Users' Socio-economic Factors to Choose Electromobility for Future Smart Cities

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Abstract. Recently, governments worldwide have sought solutions on how to lower carbon emissions. One of the more preferable options is the daily use of electromobility for various types of transportation. Clearly, reforming the different kinds of urban mobility is a far from simple task for policymakers; and from the perspective of users, there are many socioeconomic factors that are responsible. A preliminary literature search was conducted into the issues related to environmental protection, consumer awareness and knowledge of e-mobility, and purchasing behaviour. We have focused on these factors to take advantage of the usefulness of electromobility and provide a holistic overview, which will ultimately be the impetus for developing future smart cities. The study results may be a good base from which to build future discussions regarding the need for bottom-up analysis of e-mobility demand and standardisation, whilst taking into consideration the interests of various communities, including individual users, policymakers, and other industry-related stakeholders.

Keywords: Choice of vehicle · Electric vehicles (EVs) · Smart cities · Socio-economic barriers · User demand

1 Introduction

Over the past few decades, transport has become integral to human life. Smart mobility is necessary because of the increase in urbanisation, public awareness of the environment, and numerous other socioeconomic factors. Thus, in order to provide hassle-free transportation solutions, governments worldwide have become actively involved in smart mobility solutions. Electrical advances are accelerating these efforts and electric vehicles (EVs) will consequently become the solution to all daily transportation methods in future smart cities. This achieves traditional mobility goals (e.g., travel costs, user-friendliness, etc.) and is vital to reach sustainable development goals (SDGs) as defined by the United Nations, to become more accessible, inclusive, sustainable, and multimodal. In

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general, the transition to clean and smart mobility is based on four key pillars: (i) a more efficient transport system, (ii) low and zero emission vehicle, (iii) new business models and services for transport, and (iv) multi-modality and inter-modality- integration of all possible transport modes. Research and innovation play a key role in developing, testing, and bringing to market next-generation solutions in these four areas. In addition, the long-term potential of disruptive innovations needs to be explored. Particular attention should not only be paid to infrastructure and modal choices, but also to assessing the socio-economic parameters that influence the choices of users, whether as drivers, passengers, or operators of electric transport services.

User adoption of electric vehicles [1,2] has vastly increased over the past decade and has seen incredible sales growth regardless of the economic crisis caused by the COVID-19 pandemic [3]. Flexible government financial incentives have changed people's mindsets (for example, in Norway the government incentive to purchase an EV is USD8800, whereas in the USA it is USD6000 [4]). Moreover, during COVID-19 public transportation saw a decline in demand, with EVs becoming the most convenient mode of transport. Overall, over the past two years sales of EVs have surged from 43% to 108%; this is significant when global vehicle sales increased by only 4.7% [5].

Even given the remarkable growth in the EV sector, the industry is still facing challenges at all levels in the successful deployment of electric transportation [6,7]. One reason is because of the gap between electricity production and its generous distribution to the end user [8]. Other reasons include charging infrastructure availability [9–11], government subsidies on new EV purchases [12,13], intelligent battery swapping technology [14,15], and many others not yet available in many countries. There is also the possibility that people's awareness and rate of acceptance [16,17] is lower in EVs compared to conventional vehicles [18]as a result of socioeconomic barriers.

Infrastructure is now one of the main reasons for the success of any revolution; this also applies to the field of electromobility. The evolution of recharging infrastructures and the reduction of waiting times as well as the spread of public and shared electric transport are topics that have been addressed by several authors recently [19–21]. However, less attention has been paid to the role of socioeconomic factors in the success of electromobility. Such factors usually centre around the daily lives of users, which influences the adoption of new mobility technologies. This is crucial in the context of smart cities, where all components (e.g., transportation, home, other utilities, etc.) have been user-centric.

Current and future electromobility solutions require a shift in people's minds. Furthermore, daily advancements in technology and various electric mobility types (e.g., e-scooter, e-rickshaw, e-bus, e-port, e-rail, etc.) raise new socioeconomic challenges. This raises questions about the types of challenges faced when deploying electromobility on roads. A key future topic is how smart cities, and their transportation systems respond to the present concerns. Thus, the aim of this paper is to provide new informative knowledge on social influence and economic impact in the context of choosing electromobility.

In this paper, Sect. 2 includes social influential factors affecting electromobility choices. Section 3 describes how economic factors affect electromobility choices during a purchase. Finally, Sect. 4 concludes the paper with a future direction.

2 Social Factors Affecting to Choose Electromobility

Societal barriers are equally as important as technical challenges in successfully deploying electromobility at every level. It is a direct indication of the level of acceptance by society and, therefore, agencies and policymakers can plan accordingly for the future implementation of EVs on the road. The various factors which affect this are shown in Fig. 1.

