Driverless Vehicles: Opportunity for Further Greenhouse Gas Emission Reductions Under California AB 32

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Fully-automated driverless vehicles could not only provide a convenient means of transportation to many, but also become an effective tool to reduce greenhouse gas ("GHG") emissions if properly regulated. To ensure that driverless vehicles help achieve California's emission reduction goals beyond 2020, when driverless vehicles could become commercially available, this Note proposes several regulatory schemes to achieve efficient fuel economy for driverless vehicles, foster the use of fully-automated, shared driverless vehicles that would supplement public transportation systems, and prevent urban sprawl that could be caused by the use of driverless vehicles.

This Note also addresses the implications for auto manufacturers, transportation network companies ("TNC"), software developers, real estate developers, and the retail and service industry. This Note does so by primarily examining existing regulations intended to reduce the transportation-sector emissions under Assembly Bill 32 ("AB 32"), the California Global Warming Solutions Act of 2006, Senate Bill 375 ("SB 375"), the Sustainable Communities and Climate Protection Act of 2008, and the potential impacts that driverless vehicles could have on GHG emissions based on expert opinions and literature review.

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INTRODUCTION

The National Highway Traffic Safety Administration ("NHTSA") predicts that vehicle automation technology will likely significantly change motor vehicles and drivers' relationships with them in the next ten to twenty years.[1] Some experts suggest that driverless vehicles might create a forty-two billion dollar market for the technology by 2025.[2]

Fully-automated driverless vehicles will likely drastically change the way people and goods are transported, implicating the land use patterns and transportation systems.[3] In the absence of appropriate regulatory mechanisms, the use of driverless vehicles could substantially increase GHG emissions. Thus, legal mechanisms that help effectively minimize emissions from driverless vehicles are essential. These mechanisms are also critical because successful reductions in GHG emissions in the transportation sector will result in a substantial reduction in the overall GHG emissions in California, given the transportation sector's substantial contributions to California's total GHG emissions, accounting for approximately thirty-eight percent of the total emissions.[4]

California's legislature has enacted various laws to reduce GHG emissions, including AB 32, SB 32,[5] and SB 375. AB 32 requires a reduction of GHG emissions to 1990 levels by 2020 through a comprehensive set of measures, and California's legislature intends to continue GHG emission reductions beyond 2020.[6] SB 32, signed into law in September 2016, requires that GHG emissions be reduced to forty percent below 1990 levels by 2030.[7] SB 375 requires GHG emission

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1. Nat'l Highway Traffic Safety Admin., Preliminary Statement of Policy Concerning Automated Vehicles 1 (2013), https://www.nhtsa.gov/staticfiles/rulemaking/pdf/Automated_Vehicles_Policy.pdf.

2. Jeff Green, *Driverless-Car Global Market Seen Reaching $42 Billion by 2025*, Bloomberg Tech. (Jan. 8, 2015), http://www.bloomberg.com/news/articles/2015-01-08/driverless-car-global-market-seen-reaching-42-billion-by-2025. *See generally* Tim Adams, *Self-Driving Cars: From 2020 You Will Become a Permanent Backseat Driver*, Guardian (Sept. 13, 2015, 5:05 PM), http://www.theguardian.com/technology/2015/sep/13/self-driving-cars-bmw-google-2020-driving.

3. Nat'l Highway Traffic Safety Admin., *supra* note 1, at 1.

4. Cal. Air Res. Bd. & Cal. Envtl. Protection Agency, Climate Change Scoping Plan 11 (2008) [hereinafter Climate Change Scoping Plan].

5. California Global Warming Solutions Act of 2006: Emission Limit (2016), (codified as amended at Cal. Health & Safety Code § 38566 (2006)).

6. Cal. Health & Safety Code § 38551(b) (2006).

7. Cal. Air Res. Bd., The 2017 Climate Change Scoping Plan Update, The Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target 3 (2017).

reductions through coordinated land use and transportation planning.[8] These laws, however, do not specifically address potential impacts resulting from driverless vehicles or the legal mechanisms required to ensure that driverless vehicles help achieve AB 32's emission reduction goals.

Many hail driverless vehicles as one of the essential tools to reduce GHG emissions for primarily two reasons: (1) using driverless vehicles as part of shared vehicle programs can achieve substantial emission reductions; and (2) emission reductions can be achieved thanks to driverless vehicles' inherent technological capability, such as the platooning of vehicles, smooth maneuverability of vehicles, and lighter vehicle weights, as will be discussed later in Part II.A.2.

In contrast, others warn that driverless vehicles might increase the overall GHG emissions because they encourage more and longer auto trips by allowing the passengers to productively use their time while using these vehicles.[9] Driverless vehicles would also allow those who are currently not allowed to drive to make trips using these vehicles.[10]

Thus, driverless vehicles' overall impact on GHG emissions remains to be seen. Given this uncertainty, this Note proposes regulatory mechanisms to lay a foundation to develop a comprehensive schene to ensure that driverless vehicles augment the ongoing efforts to reduce GHG emissions under AB 32 beyond 2020.

Specifically, this Note proposes the following legal mechanisms. First, the California Air Resources Board ("CARB") should adopt specific GHG regulation goals for driverless vehicles. Second, the state or CARB should provide financial incentives to promote shared driverless vehicles. Third, CARB should adopt emissions standards for driverless vehicles. Fourth, the state, local governments, regional transportation agencies, auto manufactures, TNCs, software developers, and other stakeholders should work together to encourage shared driverless vehicles to be used as part of public transportation. Finally, the state, local governments, and regional transportation agencies should continue to encourage efficient land uses by promoting tech-and-transit-oriented development ("TTOD"), creating "parking to green hubs" programs, and identifying locations for charging and maintenance stations for driverless vehicles

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8. *Sustainable Communities*, Cal. Air Res. Bd. (last updated May 9, 2017), http://www.arb.ca.gov/cc/sb375/sb375.htm.

9. Adams, *supra* note 2; Raphael Barcham, Climate and Energy Impacts of Automated Vehicles 17 (2014), https:// www.arb.ca.gov/research/sustainable/automated_vehicles_climate_july2014_final1.pdf

10. Brad Plumer, *Will Driverless Cars Solve Our Energy Problems—or Just Create New Ones?*, WASH. POST (Mar. 30, 2013), https://www.washingtonpost.com/news/wonk/wp/2013/03/30/will-self-driving-cars-solve-all-our-energy-problems-or-create-new-ones/.

I. BACKGROUND

A. BRIEF OVERVIEW OF CLIMATE CHANGE

Human activity such as the burning of fossil fuels to produce energy, deforestation, industrial processes, and agricultural practices emits gases.[11] These gases, known as GHGs, act like a blanket around Earth, trapping energy in the atmosphere and causing it to warm.[12] Primary GHGs include carbon dioxide ("CO_2"), methane, nitrous oxide, and fluorinated gases.[13]

Some of the observed impacts resulting from climate change include: heat waves, droughts, floods, wildfires, changes in precipitation or melting snow and ice affecting water resources, species shifting their geographic ranges affecting ecosystems, and negative impacts on crop yields.[14] Triple-digit heat waves and smog resulting from climate change would impose health risks to many.[15] Some risks of climate change could become considerable if the average global temperature increases one or two degrees Celsius above pre-industrial levels.[16]

In December 2015, nearly 200 countries reached a historic agreement, known as the "Paris Agreement," to curb GHG emissions to keep the increase in global average temperature to well below two degrees Celsius, above pre-industrial levels.[17] As part of the Agreement, the United States intends to reduce emissions by twenty-six to twenty-eight percent below its 2005 level by 2025.[18]

California has been undertaking several unique measures to reduce GHG emissions under AB 32.[19] California's total GHG emissions decreased from 466 million metric tons carbon dioxide equivalent

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11. *Climate Change: Basic Information*, U.S. Envtl. Protection Agency, https://19january2017snapshot.epa.gov/climatechange_.html (last visited May 27, 2017).

