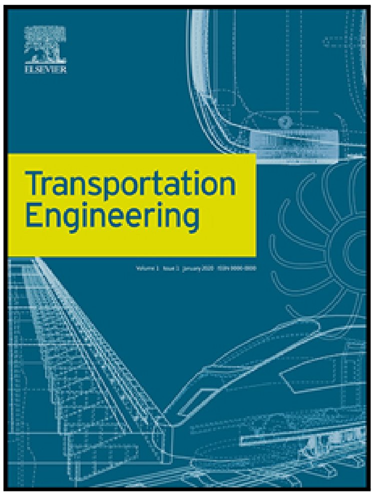
Alsalman, A, Assi, LN, Ghotbi, S, Ghahari, S and Shubbar, AAF

Users, Planners, and Governments Perspectives: A Public Survey on Autonomous Vehicles Future Advancements

Article



Users, Planners, and Governments Perspectives: A Public Survey on Autonomous Vehicles Future Advancements

Ali Alsalman , Lateef N. Assi , Shabnam Ghotbi ,
SeyedAli Ghahari , Ali Shubbar

PII: S2666-691X(20)30045-2
DOI: https://doi.org/10.1016/j.treng.2020.100044
Reference: TRENG 100044

To appear in: *Transportation Engineering*

Received date: 28 October 2020
Revised date: 30 December 2020
Accepted date: 30 December 2020

Please cite this article as: Ali Alsalman , Lateef N. Assi , Shabnam Ghotbi , SeyedAli Ghahari , Ali Shubbar , Users, Planners, and Governments Perspectives: A Public Survey on Autonomous Vehicles Future Advancements, *Transportation Engineering* (2020), doi: https://doi.org/10.1016/j.treng.2020.100044

Highlights

- Barriers including current charging stations that may hindrance the transformation to AVs.
- Sufficient stations should be provided to charge AVs batteries.
- Collaboration between auto manufacturers and planners are critical to the success.
- The survey revealed that there is a need for marketing and communication plans.
- Survey showed that there is a need for advertisements and education for self-driving cars

Users, Planners, and Governments Perspectives: A Public Survey on Autonomous Vehicles Future Advancements

Ali Alsalman[1], Lateef N. Assi[2*,] Shabnam Ghotbi[3], SeyedAli Ghahari[4], Ali Shubbar[5]

[1] Tatum-Smith-Welcher Engineers, Inc., 3100 S Market St., Rogers, AR 72758, USA
[2] University of South Carolina, Dept. of Civil and Environ. Engineering, 300 Main Street, B127 Columbia, SC 29208, USA
[3] Ph.D. Candidate, Birck Nanotechnology Center, Department of Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907
[4] Ph.D. Candidate, EPICS Advisor, USDOT Center for Connected and Automated Transportation (CCAT), Lyles School of Civil Engineering, Purdue University, West Lafayette, IN 47907
[5] Department of Civil Engineering, Liverpool John Moores University, Henry Cotton Building, Webster Street, Liverpool L3 2ET, UK.

*Corresponding author: Email: lassi@email.sc.edu

Abstract

Autonomous vehicles (AVs) are expected to change driving perspectives once they are available in the markets. This type of vehicle has received substantial attention lately from media and researchers. This technology is still under rapid advancements, and further research studies are needed to address the potential outcomes, opportunities, and challenges. The fuel system of the AVs is expected to be electrical; therefore, this study addresses the current status of electric vehicles (EVs), including charging time, charging type, and driving range. The study also discusses the barriers that may hindrance the transformation to AVs from the users, planners, and government perspectives. These barriers include the current charging stations of EVs, which provide 2kW power. These stations can be insufficient for the AVs since these cars are expected to utilize advanced sensors and computers. The authors also propose comprehensive recommendations that could facilitate the so-called transformation of EVs to AVs and AVs' associated marketing. The authors found out that conducting a survey is essential to observe the public perception, and marketing and communication plans are essential to educating the public

regarding AVs' features and advantages. Also, a collaboration between auto manufacturers and planners is critical to the success of these vehicles. Finally, a public survey which consisted of 95 participants were conducted to examine the general perspective as surveys are necessary to assist planners, governments and automakers for their future movement toward a sustainable transportation system.

Keywords

Electric vehicles; Autonomous vehicles; plug-in hybrid electric vehicles; planners; charging time; driving range; alternative fuel vehicles, public survey

1 Introduction

Debate and discussion on how autonomous vehicles (AVs) can potentially change our lives in the future are getting more convoluted, yet clear. To enable a sustainable revolution that aligns with the ideological, political, and economic elements of our lives, this is a promising idea to have pondered planning for our AVs.

AVs can be defined as conveyances to move passengers or freight without human intervention. The automation of vehicles has been considered one of the essential applications within the intelligent transportation system (ITS). This movement began in Japan in the early 1980s [1]. Subsequently, the United States, Germany, and Italy followed the steps of Japan. In the US, several states have issued and enacted legislation and executive orders or both regarding AVs' testing and manufacturing [2].

According to the Society of Automotive Engineers (SAE) [3], the functionality of the automation is classified into six levels (0-5). Many of the vehicles today are classified as level 1 where the human driver is responsible for the operation of all safety actions. However, the vehicle could support a minimum of one essential function (e.g., steering or acceleration and deceleration control). Adaptive cruise control (ACC) is one of the most common examples related to this level. On the other hand, several manufacturers have introduced vehicles with level 2 of automation, which are already in the market. Tesla, Mercedes-Benz, BMW, and Volvo are examples of this level of automation [4]. The availability of higher levels of vehicles is limited to the market. For instance, the only available level 3 vehicle in the market is Audi A8, however, other automakers have been developing this type of automation level. It might be accessible in the market shortly [5]. **Table 1** summarizes the description of each six levels.

Table 1. The classification of automation level according to SAE

Level No.	SAE Level Name	Description
0	No automation	Driving aspects are controlled completely by a human driver (a warning system might be included to assist the driver in taking action)
1	Driver assistance	Driving actions are performed by the driver. The system might have the ability of steering control, and speed limit
2	Partial automation	Controlling of steering, acceleration, and deceleration might be included
3	Conditional automation	Driving actions are controlled by the vehicles, however, the driver might need to respond to actions over the vehicle
4	High automation	Driving actions are controlled by the vehicles, however, the driver might need to respond to actions over the vehicle (the request from the vehicle might be unnecessary)
5	Full automation	Driving actions are controlled by the vehicles completely. The driver may want to manage the driving actions if desired

Due to the fact that the AVs are anticipated to be electrified, there is a crucial need to address the issues of the current technology that electric vehicles (EVs) are dealing with. Several barriers have thus far hindered the development of EVs technology which can apply to the AVs. The hindering factors include but are not limited to the driving range, which is related to the limited capacity of fuel tank/battery storages, limited numbers of refueling/charging stations, expensive battery cost, low performance, and elongated refueling/charging periods [6]. Studies have also revealed that scarce in suitable infrastructure for refueling/charging stations is another important limitation regarding the improvement of alternative fuel vehicles (AFVs) implementation, such as EVs, emerging fuels, biodiesel, compressed natural gas vehicles, and fuel-cell vehicles [7,8].

This study's central focus is to capture the perspectives of users, planners, and governments for the advancement of AVs. Although the topic can be applied to AFVs; however, the research impulse is for AVs. This study also addresses the current status of EVs, including charging time, charging type, and driving range. The authors also propose comprehensive recommendations that could facilitate the so-called transformation of EVs to AVs and AVs' associated marketing. The research study also includes a public survey regarding the AVs and EVs to develop ideas on how the public thinks towards these types of vehicles.

2 Electric vehicles (EVs) and autonomous vehicles (AVs) as of today

Among different non-fossil fuels, electricity has received more attention due to the widespread electricity grid. EVs have gained recognition over conventional vehicles because of many advantages such as the generation of low emission (global and local impact), efficiency, safety aspect (similar to conventional vehicles), and reduced noise pollution. Automotive original equipment manufacturers (OEMs) have seen EVs as the ideal approach for managing the source of energy and reducing the emission of vehicles [9,10].

According to the U.S. Department of Energy, the average annual emission of EVs is approximately 2,456 kg of CO_2 equivalent. However, the emission of conventional vehicles is approximately 5,187 kg of CO_2 equivalent [11]. On the other hand, the projected emission of

EVs is approximately 230,000 CO_2 equivalent in 2023, however, 450,000 CO_2 equivalents in the case of conventional vehicles globally [12]. Therefore, the utilizing of EVs will help to decrease the global emission that the transportation sector is responsible for approximately 30% of the total emission [10]. The emission associated with EVs depends on several factors such as electricity grid profile, time of charging, and type of vehicle [13]. It has been stated that day-charging using a charging system consists of solar cells would reduce the CO_2 emission by 90% compared to home charging during nighttime in Ohio given that the primary fuel for generating electricity is coal-fired plants. In locations where the generating of electric power depends on the wind, hydropower, the emission of the solar system's effectiveness would be varied [14].

EVs can be categorized into two major types; hybrid electric vehicles (HEVs) and all-electric vehicles (AEVs). AEVs can be subclassified into battery EVs (BEVs) and fuel cell electric vehicles (FCEVs). A plug-in hybrid electric vehicle (PHEV) is a common type of HEVs [15,16]. The automakers have adopted EVs, especially BEVs (e.g., Nissan Leaf) and PHEVs (e.g., Toyota Prius XW50). The PHEVs can consume both electricity and petroleum, which leads to generating a higher amount of emissions compared to BEVs; the annual average emission of BEVs and PHEVs in the United States are 1860 and 2670 kg of CO_2 equivalent, respectively [11]. On the other hand, PHEVs leads to a higher driving range compared to BEVs since it uses battery and fuel technology together. Thus, PHEVs are more popular among consumers at this juncture. For instance, the driving range for Toyota Prius XW50 is 588 miles with an electric range of 25 miles while the driving range for Nissan Leaf is 150 miles.

The transition from the semi-automated vehicles (level 3) to fully automated vehicles (level 5) would require considering more broad decisions. To contemplate the operational costs of refueling/recharging stations, which affect investment decisions in turn, a staircase marginal cost function should be added to models along with construction costs. The staircase functions have widely been used in facility location problems to reflect the economies of congestion and scale in transportation [17,18]. Rather than having a constant marginal cost for serving one refueling vehicle, according to this function, the marginal cost for serving one vehicle increases with the increase in the capacity of each station. Additionally, travel time to a station for refueling in a network is closely related to traffic conditions. Also, the level of service is a factor that pioneer agencies in promoting AFVs such as, H_2USA, would need to consider. Besides, several stakeholders such as the Department of Transportation (DOT), Urban Designers Association, and Metropolitan Planning Organizations, are likely willing to monitor potential changes in traffic conditions by the construction of infrastructures. To contemplate this concern, travel costs should be included in the objective functions. The travel cost should be incorporated into the models by implementing user equilibrium, which accounts for the deviation of users from their shortest routes for refueling. Therefore, as the model reflects the user's and planners' perspectives, it involves the strategic and tactical standpoints of the matter (e.g., site locations and routing choices). **Table 2** demonstrates the advantages and disadvantages of AFVs in general which can apply to EVs and AVs.

