2013

Transportation Industry Review

ACORE
American Council On Renewable Energy

American Council On Renewable Energy (ACORE)

July 2013

□ REDUCING COSTS AND OVERCOMING RANGE ANXIETY - TWO PARTIAL BRIDGES TO THE FUTURE FOR EVS

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Continuing progress of the electric vehicle (EV) industry presents an important means for the United States transportation sector to reduce carbon emissions.[20] In 2012, total sales of light duty hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) reached 487,480 units comprising 3.38% of the U.S. automotive market.[21] For the first four months of 2013, EV's sales totaling 188,466 units represented 3.80% of the market.[22] Although some EV manufacturers have struggled, 2012 EV sales represented a 73% improvement over 2011, and EV sales in the first four months of 2013 represented a 20% increase over the prior year period.[23] HEVs such as the Toyota Prius and Ford Fusion represented the bulk of these sales, however, PHEVs such as the Chevy Volt and BEVs such as the Nissan Leaf and Tesla Roadster accounted for approximately 53,000 units.[24] While HEVs are among the most fuel efficient passenger vehicles on the road today, they still rely principally on carbon-emitting internal combustion engines (ICEs) for propulsion.[25] Grid-charged vehicles -- PHEVs and BEVs -- rely principally on electric motors powered by on-board batteries to offer mostly zero emission mileage. As carbon-free renewable and nuclear energy and low carbon natural gas now comprise nearly 60% of U.S. electricity generation[26], grid-charged EVs offer strong potential for dramatically reducing transportation's carbon intensity.[27]

Two often cited impediments to more rapid progress for driver adoption of grid-charged EVs are their higher up-front costs and shorter ranges compared to ICE vehicles.[28] Many public and private sector research efforts are underway to tackle these "sticker shock" and "range anxiety" problems. For example, the Joint Center for Energy Storage Research -- a collaboration between the U.S. Department of Energy and its national labs together with private and public universities and several major corporations -- is focused on developing within five years battery and charging technologies that will provide five times the energy storage at

[20] Energy use in the transportation sector includes energy consumed in moving people and goods by road, rail, air, water, and pipeline. The road transport component includes light-duty vehicles, such as automobiles, sport utility vehicles, minivans, small trucks, and motorbikes, as well as heavy-duty vehicles, such as large trucks used for moving freight and buses for passenger travel. Approximately 82% of energy use in the transportation sector is consumed by road transport vehicles. Transportation Energy Data Book, 31st Edition, U.S. Department of Energy (2012).
[21] Electric Drive Transportation Association, "Electric drive vehicle sales figures (U.S. Market) - EV sales" http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952 (May 2013)
[22] Id.
[23] Richard Read, "Sales of Hybrids & Electric Cars Surge 73% in 2012: Data & Analysis," *Green Car Reports*, December 19, 2012, http://www.greencarreports.com/news/1081229_sales-of-hybrids-electric-cars-surge-73-in-2012.
[24] "Understanding the Electric Vehicle Landscape to 2020," *Global EV Outlook* (April 2013): 12, http://www.cleanenergyministerial.org/Portals/2/pdfs/EVI_GEO_2013_FINAL_150dpi.pdf.
[25] The latest generation Toyota Prius, while rated at 51 mpg, can run on battery power alone for only up to one mile ("Prius 2013," http://www.toyota.com/prius/#!/features). By contrast, the average driver of a PHEV Chevy Volt, which has a range of only 38 miles operates, exclusively on battery power 82% of the time (U.S. Department of Energy - Office of Energy Efficiency & Renewable Energy - Vehicle Technologies Program, *Chevrolet Volt Vehicle Demonstration Report*, 2012, 112th Cong., 2d sess., http://www1.eere.energy.gov/vehiclesandfuels/avta/pdfs/erev/gm_volt_apr-june12.pdf).
[26] For February 2013, these sources represented 59% of net generation; see "Electricity Data Browser," *U.S. Energy Information Administration*, http://www.eia.gov/electricity/data/browser/.
[27] Fuel Cell Electric Vehicles (FCEVs) are another category of zero emission EVs which use hydrogen fuel cells to power an all-electric drive train. Although promising in their own right, FCEVs are not grid-connected. Their prospects depend on the development of a hydrogen fueling infrastructure.
[28] "The Great Powertrain Race," *The Economist*, April 20, 2013, http://www.economist.com/news/special-report/21576219-carmakers-are-hedging-their-bets-powering-cars-great-powertrain-race; Sanya Carley et al., "Intent to Purchase a Plug-in Electric Vehicle: A Survey of Early Impressions in Large U.S. Cities," *Transportation Research Part D: Transport and Environment* 18 (January 2013): 39-45.