12. *Id.*; Intergovernmental Panel on Climate Change, *Summary for Policymakers*, *in* Climate Change 2014: Impacts, Adaptation, and Vulnerability 5 (2014) [hereinafter Climate Change 2014] (providing that the Framework Convention on Climate Change defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods").

13. *Overview of Greenhouse Gases*, U.S. Envtl. Protection. Agency (last visited Apr. 14, 2017), https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

14. Intergovernmental Panel on Climate Change, *Summary for Policymakers*, *in* Climate Change 2014: *supra* note 14, at 6–7.

15. Climate Change Scoping Plan, *supra* note 4, at ES–9.

16. Climate Change 2014, *supra* note 12, at 14.

17. United Nations Framework Convention on Climate Change, Adoption of the Paris Agreement 22 (Dec. 12, 2015).

18. U.S. Cover Note, INDC and Accompanying Information (2015).

19. Cal. Air Res. Bd. & Cal. Envtl. Protection Agency, First Update to Climate Change Scoping Plan 4 (2014) [hereinafter First Update to Scoping Plan].

("$MMTCO_2e$")[20] in 2000 to 456 $MMTCO_2e$ in 2012, representing a decrease of 1.7%.[21]

B. TRANSPORTATION SECTOR SUBSTANTIALLY CONTRIBUTES TO GHG EMISSIONS

The transportation sector contributes the most to GHG emissions in California, accounting for approximately thirty-eight percent of the state's total GHG emissions, followed by electricity emissions, which account for approximately twenty-three percent.[22] The California Air Resources Board ("CARB"), as the lead agency for implementing AB 32, has identified transportation as one of the nine key focus areas to reduce GHG emissions.[23]

Auto transportation is by far the largest source of household emissions, accounting for forty-seven percent of the carbon emissions of a typical American family with two cars.[24] This is at least in part attributable to the growth in automobile ownership, development of the highway system, and the rise of suburban neighborhoods in much of California and the United States over the past sixty years.[25]

Reducing GHG emissions from transportation will likely require a broad range of strategies including increasing vehicle efficiency, lowering the carbon content of fuels, and reducing vehicle miles of travel ("VMT").[26] Driverless vehicles, if appropriately regulated and utilized, could play a key role in reducing California's GHG emissions as will be discussed in detail throughout this Note.

C. AUTO MANUFACTURERS AND GOVERNMENT AGENCIES ARE PREPARING FOR DRIVERLESS VEHICLES

1. NHTSA Defines Driverless Vehicles Using Five Levels

Driverless vehicles, also known as "autonomous" or "self-driving" vehicles, are "those in which operation of the vehicle occurs without

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20. *Greenhouse Gases Equivalencies Calculator—Calculations and References*, U.S. Envtl. Protection Agency (last updated Jan. 24, 2017), http://www.epa.gov/energy/ghg-equivalencies-calculator-calculations-and-references (providing that carbon dioxide equivalent, or CO_2e, represents equivalencies calculated using global warming potentials from the Intergovernmental Panel on Climate Change's Fourth Assessment Report).

21. First Update to Scoping Plan, *supra* note 19, at 90.

22. Climate Change Scoping Plan, *supra* note 4, at 11.

23. Barcham, *supra* note 9, at 3.

24. U.S. Dep't of Transp., Public Transportation's Role in Responding to Climate Change 2 (2010).

25. First Update to Scoping Plan, *supra* note 19, at 103.

26. U.S. Dep't of Transp., *supra* note 24, at 1.

direct driver input to control the steering, acceleration, and braking."[27] These vehicles are designed so that the driver is not expected to constantly monitor the roadway while operating in self-driving mode.[28] NHTSA defines vehicle automation using five levels.[29] These levels range from no-automation ("Level 0"), where the driver has complete and sole control of the vehicle, to full self-driving automation ("Level 4"), where the vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip.[30]

2. Driverless Vehicles Could Become Commercially Available Sooner or Later

While some companies have promised to make driverless vehicles available by 2020,[31] others suggest that significant market penetration is decades away.[32] A recent survey conducted by a major management consulting firm indicates that forty-four percent of the 1500 U.S. drivers surveyed said they probably would buy a fully autonomous car in a decade.[33] There are still many barriers that exist concerning driverless vehicles, such as: (1) technology improvement relative to positioning technology and mapping; (2) failure backups and human machine interface; (3) cost; (4) regulation; (5) and consumer acceptance.[34] Despite these existing obstacles, automakers and government agencies are moving toward the adoption of driverless vehicles.

Google, Tesla, Volvo, GM, Audi, Mercedes-Benz, Toyota, and Chrysler have been undertaking the testing of driverless or partially-autonomous vehicles on public roads.[35] In 2015, Tesla updated the software in certain Model S vehicles so they can operate under the "autopilot" mode, in which the car mostly drives itself, but the driver can take over control as necessary.[36] Each time a driver intervenes, Tesla registers the correction in its software, which is distributed across its fleet

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27. *U.S. Department of Transportation Releases Policy on Automated Vehicle Development*, U.S. Dep't of Transp. (May 30, 2013), https://www.transportation.gov/briefing-room/us-department-transportation-releases-policy-automated-vehicle-development.

28. *Id.*

29. *Id.*

30. *Id.*

31. Darrell M. West & Jack Karsten, *Driverless Cars Could Arrive Sooner than You Think*, Brookings (Feb. 16, 2016), http://www.brookings.edu/blogs/techtank/posts/2016/02/16-driverless-cars-closer-than-you-think.

32. Barcham, *supra* note 9, at 3.

33. Green, *supra* note 2.

34. Barcham, *supra* note 9, at 9–13.

35. Ian Bogost, *When Cars Fly*, THE ATLANTIC (May 2016), https://www.theatlantic.com/magazine/archive/2016/05/when-cars-fly/476382/; Jonathan Rettinger, *How Close Are We to a Real Self-Driving Car?*, HUFFINGTON POST (last updated Oct. 21, 2016), http://www.huffingtonpost.com/jonathan-rettinger/how-close-are-we-to-a-rea_b_8346966.html.

36. Bogost, *supra* note 35.

to improve the cars' autopilot capability.[37] In October 2016, Tesla announced that cars currently in production would be fully driverless, pending regulatory approval and further software validation.[38]

Uber and Apple are also developing driverless vehicles.[39] A few automakers envision using the rideshare service Lyft to roll out driverless vehicles first with Lyft drivers present to help passengers acclimate to the technology.[40] An electric, driverless shuttle bus took to public roads in the Netherlands in early 2016, carrying six passengers along an approximately 656-foot stretch in the first trial of its kind worldwide.[41]

Government agencies are also moving forward with developing regulatory schemes related to driverless vehicles. Nevada, Florida, California, Michigan, and Washington, D.C. have passed legislation allowing driverless vehicles on public streets.[42] In 2016, the Obama administration proposed a four billion dollar budget to be spent over the next ten years to finance research projects and infrastructure improvements tied to driverless vehicles along with pledging to expedite regulatory guidelines for autonomous vehicles.[43]

California adopted autonomous vehicles testing regulations in May 2014, and the California Department of Motor Vehicles had issued autonomous vehicle testing permits to more than two dozen entities as of April 2017.[44] In addition, California intends to support automotive and technology industries to maximize the number of fully autonomous vehicles that are zero-emission vehicles.[45]

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37. *Id.*

38. Danielle Muoio, *These 20 Companies Are Racing to Build Self-Driving Cars in the Next 5 Years,* Bus. Insider (Dec. 11, 2016, 9:06 AM), http://www.businessinsider.com/companies-making-driverless-cars-by-2020-2016-11.

