Pepperdine Policy Review

Volume 10 Article 7

3-2-2018

Automated Vehicles and the Environment

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A recent policy brief published by the UC Davis Institute of Transportation Studies highlighted three "revolutions" that will transform the transportation sector in the coming years: automated vehicles, shared-use riding, and electrification all possess the potential to substantially reduce or dramatically increase the environmental impact of transportation. Recent papers estimated that, depending on different policy scenarios, automated vehicles could either double transportation emissions or reduce them by up to 90 percent.[1] A proper regulatory structure is critical to harness the vast potential of these new technologies and use them to create an environmentally responsible transportation sector.

Currently, there are approximately 260 million vehicles in the United States.[2] The majority of vehicles are gas-powered, single-person operated, and driven manually; these three characteristics contribute to the footprint of transportation usage. The transportation sector recently passed the power generation sector as the largest emitter of energy-related carbon dioxide emissions in America.[3] In response, policymakers must be prepared to handle the coming changes in transportation modes. This paper will examine the potential impacts of automated vehicles on the environment and provide several policy recommendations to mitigate negative consequences.

Automation of vehicles is rapidly advancing, and a litany of private companies, including Google, Tesla, Mercedes-Benz, Ford, Volkswagen, Volvo, and Toyota, are investing in this

[1] Don Anair, "Capturing the Climate Benefits of Autonomous Vehicles," *UC Davis Institute of Transportation Studies,* February, 2017, https://3rev.ucdavis.edu/wp-content/uploads/2017/03/3R.Climate.Indesign.Final_.pdf.
[2] National Bureau of Transportation Statistics, "Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances," December, 2017, https://www.bts.gov/content/number-us-aircraft-vehicles-vessels-and-other-conveyances.
[3] Matthew Goetz, "Electric Vehicle Charging Considerations for Shared, Automated Fleets," *UC Davis Institute of Transportation Studies*, July, 2017) https://3rev.ucdavis.edu/wp-content/uploads/2017/07/3R.EVSE_.final_.pdf.

technology.[4] Investment in automated vehicles is not limited to traditional car companies; transportation network companies have emerged as dominant players in the transportation sector. Transportation network companies recognize that driverless vehicles are the future and are investing time and resources in automation. It is possible that transportation network companies could soon possess entire fleets of automated vehicles. In November 2017, Uber reached a deal with Volvo that would allow Uber to purchase up to 24,000 driverless cars between 2019 and 2021.[5] Currently, Uber is experimenting with autonomous vehicles carry human drivers who can take control in cases of emergency.[6] While private industry is clearly advancing towards automation, it is not the only player that has expressed interest in driverless vehicles. Policymakers at all levels of government have started experimenting with how to address and safely integrate automated vehicles into everyday life. Cities such as Boston have considered permitting driverless taxis, and the frequency of such experimentation will only increase as time progresses.[7]

In September 2017, the National Highway Traffic Safety Administration (NHTSA) released a report outlining safety guidance for automated vehicles (NHTSA 2017).[8] It adopted the Society of Automotive Engineers' six-level classification scheme for automated vehicles, which is intended to help delineate between levels of automation and provide classification levels for future regulation. Level 0 is titled "No Automation" and incorporates zero autonomy with the driver handling all tasks. Level 1, "Driver Assistance," is defined as a driver controlling

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[4] Aakash Goel, "What Tech Will it Take to Put Self-driving Cars on the Road?" *Engineering.com*, October, 2016, https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/13270/What-Tech-Will-it-Take-to-Put-Self-Driving-Cars-on-the-Road.aspx.

[5] Peter Holley, "Uber Signs Deal to Buy Up to 24,000 Autonomous Vehicles from Volvo." *Washington Post*, November, 2017, https://www.washingtonpost.com/business/economy/uber-signs-deal-to-buy-24000-autonomous-vehicles-from-volvo/2017/11/20/d6038f28-ce2a-11e7-81bc-c55a220c8cbe_story.html?utm_term=.6150b17d8b93

[6] Ibid.

[7] Ibid.

[8] National Highway Traffic Safety Administration, "Automated Driving Systems 2.0: A Vision for Safety," September, 2017, https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf.

the vehicle with some driving assistance features included. Level 2, "Partial Automation," employs automated features such as steering, acceleration, and other basic functions. However, the driver is still responsible for monitoring the surrounding area. In Level 3, "Conditional Automation," the driver is not required to monitor the surrounding area. The car can drive itself, but the driver must remain ready to seize control if necessary. Currently, this is the highest level of automation on the road. A concrete example of this is Uber's experimentation with self-driving cars possessing a human driver in cases of emergency.[9] The last two levels address technology that is not yet road-ready but will be available in the coming years. Level 4, known as "High Automation,' means the vehicle can perform all driving functions in certain conditions. Level 5, "Full Automation," means that the vehicle can perform all driving functions in all conditions. To design knowledgeable and targeted regulation, policymakers at all levels must become well-versed in the classification scheme for automated vehicles.