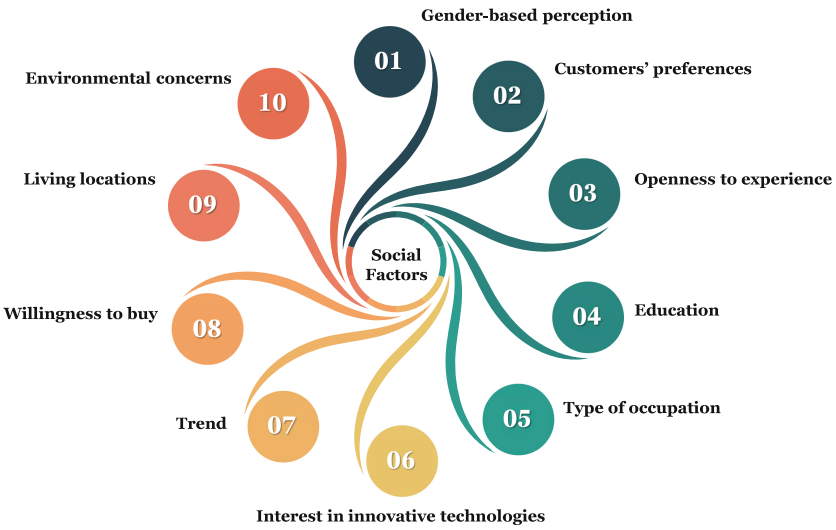

Fig. 1. Social factors

2.1 Gender-Based Perception

An idiosyncrasy to the new technological innovations, especially in terms of electromobility, is that adoption may differ between men and women [22]. For example, charging locations, vehicle usage in urban and rural areas, driving range per battery charge, etc. Without an awareness of these important issues, the sales, and services of EVs may be affected. Therefore, for the accessibility of vehicles to all end-users, it is crucial to understand gender behaviour [23,24].

2.2 Customers' Preferences

Electric vehicles have gained increased attention over the past decade, which has facilitated the diverse preference-based decision-making capabilities of the vehicle purchase, which has made the vehicles more 'personalised', and these preferences vary over time [25]. In the profitability race of original equipment manufacturers (OEMs), recent results show that vehicle body type also plays a significant role in vehicle choice [26]. Electromobility is the future of personal transportation, and therefore vehicle charging is a prime concern of users. Consequently, charging infrastructure should be made affordable and payments accessible to all users with access through all payment gateways [27,28]. Choice of brand is one of the prime reasons for the purchase of electric vehicles [29].

2.3 Openness to Experience

Car-sharing provides a more affordable and sustainable transportation option for making cities smart. Thus, users experience a more open environment of mobility, and a new path will consequently be revealed for choosing electromobility as a key fleet [30,31]. Moreover, the type of experience felt by users before and after using EVs also matters when choosing a new vehicle [32,33].

2.4 Education

EVs are a relatively new consumer technology. Therefore, to understand all of its benefits will take time. Over the past five years, EVs have changed personal transportation; yet, this has not paved the way for full utilisation by customers. One reason why adoption of EVs is not seen as a viable option is education. It is apparent that consumers who are more educated prefer hybrid vehicles for routine use [34]. Studies show that in the Netherlands, Sweden, and Norway, those with a higher level of education prefer EVs [23].

2.5 Type of Occupation

There are many influential factors when choosing EVs, yet there has been little focus on the type of occupation of the user. There is a disparity in the various results, for example, in Thailand [35] and South Korea [36] people with a higher income tend to adopt EVs, while in India [37] those who have a lower income tend to buy EVs. This clearly indicates the socio-geographical impact on the choice of electromobility.

2.6 Interest in Innovative Technologies

Continuous developments in state-of-the-art innovative technologies attract users to purchase EVs as their first vehicle of choice. These technologies include fast charging, various payment gateways, and connected cars. Users who have a greater interest in technology and want to experience their vehicle's features are more willing to choose EVs than other users [38,39]. Additionally, leveraging these features will be helpful for comprehending user experiences.

2.7 Trend

To better understand user adoption of EVs, we must also understand current market trends. This is due to the influential factor of dispersal of new technology [40]. People largely adopt new products based on their lifestyles and market trends [41].

2.8 Willingness to Buy

The psychology of users and policy concerns are also influential factors. Therefore, by knowing user preferences, the OEMs can provide user-centric features in the EVs [42]. These factors change geographically. For example, in Indonesia users are greatly affected by emotions, vehicle functionality, identity of the car, and ownership [43]. Whereas, Indian consumers have faith in new technology [44], and South Korean consumers have strong environmental concerns during the purchase of EVs [45].