39. Mark Harris, *Documents Confirm Apple Is Building Self-Driving Car*, Guardian (Aug. 14, 2015, 2:48 PM), http://www.theguardian.com/technology/2015/aug/14/apple-self-driving-car-project-titan-sooner-than-expected.

40. Ariel Wittenberg, *Lawmakers Mull Rules of the Road for Driverless Cars*, Env't & Energy Daily (Mar. 16, 2016), http://www.eenews.net/eedaily/2016/03/16/stories/1060034070.

41. *Driverless Bus Trial in Netherlands is First on Public Roads*, Guardian (Jan. 28, 2016, 9:09 PM), http://www.theguardian.com/technology/2016/jan/28/driverless-bus-trial-in-netherlands-will-be-first-on-public-roads.

42. Thad Moore, *As Self-Driving Cars Come to More States, Regulators Take a Back Seat*, WASH. POST (Aug. 29, 2015), https://www.washingtonpost.com/business/economy/as-self-driving-cars-come-to-more-states-regulators-take-a-back-seat/2015/08/28/7a29413e-474f-11e5-8ab4-c73967a143d3_story.html.

43. Bill Vlasic, *U.S. Proposes Spending $4 Billion on Self-Driving Cars*, N.Y. Times (Jan. 14, 2016), https://www.nytimes.com/2016/01/15/business/us-proposes-spending-4-billion-on-self-driving-cars.html?_r=0.

44. *Testing of Autonomous Vehicles*, St. of Cal. Dep't of Motor Vehicles, https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/testing (last visited May 27, 2017).

45. Governor's Interagency Working Grp. on Zero-Emission Vehicles, 2016 ZEV Action Plan: An Updated Roadmap toward 1.5 Million Zero-Emission Vehicles on California Roadways by 2025 32 (2016).

CARB is currently researching how vehicle automation could help meet California's emission reduction goals, and its 2017 Climate Change Scoping Plan Update includes the promotion of automated transportation systems as a primary goal.[46] Further, the Draft California Transportation Plan 2040, recently prepared by Caltrans, addressing statewide long-range policies concerning California's future transportation system,[47] recognizes that driverless vehicle technology can help reduce fuel consumption and emissions.[48] These substantial efforts coupled with proposed and ongoing auto manufacturer and government investment into driverless vehicle technology seem to suggest that driverless vehicles will hit the consumer market sooner or later.

3. Adopting Legal Mechanisms to Minimize Emissions from Driverless Vehicles

Improvements in safety have been the principal public interest concerning driverless vehicles.[49] Legal liability and insurance policies are other issues that have been raised.[50] Who would be responsible when an accident occurs: the operator, the owner, or the manufacturer of the vehicle?[51] A few scholars have addressed potential impacts that driverless vehicles would have on land use and transportation systems. However, none of these scholars or government agencies seems to have developed a comprehensive mechanism to ensure that driverless vehicles would augment the ongoing efforts to reduce GHG emissions under AB 32. As driverless vehicle technology develops, it is critical to begin developing legal mechanisms to ensure that these vehicles help achieve AB 32's emission reduction goals. The next Part discusses the potential impacts that driverless vehicles may have on GHG emissions, which were identified based on expert opinions and literature review.

II. DRIVERLESS VEHICLES' IMPACT ON OVERALL TRANSPORTATION EMISSIONS IS UNKNOWN

A. DRIVERLESS VEHICLES COULD DECREASE GHG EMISSIONS

Many hail driverless vehicles as one of the essential tools to reduce GHG emissions for primarily two reasons: (1) substantial emission

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46. First Update to Scoping Plan, *supra* note 19, at 51; Cal. Air Res. Bd., *supra* note 7, at 102.

47. Caltrans, California Transportation Plan 2040, Final Review Draft 12 (2016).

48. *Id.* at 60.

49. Barcham, *supra* note 9, at 3.

50. *See, e.g.*, Adeel Lari et al., *Self-Driving Vehicles and Policy Implications: Current Status of Autonomous Vehicle Development and Minnesota Policy Implications*, 16 Minn. J.L. Sci. & Tech. 735, 759–60 (2015).

51. *Id.* at 759.

reductions can be achieved when driverless vehicles are used as shared vehicles; and (2) emission reductions can be achieved thanks to driverless vehicles' inherent technological capability. Each of these reasons will be discussed in more detail later in this Note.[52]

1. Use of Shared Driverless Vehicles Could Substantially Reduce Emissions

Driverless vehicles, when used as shared vehicles, could substantially reduce GHG emissions by enabling networks of shared vehicles to automatically pick people up on demand through optimal routing of trips.[53] Some suggest that a single shared driverless vehicle could replace nine to thirteen vehicles in an urban scenario.[54] This could result in reduced vehicle ownership,[55] potentially resulting in fewer vehicles manufactured and thereby reducing GHG emissions from vehicle manufacturing. Further, the use of shared vehicles could result in GHG emission reductions through "right-sizing," where the size of vehicles used is tailored to each trip's occupancy needs.[56] If "right-sizing" were implemented, the per-mile GHG emissions of an electric shared driverless vehicle in 2030 are estimated to be sixty-three to eighty-two percent lower than a projected 2030 hybrid vehicle driven as a privately owned car.[57]

Shared driverless vehicles would also help reduce vehicular trips made in search for parking in congested areas. This is because these vehicles would not be parked in the same way conventional privately-owned vehicles are; they can simply park themselves or move on to their next passenger.[58] Given that an estimated thirty percent of the total vehicular trips consist of trips in search for parking,[59] shared driverless vehicles can play a significant role in reducing GHG emissions by reducing these non-essential trips.

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52. Melanie Zanona, *How Driverless Cars Can Reduce Pollution*, THE HILL (Oct. 24, 2016), http://thehill.com/policy/transportation/302550-how-driverless-cars-can-reduce-pollution; Wendy Koch, *Self-Driving 'Robocabs' Could Help Curb Global Warming*, Nat'l Geographic (July 6, 2015), http://news.nationalgeographic.com/energy/2015/07/150706-driverless-robot-taxis-could-curb-global-warming/; Barcham, *supra* note 23, at 16-17.

53. Julie Chao, *Autonomous Taxis Would Deliver Significant Environmental and Economic Benefits*, Berkeley Lab (July 6, 2015), http://newscenter.lbl.gov/2015/07/06/autonomous-taxis-would-deliver-significant-environmental-and-economic-benefits/; Barcham, *supra* note 9, at 18.

54. Barcham, *supra* note 9, at 18.

55. *Id.*

56. Chao, *supra* note 53.

57. *Id.*

58. David Levinson, *Climbing Mount Next: The Effects of Autonomous Vehicles on Society*, 16 Minn. J.L. Sci. & Tech. 787, 805 (2015).

59. *Car Parking and Traffic Congestion*, Parking Network (June 13, 2014, 11:23 AM), http://www.parking-net.com/parking-news/skyline-parking-ag/traffic-congestion.

Finally, shared driverless vehicles can use the idle time or park themselves away from city centers, which would in turn reduce the need for parking spaces in urban areas.[60] This could result in at least some of the space currently used for parking being converted to uses more conducive to creating lower-carbon urban cores, such as transit-oriented development or pedestrian-oriented areas.

2. Driverless Vehicles' Technological Capabilities Could Help Reduce Emissions

In addition to the GHG reductions that can be achieved when driverless vehicles are used as shared vehicles, driverless vehicles could help reduce GHG emissions due to their vehicle technological capabilities. First, the platooning of vehicles, which is the practice of running vehicles together closely with reduced headways to cut down on air drag resistance, would further improve fuel efficiency.[61] Fuel efficiency benefits from platooning would be ten to twenty percent.[62]

Second, driverless vehicles can also improve fuel economy by accelerating and decelerating more smoothly than a human driver.[63] Automated braking and acceleration could result in at least a twenty to thirty-nine percent reduction in energy per VMT.[64]

Third, driverless vehicles could reduce the number of auto accidents because they are not susceptible to human errors.[65] Given that ninety-three percent of the total number of vehicle crashes of six million were attributable to human errors in 2010,[66] driverless vehicles could significantly reduce the number of auto accidents. Fewer auto accidents allow car manufacturers to design and produce lighter vehicles because collisions would no longer be a significant concern.[67] These lighter vehicles would be more fuel-efficient.[68] Studies suggest a possible reduction in vehicle weight of twenty percent, with each ten percent reduction corresponding to a six to seven percent reduction in fuel consumption.[69]

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60. Lari et al., *supra* note 50, at 758.