one-fifth of the cost of today's best lithium-ion storage systems all in support of a national goal of having one million grid-charged EVs on the road by 2015.[29] Beyond U.S. borders, there are similar initiatives and deployment targets in China, Japan, India and several states of the European Union.[30]

While awaiting innovative breakthroughs of these research and development efforts, practical commercial enterprise is not standing still in building bridges to an EV future. Tesla Motors has made headlines as a public EV company that has achieved profitability, repaid its government guaranteed loans, and is rolling out fast charging stations in major markets across the United States. While this high profile, premium branded EV automotive success is garnering headlines, two other less well-known commercially viable bridge applications for EVs that address the interrelated cost and range problems are also progressing. These applications are commercial EVs and EV motorsports.

COMMERCIAL ELECTRIC VEHICLES - URBAN FLEETS

Unlike the light-duty consumer EV market, today's medium-duty commercial EV market is not hampered by range and cost constraints nor reliant on socially or status conscious consumers to spur demand. Indeed two aspects of commercial EVs that bottom-line oriented corporate purchasers find appealing are range and costs.[31]

Range anxiety is simply not an obstacle for commercial EVs that operate on fixed delivery routes of less than 100 miles principally in low-speed, start-and-stop urban settings where battery use and regenerative braking are optimized. Examples of commercial vehicle fleets that are well suited for these types of EV applications include companies that deliver mail, parcels, office supplies, foodservice products, snack foods, beverages, uniforms/linens and groceries. Fleets that move people, such as municipal buses, school buses and airport or other closed loop shuttles, also present strong opportunities for EV deployment. These commercial applications typically have predictable route distances, times of use and duty cycles that return multiple-vehicle fleets to central depots for overnight charging. As a result, these applications do not require spontaneous flexibility or long-range capability that produces range anxiety for consumers, who demand these characteristics of their personal automobiles.

With range anxiety taken out of the picture for commercial EVs, range merely becomes a variable in the capital and operating cost equation. Fleet managers can optimize capital cost and range variables by working with EV suppliers to customize each fleet vehicle's battery configuration to provide a "right sized" power pack for routes of different distances and duty cycles. One route may require only a 60 kilowatt system while another may require 100 kilowatts.[32] More importantly, EVs have fewer and simpler moving parts than ICEs, are more energy efficient than ICEs, and rely on electricity the prices for which are less volatile than diesel or gasoline and,

[29] "The National Mission" and "Science to Technology to Marketplace," accessed May 1, 2013, http://www.jcesr.org/.

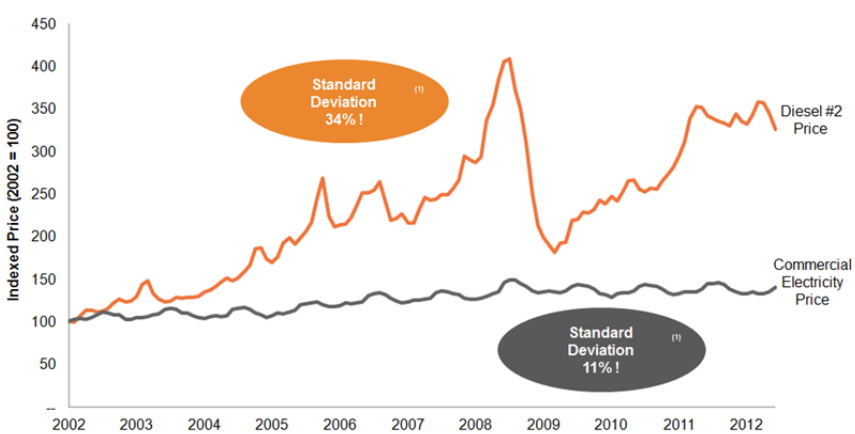
[30] "Understanding the Electric Vehicle Landscape to 2020," *Global EV Outlook* (April 2013): 10, http://www.cleanenergyministerial.org/Portals/2/pdfs/EVI_GEO_2013_FINAL_150dpi.pdf.

[31] Kim Hill and Joshua Cregger, "Deployment Rollout Estimate of Electric Vehicles 2011 - 2015," *Center for Automotive Research* (January 2011): 4-5, http://www.cargroup.org/?module=Publications&event=View&pubID=12.

