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The electrification accelerator: Understanding the implications of autonomous vehicles for electric utilities

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ABSTRACT

The intersection of autonomous vehicles, ride sharing and transportation electrification could have significant implications for electric utilities. This paper analyses how the development of shared autonomous electric vehicles may make electrified transportation more likely and why this may lead to a more rapid than expected shift in the current transportation paradigm. We also discuss how these trends may affect utilities and suggest what they can do to prepare for the transition.

1. Introduction

Rapid advancements in autonomous vehicle (AV) technology, combined with the growth of ride hailing and vehicle sharing, are creating the possibility of a radical transformation of transportation. In parallel, progress in the development of electric transportation is causing electric utility companies to analyze how their business models may need to change to accommodate electric vehicles (EVs). To date, utility studies have tended to focus on a scenario of relatively gradual adoption of EVs replacing individually owned non-electric vehicles. Those studies have not fully considered the impact that automation and ride/vehicle sharing might have on the speed of electrification of transportation and the associated opportunities and challenges for electric utilities.

This article focuses on the intersection of autonomous vehicles, ride sharing/ride hailing, and electric vehicles and the implication these phenomena may have for the utility business model. We begin by briefly introducing AV technologies and ride/vehicle sharing concepts and discussing how the development of shared autonomous electric vehicles (SAEVs) may make electrified transportation more likely. We then explain why this may lead to a more rapid than expected shift in the current transportation paradigm. We conclude with a discussion of how these trends may affect utilities and suggest what they can do to prepare for the transition.[1]

2. Autonomous vehicles and the sharing economy

Recent years have seen massive investments in autonomous driving technology by automobile manufacturers, ride sharing software companies, and technology companies. Autonomous vehicles are being promoted as a way to increase safety, driver comfort, and vehicle efficiency. The expected benefits include reduced accident and fatality rates, reduced traffic congestion, expanded access of mobility to currently underserved populations, and reduced space use in urban areas.[2]

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[1] This short paper does not discuss the benefits of electric transportation for utilities and in terms of reduced GHG emissions. For a discussion of these issues, see Jurgen Weiss, Ryan Hledik, Michael Hagerty, and Will Gorman, Electrification – Emerging Opportunities for Utility Growth, January 2017. Available at: http://www.brattle.com/system/news/pdfs/000/001/174/original/Electrification_Whitepaper_Final_Single_Pages.pdf

[2] Anderson et al. Autonomous Vehicle Technology: A Guide for Policymakers, RAND Corporation, 2016.

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Several companies have already commercially deployed technology with varying levels of autonomy.[3]

At the same time, growth in ride sharing and car sharing services[4] is also quickly transforming how consumers use transportation, particularly in urban areas. In the past three years, use of on-demand ride sharing services (such as Uber and Lyft) in New York City has doubled annually and is now approaching yellow cab ridership levels.[5] Similarly, membership in car-sharing programs (such as Zipcar and Car2Go) increased by 34% from 2012 to 2014 in North America to over 1.6 million members.[6]

Automation technology has the potential to leverage the "sharing economy" by creating an optimized network of shared vehicles and thus vastly improving the overall value of transportation services. Automated ride sharing could significantly reduce per-mile transportation costs and emissions and increase vehicle utilization by matching cars for hire with passengers traveling in similar directions.[7] This in turn could make personal vehicle ownership the exception rather than the rule, at least in densely populated urban areas. The potential benefits of this transition are evidenced by ambitious AV sharing programs being piloted across the country by Uber, Google, and others.[8]

3. Automation as an accelerator of electrification

In addition to potential improvements in safety, convenience, and efficiency, shared AVs may disrupt the economy in another way: by rapidly expediting the transition to transportation electrification. There are several reasons to believe the emergence of shared AVs could accelerate the adoption of EVs.

AVs deployed to provide mobility services could favor EVs due to advantages in cost of ownership. In the near term, EVs will likely continue to be characterized by a higher purchase price, but lower operating costs relative to internal combustion engine vehicles.[9] At higher levels of annual vehicle miles traveled, lower operating costs lead to cumulative savings that offset a higher upfront EV purchase price. Many individual consumers drive too few miles to reach this threshold. The average car is driven 11,000 miles per year and parked and left idle for more than 90% of the time.[10,11] Today's relatively high purchase price of EVs therefore remains a significant hurdle for many prospective EV buyers and likely prevents more rapid EV adoption.[12] Autonomous technology, on the other hand, enables a potential step-change increase in the utilization of vehicles. By not relying on a human driver, self-driving cars could meet the transportation needs of many owners/users by operating as part of a shared fleet of vehicles. As a consequence, AVs are forecast to drive as many as 75,000 miles per year, a more than six-fold increase over the average privately owned vehicle.[13] These high projected utilization rates likely move the needle on the economics of shared AVs such that the operational savings of EVs more than make up for their higher purchasing price. The development of large SAEV fleets could, in turn, drive EV price reduction for all consumer segments, whether autonomous or not, by allowing automakers to achieve greater economies of scale for EV production.

Fig. 1 illustrates qualitatively how the cost of mobility decreases from the current model of a personally owned internal combustion engine (ICE) vehicle with the adoption of increasing levels of autonomy (privately owned EV/AEV), car sharing (fleet-owned AEV with one passenger), and ride sharing (fleet owned AEV with two passengers).