61. Barcham, *supra* note 9, at 16.

62. *Id.* at 17; Austin Brown et al., National Renewable Energy Laboratory: Autonomous Vehicles Have a Wide Range of Possible Energy Impacts (2013), http://www.nrel.gov/docs/fy13osti/59210.pdf.

63. James M. Anderson et al., Autonomous Vehicle Technology: A Guide for Policymakers 16 (2016), http://www.rand.org/content/dam/rand/pubs/research_reports/RR400/RR443-2/RAND_RR443-2.pdf.

64. Barcham, *supra* note 9, at 16.

65. Anderson et al., *supra* note 63, at 47.

66. KPMG, Self-Driving Cars: The Next Revolution 7 (2012), https://faculty.washington.edu/jbs/itrans/self_driving_cars[1].pdf.

67. Plumer, *supra* note 10.

68. Barcham, *supra* note 9, at 16.

69. *Id.*

Fourth, driverless vehicles' ability to drive more efficiently vehicles drive more smoothly with reduced headways could have indirect benefits as well. The efficiency in driving will reduce congestion, thereby increasing highway capacity without requiring new construction.[70] Congestion reduction would in turn reduce emissions by cutting down on vehicle idling, which emits more GHG per mile than a vehicle operating at a moderate but consistent speed.[71] A reduced need for new highway construction would also result in reduced emissions.[72]

Lastly, driverless vehicles could also reduce the number and width of roadways, which are currently designed to accommodate the imprecise and unpredictable movement patterns of human-driven vehicles.[73] Similar to the space that would become no longer necessary for parking, this unnecessary space can be converted to uses more conducive to emission reductions.

B. DRIVERLESS VEHICLES COULD INCREASE GHG EMISSIONS

Despite the possible reasons that fully-automated driverless vehicles could *reduce* GHG emissions that were just discussed, it is also possible that they could *increase* the overall GHG emissions for the following reasons.

First, driverless vehicles would allow people to productively use commute time to read and email.[74] With the less effort required to make a trip and productivity gained from using driverless vehicles, individuals may choose to take more trips,[75] increasing the overall emissions. Congestion relief provided by driverless vehicles[76] could also encourage people to drive longer and more often. In an extreme case, driverless vehicles and buses could replace public transit, causing VMT to increase[77] and thereby increasing GHG emissions.

Second, the decreased travel costs in both time and energy allowed by driverless vehicles could result in people living further from urban centers, resulting in urban sprawl,[78] which generally increases GHG emissions as a result of increased demand for travel.[79]

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70. *Id.* at 17.

71. Am. Ass'n of State Highway & Transp. Officials, Real Transportation Solutions for Greenhouse Gas Emissions Reductions 16, http://climatechange.transportation.org/pdf/realsolutionsreport.pdf.

72. Barcham, *supra* note 9, at 17.

73. KPMG, *supra* note 66, at 26.

74. Adams, *supra* note 2.

75. Lari et al., *supra* note 50, at 756.

76. Barcham, *supra* note 9, at 17.

77. *Id.* at 18.

78. Lari et al., *supra* note 50, at 756–57.

79. *Sources of Greenhouse Gas Emissions*, U.S. Envtl. Protection Agency, (last updated Apr. 14, 2017), https://www3.epa.gov/climatechange/ghgemissions/sources/transportation.html.

Third, driverless vehicles would allow those who are currently not allowed to drive, including elderly, disabled, underage, intoxicated, or on medication, to make trips using these vehicles.[80] Some predict "a possible seventy-percent increase in VMT per vehicle if all people over age thirteen had the same VMT as the highest use demographic."[81]

In light of the potential impacts that driverless vehicles could have on GHG emissions, this Note next reviews applicable existing California laws to examine whether existing measures could be made applicable to driverless vehicles and what additional measures would be necessary to ensure that they augment the ongoing efforts to reduce transportation sector emissions.

III. CALIFORNIA'S EXISTING MECHANISMS ARE INSUFFICIENT TO ENSURE THAT DRIVERLESS VEHICLES EFFECTIVELY AUGMENT THE ONGOING EFFORTS TO REDUCE GHG EMISSIONS

A. AB 32, SB 32, AND SCOPING PLAN

AB 32, signed into law in September 2006, requires a reduction of GHG emissions to 1990 levels by 2020.[82] SB 32, signed into law in September 2016, requires that GHG emissions be reduced to at least fourty percent below 1990 levels by 2030.[83] CARB, as the lead agency for implementing AB 32, was required to develop a Scoping Plan outlining the state's strategy to achieve the 2020 GHG emissions limit.[84] CARB adopted a Scoping Plan in December 2008,[85] which includes a comprehensive set of GHG emission reduction measures involving every sector of the economy.[86] In 2014, CARB approved its first Update to the 2008 Scoping Plan,[87] which described progress made to meet the objectives of AB 32 and defined California climate change priorities and activities for the following several years.[88]

The 2008 Scoping Plan provides several mechanisms to use the revenues from the cap-and-trade program to further AB 32's goals, including dedicating the revenues to provide incentives for local governments and others to promote energy efficiency and better land use planning.[89] These revenues should be used to promote the use of shared

80. Plumer, *supra* note 10; Barcham, *supra* note 9, at 17.
81. Barcham, *supra* note 9, at 17.
82. Climate Change Scoping Plan, *supra* note 4, at ES–1.
83. Cal. Air Res. Bd., *supra* note 7, at 3.
84. Climate Change Scoping Plan, *supra* note 4.
85. *Id.*
86. *Id.* at 2.
87. *See* First Update to Scoping Plan, *supra* note 19, at 2.
88. *See id.* at 4–5.
89. Climate Change Scoping Plan, *supra* note 4, at 35. The cap and trade program is a market based mechanism designed to reduce GHG emissions from covered entities, including electricity,

driverless vehicles which will be discussed further in Part IV.B. The 2008 Scoping Plan also includes several fuel and vehicle efficiency standards[90] to achieve approximately 52.6% of the total reduction goals for 2020 under AB 32.[91] No reasons have been identified as to why regulations that can apply to regular cars would not be able to apply to driverless vehicles. Thus, future vehicle and fuel efficiency standards should apply to driverless vehicles along with the relevant measures that will be discussed in Part IV.C.

Even if all of these standards were to be expanded beyond 2020, however, the Scoping Plan predicts that significant changes to California's current land use and transportation planning policies would be necessary to achieve substantial GHG emission reductions beyond 2020.[92] To help foster such significant changes, the California legislature passed SB 375.

B. SB 375 AND SUSTAINABLE COMMUNITIES STRATEGIES

SB 375, signed into law in September 2008, requires CARB to develop, in consultation with Metropolitan Planning Organizations, passenger vehicle GHG emission reduction targets for 2020 and 2035.[93] GHG emission reductions from passenger vehicles would be achieved through better-integrated regional transportation, land use, and housing planning that provides easier access to jobs, services, public transit, and active transportation options.[94]

Under SB 375, Metropolitan Planning Organizations are responsible for, among other things, developing Sustainable Communities Strategies ("SCSs").[95] SCSs promote greater travel and housing choices and

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natural gas, and fuel suppliers, by setting a cap on statewide GHG emissions from the covered entities. Cal. Chamber of Commerce v. Cal. Air Res. Bd. 10 Cal. App. 5th 604, 616 (2017). CARB lowers the cap over time and issues allowances, the total value of which is equal to the amount of the cap. *Id.* Each allowance authorizes the emission of up to one metric ton of carbon dioxide equivalent of greenhouse gases (CO_2e). *Id.* CARB distributes some allowances for free to covered entities and sells others at quarterly auctions. *Id.* at 613. To emit in compliance with the program a covered entity must surrender allowances or use offsets, which can be obtained through voluntary emission reductions from a source that is not directly covered by the program. *Id.* at 613–616.