2.9 Living Locations

The market growth of electromobility is highly dependent on the location of users. It is particularly important that the purchasing power of urban and rural users is different, for various reasons. This includes availability of charging facilities, incentives from central and state governments, government policies, education, income level, willingness to pay more for charging, etc. Various preference levels have been observed in rural and urban users, especially in terms of the ownership of the vehicle and charging profiles [46].

2.10 Environmental Concerns

The key responsibility of any revolution in the mobility sector should be to ensure the needs of the environment. Recent years have witnessed the awareness of users towards electromobility in regard to environmental concerns. The aforementioned social and environmental confluence will be the game changer for automotive transportation in paving the way for the widespread adoption of EVs [47]. Indian [48] and Australian [49] consumers are pro-environment and have a greater sense of adaptive behaviour when choosing EVs. In the USA, because of federal policies towards sustainability, customers have a deeper interest in environmental and legal matters [50].

3 Economic Factors Affecting to Choose Electromobility

An economy acts as a bridge between customers and policymakers and includes various factors which directly or indirectly affect the infrastructure, policy, finance, and technical variability to formulate user preferences [25]. The active involvement of various economic factors are shown in Fig. 2.

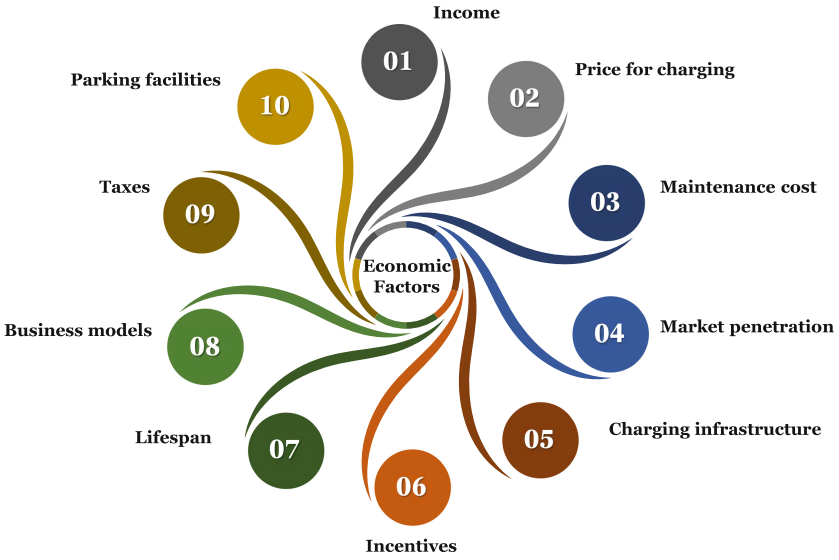

Fig. 2. Economic factors

3.1 Income

There is sufficient evidence that there is a connection between the choice of vehicle and user income [51]. For example, countries such as France and Germany, where a large number of users are in a higher income bracket, opt for EVs [52]. Conversely, in Ireland [53] and India [54] the first preference of users is EVs regardless of income level.

3.2 Price for Charging

Whenever we are thinking of purchasing EVs, the first question we come across is what the vehicle will cost. There are four main purchase factors: Owner of the vehicle, charging points, prospective EV buyers, and distribution companies [55]. It is important to manage the smart charging of electric vehicles according to the tariff rate and attitude of the customers [56,57].

3.3 Maintenance Cost

In electromobility, the high cost of maintenance is due to the batteries, and users are always keen to know the life expectancy of the batteries. Depending upon the cost analysis, user trends towards purchasing EVs will increase [58].

3.4 Market Penetration

By knowing the consumer adoption rate and purchasing behaviour, one can predict EV penetration. The rate of EV penetration characterises the future

market share of electromobility [59]. For example, the EV penetration rate in the Netherlands is higher than in Germany [60]. This demonstrates the willingness of users to buy EVs and provide sustainable mobility for upcoming generations.

3.5 Charging Infrastructure

Commercial success, as well as the wide adoption of electromobility, is highly dependent on the charging infrastructure. This is crucial as the needs of most users revolve around affordable, easy to use, and easy access charging infrastructure. In addition, charging infrastructure locations provide information on which to base future policies and power network services [61]. In the field of charging facilities, technological developments have been seen in recent times, for example, mobile charging [62], two-charging station charging method [27], etc. Providing consumers with friendly charging facilities at users' doorsteps will increase the EV adoption rate [63].

3.6 Incentives

Recent years have witnessed the increased adoption of electromobility. However, there is a huge gap between traditional vehicles and electromobility. One of the easiest ways to bridge the gap between them is to provide financing with a loan at a low interest rate. To promote and increase the market share of electric vehicles, many incentives are provided to consumers. This is necessary because the technology is relatively new, and consumers can be hesitant in their purchasing behaviours. Various studies in Norway [13], Australia [64], and the USA [65] have shown that providing sufficient incentives increases users' belief towards buying electric vehicles.