Table 2. Pros and cons of AFVs.

Pros	Cons
• Long Driving Range • Quick Refueling • Only Emissions Are Water Vapor • Can Be Made by Renewable Sources • Quiet Electric Drive	• Lack of Refueling Stations • Uncertain Well-to-Wheels Advantage • High Cost of Cars • High Fuel Cost • Limited Vehicle Choices • Has high transportation and storage costs • Does not perform well under hot temperatures

There are several obstacles in endorsing EVs, which can be applied to AVs as AVs are expected to be electrified. These hindrances include the high initial cost, cost of batteries, the limited life of the battery, charging time (typically, slower charger at homes), shortage of charging stations, public interest, and range of anxiety [10,19,20]. Range of anxiety is generally associated with the life of a charged battery. According to one survey, the range of anxiety was the major barrier toward the adoption of EVs by the public [21]. This is a very serious challenge for the consumers of AEVs (e.g., EVs); however, this issue might not be a challenge for future AVs given that automakers have been developing and evaluating the efficiency of the batteries for a long time. Furthermore, it is not clear yet whether AVs will be fully electrified or hybrid systems.

On the other hand, the charging cost could be a challenge for EVs and AVs. Since EVs are considered conventional vehicles in terms of the degree of autonomy, the reliability is not a challenge. However, the reliability of AVs can be a debatable topic, and thus it is a real challenge for automakers since all driving actions are controlled by vehicles (level 5). It is expected that AVs will primarily be unaffordable to the majority of households and therefore, vehicles might be used in a rideshare scheme; fewer people own AVs and fewer AVs on the roads will reduce the required parking, and hence parking areas might be replanned into housing or green areas. **Table 3** summarizes the current and potential challenges and opportunities of EVs and AVs [22].

Table 3. The overall opportunities (+) and challenges (-) of EVs[a] and AVs

Opportunity / Challenge	EVs	AVs
Range of anxiety	-	+
Charging cost	-	-
Reliability	+	-
Battery life	-	-
Charging time	-	+
Land use and increase housing	-	+

[a] The focus of this table is on battery electric vehicles (BEVs)

Note: EVs = electric vehicles; AVs = Autonomous vehicles

3 The advancement of AVs and EVs from different perspectives

This section presents the current advancements in the technology of EVs and AVs. The section also addresses changeless that hinder the implementation of these technologies based on different perspectives, such as users, planners, governments, and communities.

3.1 User's perspective

There are three common electric charging methods for EVs. The first and foremost common method is static charging through a cable when a vehicle is parked. Based on the power level that the equipment provides to recharge a battery, the static charging method can be classified into three levels. The first level charges EVs from a standard residential 120-volt AC outlet which could take up to 20 hours to recharge a depleted battery. The second level charges EVs using a 220-volt residential or 208-volt commercial AC electrical service which takes up to seven hours to restore a depleted battery. The third level, DC fast charging, charges EVs using a commercial-grade 480-volt AC power service which takes up to 30 minutes to recharge a depleted battery.

The second charging method is inductive/wireless charging which allows EVs consumers to charge the battery without the use of a cable. This can be done either when the vehicle is parked or moving using the charging pads installed in the pavement. The third method is battery swapping, which requires huge space for swapping chargers, swapping machines, and EV batteries [23]. Further, it needs the battery of EVs to be easily removable, which currently seems to be unrealistic for the EV companies [24]. This method can replace the depleted battery with a fully charged one in less than five minutes.

The charging period for entirely electric vehicles impedes the market penetration for EVs. The current status of battery cell technology allows near 100 miles of full charge driving.

More advanced battery technologies allow 250-300 miles of driving which is fully dependent on battery capacity, charging schemes, electric power connectors, etc. [25]. It is known that at the right moment, a sluggish complete charge takes near ~8-10 hours. With rapid charging technology, it will take ~10-20 minutes to charge the battery. However, delivering a tier 3 power connector, which in turn provides a direct current of 550A, 600V (~500 kW), is substantially costly that few charging stations are currently available. **Figure 1** presents the required time of charging for the commercially available vehicles in the market using the three levels of charging of the first method if it is applicable. The average time of levels 1, 2, and 3 is 83, 8, and 1 hour, respectively [26–35]. Several factors can influence the required charging time, such as the vehicle model, driving range, and battery type.

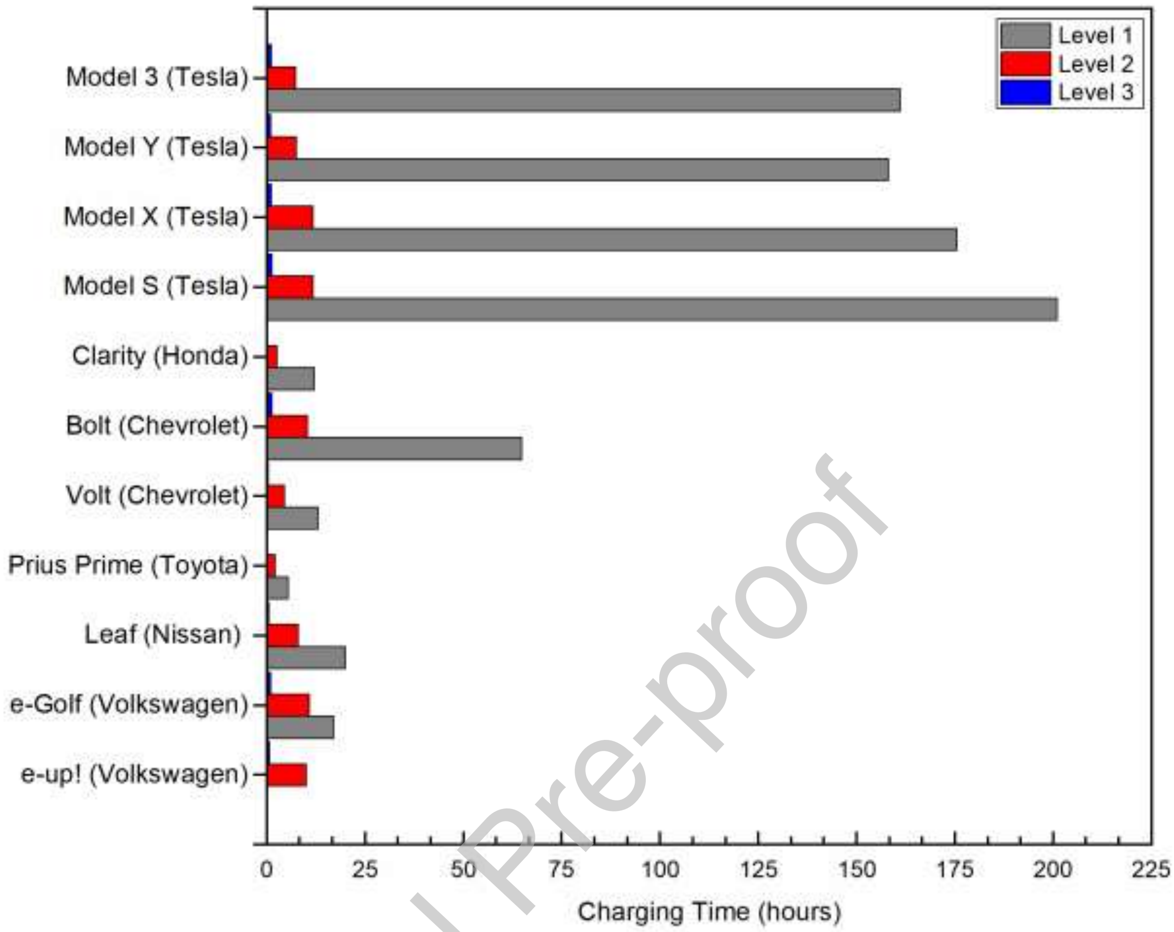


Figure 1. Charging level time of the static method for different brands of EVs

In addition to the extended recharging time, the limited driving range also restricts the public from purchasing BEVs. Reports show that the expectation of consumers on alternative fuel vehicle ranges is at least 300 miles [36]. The driving range of EVs is considered one of the predominant barriers in terms of the users' perspective. **Figure 2** illustrates the driving limit (battery capacity) of commercially available vehicle BEVs and PHEVs [26–35]. The average battery capacity of EVs presented in **Figure 2** is approximately 263 miles (less than the users' desired range). The auto manufacturers might need to enhance battery capacity to satisfy the requirements of their customers. Tesla BEV (Models S) currently provides the highest nominal driving range in the market. On the other hand, PHEVs have a lower driving range using the battery since these vehicles can use gasoline such as Honda (Charity), Chevrolet (Volt), and Toyota (Prius Prime); the average drive range of these vehicles using the battery is 42 miles. Therefore, from a user's perspective, the battery life plays an important role in convincing consumers to the new technology. This can apply to the AVs since they are expected to be electrified or hybrid systems.