The federal government is not alone in investigating automated vehicles; many state governments have also taken steps to address this issue. The National Conference of State Legislatures, which tracks autonomous vehicle legislation, reported that thirty-three states introduced legislation related to such modes of transportation in 2017 (NCSL 2017).[10] Many of these laws and executive orders authorized studies and pilot programs as preparation for the rise of automated vehicles. It is crucial for the environment that states compile knowledge and understand the full impacts of autonomous vehicles. There is wide variance in estimates of vehicle automation on greenhouse gas emissions.

[9] Holley, "Uber Signs Deal."
[10] National Conference of State Legislatures, "Autonomous Vehicles: Self-driving Vehicles Enacted Legislation," November, 2017, http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx

Different policy scenarios are responsible for the broad range of estimates. For example, emissions could double if automated vehicles, using internal combustion engines, correspond with a substantial increase in vehicle miles traveled.[11] Meanwhile, increased usage of automated cars, particularly in single-occupant trips, could boost greenhouse gas emissions produced by the transportation sector. The low-emissions scenario relies on the coupling of autonomous vehicles with widespread electrification.[12] Ride-sharing companies could provide crucial first-and-last mile connections to public transit hubs, a partnership that would likely result in the decrease of single-occupant trips. Clean electricity powering strategic vehicle charging would dramatically reduce emissions.[13]

Automated vehicles have the power to increase or decrease the environmental impact of transportation. Targeted and informed policies can ensure the future protection of the environment. Policies that promote a healthy scenario include occupancy requirements, fuel-mileage standards, and fees based on vehicle-miles traveled.[14] Many of these policies are currently being developed and tested. States such as California and Oregon have deployed pilot programs assessing the viability of a vehicle-miles traveled fee (Caltrans 2017).[15] Many states have existing fuel-mileage standards and ten states adopted zero emission vehicle (ZEV) programs. The ZEV block, which consists of California, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont, accounted for 28 percent of United States new car registrations in 2015.[16] Expanding ZEV programs to other

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[11] Don Anair, "Capturing the Climate Benefits of Autonomous Vehicles," *UC Davis Institute of Transportation Studies,* February, 2017, https://3rev.ucdavis.edu/wp-content/uploads/2017/03/3R.Climate.Indesign.Final_.pdf.

[12] Ibid.

[13] Ibid.

[14] Ibid.

[15] California Department of Transportation, "The California Road Charge Pilot Program," November, 2017, http://www.dot.ca.gov/road_charge/documents/Pilot_By_the_Numbers_Factsheet.pdf.

[16] Dave Guildford, "ZEV Mandates Get Harder to Ignore," *Automotive News,* June, 2016, http://www.autonews.com/article/20160627/OEM11/306279987/zev-mandates-get-harder-to-ignore.d

states could increase regulatory pull and reduce the environmental impacts of automated vehicles.

Researchers at the University of California at Davis, in conjunction with the Governor's Office of Planning and Research, outline seven concrete policy suggestions for reducing greenhouse gas emissions in a world filled with driverless vehicles. The policy suggestions are shared-use vehicles, widespread carpooling, zero tailpipe emissions, congestion pricing, promotion of public transit, control of driverless vehicle size, and the programming of optimal vehicle behavior.[17] The first three suggestions are intertwined and must be implemented together to achieve the best outcome. The first policy suggestion addresses widespread private ownership of vehicles.

Private ownership of driverless vehicles is problematic for numerous reasons. First, the comfort provided by driverless vehicles could increase vehicles-miles traveled. Consumers could drive instead of using public transit, walking, or combining several stops into one trip. The ability to work while riding in a driverless vehicle can increase productivity and produce economic benefits; however, studies have estimated that it could also reduce the use of rail and other public modes of transportation.[18] Similar to the subway, driverless vehicles provide the benefits of completing work during a commute, yet driverless vehicles will provide infinitely greater comfort and privacy than a crowded subway. It is easy to see why consumers might shift toward longer commutes in driverless vehicles. The comfort and productivity benefits gained from these commutes could also increase sprawl, which would increase greenhouse gas

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[17] Giovanna Circella et al., "Keeping Vehicle Use and Greenhouse Gas Emissions in Check in a Driverless Vehicle World," *UC Davis Institute of Transportation Studies*, April, 2017, https://3rev.ucdavis.edu/wp-content/uploads/2017/04/3R.VMT-GHG.final_-1.pdf
[18] Ibid.

emissions and vehicle-miles traveled.[19] Shared-use vehicles could mitigate some of these negative impacts by decreasing the number of individual trips.

The provision of shared-use vehicles through private companies or public agencies could have positive impacts on land-use and city planning. Areas allotted for parking could be reduced, density could be increased, and walkability in cities could be promoted. These would all have positive environmental effects. Despite the positive effects, researchers estimate that shared-use vehicles would probably increase vehicle-miles traveled, though at a lesser rate than privately owned driverless vehicles.[20] Widespread carpooling is essential to combating this phenomenon and ensuring a reduction in the environmental impact of driverless vehicles.