3.7 Lifespan

An important user concern is in regard to the vehicle's lifespan. A longer vehicle lifespan provides both the users and manufacturing companies with ease-of-use access to electromobility. Current versions of electric vehicles have a lifetime driving distance in the range of 100,000 to 300,000 km, which is expected to increase to 150,000 to 350,000 km in the future through high performance batteries [66]. To boost battery lifespan, various techniques have been applied; for example, the ultracapacitor based method [67], thermally modulated lithium iron phosphate batteries which have the capacity to operate at a temperature of 60 °C [68], etc.

3.8 Business Models

New business models in electromobility should also foster the needs of the customer. Therefore, the interaction between the various business models (such as vehicle sharing, e-mobility services, or mobility shops) has been measured. This will help customers to define their interest in new mobility solutions and allow companies to decide where to invest their money for providing future innovative solutions [69].

3.9 Taxes

To encourage people to buy electric vehicles, governments should think about providing tax benefits. What kind of financial mechanisms can be used so that consumers will benefit from the mileage tax [70]? Tax locations also matter in the case of electromobility, for example, at the domestic supply side or at the public charging station end.

3.10 Parking Facilities

As the size of the electromobility market increases with time, a crucial question is where will users park their vehicles? One of the simplest answers is to park the vehicle near existing charging facilities. However, it is not enough only to add new users into the electromobility sector. Therefore, to persuade people to purchase a vehicle, parking facilities must have incentives and policies to promote the technology and user awareness. For example, managed parking and charging at parking lots using solar power generation [71], enough prior information provided for the use of information technology [72], optimal residential parking slots information [73], etc. Additionally, it has been noticed that consumer preference for charging locations matters. Consumers prefer to charge first at home, then at work, and then at other destinations and service stations [74].

4 Discussion and Conclusion

Although there has been widespread acceptance of electromobility in recent years, much of the focus has not been on choice elements, such as societal and economic factors. In the paper, we have discussed the various socio-economic factors which are key when a consumer purchases an electric vehicle. Broadly speaking, the user plays a central role in the transformation of going from purchasing a conventional vehicle to adopting an electric vehicle. Thus, the factors that affect the understanding of the socio-economic situation of users is crucial.

It is important to define the holistic view of these socio-economic factors in future studies. This could be in terms of understanding user perceptions of electric transformation of vehicles and how we can build up future, liveable, smart cities. To define socio-economic factors more concisely, a user study would be a preferable choice.

Future research steps should focus on an in-depth survey related to the definition of potential users of electric vehicles: whether they are potential buyers of vehicles (cars, scooters...) or potential managers of transport services with electric vehicles, especially vehicles related to public and/or shared transport such as taxis or DRT. This will provide an insight into the various criteria of different users in different geospatial locations.

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References

1. Jabeen, F., Olaru, D., Smith, B., Braunl, T., Speidel, S.: Acceptability of electric vehicles: findings from a driver survey. In: Proceedings of 35th Australasian Transport Research Forum (ATRF), pp. 1–15, Perth, Australia (2012). https://trid.trb.org/view/1224115
2. Lioutas, V., Adamos, G., Nathanail, E.: How ready are Greek consumers to use electric vehicles? In: Nathanail, E.G., Adamos, G., Karakikes, I. (eds.) CSUM 2020. AISC, vol. 1278, pp. 760–769. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-61075-3_74
3. Marie R.B., Dale, H., Nic, L.: Update on electric vehicle uptake in European cities. In: International Council on Clean Transportation, Working Paper 2021-37, pp. 1–18 (2021). https://theicct.org/publication/update-on-electric-vehicle-uptake-in-european-cities/. Accessed 13 Mar 2022
4. If you build it, they will come: Lessons from the first decade of electric vehicles. https://blogs.worldbank.org/transport/if-you-build-it-they-will-come-lessons-first-decade-electric-vehicles. Accessed 13 Mar 2022
5. Global EV sales for 2021. https://www.ev-volumes.com/. Accessed 13 Mar 2022
6. Sreeram, K., Preetha, P.K., Pooranchandran, P.: Electric vehicle scenario in India: roadmap, challenges, and opportunities. In: Proceedings of IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), Coimbatore, India, pp. 1–7 (2019). https://doi.org/10.1109/ICECCT.2019.8869479
7. Ona, E., Suzanna, L.: Barriers to widespread adoption of electric vehicles: an analysis of consumer attitudes and perceptions. Energy Policy **48**, 717–729 (2012). https://doi.org/10.1016/j.enpol.2012.06.009
8. Ghazale, H., Mohammad, K., Shahidehpour, M.: Accelerating the global adoption of electric vehicles: barriers and drivers. Electr. J. **28**(10), 53–68 (2015). https://doi.org/10.1016/j.tej.2015.11.011
9. Sun, X.-H., Yamamoto, T., Morikawa, T.: Charge timing choice behavior of battery electric vehicle users. Transp. Res. Part D Transp. Environ. **37**, 97–107 (2015). https://doi.org/10.1016/j.trd.2015.04.007
10. Levinson, R.S., West, T.H.: Impact of public electric vehicle charging infrastructure. Transp. Res. Part D Transp. Environ. **64**, 158–177 (2018). https://doi.org/10.1016/j.trd.2017.10.006
11. Funke, S.Á., Sprei, F., Gnann, T., Plötz, P.: How much charging infrastructure do electric vehicles need? A review of the evidence and international comparison. Transp. Res. Part D Transp. Environ. **77**, 224–242 (2019). https://doi.org/10.1016/j.trd.2019.10.024
12. Rudolph, C.: How may incentives for electric cars affect purchase decisions? Transp. Policy **52**, 113–120 (2016). https://doi.org/10.1016/j.tranpol.2016.07.014