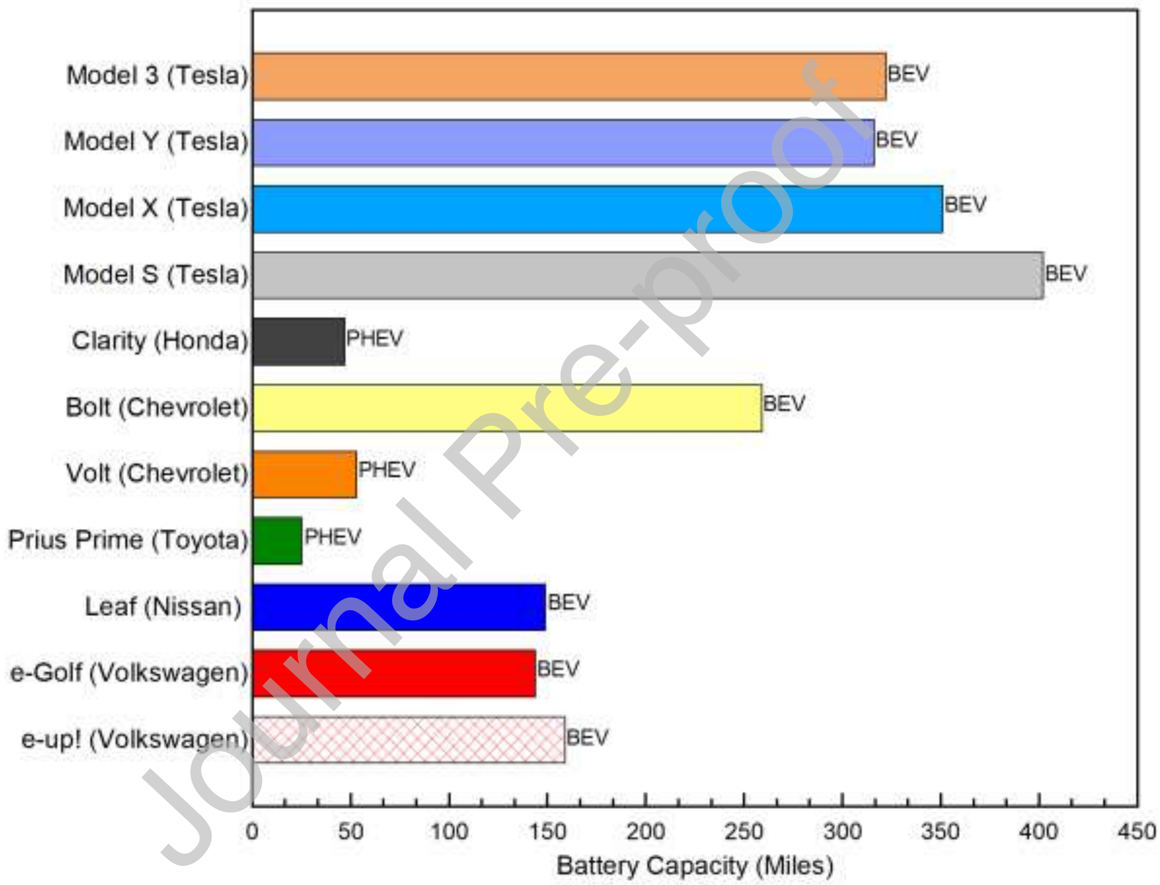


Figure 2. The battery capacity of commercially available BEVs and PHEVs
Note: BEVs = battery electric vehicles; PHEVs = plug-in hybrid electric vehicles; 1 mile = 1.60934 kilometer

As said, the charging time and driving range have been a hindrance to the market penetration of EVs. **Figure 3 (a) and (b)** show the global EV market stock and new sales of EVs in selected countries. The figures include both major types of EVs; BEVs and PHEVs. The increase in the stock of BEVs and PHEVs from 2010 to 2019 is marginal as shown in **Figure 3 (a)**. The total number of EVs in 2019 reached seven million; approximately, five million BEVs and two million PHEVs [37]. The number of BEVs is higher in all years compared to PHEVs which can be attributed to that the BEVs having a longer driving range based on battery life (**Figure 2**), lower running cost, low-emission, high equipment level, and significantly silent engine compared to PHEVs. On the other hand, **Figure 3 (a)** presents all the new sales of BEVs and PHEVs. The figure indicates a significant increase in sales from 2010 to 2019. In 2010, the sales of BEVs were 7,860 vehicles compared to 1,533420 vehicles (2000% increase). For PHEVs, the sales in 2010 were only 380 vehicles while in 2018 was 636,740 vehicles. The sales dropped by approximately 70,000 between 2018 and 2019 as shown in Figure 3 (b). This is possible that the BEVs' market has grown more compared to PHEVs. It can be concluded from **Figure 3 (a)** and **(b)** that users are willing to change their vehicles from conventional vehicle to EVs. Also, the figures indicate the acceptance of EVs by customers. The market share of EVs has been evolved as well. **Figure 4** shows the growth of the market share for four years based on the selected countries (Australia, Brazil, Canada, Chile, China, Finland, France, Germany, India, Japan, South Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, South Africa, Sweden, Thailand, United Kingdom, United States, and others). The average increase in the share market from 2015 to 2019 is 285% and 106% for BEVs and PHEVs, respectively.

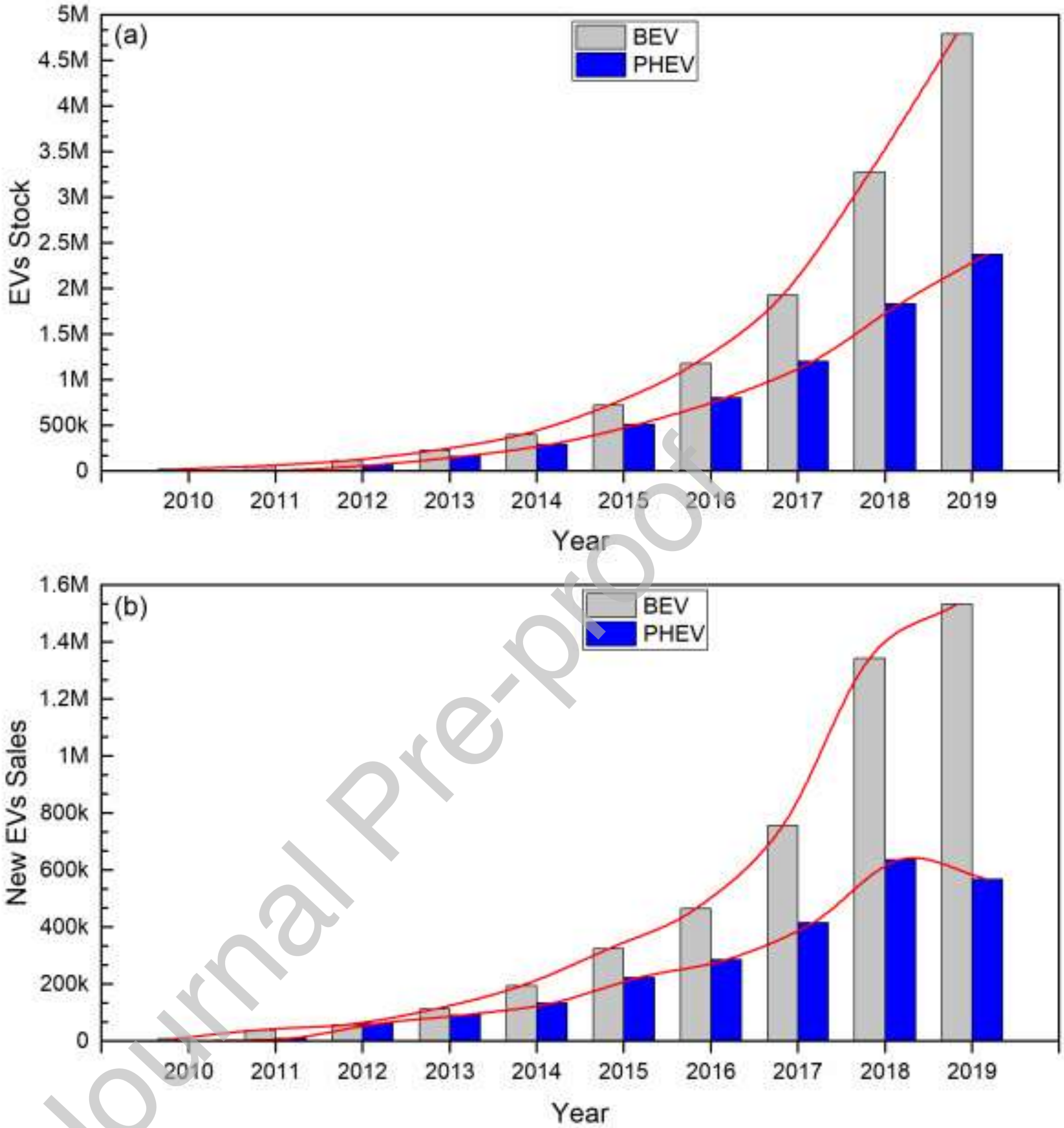


Figure 3. EVs (a) stock in selected countries from 2010 to 2019; (b) new sales from 2010 to 2019

Note: BEV = battery electric vehicle, PHEV = plug-in hybrid electric vehicle.
Note: Selected countries include Australia, Brazil, Canada, Chile, China, Finland, France, Germany, India, Japan, South Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, South Africa, Sweden, Thailand, United Kingdom, United States, and others [37]

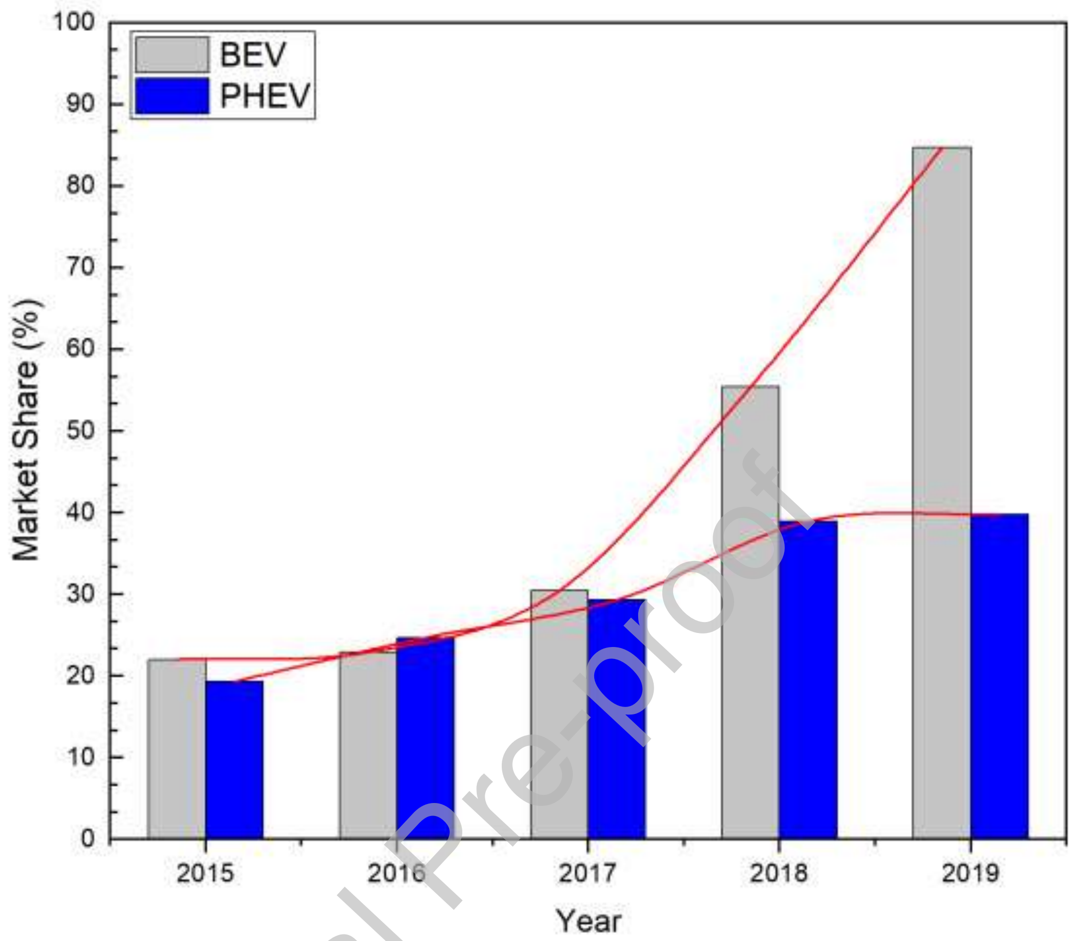


Figure 4. The share market of EVs from 2015 to 2019
Note: BEV = battery electric vehicle, PHEV = plug-in hybrid electric vehicle.