90. Climate Change Scoping Plan, *supra* note 4 at 38–47 (providing that these standards include low carbon fuel standards, vehicle efficiency measures promoting sustainable tire practices, and vehicle emission standards, including the Pavley GHG vehicle standards under AB 1493, the Zero-Emission Vehicle Program, and the Air Quality Improvement Program under AB 118).

91. *Id.* at 17. These fuel and vehicle efficiency standards include the California Light-Duty Vehicle Greenhouse Gas Standards (31.7%), Low Carbon Fuel Standard (15%), Vehicle Efficiency Measures (4.5%), and Medium/Heavy Duty Vehicles Measures (1.4%).

92. *Id.* at ES–12, 28.

93. *Id.* at 47.

94. First Update to Scoping Plan, *supra* note 19, at 49.

95. *Id.*

development patterns where people can live, work, and play without having to drive.[96]

For instance, CARB assigned the San Francisco Bay Area a per capita GHG emission reduction target of seven percent by 2020 and fifteen percent by 2035.[97] As a SCS for the Bay Area, the 2013 Plan Bay Area ("Plan") was adopted by the Association of Bay Area Governments ("ABAG") and Metropolitan Transportation Commission ("MTC").[98] The Plan is anticipated to reduce per-capita CO_2 emissions from cars and light-duty trucks by sixteen percent by 2035, through combinations of denser land use patterns, increased investments in the region's public transit infrastructure, and enhanced funding for climate initiatives such as electric vehicle adoption incentives.[99]

The 2008 Scoping Plan recommends several measures for SCSs, including programs to reduce vehicles trips that can at the same time preserve personal mobility, such as car sharing and parking policies, indirect source rules for new development, and congestion pricing strategies.[100] Car sharing and parking policies would be implicated by the use of driverless vehicles, and this Note proposes measures concerning these policies and recommends further research which will be discussed in Parts IV.D and IV.E.2, respectively. Indirect source rules include land use controls and strategies to reduce emissions, including measures to reduce the need for vehicle travel and increase transit, bicycle and pedestrian access, and regulations related to vehicle idling.[101] These measures, along with congestion pricing strategies, will also be further discussed in Part IV.D.

IV. CALIFORNIA SHOULD ADOPT THE FOLLOWING PROPOSED REGULATORY MECHANISMS

While some of the existing legal mechanisms adopted under AB 32 and SB 375 can be made applicable to driverless vehicles, the use of driverless vehicles could pose new challenges, as well as possibly hindering the ongoing efforts to reduce GHG emissions as a result. At the same time, driverless vehicle technology can become an effective tool to help achieve AB 32's emission reduction goals. Thus, this Note proposes the implementation of the following regulatory mechanisms.

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96. *Id.*

97. Ass'n of Bay Area Gov'ts & Metro. Transp. Comm'n, Plan Bay Area: A Strategy for a Sustainable Region 87 (2013).

98. *Id.* at 98–99.

99. *Id.*

100. Climate Change Scoping Plan, *supra* note 4, at 48–49. Congestion pricing strategies can help efficiently manage traffic demand while raising funds for needed transit, biking, and pedestrian infrastructure investment. *Id.*

101. *Glossary of Air Pollution Terms*, Cal. Air Res. Bd., http://www.arb.ca.gov/html/gloss.htm#I (last visited May 27, 2017).

A. CARB SHOULD ADOPT SPECIFIC GHG REDUCTION GOALS FOR DRIVERLESS VEHICLES

Neither AB 32 nor SB 375 provides specific GHG reduction goals concerning the use of driverless vehicles. As driverless vehicle technology further develops, CARB should adopt such GHG reduction goals. These goals might be established using sophisticated modeling or empirical data of the market penetration and actual usage of driverless vehicles. These goals are essential. Once established, they would guide the level of vehicle efficiency standards that should be required, the land use patterns that should be encouraged, and the extent of financial incentives that should be provided to meet AB 32's emission reduction goals.

B. PROVIDE FINANCIAL INCENTIVES TO PROMOTE SHARED DRIVERLESS VEHICLES

The 2008 Scoping Plan provides several mechanisms to use the revenues from the cap-and-trade program to further AB 32's goals by promoting energy efficiency and better land use planning.[102] Similar financial incentives should be used to promote shared driverless vehicles. First, financial incentives should be provided to individuals to encourage the use of shared driverless vehicles for example, rebates, pre-tax deductions, or similar tax incentives.

In addition, grants or funding should be provided to automakers, TNCs, software companies, existing transit agencies, and research institutions to cover the upfront capital investments to research and develop systems where shared driverless vehicles are used to supplement the existing public transit. Similarly, financial incentives or exemptions from development regulations could be provided to developers or property owners undertaking projects that would promote the coordination of shared driverless vehicles and public transit.

With that said, these incentives would be difficult to gain political support for, given that similar incentives to existing TNC vehicles or taxis, which could act similarly to shared driverless vehicles, have not been widely adopted as of today. However, driverless vehicles' unique capabilities, such as the capability of platooning or smooth acceleration and braking, could encourage support for providing financial disincentives to using conventional vehicles in certain geographic areas. This is because these driverless vehicles' capabilities would be compromised when there are conventional vehicles on the same roadway.

Finally, should the cap-and-trade program prove to be not as effective at reducing GHG emissions or fails to generate revenues as envisioned, the state might consider adopting alternative mechanisms,

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102. Climate Change Scoping Plan, *supra* note 4, at 34–35.

such as a carbon tax to raise revenues. A revenue-neutral carbon tax was adopted in British Columbia in 2008, and has since proven effective in reducing GHG emissions without harming the economy.[103]

C. ADOPTING EMISSION STANDARDS FOR DRIVERLESS VEHICLES

The federal emission standards for model years 2012 through 2016 will require a fuel economy standard of 35.5 miles per gallon for conventional passenger vehicles in 2016.[104] Both California and the federal government are currently developing emissions standards for conventional vehicles, model years 2017 through 2025.[105] However, no vehicle or fuel standards currently exist that apply to driverless vehicles.

AB 32 addresses vehicle and fuel efficiency standards as has been discussed, and many of these standards could be made applicable to driverless vehicles. And, as new emission control technologies develop, the most up-to-date, technology-based vehicle or fuel standards should be made applicable to driverless vehicles. Further, driverless vehicles should be, at minimum, electric, given that driverless vehicles can be lighter in weight than conventional vehicles and that electric vehicles in the United States produce fewer GHG emissions than the most efficient gasoline vehicles even when power plant emissions are considered.[106] Assuming that large automakers manufacture driverless vehicles, they automakers would be encouraged to make driverless vehicles fuel efficient because fuel-efficient driverless vehicles would help them meet the corporate average fuel economy ("CAFE") standards, given that the CAFE standards are fleet-wide averages.[107]

In addition to these tailpipe emission and fuel standards, some sort of GHG emission standards calculated based on the life cycle of vehicles, not merely based on the tailpipe emissions, should be considered for adoption. Such life-cycle emissions can be based on the embodied emissions of a car, which is broadly defined as energy required to manufacture a car, and typically rivals the exhaust pipe emissions over

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103. Diane Toomey, *How British Columbia Gained by Putting a Price on Carbon*, Yale Env't 360 (Apr. 30, 2015), http://e360.yale.edu/feature/how_british_columbia_gained_by_putting_a_price_on_carbon/2870/.