13. Bjerkan, K.Y., Nørbech, T.E., Nordtømme, M.E.: Incentives for promoting battery electric vehicle (BEV) adoption in Norway. Transp. Res. Part D Transp. Environ. **43**, 169–180 (2016). https://doi.org/10.1016/j.trd.2015.12.002
14. Raj, N., Suri, M., Deepa, K.: Integration of battery charging and swapping using metaheuristics: a review. In: Tomar, A., Malik, H., Kumar, P., Iqbal, A. (eds.) Machine Learning, Advances in Computing, Renewable Energy and Communication. LNEE, vol. 768, pp. 247–258. Springer, Singapore (2022). https://doi.org/10.1007/978-981-16-2354-7_23
15. Jatschka, T., Oberweger, F.F., Rodemann, T., Raidl, G.R.: Distributing battery swapping stations for electric scooters in an urban area. In: Olenev, N., Evtushenko, Y., Khachay, M., Malkova, V. (eds.) OPTIMA 2020. LNCS, vol. 12422, pp. 150–165. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-62867-3_12
16. Campisi, T., Ticali, D., Ignaccolo, M., Tesoriere, G., Inturri, G., Torrisi, V.: Factors influencing the implementation and deployment of e-vehicles in small cities: a preliminary two-dimensional statistical study on user acceptance. Transp. Res. Procedia **62**, 333–340 (2022). https://doi.org/10.1016/j.trpro.2022.02.042
17. Bühler, F., Cocron, P., Neumann, I., Franke, T., Krems, J.F.: Is EV experience related to EV acceptance? Results from a German field study. Transp. Res. Part F Traffic Psychol. Behav. **25**, 34–49 (2014). https://doi.org/10.1016/j.trf.2014.05.002
18. Hackbarth, A., Madlener, R.: Consumer preferences for alternative fuel vehicles: a discrete choice analysis. Transp. Res. Part D: Transp. Environ. **25**, 5–17 (2013). https://doi.org/10.1016/j.trd.2013.07.002
19. Kaya, Ö., Alemdar, K.D., Campisi, T., Tortum, A., Çodur, M.K.: The development of decarbonisation strategies: a three-step methodology for the suitable analysis of current EVCS locations applied to Istanbul, Turkey. Energies **14**(10), 2756 (2021). https://doi.org/10.3390/en14102756
20. Campisi, T., Cocuzza, E., Ignaccolo, M., Inturri, G., Torrisi, V.: Exploring the factors that encourage the spread of EV-DRT into the sustainable urban mobility plans. In: Gervasi, O., et al. (eds.) ICCSA 2021. LNCS, vol. 12953, pp. 699–714. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-86976-2_48
21. Acampa, G., Campisi, T., Grasso, M., Marino, G., Torrisi, V.: Exploring European strategies for the optimization of the benefits and cost-effectiveness of private electric mobility. In: Gervasi, O., et al. (eds.) ICCSA 2021. LNCS, vol. 12953, pp. 715–729. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-86976-2_49
22. Hanson, S.: Gender and mobility: new approaches for informing sustainability. Gend. Place Cult. **17**(1), 5–23 (2010). https://doi.org/10.1080/09663690903498225
23. Sovacool, B.K., Kester, J., Noel, L., de Rubens, G.Z.: The demographics of decarbonizing transport: the influence of gender, education, occupation, age, and household size on electric mobility preferences in the Nordic region. Glob. Environ. Chang. **52**, 86–100 (2018). https://doi.org/10.1016/j.gloenvcha.2018.06.008
24. Caperello, N., TyreeHageman, J., Kurani, K.: Engendering the future of electric vehicles: conversations with men and women. In: Proceedings of 5th International Conference on Women's Issues in Transportation (WIIT), Paris, France, pp. 427–437 (2014). https://escholarship.org/uc/item/4fv7x1qv
25. Liao, F., Molin, E., van Wee, B.: Consumer preferences for electric vehicles: a literature review. Transp. Rev. **37**(3), 252–275 (2017). https://doi.org/10.1080/01441647.2016.1230794
26. Higgins, C.D., Mohamed, M., Ferguson, M.R.: Size matters: how vehicle body type affects consumer preferences for electric vehicles. Transp. Res. Part A Policy Pract. **100**, 182–201 (2017). https://doi.org/10.1016/j.tra.2017.04.014