Users' perspective can be understood as the public interest which may hinder the adoption of AVs. Several studies have conducted surveys regarding the public's opinion or potential users' perspective. According to one survey, approximately 67%, 64%, 50%, and 29% of the public have heard of the AVs in Germany, China, the US, and Japan, respectively. Also, 59% of the respondents in these considered the AVs as a beneficial innovation. On the other hand, 53% of the respondents (66% in the US) stated that they would be scared of AVs. Also, 54% believed this technology will no be function appropriately [38]. Howard and Dai [39] conducted a survey that included 107 participants with ages ranged from 19 to 84; 75% earned at least a Bachelor's degree. Respondents stated that safety, amenities, and convenience were the most desirable features of AVs. Also, liability and cost were the most concerned by the participants. Safety concern was also found to be the most critical issue by another survey that consisted of 32 participants across California, New Jersey, and Chicago [40]. Another study on public opinions indicated 18% of the respondents agree that AVs is an important advancement, however, 41% indicated the opposite. The survey also concluded that these indications were related to the age of the participants; 50% of respondents aged over 55 were less likely to adopt AVs compared to 30% of the participants aged from 16 to 24 [41]. Kyriakidis et al. [42] conducted an international survey that included the responses from 5,000 participants. The analysis indicated that only 5% of the respondents were willing to purchase an AV that costs more than $30,000. At the same time, the majority of the respondents were concerned about the technology itself (e.g., software, banking, etc.). On the other hand, Bansal et al. [43] indicated the average of willing to pay for level 4 AVs is $7,252 based on a study that included 347 in Austin, Texas. Brinkley et al. [44] conducted a survey that addressed the public opinion of people with vision disabilities, such as blindness and low vision. Analysis indicated that these respondents viewed the AVs as advanced technology that may aid them and they showed a high degree of trust. Yet they believed that their particular needs are not satisfactorily considered in the technology in general.

3.2 Planner's perspective

As mentioned in the previous section, it is anticipated that AVs will adopt alternative fuel technology (e.g., electricity) instead of conventional fuel (gasoline), therefore, any obstacle that might face the planners of the AFVs would be a potential hindrance to the advancement of AVs.

Soon, policymakers should prepare infrastructure systems in a way that travelers can switch from traditional vehicles to AFVs without extra burdens over a long planning horizon. If the transportation policymakers suddenly convert all gas stations to charging stations, conventional vehicle consumers will not be able to address their refueling needs. At the same time, assuming the policymakers offer charging stations at a lower rate compared to AFV adoption, then AFV travelers will not have enough accessibility to charging stations. This may cause discouragement in travelers to purchase AFVs. Also, in small cities or the countryside, it might be easier to charge the vehicles since almost all homes have a parking garage. However, in large cities with a massive population, it is necessary to improve the production of energy and the capacity to recharge [45].

The near future research has to perform a market penetration analysis to develop a framework to provide a smooth transition toward establishing a robust AFV infrastructure. The framework should (i) meets the charging need of growing AFV consumers, and (ii) addresses the refueling need of traditional vehicle consumers over a long planning horizon (e.g., 20 years in the case of France and the United Kingdom) [46]. The framework has also to be capable to capture the impact of charging infrastructure on the market adoption of EVs during the planning horizon. As far as the prices associated with midsize fuel cell passenger vehicles, it is noteworthy to reiterate that such vehicles in 2015-2017 could sell for about $50,000 (supposing manufacturers did not attempt to recoup full overhead costs.) However, additional industrial progress is crucial for reducing fuel cell system costs to have a sustainable fuel cell vehicle market. Supposing plausible scale economies, and considering the fact that rates of learning and technological progress are comparatively slow, these objectives are achievable by the year 2025 [47].

Additionally, travel time to a station for refueling in a network is closely related to traffic conditions. Also, the level of service is a factor that pioneer agencies in promoting AFVs such as, H_2USA, would need to consider. Besides, several stakeholders such as DOT, Urban Designers Association, and Metropolitan Planning Organizations, are likely willing to monitor potential changes in traffic conditions by the construction of infrastructures. To contemplate this concern, travel costs should be included in the objective function. The travel cost should be incorporated into the models by implementing user equilibrium, which accounts for the deviation of users from their shortest routes for refueling. Therefore, as the model reflects the users' and planners' perspectives, it involves the strategic and tactical standpoints of the matter (i.e., site locations and routing choices).

Some marketing techniques that have been followed by automakers to increase their penetration into the automakers' industry. To overcome the emissions-cheating scandal, Volkswagen has initiated several marketing techniques: A $2000 voucher was offered as a loyalty incentive to purchase or lease any new Volkswagen vehicle [48]. Besides, great offers on the maintenance of newly sold cars were offered to build up trust between the company and its loyal consumers. Offering new fuel options, reconnecting to loyal customers, and marketing campaigns are going to enhance the selling rate [48]. Another study showed that the Volkswagen fallout intensified the eco-friendly car markets and it is going to reshape the market towards eco-friendly vehicles. In addition to the Volkswagen fallout reason, the improvements in energy charging and storage will further flourish eco-friendly cars such as electric and hydrogen cell vehicles [49]. Figure 5 shows the number of light-duty plug-in electric vehicles sold in selected countries in 2018 [12].

Planners also need to evaluate the existing charging system to accommodate the system required of AVs. Nowadays, the world is using 2 kW chargers. These chargers satisfy the requirements of EVs features, such as heated seats, heated steering wheels, audio systems, and other advanced features. AVs require approximately 4 kW power to drive. The existing charging stations will not be able to comply with the requirements of future AVs such as sensors, actuators, and computers [50]. In this case, the authors suggest that the new AVs use a hybrid fuel system to reduce the associated costs. Additionally, planners or automakers need to consider high-performance software, capillary maps, higher efficient sensors, and better communication of vehicle to vehicle and vehicle to infrastructures [51,52].

3.3 Government, supply, and demand and price for AVs

Governments, as well as private sectors, seek to optimize the costs of investment in urban and rural projects, not only because of the recent financial crisis and tight budget constraints but also due to the competitive status quo among the construction/contractor bidders. Investment cost optimization is an important step towards sustainable development, where the projects will be dominated by ecology, environment, and society requirements.

AVs are consisted of various system elements and smart devices and are made up of a variety of complex interconnected and sensors. Therefore, without the correct security methods, the possibility of cyberattacks is highly probable; AVs have the potential to be influenced and exposed to cyber or virus attacks [53,54]. Global navigation satellite systems (GNSS) influences the locating of the AVs on an accurate map. Thus, manipulating GNSS data could cause unreliable and inaccurate management, therefore, the passengers' lives would be jeopardized. Public awareness of this type of vehicle has been increased by the Defense Advanced Research Projects Agency (DARPA) Grand Challenge in the United States [53]. The automakers need to do extensive testing before they can start penetrating the market regarding the efficiency of sensors, computers, and control devices. They also need to incorporate a novel sort of crucial infrastructure depending on the interaction between vehicles and vehicles and infrastructure, and local traffic control centers to entirely optimize the traffic not only between the vehicle and its environment [55]. The cyberattack of automated trucks induces more risk compared to SUVs since large vehicles can cause a road to be blocked. One study suggests that a significant degree of danger is related to the actuators which can be accessed from the computer of the vehicle [56].

Ethical decision making for AVs is another serious issue from the perspective of users. To certify the safety of the passengers, AVs must constantly evaluate risks, such as the risk of traveling at a specific speed, passing a cyclist, and avoiding running into other vehicles from behind. Therefore, it is strictly required for an AV to decide how much risk to admit. If the risk is considered acceptable by the vehicle itself, the AV then be required to allocate the risk among influenced groups (e.g., adjacent vehicles, cyclists). Another issue is that the AVs should be programmed to follow the traffic law of a specific area, however, the current laws are not universal to generate rational measures in a computer [57]. This issue of the traffic flow might be solved by implementing platooning using IEEE 802.11p for the future AVs. It is anticipated that the self-sufficient platooning system takes over the steering, accelerating, and braking while the passenger/driver can enjoy other activities such as reading, or using laptops [58,59].

Greenhouse gas (GHG) emissions are known as the main reason for climate change [60]. The global efforts to reduce GHG emissions increased after the Paris agreement signed in 2017 by 195 countries worldwide. The transportation sector is the second-largest source of GHG emissions worldwide which is mainly due to the consumption of fossil fuels in internal combustion engine vehicles (ICEVs). In this global effort, France and Britain announced to end sales of ICEVs by 2040 to meet the target emissions of the Paris agreement [61]. Automakers also have joined this effort to protect the environment by investing billions of dollars to increase the share of electric vehicles (EV), including all-electric or battery electric vehicles (BEV) and Plug-in hybrid electric vehicle (PHEV). For instance, Volvo has a historic plan by ending the production line of ICEVs from 2019 onwards, and specifically, it aims to produce only BEVs and PHEVs in the near future.

It is known that at the right moment, a slow full charge takes near 8 hours (level 2). With fast charging technology, it will take less than one hour to charge the battery, however, providing a tier 3 power connector, which in turn provides a direct current of 550A, 600V (~500 kW), is significantly costly that few charging stations are accessible. Exchanging batteries is another method that could be implemented to ease the refueling, however, providing identical pallets and batteries is the most crucial barrier associated with this process [62], moreover, few battery manufacturers would accept presenting battery cells that fit all cars models (like what is common in the traditional batteries). Such issues may be solved by the following suggestion: The authors believe the problem can be alleviated by having charging stations located in pre-defined areas say in the spots far from the populated areas and downtown (with a maximum driving range of 30 minutes). The automated vehicle will be sent to the assigned charging station and parked at the spot until it is needed to be driven again. Following this strategy, the designation of parking spots will be significantly lowered, and there would be less hassle finding methods to refuel the electric cars.

One can breakdown the costs associated with automated fleets as follows: Costs related to planner and costs related to user and community. A cost breakdown for a planner/owner to initiate running a gas station is listed in Table 3. Table 3 also includes the costs for a user who may want to have a plug-in electric car charging station at her residential home. Although it has been shown that setting up a supercharger station in public places costs ~$10,000, the planner/owner would need to add a convenience store, gas station, etc. to make the business profitable. Therefore, the cost of having a level 3 charging station would increase from ~$32,000 to ~$300,000.