Carpooling and shared-use vehicles alone are not projected to decrease vehicle-miles traveled, but if combined, could have extremely positive impacts on vehicle-miles traveled, greenhouse gas emissions, and travel costs. Ideally, such a partnership could reduce emissions by one-third, vehicle-miles traveled by half, and travel costs by half.[21] Unfortunately, it is unlikely that widespread carpooling with shared-use vehicles would be easily embraced. Policy incentives would be necessary to guide such a drastic shift in the transportation preferences of consumers.

Mandating zero tailpipe emissions would clearly reduce greenhouse gas emissions. Combining such a mandate with shared-use and carpooling would be an ideal scenario. Several other alternatives can lessen the impact of zero tailpipe emissions. For example, shared-use vehicles without carpooling would result in an increase in vehicle-miles traveled and would need

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[19] Daniel J. Fangant and Kara Kockelman, "Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations," *Transportation Research Part A: Policy and Practice* 77, (July 2015): 167- 81. https://www.sciencedirect.com/science/article/pii/S0965856415000804

[20] Giovanna Circella et al., "Keeping Vehicle Use and Greenhouse Gas Emissions in Check in a Driverless Vehicle World," UC Davis Institute of Transportation Studies, April, 2017, https://3rev.ucdavis.edu/wp-content/uploads/2017/04/3R.VMT-GHG.final_-1.pdf

[21] Ibid.

zero tailpipe emissions to meet reduction goals.[22] Privately owned vehicles still on the road could increase vehicle-miles traveled to such a great degree that zero tailpipe emissions in shared-use vehicles would not help meet reduction goals.[23] This is the worst-case scenario, which policymakers should avoid.

The first three suggestions—shared-use, carpooling, and zero tailpipe emissions—should be combined for maximum positive environmental effects. The remaining four suggestions—congestion pricing, promoting public transit, driverless vehicle design, and programming optimal vehicle behavior—are also essential in reducing emissions. Congestion pricing has the potential to combat an increase in vehicles-miles traveled, promote high-value trips, and mitigate traffic. As mentioned previously, the ease of driverless vehicles will likely increase usage and travel. Responsive pricing that adjusts to different locations and times could moderate the effects of an increase in travel. The city of Sacramento, for example, has experimented with a subsidized, lower pricing approach for trips to public transit hubs.[24] Such pricing, combined with effective first-and-last mile service to these hubs, could incentivize public transit usage. This corresponds with the fifth suggestion of promoting public transit. Responsive pricing mechanisms are common in transportation network companies. For example, companies such as Uber and Lyft currently practice “surge pricing” based on supply of drivers and demand of passengers. Policymakers could emulate this model and impose congestion pricing on transportation network companies, which would then pass the costs on to consumers.[25]

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[22] Giovanna Circella et al., “Keeping Vehicle Use and Greenhouse Gas Emissions in Check in a Driverless Vehicle World,” UC Davis Institute of Transportation Studies, April, 2017, https://3rev.ucdavis.edu/wp-content/uploads/2017/04/3R.VMT-GHG.final_-1.pdf
[23] Ibid.
[24] Ibid.
[25] Ibid.

Controlling the design of driverless vehicles is a proactive step in advancing the automotive industry. Currently, this is not a pressing concern because driverless cars are not ready for the market, but the eventual emergence of driverless vehicles will have dramatic impacts on vehicle layout. For instance, passengers will no longer need to face the direction the car is driving which opens the door for a variety of new vehicle models. Additionally, riders could demand amenities such as kitchens, lounge chairs, movie screens, or exercise rooms to augment the comfort of their ride.[26] Such designs could have negative impacts on the energy usage and efficiency of vehicles. Policymakers institute responsible design limits for driverless vehicles, as well as consider what programming will produce optimal results. For example, the National Association of City Transportation Officials currently recommends a speed limit of 25 mph for driverless vehicles in urban areas, to ensure cyclist and pedestrian safety.[27]

Looking forward, cultural trends may favor shared-use riding over privately owned vehicles. Millennials are attaining licenses at historically low rates and appear comfortable to embrace ride-sharing (Bomey 2016).[28] Future generations will likely be more accustomed with not owning cars and instead participating in shared-use programs. The duration and impact of this trend on the transportation sector continues to remain in question. Car ownership is deeply ingrained in the culture of older generations. They are more likely to resist using shared-use vehicles and prefer to own their own car. When considering policy implementation, therefore, one should not overlook or underestimate the power of cultural values.

In conclusion, driverless vehicles cannot simply be unleashed on roads without direction or guidance. The technology must be paired with basic governmental standards to create a

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[26] Ibid.
[27] Ibid.
[28] Nathan Bomey, "Millennials Spurn Driver's Licenses, Study Finds," *USA Today*, January, 2016, https://www.usatoday.com/story/money/cars/2016/01/19/drivers-licenses-uber-lyft/78994526/.

transportation sector that is integrated with environmental goals. Appropriate policy criteria can ensure automated vehicles have a positive impact on the environment. As argued in this paper, automated vehicles can decrease emissions and reduce the transportation sector's environmental footprint while shared-use vehicles and carpooling can increase the efficiency of vehicle trips. It is certainly possible that smart driving technology may improve the carrying capacity of roads and parking garages and allow cities to repurpose unnecessary infrastructure. A responsible policy should take the necessary steps to ensure a promising future with automated vehicles.

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