27. Patel, A.R., Trivedi, G., Vyas, D., Mihaita, A.S., Padmanaban, S.: Framework for user-centered access to electric charging facilities via energy-trading blockchain. In: Proceedings of 24th International Symposium on Wireless Personal Multimedia Communications (WPMC), Okayama, Japan, pp. 1–6 (2021). https://doi.org/10.1109/WPMC52694.2021.9700475
28. Anderson, J.E., Lehne, M., Hardinghaus, M.: What electric vehicle users want: real-world preferences for public charging infrastructure. Int. J. Sustain. Transp. **12**(5), 341–352 (2018). https://doi.org/10.1080/15568318.2017.1372538
29. Vongurai, R.: Factors affecting customer brand preference toward electric vehicle in Bangkok, Thailand. J. Asian Financ. Econ. Bus. **7**(8), 383–393 (2020). https://doi.org/10.13106/jafeb.2020.vol7.no8.383
30. Schlüter, J., Weyer, J.: Car sharing as a means to raise acceptance of electric vehicles: an empirical study on regime change in automobility. Transport. Res. F Traffic Psychol. Behav. **60**, 185–201 (2019). https://doi.org/10.1016/j.trf.2018.09.005
31. Tiziana, C., Matteo, I., Giovanni, T., Giuseppe, I., Vincenza, T.: The evaluation of car-sharing to raise acceptance of electric vehicles: evidences from an Italian survey among university students. SAE Technical Paper, 2020-24-0021, pp. 1–10 (2020). https://doi.org/10.4271/2020-24-0021
32. Jensen, A.F., Cherchi, E., Mabit, S.L.: On the stability of preferences and attitudes before and after experiencing an electric vehicle. Transp. Res. Part D Transp. Environ. **25**, 24–32 (2013). https://doi.org/10.1016/j.trd.2013.07.006
33. Roberson, L.A., Helveston, J.P.: Electric vehicle adoption: can short experiences lead to big change? Environ. Res. Lett. **15**(9), 0940c3 (2020). https://doi.org/10.1088/1748-9326/aba715
34. He, L., Chen, W., Conzelmann, G.: Impact of vehicle usage on consumer choice of hybrid electric vehicles. Transp. Res. Part D Transp. Environ. **17**(3), 208–214 (2012). https://doi.org/10.1016/j.trd.2011.11.005
35. Kongklaew, C., et al.: Barriers to electric vehicle adoption in Thailand. Sustainability **13**(22), 12839 (2021). https://doi.org/10.3390/su132212839
36. Javid, R.J., Nejat, A.: A comprehensive model of regional electric vehicle adoption and penetration. Transp. Policy **54**, 30–42 (2017). https://doi.org/10.1016/j.tranpol.2016.11.003
37. Bansal, P., Kumar, R.R., Raj, A., Dubey, S., Graham, D.J.: Willingness to pay and attitudinal preferences of Indian consumers for electric vehicles. Energy Econ. **100**, 105340 (2021). https://doi.org/10.1016/j.eneco.2021.105340
38. Anthony Jnr., B.: Integrating electric vehicles to achieve sustainable energy as a service business model in smart cities. Front. Sustain. Cities **3**, 1–12 (2021). https://doi.org/10.3389/frsc.2021.685716
39. Kotilainen, K., Mäkinen, S.J., Valta, J.: Sustainable electric vehicle - prosumer framework and policy mix. In: 2017 IEEE Innovative Smart Grid Technologies - Asia (ISGT-Asia), Auckland, New Zealand, pp. 1–6 (2017). https://doi.org/10.1109/ISGT-Asia.2017.8378406
40. Rasouli, S., Timmermans, H.: Influence of social networks on latent choice of electric cars: a mixed logit specification using experimental design data. Netw. Spat. Econ. **16**(1), 99–130 (2016). https://doi.org/10.1007/s11067-013-9194-6
41. Jung Moon, S.: Integrating diffusion of innovations and theory of planned behavior to predict intention to adopt electric vehicles. Int. J. Bus. Manage. **15**(11), 88–103 (2020). https://doi.org/10.5539/ijbm.v15n11p88