Table 4. Cost breakdown for having a level 3 (DC-Fast) charging station [63–65]

Planner/Owner Costs ($)		**User Costs ($)**	
Legal Fees	$2,000	Legal Fees	$200
Insurance Premiums	$2,000	Station	$1,000 - $2,000
State Permits	$3,000	Parts & Labors	$2,300 - $6,000
Promotional Signage	$5,000	Hourly Fee for Charging	$65-$85/hr (30 min. for 80%)
Initial Inventory	$10,000	Total	$3,400 - $8,200 + $65-$85/hr
Setting Up a Convenience Store	$20,000 (Declinable)		
Setting Up the Gas Station	$100,000 (Declinable)		
Purchasing a Building	$150,000 (Declinable)		
Setting Up a Supercharger Station	10,000		
Hourly Fee for Charging	$10 (30 min. for 80%)		
Total	$32,000 + $10/hr		

This rough estimate illustrates the fact that establishing a charging station by a third party or government considering the incentives from planners would save a significant amount of money for users and the community.

With having level 5 automated fleet, depending on the distance of the user from the residential home and the available time for the next travel, the vehicle could be sent to the home. After getting fully charged, the car can be called to the destination to drive the user to her destination. This method would cost more for the user since all users would need to set charging stations at their homes. However, the planner and community would significantly benefit from this strategy; the populated areas downtown would require less parking lot spaces because automated fleets would be parked at the residential areas.

The available charging stations in Chicago (as of 2020) are illustrated in **Figure 5** with green dots. The future charging stations proposed by the authors according to the model described above are shown in red. Supposing the average value of land suitable for five electric charging stations in downtown Chicago is around $200k, the green dots' cost more than $20M. This value for land out of the downtown area can be lowered to $100k for ten electric charging stations, and therefore, the overall cost for charging stations (red dots) would cost less than $5M. Shortly, an optimization programmer for the level 5 automated fleet will be required. This programmer will find the optimized schedule for charging vehicles according to the daily schedule of users, weather forecasts, traffic congestions, etc.

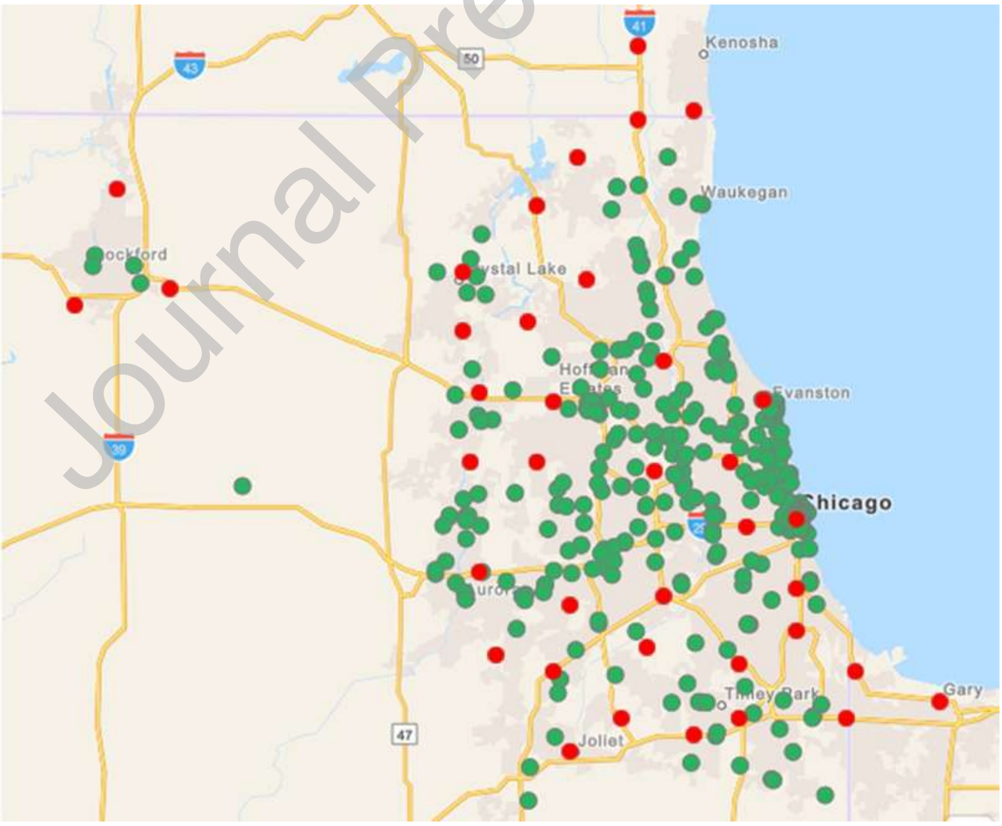


Figure 5. Available (Green) charging stations in Chicago as of 2018 and future charging stations proposed by the authors (Red)

4 Survey

4.1 Respondents background and questionnaires

The survey has been conducted to investigate the general information for 95 samples. **Figure 6** shows the demographic distribution, education, and gender for the group sample. The gender of the respondents is approximately equally divided between female and male as shown in **Figure 6 (a)**. **Figure 6 (b)** illustrates the age distribution of the participants; approximately half of the entire sample had ages ranged from 25-34 years old. **Figure 6 (c)** demonstrates the region of the respondents; roughly half of them from North America (43.7%). Finally, **Figure 6 (d)** presents the highest education level of the respondents. The majority of them earned a college degree or a graduate degree; 42.9% and 44.3%, respectively.

The survey sample might not be big; however, the results can indicate the general view of the public since it includes respondents from different parts of the world. There are several questionnaires considered in this survey and they mainly included the following topics.

- Type of vehicles and fuel.
- The familiarity of respondents with EVs and AVs.
- The advantages and disadvantages of EVs and AVs.
- The future anticipation of respondents of EVs and AVs.

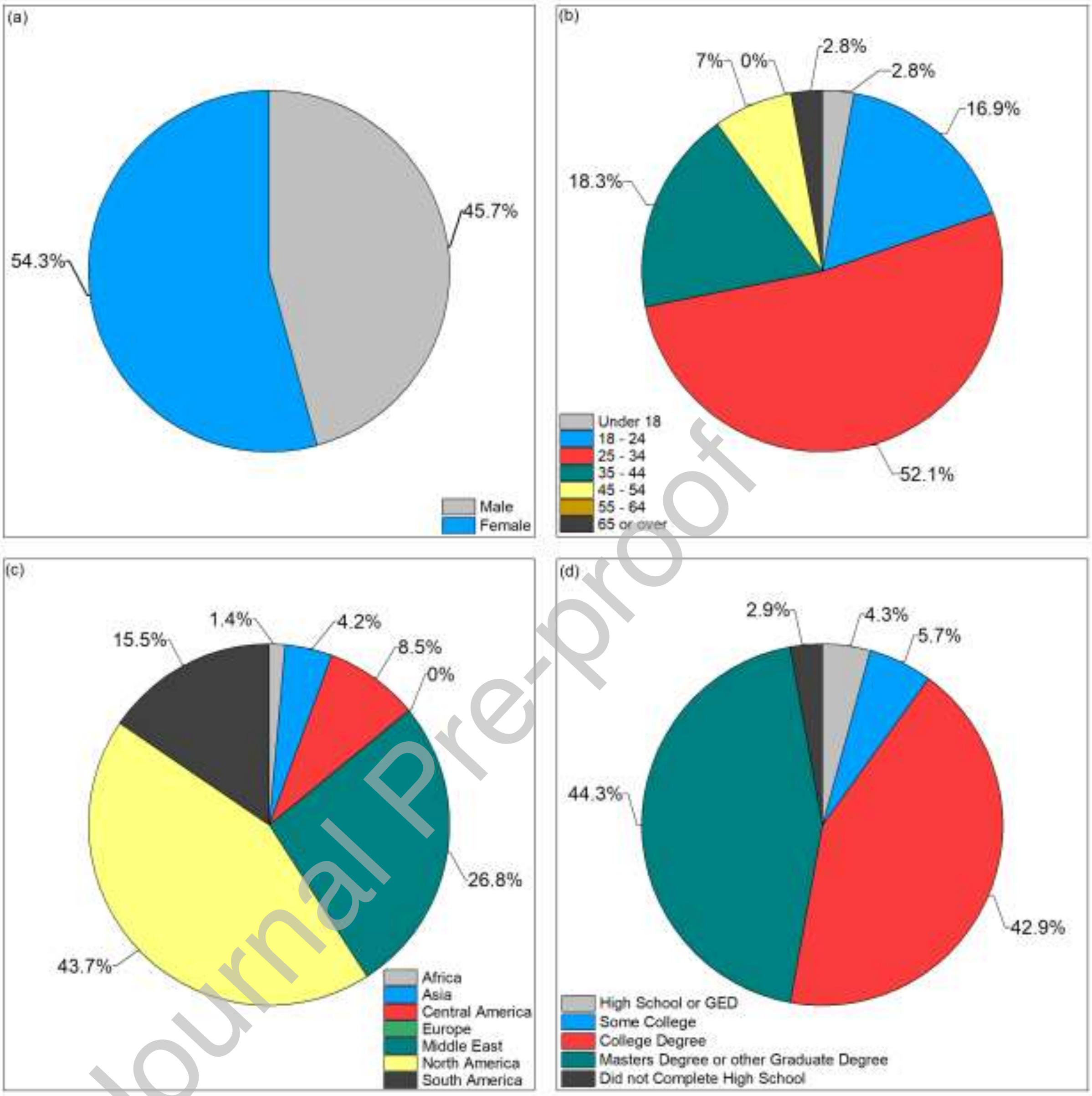


Figure 6. The background of the respondents of the survey (a) **gender**, (b) age, (c) **region**, and (d) highest level of education.

4.2 ***Results***

Figure 7 (a) and **(b)** demonstrates that most of the respondents drive Sedan and SUV vehicles that are working using gas (80%). On the other hand, respondents who drive vehicles using electricity and hybrid fuels are few; 4.8% and 1.2%, respectively. These results indicate the low popularity of EVs and HEVs among the public.

