DOE) announced $19 million to support 12 new cost-shared research projects focused on batteries and vehicle electrification technologies to enable extreme fast charging. Selected research projects are focused on developing EV systems that can recharge rapidly at high power levels, decreasing typical charge times to 15 minutes or less using a connector or wireless fast charging system. The projects will help advance DOE's research on batteries and electrification aimed at reducing battery pack cost to under $100 per kilowatt-hour, increasing range to over 300 miles, and charging in under 15 minutes or less by 2028. U.S. DOE.

EV Fires Back in the News

A couple of high-profile accidents involving Teslas have brought the issue of battery fires back to the news pages. Bloomberg.

EPRI's Take: Despite the cringe-worthy lead paragraphs, this story takes a thoughtful and reasonably balanced look at the issues facing emergency responders today. The EV industry has collaborated effectively to address the new challenges through training and educational materials since well before the current generation of cars hit the road. Still, more education and training never hurts, especially as more and more EVs come to market including transit buses, school buses, and garbage trucks.

Infrastructure and Charging

NE States Launch Coordinated EV Charging Strategy

Demonstrating that there's strength in numbers, a dozen Eastern states from Maine to Virginia, plus the District of Columbia, have signed on to a coordinated strategy for building EV charging infrastructure. Facilitated by NESCAUM, the Northeast Corridor states worked collaboratively to develop a set of recommendations that would inform regional infrastructure development. The multistate vision examines different home, work, around town, highway and destination charging use cases, and identifies priorities and key roles for investors in each one. Read the document at nescaum.org. CNET, Automotive News.

Electrify America Makes Headway

Electrify America, the infrastructure subsidiary of Volkswagen created as part of the VW diesel emissions fraud settlement, has announced it has chosen infrastructure partners ABB, BTC Power, Efacec, and Signet to build a network of 2,000 fast charging stations across the country. Power will range from 50kW to 350kW Electrive.com. The first ultra-high power station opened in early May in Chicopee, Mass. EA has also announced a set of retail partners such as Target, that will serve as hosts. Inside EVs. More than 100 Walmart stores will host charging, as well. Reuters. See the full nationwide charging map at Electrek. Although all stations will support both CCS and CHAdeMO, the CHAdeMO side reportedly will be limited to 50kW at launch and 100kW in the future, while the CCS side will charge at 150kW to 350kW.

Autonomy and New Mobility

Autonomous Bolts Go Into Production Next Year

The Chevy Bolt is going to receive further autonomous driving capabilities. The Cruise AV, as the autonomous Bolt will be called, is expected to go into serial production in time for a driverless ride-share program launching in 2019. The Drive.

EPRI's Take: Despite some recent negative news involving two fatal crashes in Arizona and California of Teslas in "autopilot" mode, autonomy is coming – especially for the ride-sharing companies that still aren't making a profit. To be able to remove one of their costs, the driver, will help their bottom line.

Electrification Benefits TNCs

In New York and San Francisco, Transportation Network Company (TNC) and cab rides account for 19% of all local vehicle miles traveled during weekdays. If half of these TNC drivers went electric, they would offset 1.5 billion pounds of carbon from the atmosphere each year and improve local air quality within the city, says a new report from the Rocky Mountain Institute.

> "In addition to these environmental benefits, electric vehicles (EVs) are also significantly cheaper to operate than gas vehicles, despite having a higher up-front price tag. This can be attributed to savings in fuel and maintenance, which scale by how much the vehicle is driven. Highly active TNC drivers are ideal candidates for EVs because they put more miles on their car each year than the average driver. Based on our calculations, full-time TNC drivers working 50 hours a week can save an average of $5,200 per year in total vehicle expenses with an EV as compared to a typical gas vehicle." RMI.

EPRI's Take: Once TNC drivers get the hang of how many miles they drive on a daily basis, their need to sit in one place to get a quick charge may become a lower priority. A 20- to 30-minute fast charge break might return 60% of the energy (that's about 36kWh for Bolt). That said, on the topic of wages, while $5,200 is a great savings, there's been a lot written about the low wages for these "gig economy" workers. Of course, free charging (not that we're advocating that!) might change the calculous even more…

Regulation and Policy

Battle Continues Over Vehicle Emission and Fuel Economy Regulations

A dozen utilities joined with Tesla to sue the U.S. Environmental Protection Agency over its efforts to roll back federal vehicle greenhouse gas emission and fuel economy standards. The plaintiffs asked a D.C. Circuit court to review the agency's decision to review the standards that are currently in place for model-year 2020 to 2026 cars. Utility Dive.