42. Ye, F., Kang, W., Li, L., Wang, Z.: Why do consumers choose to buy electric vehicles? A paired data analysis of purchase intention configurations. Transp. Res. Part A Policy Pract. **147**, 14–27 (2021). https://doi.org/10.1016/j.tra.2021.02.014
43. Febransyah, A.: Predicting purchase intention towards battery electric vehicles: a case of Indonesian market. World Electr. Veh. J. **12**(4), 240 (2021). https://doi.org/10.3390/wevj12040240
44. Irfan, M., Ahmad, M.: Relating consumers' information and willingness to buy electric vehicles: does personality matter? Transp. Res. Part D Transp. Environ. **100**, 103049 (2021). https://doi.org/10.1016/j.trd.2021.103049
45. Lashari, Z.A., Ko, J., Jang, J.: Consumers' intention to purchase electric vehicles: influences of user attitude and perception. Sustainability **13**(12), 6778 (2021). https://doi.org/10.3390/su13126778
46. Lee, R., Brown, S.: Social & locational impacts on electric vehicle ownership and charging profiles. Energy Rep. **7**, 42–48 (2021). https://doi.org/10.1016/j.egyr.2021.02.057
47. Krause, R.M., Carley, S.R., Lane, B.W., Graham, J.D.: Perception and reality: public knowledge of plug-in electric vehicles in 21 U.S. cities. Energy Policy **63**, 433–440 (2013). https://doi.org/10.1016/j.enpol.2013.09.018
48. Verma, M., Verma, A., Khan, M.: Factors influencing the adoption of electric vehicles in Bengaluru. Transp. Dev. Econ. **6**(2), 1–10 (2020). https://doi.org/10.1007/s40890-020-0100-x
49. Smith, B., Olaru, D., Jabeen, F., Greaves, S.: Electric vehicles adoption: environmental enthusiast bias in discrete choice models. Transp. Res. Part D Transp. Environ. **51**, 290–303 (2017). https://doi.org/10.1016/j.trd.2017.01.008
50. Debnath, R., Bardhan, R., Reiner, D.M., Miller, J.R.: Political, economic, social, technological, legal and environmental dimensions of electric vehicle adoption in the United States: a social-media interaction analysis. Renew. Sustain. Energy Rev. **152**, 111707 (2021). https://doi.org/10.1016/j.rser.2021.111707
51. Sovacool, B.K., Kester, J., Noel, L., de Rubens, G.Z.: Income, political affiliation, urbanism and geography in stated preferences for electric vehicles (EVs) and vehicle-to-grid (V2G) technologies in Northern Europe. J. Transp. Geogr. **78**, 214–229 (2019). https://doi.org/10.1016/j.jtrangeo.2019.06.006
52. Ensslen, A., Paetz, A.-G., Babrowski, S., Jochem, P., Fichtner, W.: On the road to an electric mobility mass market—how can early adopters be characterized? In: Fornahl, D., Hülsmann, M. (eds.) Markets and Policy Measures in the Evolution of Electric Mobility. LNM, pp. 21–51. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-24229-3_3
53. McCoy, D., Lyons, S.: Consumer preferences and the influence of networks in electric vehicle diffusion: an agent-based microsimulation in Ireland. Energy Res. Soc. Sci. **3**, 89–101 (2014). https://doi.org/10.1016/j.erss.2014.07.008
54. Rastogi, A., Thomas, R.G., Digalwar, A.K.: Identification and analysis of social factors responsible for adoption of electric vehicles in India. Curr. Sci. **121**(9), 1180–1187 (2021). https://doi.org/10.18520/cs/v121/i9/1180-1187
55. Kenneth, N.J.J., Logenthiran, T.: A novel concept for calculating electricity price for electrical vehicles. In: Proceedings of 2017 IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC), Bangalore, India, pp. 1–6 (2017). https://doi.org/10.1109/APPEEC.2017.8308963
56. Nour, M., Said, S.M., Ali, A., Farkas, C.: Smart charging of electric vehicles according to electricity price. In: Proceedings of 2019 International Conference on Innovative Trends in Computer Engineering (ITCE), Aswan, Egypt, pp. 432–437 (2019). https://doi.org/10.1109/ITCE.2019.8646425