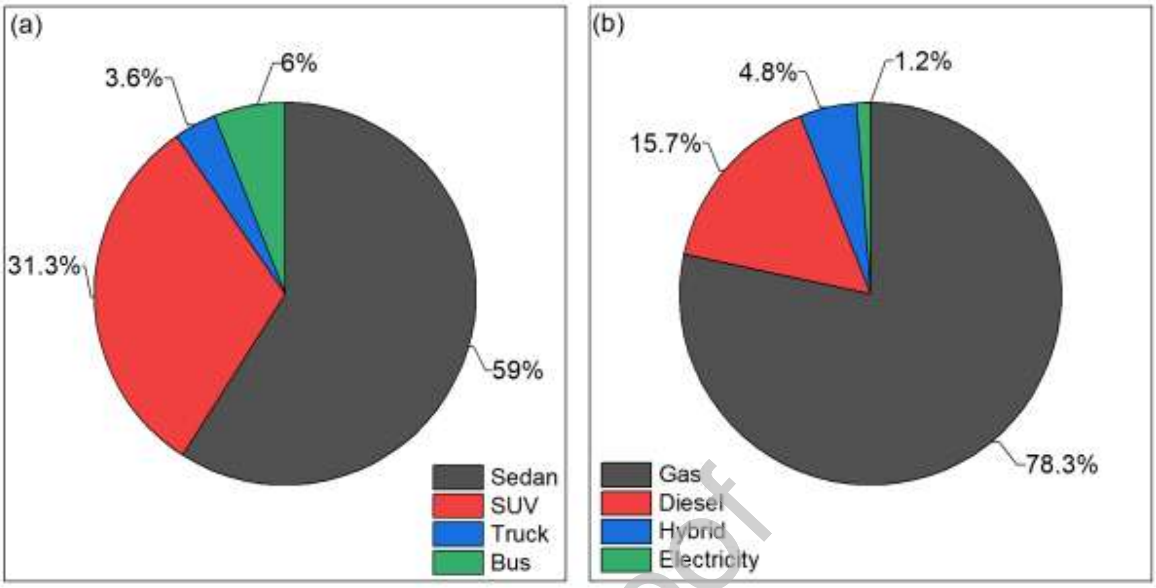


Figure 7. Type of (a) owned vehicles and (b) type of fuel operation.

Figure 8 indicates that most of the respondents were familiar with EVs; approximately, 70% were either familiar and very familiar. On the other hand, 50% were familiar and very familiar (**Figure (a)**). However, when there were asked about the classification of automation 70% of the sample did not know and only 10% of the sample had the correct answer (**Figure 8 (b)**). This shows that the public has heard about AVs or self-driving vehicles, although they did not have a chance to learn more about the classification of the automation. In other words, the marketing plans are deficient and did not send their message well enough to achieve their objectives.

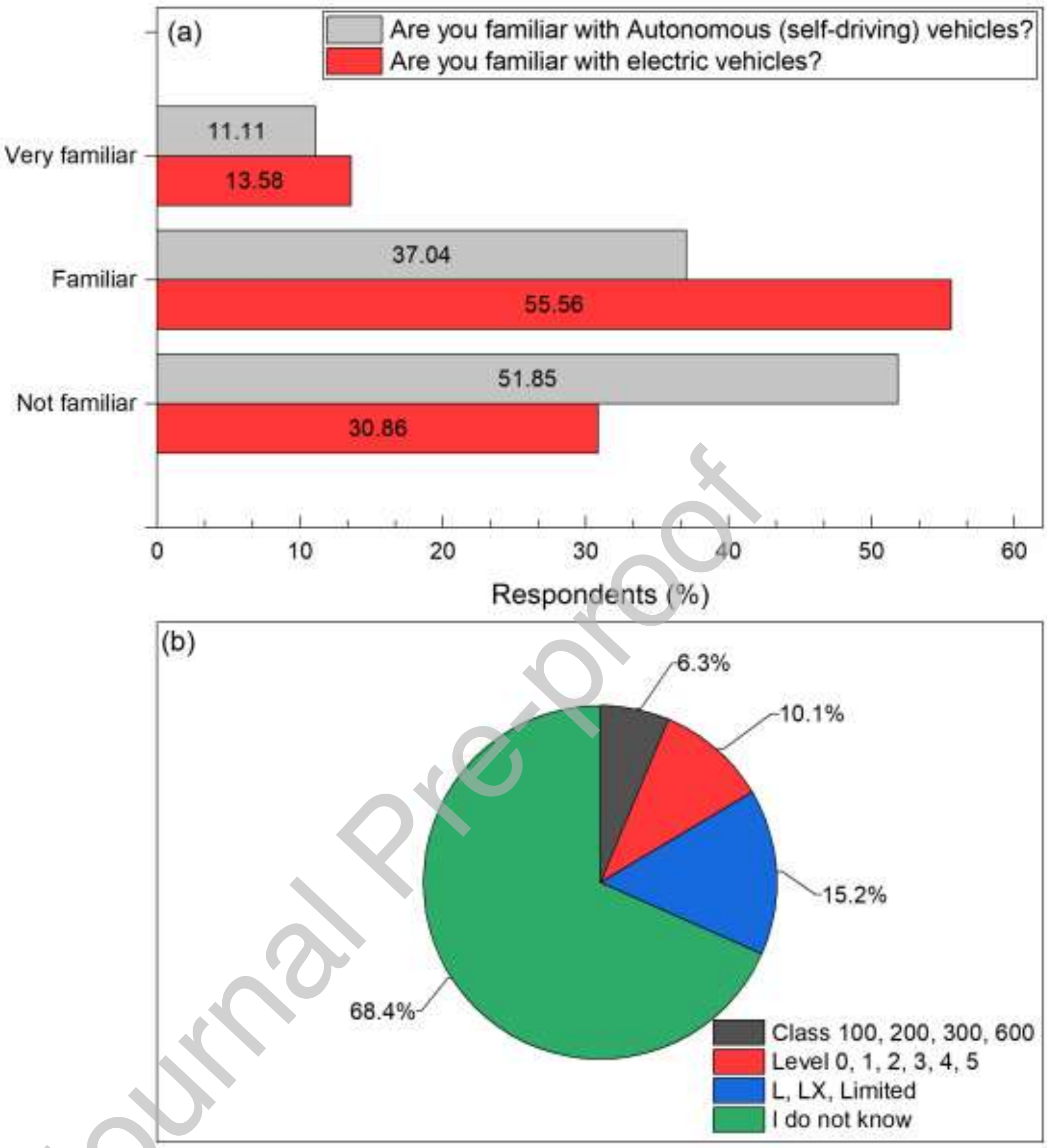


Figure 8. The familiarity of respondents with (a) EVs and AVs (b) the automation levels of according to the Society of Automotive Engineers (SAE).

Figure 9 (a) and **(b)** present the advantages and disadvantages of EVs that may encourage or hinder the public to purchase EVs. 70% of the answers indicated that the environmental effect of using EVs is the main advantage of this type of vehicle. On the other hand, roughly 60% of the respondents' answers showed that the limiting charging station is the major disadvantage of EVs. However, 25% of the answers were that limited availability of maintenance shops. The least percentage of the answers was lack of confidence. Based on the previous section, there are plenty of charging stations were distributed around the United States (refer to **Figure 5**); however, by considering the survey, customers have not been acknowledged. This is another evidence of a lack of coherent marketing and communication plans for EVs. **Figure 9 (c)** shows the rating of the advantages and disadvantages of AVs. In this part, the respondents were given the possibility to evaluate the advantages/disadvantages on a numerical scale with a slider question type. This type allows the respondents to quantify a specific response sentiment at the individual and aggregate level. The presented responses in this figure are the mean values. It can be seen that all the mean values are similar; the highest mean values are associated with the cost, safety concern, and the likelihood of a cyberattack.

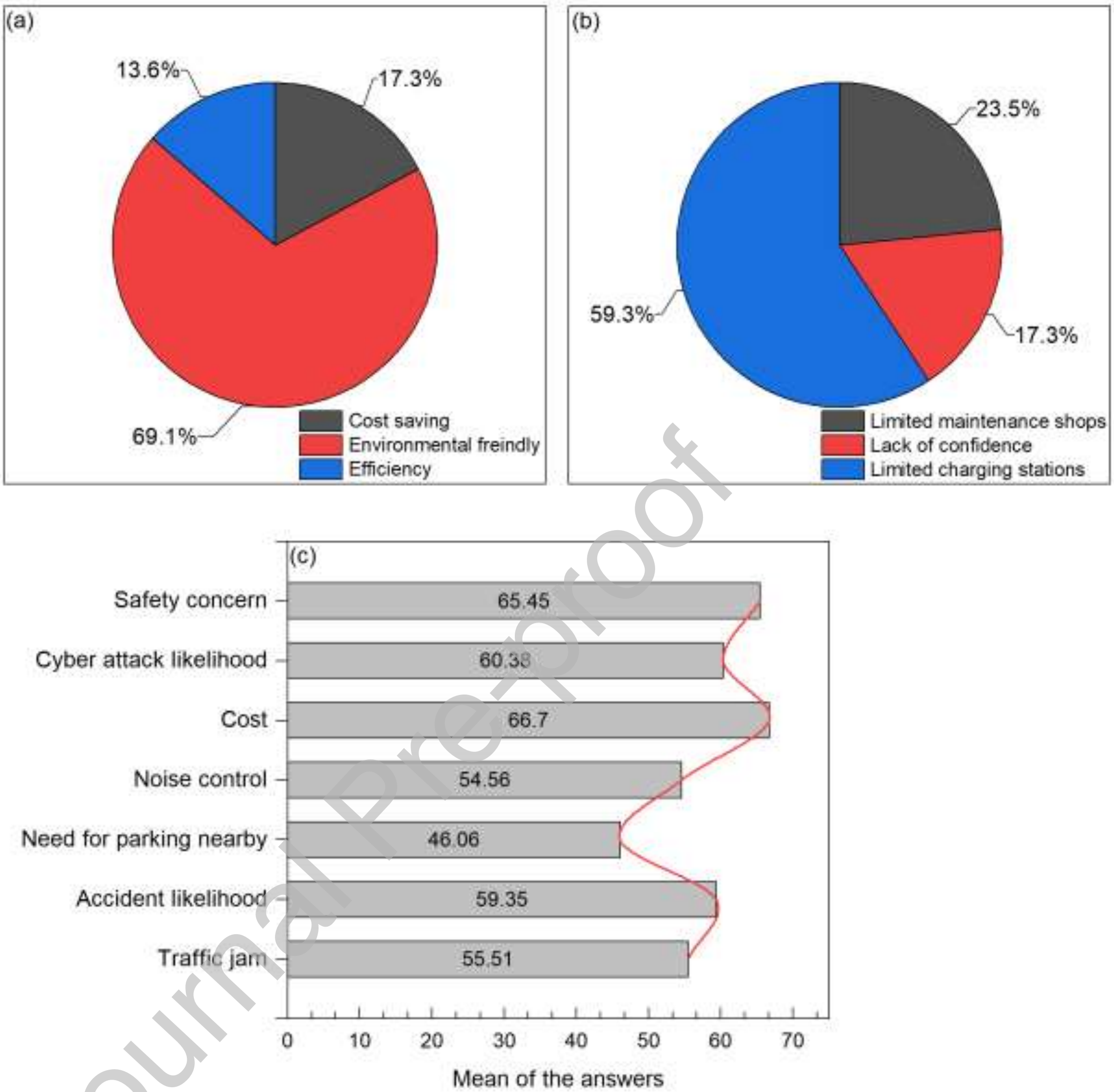


Figure 9. EVs (a) advantages, (b) disadvantages, and (c) the rating of advantages and disadvantages of AVs

Figure 10 illustrates the future anticipation of the respondents regarding the EVs and AVs. Figure 10 (a) shows the answers regarding the preferred fuel type of future AVs. The majority of the respondents preferred the hybrid fuel type (44%). This might be a reasonable choice since planners cannot be able to convert all regular gas stations into electrical type. **Figure 10 (b)** shows the answers to the preferred range for EVs and AVs batteries. More than

40% of respondents preferred the range between 200 to 400 km, which would be convenient for them to purchase EVs or AVs. This question is a very remarkable indication of the preferred range for batteries. Hence, EVs and AVs should be equipped to compete with other vehicles in the auto markets. **Figure 10 (c)** shows the likelihood of the respondents' willingness to purchase EVs soon or AVs once they are available in the market. Results indicate approximately 37% of the respondents extremely likely and somewhat likely to purchase EVs soon. However, roughly 47% of respondents extremely unlikely and somewhat unlikely to purchase EVs soon, and 16% do not have a decision. On the other hand, only 32% of the respondents extremely likely and somewhat likely to purchase an AV in the future. Nevertheless, 43% of respondents extremely unlikely and somewhat unlikely to purchase EVs soon, and 25% do not have a decision.