As shown in Fig. 1, the relative total cost of ownership of individually owned ICE vehicles (first bar) versus EVs (second bar) will continue to depend on the annual miles traveled. With the adoption of autonomous technology and higher utilization rates, the fuel cost savings stemming from higher utilization of vehicles directly will result in lower costs (third bar) with SAEVs that carry additional passengers per ride further lowering the cost of transportation services provided to consumers by pooling passengers through ride sharing (fourth bar).

However, more widespread adoption of pooling is highly contingent on consumer behavioral preferences. In fact, the economics of carpooling have always been compelling—independent of powertrain or autonomous functionality—and incentives have sought to encourage the behavior, to little avail.[14] Nonetheless, it is conceivable that AVs may overcome some of the traditional barriers to more pooling, for example by making pooled transportation services much more attractive than has historically been the case due to both the lower costs and increased comfort through the use of familiar mobile applications, such as UberPOOL. Hence, even though shared AVs may significantly lower the cost of transportation services relative to the current cost of personal transportation with individually owned ICE cars, it remains to be seen whether or not (or at what speed) pooling through SAEVs will increase.

It should be noted that AVs may also provide other opportunities for lowering the cost per passenger-mile of transportation services, in ways that are equivalent to pooling. Electric AVs could be built for specific purposes more so than current vehicles. For example, electric AVs for urban (low speed) use could be constructed to be significantly smaller (and perhaps have fewer seats) than "standard" cars are today with engines designed for efficiency rather than consumer preferences for higher-horsepower engines. Designing electric AVs for specific purposes could lead to much cheaper total costs and hence lower the cost per

[3] There are several levels of autonomy, typically classified as Level 1 to Level 5 (full autonomy). We focus on the implications of Level 5 autonomous vehicles. Many car makers have already introduced models with lower levels of autonomy, such as adaptive cruise control and self-parking (Level 1) and Tesla's Autopilot feature (Level 2).

[4] Many terms are being used to describe various product offerings. We use the term car sharing to identify situations where the same vehicle is sequentially shared by different drivers and/or passengers. Ride sharing refers to situations where different users share the same car at the same time as a passenger, essentially as a taxi substitute. The distinction between the two loses relevance with driverless cars, since all trips are essentially being undertaken in passenger mode, which is why our term SAEV (shared autonomous electric vehicle) covers both services. SAEVs can be used in single occupancy or multiple occupancy mode.

[5] Bruce Schaller, Unsustainable? − The Growth of App-Based Ride Services and Traffic, Travel and the Future of New York City, Feb. 27, 2017. Available at schaller-consult.com/rideservices/unsustainable.pdf.

[6] Susan Shaheen and Adam Cohen, Innovative Mobility Carsharing Outlook, Transportation Sustainability Research Center, Winter 2016. Available at http://innovativemobility.org/wp-content/uploads/2016/02/Innovative-Mobility-Industry-Outlook_World-2016-Final.pdf.

[7] Princeton researchers have found that Uber drivers spend more time and drive a higher share of miles with a passenger in their car than do taxi drivers across several U.S. cities. Shared AVs could have even higher utilization than ride-sharing vehicles today due to reduced traffic congestion and improved vehicle coordination and dispatch. See Judd Cramer & Alan B. Krueger, 2016, Disruptive Change in the Taxi Business: The Case of Uber, *American Economic Review*, Vol 106(5), pages 177–182. Available at http://www.nber.org/papers/w22083?utm_campaign=ntw&utm_medium=email&utm_source=ntw.

[8] Uber launched a test fleet of partially automated internal combustion vehicles in Pittsburgh in August 2016, while Lyft has partnered with General Motors to test automated electric vehicles in 2017. (a) See: http://www.wsj.com/articles/gm-lyft-to-test-self-driving-electric-taxis-1462460094 (accessed 15 November 2017). (b) See: http://www.csmonitor.com/Business/In-Gear/2016/1009/How-are-Uber-s-self-driving-cars-doing-in-Pittsburgh (accessed 15 Nov. 2017)

[9] Buyers trade higher upfront costs for lower running costs over time. See: https://www.edmunds.com/electric-car/ (accessed 15 Nov. 2017)

[10] The average amount of time spent in a vehicle is approximately one hour per day for the average U.S. individual. See: "Summary of Travel Trends: 2009 National Household Travel Survey," Federal Highway Administration. Available at http://nhts.ornl.gov/2009/pub/stt.pdf.

[11] The average U.S. resident drove an average of 10,874 miles annually in 2014 and 2015. See: American Driving Survey: 2014–2015, AAA Foundation for Traffic Safety, September 2016. Available at https://www.aaafoundation.org/sites/default/files/AmericanDrivingSurvey2015. pdf.

[12] Jens Hagman et al. Total cost of ownership and its potential implications for battery electric vehicle diffusion, *Research in Transportation Business & Management* 18 (March 2016): 11–17.

[13] Jonathan Walker and Charlie Johnson, Peak Car Ownership: *The Market Opportunity of Electric Automated Mobility Services*, Rocky Mountain Institute, 2016. Available at http://www.rmi.org/peak_car_ownership.

[14] National Task Force on Ridesharing, 1979. See: http://www.presidency.ucsb.edu/ws/?pid=31587 (accessed 15 Nov. 2017)