57. Kämpfe, B., et al.: Preferences and perceptions of bidirectional charging from a customer's perspective – a literature review and qualitative approach. In: Liebl, J. (ed.) Electrified Mobility 2019: Including Grid Integration of Electric Mobility, pp. 177–191. Springer, Wiesbaden (2022). https://doi.org/10.1007/978-3-658-32471-1_16
58. Hagman, J., Ritzén, S., Stier, J.J., Susilo, Y.: Total cost of ownership and its potential implications for battery electric vehicle diffusion. Res. Transp. Bus. Manage. **18**, 11–17 (2016). https://doi.org/10.1016/j.rtbm.2016.01.003
59. Vibhor, T., Paulus, A., Dilum, D.: Public attitudes towards electric vehicle adoption using structural equation modelling. In: Proceedings of 2019 World Conference on Transport Research (WCTR), Mumbai, India, pp. 1615–1634 (2019). https://doi.org/10.1016/j.trpro.2020.08.203
60. van Heuveln, K., Ghotge, R., Annema, J.A., van Bergen, E., van Wee, B., Pesch, U.: Factors influencing consumer acceptance of vehicle-to-grid by electric vehicle drivers in the Netherlands. Travel Behav. Soc. **24**, 34–45 (2021). https://doi.org/10.1016/j.tbs.2020.12.008
61. Lee, R., Brown, S.: Evaluating the role of behavior and social class in electric vehicle adoption and charging demands. iScience **24**(8), 102914 (2021). https://doi.org/10.1016/j.isci.2021.102914
62. Daniel, F., Filip, C., Maria, S.R., Constantin, F.: New mobile charging station for urban and resort areas. In: Proceedings of 2019 Electric Vehicles International Conference (EV), Bucharest, Romania, pp. 1–6 (2019). https://doi.org/10.1109/EV.2019.8892866
63. Abdullah-Al-Nahid, S., Khan, T.A., Taseen, M.A., Aziz, T.: A consumer-friendly electric vehicle charging scheme for residential consumers. In: Proceedings of 2020 International Conference on Smart Grids and Energy Systems (SGES), Perth, Australia, pp. 893–897 (2020). https://doi.org/10.1109/SGES51519.2020.00164
64. Broadbent, G., Metternicht, G., Drozdzewski, D.: An analysis of consumer incentives in support of electric vehicle uptake: an Australian case study. World Electr. Veh. J. **10**(1), 11 (2019). https://doi.org/10.3390/wevj10010011
65. Wee, S., Coffman, M., La Croix, S.: Do electric vehicle incentives matter? Evidence from the 50 U.S. states. Res. Policy **47**(9), 1601–1610 (2018). https://doi.org/10.1016/j.respol.2018.05.003
66. Cox, B., Bauer, C., Mendoza Beltran, A., van Vuuren, D.P., Mutel, C.L.: Life cycle environmental and cost comparison of current and future passenger cars under different energy scenarios. Appl. Energy **269**, 115021 (2020). https://doi.org/10.1016/j.apenergy.2020.115021
67. Alobeidli, K., Khadkikar, V.: A new ultracapacitor state of charge control concept to enhance battery lifespan of dual storage electric vehicles. IEEE Trans. Veh. Technol. **67**(11), 10470–10481 (2018). https://doi.org/10.1109/TVT.2018.2871038
68. Yang, X.-G., Liu, T., Wang, C.-Y.: Thermally modulated lithium iron phosphate batteries for mass-market electric vehicles. Nat. Energy **6**(2), 176–185 (2021). https://doi.org/10.1038/s41560-020-00757-7
69. Knoppe, M.: E-mobility generates new services and business models, increasing sustainability. In: Subic, A., Wellnitz, J., Leary, M., Koopmans, L. (eds.) Sustainable Automotive Technologies 2012, pp. 275–281. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-24145-1_36
70. Davis, L.W., Sallee, J.M.: Should electric vehicle drivers pay a mileage tax? Environ. Energy Policy Econ. **1**, 65–94 (2020). https://doi.org/10.1086/706793

71. Anil, K.M., Charan, T.S., Pradeep, K.Y.: Optimal charging schedule for electric vehicles in parking lot with solar power generation. In: Proceedings of 2018 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia), Singapore, pp. 611–615 (2018). https://doi.org/10.1109/ISGT-Asia.2018.8467916
72. Babic, J., Carvalho, A., Ketter, W., Podobnik, V.: Evaluating policies for parking lots handling electric vehicles. IEEE Access **6**, 944–961 (2018). https://doi.org/10.1109/ACCESS.2017.2777098
73. Abdelhak, B., Hamid, O., Mohamed, N.: Optimal sizing of electric vehicle charging stations in residential parking. In: Proceedings of 47th Annual Conference on the IEEE Industrial Electronics Society (IECON), Toronto, Canada, pp. 1–6 (2021). https://doi.org/10.1109/IECON48115.2021.9589453
74. Lavieri, P., Carmen, B.D.: Electric vehicle uptake and charging - a consumer-focused review. In: Technical Report of Large-Scale Network and System Integration of Electric Vehicles: A Techno-Economic Perspective, pp. 1–55 (2021). https://doi.org/10.13140/RG.2.2.17678.08009