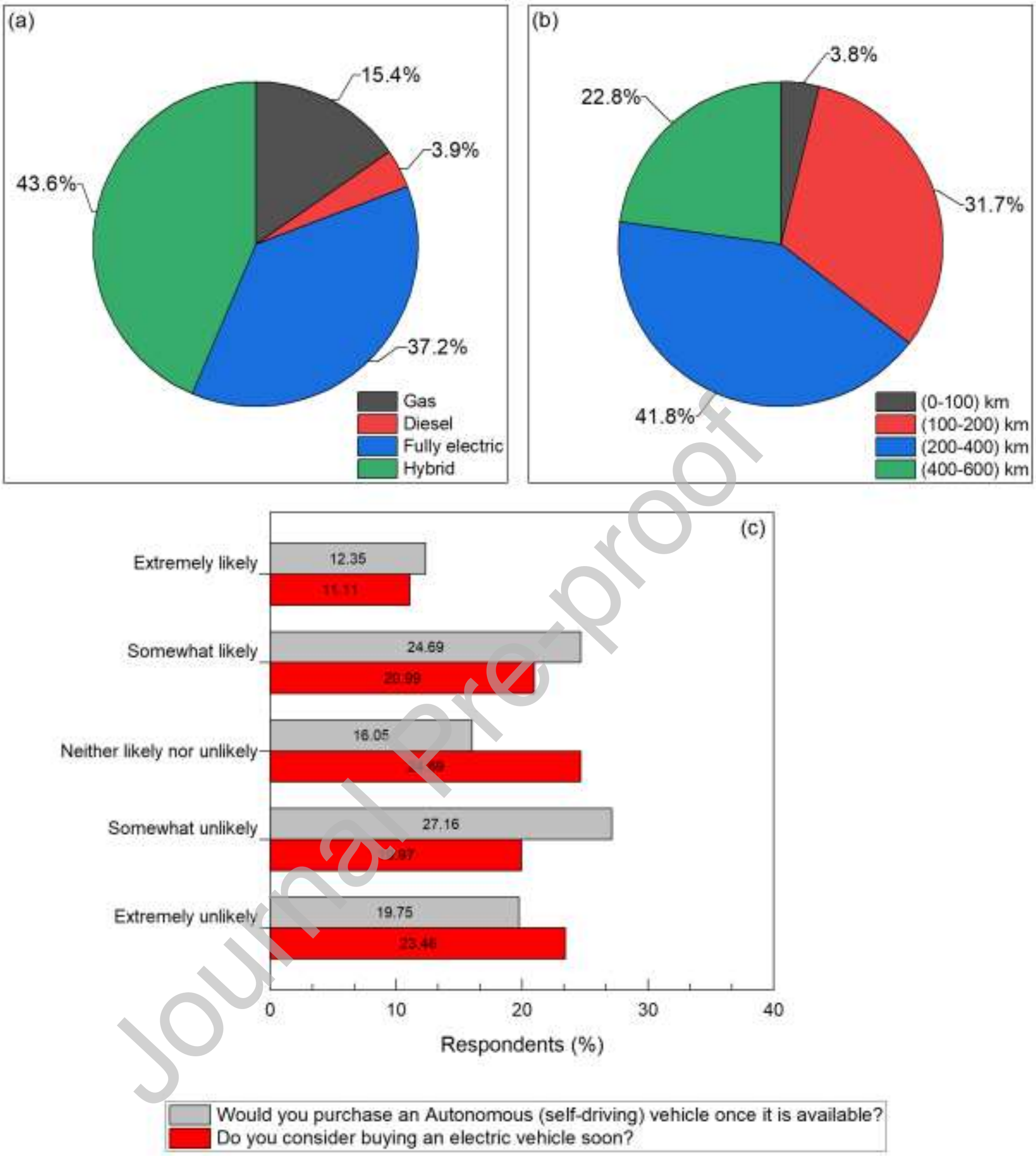


Figure 10. Future anticipation of (a) fuel type of EVs or AVs, (b) driving range of EVs or AVs, and (c) vehicle type

5 Conclusions and recommendations

Based on the review of this study, the following conclusions and recommendation for future work can be drawn:

- The conducted public survey indicated that the majority of the public is not well educated with electric and automotive vehicles which can be due to the lack of a good marketing strategy. Approximately, 70% of the respondents did not know about the classification of autonomous vehicles.
- The survey results indicated that the desired driving range of electric vehicles is between 200 to 400 km which complies with the previous findings. The respondents also believe that electric and self-driving cars did not have enough maintenances shops around the city and there is no confidence in these vehicles yet.
- Charging time, and driving range are the most well-recognized barriers by the public even though automakers have improved the efficiency of the battery for EVs. The average driving limit for the vehicles available commercially is approximately 200 miles.
- The probability of cyberattacks is likely to happen in the case of the AVs, therefore this point should be considered as a serious issue since it is directly related to humans' life. Moreover, ethical decision making is considered one of the most raised barriers regarding the public point of view.
- To increase the penetration of AVs into the market, motivations should be considered by automakers to encourage the public for buying. These motivations can be as tax credits (tax-free), and safety trust, and ecologically minded (reduce the CO_2 emission). The cost can be the main influential factor affecting the decision of the public.

- A collaboration between auto manufacturers and planners is needed for the evaluation of the current traffic system and how will/will not AVs can affect the traffic. The potential cyber-attacks need to be considered as well. The automakers need to carry out extensive testing regarding the decision-making of AVs (such as when to brake, accelerate, pass other vehicles) and publish their data.

6 ACKNOWLEDGMENTS

The contents of this paper reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein, and do not necessarily reflect the official views or policies of any of the agencies included in the paper, nor do the contents constitute a standard, specification, or regulation. The authors are grateful to Dr. Samuel Labi, the associate director for the University Transportation Center for Connected and Autonomous Vehicles (CCAT), and the director for the Next Generation Transportation Systems (Nextrans), USDOT Region 5 at Purdue University, for his invaluable guidance and notes.

7 AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: Ali Alsalman, writing, study conception: Lateef N. Assi, analysis and interpretation of results, draft manuscript preparation. Ali Ghaari; writing, study conception. All authors reviewed the results and approved the final version of the manuscript.

8 List of Abbreviations

AVs	Autonomous vehicles
SAE	Society of automotive engineers
EVs	Electric vehicles
OEMs	Original equipment manufacture
HEVs	Hybrid electric vehicles
AEVs	All-electric vehicles
BEVs	Battery electric vehicles
FCEVs	Fuel cell electric vehicles
PHEVs	Plug-in hybrid electric vehicles

ITS	Intelligent transportation system
ACC	Adaptive cruise control
AFVs	Alternative fuel vehicles
DOT	Department of transportation
ICEVs	Internal combustion engine vehicles
GNSS	Global navigation satellite systems
GHG	Greenhouse gas
DARPA	Defense advanced research projects agency

Declaration of interest statement
The authors confirm that this paper has no conflicting interest

9 References

[1] J.B. Greenblatt, S. Shaheen, Automated Vehicles, On-Demand Mobility, and Environmental Impacts, Curr Sustainable Renewable Energy Rep. 2 (2015) 74–81. https://doi.org/10.1007/s40518-015-0038-5.

[2] Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation, National Conference of State Legislatures (NCSL). (2020). https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx (accessed June 6, 2020).

[3] S.O.-R.A.V.S. Committee, Taxonomy and definitions for terms related to on-road motor vehicle automated driving systems, SAE Standard J. 3016 (2014) 1–16.

[4] K. Barry, J. Plungis, Do Levels of Car Automation Matter?, Consumer Reports. (n.d.). https://www.consumerreports.org/autonomous-driving/levels-of-car-automation/ (accessed June 7, 2020).

[5] New Level 3 Autonomous Vehicles Hitting the Road in 2020, IEEE Innovation at Work. (2020). https://innovationatwork.ieee.org/new-level-3-autonomous-vehicles-hitting-the-road-in-2020/ (accessed June 7, 2020).

[6] S. Peters, G. Lanza, J. Ni, J. Xiaoning, Y. Pei-Yun, M. Colledani, Automotive manufacturing technologies – an international viewpoint, Manufacturing Rev. 1 (2014) 10. https://doi.org/10.1051/mfreview/2014010.

[7] M. Kuby, S. Lim, Location of alternative-fuel stations using the flow-refueling location model and dispersion of candidate sites on arcs, Networks and Spatial Economics. 7 (2007) 129–152.

[8] M. Melendez, Transitioning to a hydrogen future: learning from the alternative fuels experience, National Renewable Energy Lab.(NREL), Golden, CO (United States), 2006.

[9] T. Bunsen, P. Cazzola, M. Gorner, L. Paoli, S. Scheffer, R. Scuitmaker, J. Tattini, J. Teter, Global EV Outlook 2018: Towards cross-modal electrification, International Energy Agency, 2018.

[10] T. Capuder, D. Miloš Sprčić, D. Zoričić, H. Pandžić, Review of challenges and assessment of electric vehicles integration policy goals: Integrated risk analysis approach, International Journal of Electrical Power & Energy Systems. 119 (2020) 105894. https://doi.org/10.1016/j.ijepes.2020.105894.

[11] U.S. Department of Energy, Alternative Fuels Data Center: Emissions from Hybrid and Plug-In Electric Vehicles, (n.d.). https://afdc.energy.gov/vehicles/electric_emissions.html (accessed October 11, 2020).