[32] For example, Smith Electric Vehicles offers multiple battery configurations of its Newton model truck that allows the purchaser to select vehicle ranges from short as 40 miles to as long as 150 miles ("Smith Vehicles: Models and Configurations," http://www.smithelectric.com/smith-vehicles/models-and-configurations/).

for U.S. commercial customers at overnight, off-peak rates, are among the lowest cost energy sources available.[33] These lower energy and maintenance costs allow corporate purchasers that select EVs to reduce total costs of operating their fleets from an average of $0.72 per mile for diesel vehicles to $0.22 per mile for EVs.[34] Thus, the longer the range and usage of the commercial EV, the greater opportunity there is for increased operational savings and faster payback on the initial capital cost. In addition to these direct, bottom-line economic benefits, other factors spurring corporate demand for commercial EVs as a replacement for traditional ICE trucks and buses include dramatic reductions in noise, vibration and fumes and faster acceleration resulting in a superior and healthier experience for drivers, which, in turn, improves employee retention and satisfaction and reduces health care costs.[35] These environmental and health benefits also create a public good that has been translated by federal and some state and local governments into incentive programs to spur faster adoption of commercial EVs.[36]

Diesel Fuel Prices versus Commercial Electricity Prices in the U.S.
(Indexed to 100; 2002 = 100)



Source: U.S. Energy Information Administration
(1) Standard deviation to the mean

A snapshot of the current addressable and addressed commercial EV market reveals favorable dynamics for continued growth. The U.S. commercial vehicle fleet totals approximately 11.5 million units, approximately 3.3 million of which are comprised of the medium-duty class which are used mostly in the types of applications that are best suited for commercial EVs.[37] Within this addressable market, there are many large corporations that have strong economic incentives to transition all or major portions of their medium duty fleets to EVs.[38] The top 100 commercial fleets represent nearly 1 million of the total U.S. medium-duty fleet -- and this excludes government owned fleets and buses.[39] This concentration of profit-focused corporate customers requires a relatively small number of buying decisions to facilitate rapid deployment of EVs at scale and companies like PepsiCo, Federal Express, and Staples have been early adopters. A number of large multi-class ICE vehicle manufacturers and smaller manufacturers that are focused solely on commercial electric vehicles are addressing this market today. These include in the multi-class category, Ford, Navistar, Mitsubishi and Freightliner, and smaller companies, Smith Electric Vehicles, Odyne Systems, Zero

[33] Sean Lyden, "What Staples Expects from All-Electric Medium-Duty Work Trucks," *Work Truck Magazine* (March 2011), accessed May 1, 2013, http://www.worktruckonline.com/channel/green-fleet/article/story/2011/03/what-staples-expects-from-all-electric-medium-duty-work-trucks.aspx.
[34] "Hybrid Medium and Heavy Duty Trucks: Hybrid, Plug-in Hybrid, and Battery Electric Medium and Heavy Trucks: Market Analysis and Forecasts," (Pike Research LLC, 2011): 3.
[35] Nick Kurczewski, "Doing Delivery Rounds in an Electric Smith Newton," *Edmonds Auto Observer*, March 25, 2011, http://www.edmunds.com/autoobserver-archive/2011/03/doing-delivery-rounds-in-an-electric-smith-newton.html.
[36] See Clean Cities Program administered by the U.S. Department of Energy - Office of Energy Efficiency & Renewable Energy (http://www1.eere.energy.gov/cleancities/).
[37] 11.5 million represents the total number of Class 3-8 commercial vehicles in operation and 3.3 million represents the total number of Class 4-6 trucks in operation (R. L. Polk & Co., *Quarterly Commercial Vehicle Report* (March 2012), https://www.polk.com/knowledge/reports/march_2012_quarterly_commercial_vehicle_report).
[38] Daniel P. Bearth, "2012 Top 100 Commercial Fleets," *Light & Medium Truck Magazine* (July 2012).
[39] Daniel P. Bearth, "2012 Top 100 Commercial Fleets," *Light & Medium Truck Magazine* (July 2012).

Truck, Electric Vehicles International and Boulder Electric Vehicles. Transtech, Proterra and BYD (which also manufactures EV consumer vehicles and battery systems) are focused on EV buses.

Continued growth in the commercial EV market should help lower costs and increase demand for consumer EVs. Battery system costs are the biggest factor in the cost equation and a scarcity of maintenance infrastructure is another concern affecting demand.[40] The current economic viability of commercial EVs will help support development of the necessary component supply chain and maintenance expertise for EVs that is already well embedded for consumer ICE vehicles. Over time the continued cost-down pressures of bottom-line focused corporate fleet managers and EV manufacturers together with volume increases should drive down capital and maintenance costs for commercial EVs which in turn should help lower costs for consumer EVs. Finally, more drivers having workplace experience of the superior performance characteristics of EVs should translate into greater demand for consumer EVs. For example, as people see the benefits of commercial EVs for shorter range predictable journeys, this could also drive the demand for consumer EVs as second vehicles for local journeys, commuting, school runs, etc.