EPRI's Take: The political drama between California, federal regulators, and the White House over the national rules changes from day to day. We will keep an eye on actions in DC, but remember, it's a global market, and China is unlikely to let up (for economic and environmental reasons).
Green Car Reports. Bloomberg, Reuters, The Detroit Bureau, Chicago Tribune.

Report: How Governments are Spurring EVs

A new report from the International Council on Clean Transportation analyzes where EVs and their batteries are manufactured, sold, and promoted via policy globally, and includes comparisons between China, Europe, Japan, and the U.S. "Power play: How governments are spurring the electric vehicle industry" is focused on the looming risk of getting behind as the global industry electrifies.

WHAT ARE WE WORKING ON

Environmental Impacts of EVs

Another study appeared recently claiming that EVs were largely worse than conventional cars and trucks. (The study, "Short Circuit: The High Cost of Electric Vehicles," was published by the Manhattan Institute.) EPRI's Electric Transportation and Environment teams co-produced this downloadable public quick-read article on the environmental benefits of electric transportation.

California V2G Demonstration

The California Energy Commission funded a vehicle-to-grid (V2G) demonstration using EPRI technology and Chrysler and Honda EVs at UC San Diego. Using three Chrysler Pacifica PHEVs and one Honda Accord PHEV, the project is testing:

- Dynamic charge scheduling based on transformer capacity
- Dynamic charging synchronization with available PV energy (flattening the 'belly of the duck')
- Dynamic reverse power flow synchronization with grid need for peak shaving
- Managed charging to alleviate transformer grid stress

The project will be completed June 30, 2018. V2G research will continue into another DOE funded project that is examining V2G battery impacts, among other things. (Sunil Chhaya)

Key EPRI Electric Transportation Supplemental Offerings

What Motivates a Utility Customer to Purchase a Plug-in EV? Through surveys we will be testing, on a regional basis, what motivates someone to buy an EV. Surveys will be sent out in June for project completion in December. We are currently working on a draft of the survey. (Jamie Dunckley)

Energy Management Circuit Breaker – How does a circuit breaker with control, metrology, and communication compare to a networked EV charging station? The devices have completed UL certification and are being installed in the field. (John Halliwell)

Electric Transit Bus Demonstration and Charging Comparison – Which is better: overnight depot charging or on-route charging of electric transit buses? (Mark Kosowski)

Open Vehicle-Grid-Integration (VGI) Platform – Recent success: the Open VGI Platform was demonstrated publicly in San Francisco. A Daimler Smart EV connected to the grid via the IEC/ISO15118-equipped EVSE, whose back-end was communicating to Open VGI Platform and acting as the Demand Clearinghouse. The Open VGI Platform provides a uniform utility-side approach to manage the EV charging while allowing the OEMs to choose their

preferred way to route the utility signals to the EVs. Here, the Daimler EV connected to the EVSE, identified itself as a valid customer, obtained the utility-specific tariff information, and charged according to utility, EV and customer preferences. More demonstrations are planned involving hundreds of customers and EVs around the U.S. in the next 12-18 months. The next pilot launches in the Southern California region. (Sunil Chhaya)

Electric School Bus Demonstration (in process) – Deploy, test, and collect data on electric school buses at various locations and climate conditions over two years. Testing to include charging infrastructure, grid impact, renewable integration, and possible vehicle-to-load (V2L) (Mark Kosowski)

MEETINGS AND CONFERENCES

2018 Webcasts

Date	Time	Subject	EPRI Lead	Audience
Thurs., July 5	11 a.m. PDT	2018 Q2 EV Market Update	D. Bowermaster	All ET Advisors
Thurs., Oct. 4	11 a.m. PDT	2018 Q3 EV Market Update	D. Bowermaster	All ET Advisors
Thurs, Jan. 3, 2019	11 a.m. PST	2018 Q4 EV Market Update	D. Bowermaster	All ET Advisors

2018 Meetings

Fleet/Bus & Truck/IWC: June 12–14, Columbus, OH (hosted by American Electric Power)

EPRI Electrification 2018 Conference: August 20–23, Long Beach, CA

EPRI Advisory Meeting: September 17–20, Atlanta, GA

Fleet/Bus & Truck/IWC: 23–25 October, Phoenix, AZ (hosted by Salt River Project)

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