[12] I.G.E. Outlook, Scaling -up the transition to Electric Mobility, IEA: Paris, France. (2019).

[13] D. Anair, A. Mahmassani, State of charge, Union of Concerned Scientists. 10 (2012).

[14] P.J. Tulpule, V. Marano, S. Yurkovich, G. Rizzoni, Economic and environmental impacts of a PV powered workplace parking garage charging station, Applied Energy. 108 (2013) 323–332. https://doi.org/10.1016/j.apenergy.2013.02.068.

[15] D. Knutsen, O. Willén, A study of electric vehicle charging patterns and range anxiety, 2013.

[16] A. Purwadi, J. Dozeno, N. Heryana, Simulation and Testing of a Typical On-board Charger for ITB Electric Vehicle Prototype Application, Procedia Technology. 11 (2013) 974–979. https://doi.org/10.1016/j.protcy.2013.12.283.

[17] K. Holmberg, Solving the staircase cost facility location problem with decomposition and piecewise linearization, European Journal of Operational Research. 75 (1994) 41–61. https://doi.org/10.1016/0377-2217(94)90184-8.

[18] M.T. Hajiaghayi, M. Mahdian, V.S. Mirrokni, The facility location problem with general cost functions, Networks. 42 (2003) 42–47. https://doi.org/10.1002/net.10080.

[19] Y. Huang, S. Li, Z.S. Qian, Optimal deployment of alternative fueling stations on transportation networks considering deviation paths, Networks and Spatial Economics. 15 (2015) 183–204. https://doi.org/10.1007/s11067-014-9275-1.

[20] M. Yavuz, B. Oztaysi, S. Cevik Onar, C. Kahraman, Multi-criteria evaluation of alternative-fuel vehicles via a hierarchical hesitant fuzzy linguistic model, Expert Systems with Applications. 42 (2015) 2835–2848. https://doi.org/10.1016/j.eswa.2014.11.010.

[21] N. Markovska, V. Taseska, J. Pop-Jordanov, SWOT analyses of the national energy sector for sustainable energy development, Energy. 34 (2009) 752–756.

[22] How autonomous vehicles will redefine land valuation, VentureBeat. (2018). https://venturebeat.com/2018/11/03/how-autonomous-vehicles-will-redefine-land-valuation/ (accessed October 12, 2020).

[23] J.D. Adler, P. Mirchandani, Online routing and battery reservations for electric vehicles with swappable batteries, Transp Res Part B. 70 (2014) 285–302. https://doi.org/10.1016/j.trb.2014.09.005.

[24] H. Liu, D.Z.W. Wang, Locating multiple types of charging facilities for battery electric vehicles, Transportation Research Part B: Methodological. 103 (2017) 30–55. https://doi.org/10.1016/j.trb.2017.01.005.

[25] C. Botsford, A. Szczepanek, Fast Charging vs. Slow Charging: Pros and cons for the New Age of Electric Vehicles, (n.d.) 9.

[26] Model 3 | Tesla, (n.d.). https://www.tesla.com/model3 (accessed June 11, 2020).

[27] Model S | Tesla, (n.d.). https://www.tesla.com/models (accessed June 20, 2020).

[28] Model X | Tesla, (n.d.). https://www.tesla.com/modelx (accessed June 20, 2020).

[29] Model Y | Tesla, (n.d.). https://www.tesla.com/modely (accessed June 20, 2020).

[30] 2020 Honda Clarity Plug-In Hybrid – The Versatile Hybrid | Honda, Honda Automobiles. (n.d.). https://automobiles.honda.com:443/clarity-plug-in-hybrid (accessed June 11, 2020).

[31] 2020 Chevy Bolt EV | Affordable All Electric Car, Chevrolet. (n.d.). https://www.chevrolet.com/index/vehicles/2020/cars/bolt-ev/overview.html (accessed June 11, 2020).

[32] Top Flight - Chevrolet Volt Plug-In Hybrid: New Roads, Chevrolet. (n.d.). https://www.chevrolet.com/index/about/new-roads-issue-12/places/articles/top-flight.html (accessed June 11, 2020).

[33] 2020 Toyota Prius Prime FAQ, (n.d.). https://www.toyota.com/priusprime/faq/ (accessed June 11, 2020).

[34] 2020 Nissan LEAF Range, Charging & Battery | Nissan USA, Nissan. (n.d.). https://www.nissanusa.com/vehicles/electric-cars/leaf/features/range-charging-battery.html (accessed June 11, 2020).

[35] New Electric Cars | Volkswagen UK, (n.d.). https://www.volkswagen.co.uk/electric (accessed June 10, 2020).

[36] P. Nieuwenhuis, P. Wells, New Business Models for Alternative Fuel and Alternative Powertrain vehicles; an infrastructure perspective, New Business Models for Alternative Fuel and Powertrain Vehicles. (2012).

[37] I.G.E. Outlook, Entering the Decade of Electric Drive, 2020.

[38] Mobility Study 2013, Home | Continental. (n.d.). https://www.continental.com/en/press/initiatives-surveys/continental-mobility-studies/mobility-study-2013 (accessed December 14, 2020).

[39] D. Howard, D. Dai, Public perceptions of self-driving cars: The case of Berkeley, California, in: Transportation Research Board 93rd Annual Meeting, 2014: pp. 1–16.

[40] G. Silberg, M. Manassa, K. Everhart, D. Subramanian, M. Corley, H. Fraser, V. Sinha, Self-driving cars: Are we ready, Kpmg Llp. (2013) 1–36.

[41] J. Missel, Ipsos MORI Loyalty automotive survey, Ipsos, 2014.

[42] M. Kyriakidis, R. Happee, J.C.F. de Winter, Public opinion on automated driving: Results of an international questionnaire among 5000 respondents, Transportation Research Part F: Traffic Psychology and Behaviour. 32 (2015) 127–140. https://doi.org/10.1016/j.trf.2015.04.014.

[43] P. Bansal, K.M. Kockelman, A. Singh, Assessing public opinions of and interest in new vehicle technologies: An Austin perspective, Transportation Research Part C: Emerging Technologies. 67 (2016) 1–14. https://doi.org/10.1016/j.trc.2016.01.019.

[44] J. Brinkley, B. Posadas, J. Woodward, J.E. Gilbert, Opinions and preferences of blind and low vision consumers regarding self-driving vehicles: Results of focus group discussions, in: Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility, 2017: pp. 290–299.

[45] F. Arena, G. Pau, A. Severino, An Overview on the Current Status and Future Perspectives of Smart Cars, Infrastructures. 5 (2020) 53. https://doi.org/10.3390/infrastructures5070053.

[46] M.J. Kass, The End of the Road for Gas Powered Automobiles?, (2017).

[47] D.L. Greene, G. Duleep, Status and prospects of the global automotive fuel cell industry and plans for deployment of fuel cell vehicles and hydrogen refueling infrastructure, Oak Ridge National Laboratory. (2013).

[48] A. Dave, Volkswagen Crisis: New Marketing Strategy, Just About Marketing. (2019) 3.

[49] L. Hepler, Death to diesel? Volkswagen, Tesla and the new clean car market, GreenBiz. (2015) 8.

[50] C. Murray, Here’s Why Autonomous Vehicles Will Need to Be Electrified, Design News. (2019). https://www.designnews.com/electronics-test/here-s-why-autonomous-vehicles-will-need-be-electrified/22065969260879 (accessed June 23, 2020).

[51] A.M. Khan, A. Bacchus, S. Erwin, Policy challenges of increasing automation in driving, IATSS Research. 35 (2012) 79–89. https://doi.org/10.1016/j.iatssr.2012.02.002.

[52] B.M. Masini, C.M. Silva, A. Balador, The Use of Meta-Surfaces in Vehicular Networks, Journal of Sensor and Actuator Networks. 9 (2020) 15. https://doi.org/10.3390/jsan9010015.

[53] J. Petit, S.E. Shladover, Potential Cyberattacks on Automated Vehicles, IEEE Trans. Intell. Transport. Syst. (2014) 1–11. https://doi.org/10.1109/TITS.2014.2342271.

[54] L. Meagher, Cybersecurity and Safety Concerns of Future Automated Vehicle Software, Utica College, 2018.

[55] E. Schoitsch, C. Schmittner, Z. Ma, T. Gruber, The need for safety and cyber-security co-engineering and standardization for highly automated automotive vehicles, in: Advanced Microsystems for Automotive Applications 2015, Springer, 2016: pp. 251–261.

[56] J. Petit, Automated Vehicles Cybersecurity: Summary AVS'17 and Stakeholder Analysis, in: Road Vehicle Automation 5, Springer, 2019: pp. 171–181.

[57] N.J. Goodall, Machine Ethics and Automated Vehicles, in: G. Meyer, S. Beiker (Eds.), Road Vehicle Automation, Springer International Publishing, Cham, 2014: pp. 93–102. https://doi.org/10.1007/978-3-319-05990-7_9.

[58] F. Arena, G. Pau, A. Severino, A Review on IEEE 802.11p for Intelligent Transportation Systems, Journal of Sensor and Actuator Networks. 9 (2020) 22. https://doi.org/10.3390/jsan9020022.

[59] H. Peng, D. Li, K. Abboud, H. Zhou, H. Zhao, W. Zhuang, X.S. Shen, Performance analysis of IEEE 802.11 p DCF for multiplatooning communications with autonomous vehicles, IEEE Transactions on Vehicular Technology. 66 (2016) 2485–2498.

[60] S. Solomon, Intergovernmental Panel on Climate Change, eds., Climate change 2007: the physical science basis: contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge ; New York, 2007.

[61] K. Racherla, M. Waight, Addressing EMI in Electric Cars with Radio Tuner Architecture [Future Directions], IEEE Consumer Electronics Magazine. 7 (2018) 15–124. https://doi.org/10.1109/MCE.2017.2755278.

[62] A. Senart, S. Kurth, G. Le Roux, Assessment framework of plug-in electric vehicles strategies, in: 2010 First IEEE International Conference on Smart Grid Communications, IEEE, 2010: pp. 155–160.

[63] Truic, How to Open a Gas Station, HowToStartAnLLC.Com. (n.d.). https://howtostartanllc.com/business-ideas/gas-station (accessed June 22, 2020).

[64] Fixer, 2020 Cost to Install EV Charger at Home | Electric Car Charging Station Home Installation, Fixr.Com. (n.d.). https://www.fixr.com/costs/home-electric-vehicle-charging-station (accessed June 22, 2020).

[65] J. Agenbroad, B. Holland, Ev charging station infrastructure costs, Rocky Mountain Institute. URL Http://Blog. Rmi. Org/Blog_2014_04_29_pulling_back_the_veil_on_ Ev_charging_station_costs. (2014).