104. *Federal Fuel Efficiency Standards*, St. of Cal. Dep't of Justice, https://oag.ca.gov/environment/clean-air/clean-cars/fuel-standards (last visited May 27, 2017).

105. *Id.*; *The Advanced Clean Cars Program*, Cal. Envtl. Protection Agency, (last updated Jan. 18, 2017), https://www.arb.ca.gov/msprog/acc/acc.htm.

106. Jerry Hirsch, *Electric Vehicles Beat Gasoline Cars in Cradle-to-Grave Emissions Study*, L.A. TIMES (Nov. 12, 2015, 6:00 AM), http://www.latimes.com/business/autos/la-fi-hy-ucs-electric-vehicles-emissions-study-20151110-story.html.

107. *Corporate Average Fuel Economy (CAFE) Standards*, U.S. Dep't of Transp., (last updated Aug. 27, 2014), https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards.

the car's entire lifetime.[108] Although this is not the main focus of this Note given the complex nature of the issue, further research should be conducted on driverless vehicles' life-cycle emissions to understand GHG emissions from the manufacturing, use, and disposal of driverless vehicles in a more comprehensive manner.

Further, auto manufacturers, transportation engineers, and urban planners should collaborate to determine the most effective parameters within which the platooning of driverless vehicles should be operated and the optimal speed at which driverless vehicles should operate to minimize GHG emissions from the vehicles. In urban settings, such optimal speeds should be determined to minimize vehicles' GHG emissions and create safe and attractive pedestrian- and bicyclist-friendly streets and a public realm consistent with the applicable SCS. Such optimal speeds would depend on not only the vehicles' emission technology, but also the location and type of streets and nearby land uses. Each jurisdiction's transportation agency should establish these speed limits by working with the nearby property owners and other stakeholders as part of the jurisdiction's general plan or transportation plan update process.

The vehicle and fuel efficiency measures that would be applicable to driverless vehicles and reduced emissions that can be achieved thanks to the driverless vehicles' inherent technological capabilities the platooning and fuel efficiency gained thanks to driverless vehicles' smoother driving and lighter weight would foster effective implementation of AB 32. However, greater challenges would arise in ensuring effective implementation of SB 375 due to the uncertainty concerning the actual driverless vehicles' impact on land use and transportation. Considering this uncertainty, this Note proposes the following measures discussed in Parts IV.D and IV.E.

D. USE SHARED DRIVERLESS VEHICLES AS PART OF PUBLIC TRANSPORTATION

As previously mentioned, California is implementing SB 375 to reduce GHGs resulting from land use and transportation. In this framework, public transportation will continue to play a key role. The extent to which driverless vehicles and buses may affect the demand for public transportation is unknown at this time.[109] Although driverless vehicles and buses could entirely replace existing public bus services, it

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108. Mike Berners-Lee & Duncan Clark, *What's the Carbon Footprint of … a New Car?*, Guardian (Sept. 23, 2010, 2:30 PM), http://www.theguardian.com/environment/green-living-blog/2010/sep/23/carbon-footprint-new-car.

109. Barcham, *supra* note 9, at 21.

seems unlikely that these driverless vehicles would entirely replace subway, light rail, and passenger train systems for the following reasons.

First, SB 375 relies on subway, light rail, and passenger train systems as a means to reduce emissions, and California has been making a substantial investment in these public transportation systems, including the nation's first true high-speed rail system.[110] Second, transit-based GHG emissions per passenger mile are significantly lower than those from cars, when life cycle emissions are considered including emissions from building the highway or rail system, manufacturing the vehicles, maintaining the infrastructure and vehicles, producing and using the fuel, and eventually disposing of the vehicles and infrastructure.[111] Finally, these public transportation systems facilitate compact and higher-density land use, which in turn helps reduce GHG emissions by conserving land and decreasing the distances people need to travel to reach destinations.[112]

The recommended measures included in this section are developed based partly on the assumption that driverless vehicles and buses would not substantially replace existing subway, light rail, and passenger train systems. If this assumption proves wrong in the future, the use of shared driverless vehicles will likely substantially contribute to GHG emission reductions if they are properly regulated.

To maximize the emission reduction potential of driverless vehicles consistently with SB 375, transportation agencies or private entities should establish a mechanism where shared driverless vehicles are utilized to remove existing factors discouraging the use of public transportation or supplement public transportation.

One such discouraging factors is that public transportation lacks door-to-door service,[113] creating gaps in service. Driverless vehicles can fill such service gaps, particularly in suburban or low-density communities that lack critical mass of population to efficiently support public transportation systems. Some of the TNCs are already offering their service in conjunction with public transportation. In Dallas, Dallas Area Rapid Transit riders can access Uber via the agency's mobile ticketing app intended to simplify connections at transit stations.[114] A similar cooperation has emerged between Uber and the Metropolitan Atlanta Rapid Transit Authority in Atlanta.[115]

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110. First Update to Scoping Plan, *supra* note 19, at 50.

111. U.S. Dep't of Transp., *supra* note 24, at 3.

112. *Id.* at 4.

113. Susan Shaheen et al., Public Transit Training: A Mechanism to Increase Ridership Among Older Adults 9, http://tsrc.berkeley.edu/sites/default/files/Public%20Transit%20Training_A%20Mechanism%20to%20Increase%20Ridership%20Among%20Older%20Adults.pdf.

114. Eric Jaffe, *Uber and Public Transit Are Trying to Get Along*, Citylab (Aug. 3, 2015), http://www.citylab.com/cityfixer/2015/08/uber-and-public-transit-are-trying-to-get-along/400283/.

115. *Id.*

Similar services can be provided with shared driverless vehicles, regardless of who owns or maintains them. One of the ways to achieve this would be to develop software applications that allow those who prepay for public transportation to be prioritized in reserving or receiving a driverless vehicle. In addition, these applications should be programmed to "right-size" driverless vehicles for each trip's occupancy need and determine the "optimal route" in transporting users. The "right-sizing" of vehicles is a unique capability attributable to driverless vehicle technology that existing TNCs or taxis do not usually offer.[116] These software applications should also provide real-time travel information and routing suggestions combined with coordinated traffic signal timing.[117] Driverless vehicles equipped with all of these capabilities, as a recent study by Berkeley Lab suggests, would significantly reduce GHG emissions.[118]

Another way to use shared driverless vehicles effectively as part of public transportation would be to introduce a point-based system, where the more one uses shared driverless vehicles along with public transportation, the more quickly the ride arrives or the lower the fares become for the ride. Although these mechanisms would by no means guarantee increased ridership in public transportation, they could help implement SB 375 by providing another, very convenient choice of transportation to many.

To best utilize shared driverless vehicles in coordination with public transportation, it may make sense to discourage or prohibit conventional vehicles in at least certain parts of a city to maximize efficient operation of driverless vehicles.[119] Other ways to achieve a similar result would be to adopt a congestion pricing mechanism or indirect source rules for new development to reduce the total VMT.[120]

For instance, as a congestion pricing mechanism, the use of driverless vehicles with lower GHG emissions during the traffic peak hours can be incentivized through lower fees. Further, new development projects that would increase total VMT can be discouraged through indirect source rules such as land use controls that promote pedestrian-oriented development. These measures would require further research as driverless vehicle technology continues to advance. As the driverless vehicle technology further develops and driverless vehicles become commercially available, local governments and transportation agencies should also examine, through modeling, pilot programs, or traffic counts,

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116. Chao, *supra* note 53.

117. First Update to Scoping Plan, *supra* note 19, at 50.

118. Chao, *supra* note 53.

119. Dorothy J. Glancy, *Autonomous and Automated and Connected Cars Oh My! First Generation Autonomous Cars in the Legal Ecosystem*, 16 Minn. J.L. Sci. & Tech. 619, 673 (2015).