EV MOTORSPORTS - FIA FORMULA E CHAMPIONSHIP

Motorsports has long been a proving ground for automotive innovation, one that provides a business platform both to pay for research and development and to create mass market appeal for new vehicle technologies. The EV industry is poised to follow in this long tradition of the ICE industry with the launch in 2014 of the FIA Formula E Championship. This new motorsports circuit officially sanctioned by the Fédération Internationale de l'Automobile (FIA) will initially feature 10 teams, 20 drivers and 40 Formula cars powered exclusively by electric energy in "e-Prix" events held in 10 cities across the world, including Los Angeles and Miami. Formula E Holdings, a venture led by Spanish racing entrepreneur Alejandro Agag, is the official promoter of the new race circuit. A major focus of Formula E Holdings' promotional effort is to tout sustainability and electrification of consumer vehicles.[41]

In preparation for the launch, EV developers such as Spark Racing Technology and Drayson Racing Technologies have been busy collaborating with technology partners to innovate the electric drivetrain, energy storage, regenerative braking, charging and other vehicle components needed to maximize the performance, efficiency and safety of this new category of racecar. Some of these racing specific innovations will inevitably be translated to improve the range and lower the costs of commercial and consumer EVs.

One example is the wireless EV charging (WEVC) technology pioneered by Qualcomm Halo and being promoted to Formula E by Drayson Racing.[42] Qualcomm states that it is pioneering WEVC technology as a way to bring EVs to the mass market

[40] "GM's Fletcher Says Cost Top Issue for Electric Cars," *Bloomberg News*, April 24, 2012, http://www.businessweek.com/videos/2013-04-24/gms-fletcher-says-cost-top-issue-for-electric-cars.

[41] "Formula E CEO Alejandro Agag on Bloomberg News 03.09.12," *Bloomberg News*, March 9, 2013, http://www.youtube.com/watch?v=_ayQAf80XpQ.

[42] "Qualcomm and Drayson Racing Team up in New FIA Formula Electric," Drayson Racing Technologies. press release, January 9, 2013, http://www.draysonracingtechnologies.com/news_article.html?Qualcomm-and-Drayson-Racing-Team-up-in-New-FIA-Formula-Electric-20.

and help drive global EV adoption.[43] Inductive charging provided by WEVC technology eliminates the need for ICE drivers to change their parking behavior as they transition to EVs. Drivers can merely "park and charge" their EVs equipped with WEVC vehicle charging units (VCUs) in parking slots equipped with base charging units (BCUs) that are installed on or under the floor of the garage and then walk away without having to plug in cables from charging stations. The company has developed three sizes of VCU/BCU systems ranging from 3.3kW for consumer vehicles, 7kW for large luxury vehicles, and 20kW for the Drayson Lola B12/69 EV prototype racing car.[44]

While Qualcomm is marketing these stationary charging systems to become an industry standard in the short-term, the company's medium/long-term vision is to augment stationary charging with dynamic charging by embedding BCUs in special charging lanes of roads and highways.[45] One could envision financing this type of infrastructure through public-private partnerships similar to structures used for traditional toll roads or bridges. Drivers could be charged a "toll" for energy consumption as they recharge while passing through charging lanes. Deployment of ubiquitous stationary WEVC technology together with dynamic charging would effectively eliminate EV range anxiety and permit EVs to use smaller, lower cost battery systems.[46] While this may seem to some to be more visionary than realistic, the same might have been said fifteen years ago about the prospect of ubiquitous Wi-Fi enabling handheld mobile devices that provide immediate access to virtually all of the world's accumulated knowledge -- technologies that Qualcomm was also at the vanguard in enabling.[47]

MOVING TO AN EV FUTURE?

Paradigm shifts occur from accumulations of small changes coupled with some elements of disruptive innovation and responses to external necessity. The U.S. transportation system of the last 110 years has been the province of petroleum and ICEs. While this regime is likely to remain dominant for some time to come, continued step-by-step evolution of the EV industry through practical small changes, occasional disruptive innovation, and driven by external necessity (such as government policies that impose higher corporate average fuel efficiency (CAFE) standards, higher fuel taxes, and more stringent urban emissions regulations) may lead ultimately to a dominant EV future.

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[43] "The Future is Wireless EV Charging," Qualcomm Halo, http://www.qualcommhalo.com/.
[44] "Advantages," Qualcomm Halo, http://www.qualcommhalo.com/index.php/advantages.html?id=22#advantages.
[45] "It's about wireless," Qualcomm Halo, http://www.qualcommhalo.com/index.php/vision.html.
[46] "Dynamic Charging," Qualcomm Halo, http://www.qualcommhalo.com/index.php/vision.html?id=12#learn-more.
[47] "History," Qualcomm Halo, http://www.qualcomm.com/about/history.

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