120. *See* Climate Change Scoping Plan, *supra* note 4, at 49.

the need for road lanes dedicated for the users of shared driverless vehicles similar to the existing High Occupancy Vehicle ("HOV") lanes.

How shared driverless vehicles can be best used in sync with public transportation in any given jurisdiction would partly depend on the type and extent of public transportation service present in that jurisdiction. Local governments and transportation agencies should examine how those who use driverless vehicles in conjunction with public transportation can be prioritized or incentivized in their jurisdictions in particular.

Finally, municipalities, regional transportation agencies, and stakeholders should identify the extent to which driverless vehicles and buses may replace existing public transportation systems and determine what transportation policies and systems would best achieve their jurisdiction's SCS as well as whether other measures would be required to meet the goals of the SCS, SB 375, general plan, and any other applicable plans.

E. CONTINUE ENCOURAGING EFFICIENT LAND USES

Given that driverless vehicles could potentially encourage urban sprawl,[121] effective land use and transportation planning that would promote compact development will continue to play an important role in reducing GHG emissions. This Note proposes the following measures to minimize urban sprawl that could be caused by the use of driverless vehicles as well as to promote transit-oriented development consistent with AB 32 and SB 375.

1. Promote Tech-and-Transit-Oriented Development

Realizing that cutting-edge information technology will play a substantial role in promoting the use of shared driverless vehicles along with conventional transit-oriented development, this Note proposes a concept of TTOD in which information technology is fully utilized to encourage the use of shared driverless vehicles in sync with public transportation,[122] as discussed in Part IV.D.

To promote TTOD, local governments, Metropolitan Planning Organizations, and the state should devise effective methods for assessing transportation impacts from development projects, particularly impacts resulting from the use of driverless vehicles, under the California Environmental Quality Act ("CEQA"). This is critical as the current transportation and land use models do not reflect impacts from

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121. Lari et al., *supra* note 50, at 756–57.

122. TOD helps create "compact mixed-use communities near transit" where people can have easy access to jobs and services. *Fed. Transit Admin., Transit Oriented Development*, https://www.transit.dot.gov/TOD.

vehicle automation.[123] This effort should be made in accordance with the ongoing efforts required by SB 743[124] to reframe the transportation impact analyses under CEQA.[125] Traffic studies currently used in CEQA documents, which primarily focus on the impact of projects on traffic flows and intersection delays, often suggest the need for construction of bigger roads and intersections as "mitigation" for traffic impacts.[126] As a result, these studies have discouraged projects intended to improve conditions for pedestrians, bicyclists and transit,[127] undermining the goals of SB 375. To address these issues, the California Governor's Office of Planning and Research issued a preliminary proposal in August 2014, which encourages analyses of auto trip generation and VMT, as opposed to conventional intersection delay analyses.[128] Further research is required to develop the appropriate method of undertaking impact analysis relative to driverless vehicles under CEQA for development projects.

Another important task required to encourage TTOD is to reexamine and update the parking requirements for development projects, reflecting the potential reduced parking demand that could result from the use of driverless vehicles. Many cities have recently relaxed or removed minimum parking requirements for development projects partly in an effort to discourage reliance on cars.[129] AB 744,[130] a bill signed into law in October 2015, allows developers to request reduced minimum parking requirements within affordable housing projects located near public transit.[131] As driverless vehicles become commercially

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123. Barcham, *supra* note 9, at 21.

124. Environmental Quality: Transit Oriented Infill Projects, Judicial Review Streamlining for Environmental Leadership Development Projects, and Entertainment and Sports Center In the City of Sacramento.

125. *See* State of Cal. Governor's Office of Planning & Research, Updating Transportation Impacts Analysis in the CEQA Guidelines 5 (2014).

126. *Id.*

127. *Id.*

128. *Id.* at 7; The Office of Planning and Research issued a revised proposal in January 2016, which continued to recommend VMT as the most appropriate measure of project transportation impacts. State of Cal. Governor's Office of Planning & Research, Revised Proposal on Updates to the CEQA Guidelines on Evaluating Transportation Impacts in CEQA (2016).

129. Aaron Bialick, *Supervisors Pass Breed's Bill to Loosen Some Parking Mandates*, Streetsblog SF (Apr. 15, 2015), http://sf.streetsblog.org/2015/04/15/supervisors-pass-breeds-bill-to-loosen-some-parking-mandates/; Eric Jaffe, *An Unusual Objection to Less Parking: It Will Make Our City Too Nice*, Citylab (Sept. 21, 2015), http://www.citylab.com/cityfixer/2015/09/an-unusual-objection-to-less-parking-it-will-make-our-city-too-nice/406096/.

130. Planning and Zoning: Density Bonuses (2015) (codified as amended in Cal. Gov. Code § 65915).

131. Mary Eveleigh, *California Governor Signs Bill to Ease Parking Requirements and Create More Affordable Housing*, Smart Growth Am. (Oct. 12, 2015), http://www.smartgrowthamerica.org/2015/10/12/california-governor-signs-bill-to-ease-parking-requirements-and-create-more-affordable-housing/.

available, local governments should examine if and how much further reduction in the parking requirements is warranted to promote TTOD.

Lastly, local governments and the state should keep abreast of innovative business models that may emerge utilizing driverless vehicles and monitor how they might impact the implementation of TTOD. Some of these innovative businesses may include "mobile retail" or stores on wheels□for example, vending machines zooming around on the roads on their own.[132] Some government services, such as library pickup/drop off services or the postal service, could utilize driverless vehicles for their deliveries. Further research will be required to examine how these new businesses may implicate the implementation of TTOD and how to develop necessary measures to ensure successful implementation of SB 375.

2. Create "Parking to Green Hubs" Programs

As discussed in Part II.A.1, the use of shared driverless vehicles could decrease the demand for parking spaces in urban areas.[133] Some scholars estimate that the areas used for parking on average comprise approximately thirty-one percent of the total land area in major cities in the United States.[134] In addition, driverless vehicles could also reduce the width of roadways or the number of road lanes needed due to the vehicles' capability for precise and predicable movement patterns.[135]

The reduced demand for parking would provide a unique and substantial opportunity to convert the space no longer needed for parking to uses conducive to reducing GHG emissions. Similarly, parts of the roadway and rights-of-way no longer necessary for automobiles could be converted to low carbon uses that are less maintenance intensive. This would result in both environmental and economic benefits, given that construction, repair, and maintenance of streets increase GHG emissions[136] and the state and local governments are experiencing difficulty in funding operations and maintenance of existing roadway networks.[137] San Francisco and New York City, for example, are already implementing a program where rights-of-way that are excessively wide are converted to parks.[138]

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132. Len Epp, *A Vision of a Driverless Future*, TechCrunch (Apr. 4, 2015), http://techcrunch.com/2015/04/04/a-driverless-vision/.

133. Lari et al., *supra* note 50, at 758.

134. Anderson et al., *supra* note 63, at 26.

135. KPMG, *supra* note 66, at 26.

136. U.S. Dep't of Transp., *supra* note 24, at 3.

137. State of Cal. Governor's Office of Planning & Research, *supra* note 125, at 5.

138. *About Pavement to Parks*, Pavement to Parks, http://pavementtoparks.org/about/ (last visited May 27, 2017); Allison Arieff, *Pavement to Parks*, N.Y. Times (Sept. 22, 2009, 10:00 PM), http://opinionator.blogs.nytimes.com/2009/09/22/pavement-to-parks/.

Local governments, in coordination with nearby property owners and other stakeholders, should also examine the extent of potential decrease in the parking demand and roadway widths in their jurisdiction, and develop a "parking to green hubs" program in which the space no longer needed for automobiles is converted to uses conducive to reducing GHG emissions. Some of these uses can include attractive transit-oriented development, transit facilities, bike parking and lanes, parks, urban habitats, community gardens, and bioswales.[139]

3. Identify Ideal Locations for Charging and Maintenance Stations

The use of electric driverless vehicles will likely impact the number and location of charging and maintenance stations required for these vehicles. Fully-automated driverless vehicles can drive to charging stations on their own to have themselves charged at a time during which the demand for their service is low. Further, similar to the innovative businesses noted in the preceding Part, some of the driverless vehicles themselves could serve as mobile charging stations. Similarly, driverless vehicles can drive to maintenance stations, or mobile maintenance trucks may emerge.

Given these potential scenarios, local governments, regional transportation agencies, and stakeholders should identify the ideal locations for charging and maintenance stations to minimize GHG emissions resulting from the operation of driverless vehicles by considering vehicles' technological capabilities, existing land use in their jurisdiction, and goals and interests of their community. These charging and maintenance stations could be located outside a city, near transit hubs, in commercial districts, or in industrial districts.

V. IMPLICATIONS FOR BUSINESSES

Driverless vehicles will bring new and unique business opportunities due to the fact that these vehicles would substantially

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139. Bioswales are "vegetated, mulched, or xeriscaped channels" that treat and retain stormwater. *U.S. Envtl. Protection Agency*, *What is Green Infrastructure?*, https://www.epa.gov/green-infrastructure/what-green-infrastructure#bioswales. The use of bioswales in urban settings is one of the best management practices ("BMPs") of Low Impact Development ("LID") that help capture, treat, infiltrate, and reuse potential water resources. Haan-Fawn Chau, UCLA Dep't of Urban Planning, Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply Through Low Impact Development 26 (2009), http://www.environmentla.org/pdf/LID-Paper_4-1-09_530pm.pdf. LID could help reduce GHG gases. *Id.* at 36. LID practices would promote groundwater recharge and water capture and reuse, reducing the dependence on distant sources of water, which in turn reduces the amount of energy required to pump water from distant locations. *Id.* A study suggests that in the case of Los Angeles, the use of LID would help save 131,700 to 427,000 MWH per year by 2030, which is equivalent to the electricity used by 20,000 to 64,800 households. *Id.*

change how people and goods are transported. Because the realm of potential implications that driverless vehicles could have on businesses is far too broad to be thoroughly discussed in this Note, I will instead focus my discussion of potential implications for businesses on those implications that are relevant to the legal mechanisms proposed in this Note.

Several government agencies in California are currently examining the potential implications of driverless vehicles on the GHG emissions, land use, and transportation systems to develop regulations for these vehicles. Businesses and property owners should keep abreast of these efforts to best position themselves in the changing regulatory scheme. As driverless vehicle technology further develops, potential markets for these vehicles will become more clearly identified. This would provide automakers with new marketing opportunities. Automakers should also pay attention to the potential shift from the current tailpipe emission and fuel standards to standards that could be developed based on the life cycle of vehicles. Further, if electric driverless vehicles wind up replacing the majority of gasoline-run vehicles under the regulatory mechanisms suggested in this Note, the consumption of gasoline for vehicles could decline, affecting the consumption of electricity.

Beyond these more straightforward implications, there would also be more subtle implications for businesses. Auto manufacturers may develop new vehicle designs that are primarily used as shared vehicles, reflecting the vehicle design that would make it easier for the passengers to get in and out of the car, the need to secure privacy in these vehicles, or possible changes in road and intersection design. Some automakers have already developed and designed the interiors of driverless vehicles to be drastically different from those of existing vehicles.[140] For example, in a driverless vehicle the front windshield could show you a movie while you are traveling.[141] In addition, Goodyear is developing revolutionary ball-shaped tires that would help driverless vehicles execute efficient movements.[142]

The retail and service industry should reconsider their locations or methods of service delivery as this new mode of transportation emerges. For instance, the food service industry may develop new business models, including mobile vending machines, mobile convenience stores, and food trucks that do not require drivers, to name a few. Municipalities or the

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140. Matt McFarland, *Goodyear's Radical Idea of What Driverless Car Tires Will Look Like*, WASH. POST (Mar. 4, 2016), https://www.washingtonpost.com/news/innovations/wp/2016/03/04/goodyears-radical-idea-of-what-driverless-car-tires-will-look-like/.

141. Martin Belam, *Driverless Cars Are the Future. We're Living in the Motorised Middle Ages*, Guardian (Mar. 2, 2016, 8:19 AM), http://www.theguardian.com/commentisfree/2016/mar/02/driverless-cars-future-motorised-middle-ages.

142. McFarland, *supra* note 140.

state may adopt measures to reduce emissions from these new business models.

These changes in vehicle design and retail and service industry practices could provide new business opportunities for software application developers in particular. For example, the demand for shared driverless vehicles used in sync with public transportation systems would increase demand for reliable software applications to facilitate networks for these vehicles as well as public transportation. TNCs should also keep abreast of new regulations adopted and financial incentives provided to facilitate shared driverless vehicles.

Real estate developers and property owners may also want to seek development opportunities that could emerge as the demand for parking decreases and the space no longer needed for automobiles such as parking garages is converted to other uses. Further, the state and local governments would not only update methods for transportation impact analyses under CEQA and reduce parking requirements for development projects, but also adopt additional congestion pricing strategies and indirect source rules for development projects. Real estate developers and property owners should keep up-to-date with these changes.

CONCLUSION

Fully-automated, shared driverless vehicles could become an effective tool to substantially reduce GHG emissions beyond the year 2020 if appropriately regulated. Such vehicles could simultaneously provide a convenient means of transportation for many. To ensure that these vehicles effectively augment the ongoing efforts to achieve AB 32's emission reduction goals, this Note proposes that the following legal mechanisms be considered for adoption.

First, CARB should adopt GHG reduction goals concerning the use of driverless vehicles. Second, financial incentives should be provided to promote the use of shared driverless vehicles. Third, the government should apply technology-based emissions standards to driverless vehicles and require these vehicles to be electric to minimize their GHG emissions. Fourth, legal mechanisms should be adopted to foster the use of shared driverless vehicles to supplement rather than replace public transportation systems due to the critical role that public transportation plays in reducing GHG emissions. Fifth, the use of driverless vehicles underscores the need for additional anti-sprawl land use controls due to the potential for such vehicles to encourage sprawl. Such additional land use controls should include: (A) promoting TTOD to minimize urban sprawl; (B) creating "parking to green hubs" programs to convert the space no longer needed for parking or roadways to uses conducive to reducing GHG emissions; and (C) identifying ideal locations for charging

stations to minimize GHG emissions from the operation of driverless vehicles.

These recommended legal mechanisms have been developed based on expert opinions and literature review concerning how driverless vehicles could impact GHG emissions given the driverless vehicle technologies that are currently available. As of the time this Note was written, these technologies are rapidly developing. Thus, as new technology continues to develop it will be necessary to review and revise the legal mechanisms currently being proposed. To develop effective and feasible regulatory mechanisms, local governments, Metropolitan Planning Organizations, and the state should work closely with TNCs, auto manufacturers, software developers, and other stakeholders, such as real estate experts, business owners, and property owners. Continuous monitoring of driverless vehicle technology, the degree of market penetration, development of state and federal regulations, and actual usage of driverless vehicles would be necessary.

Climate change is a global issue that must be addressed in an expeditious manner. Since the adoption of AB 32 in 2006, California has developed a successful model that helps achieve environmental sustainability and at the same time spurs innovation in advanced technologies.[143] In light of this trend, it is critical to successfully utilize emerging technologies such as driverless vehicles to further AB 32's emission reduction goals and contribute to global efforts to tackle climate change. California's continued commitment to providing innovative strategies to fight climate change could lead to not only sustainable communities for current and future generations, but also economic prosperity, by spawning new business opportunities and attracting investment.

143. First Update to Scoping Plan, *supra* note 19, at ES1.