Industrial Engineering Journal
ISSN: 0970-2555
Volume: 54, Issue 1, January:2025

A STUDY ON THE DIFFICULTIES AND POTENTIAL BENEFITS OF ELECTRIC VEHICLES (EVS)

Ms Ratnamanjari Mishra, Research Scholar ITM University, Raipur, Chhattisgarh, India
ratnamanjarim.2022@itmuniversity.org
Dr.Khushboo Sahu, Associate Professor, ITM University, Raipur, Chhattisgarh, India
skhushboo@itmuniversity.org

ABSTRACT:
The continuous advancement of technology within the automotive sector has led to an increased awareness of environmental and energy efficiency issues. Electric vehicles (EVs) are regarded as viable alternatives to traditional internal combustion engine (ICE) vehicles due to their various benefits. This paper examines the challenges and opportunities associated with the mass market introduction of EVs. The challenges are classified according to the establishment of a sustainable business model, encompassing economic, technological, social, and environmental dimensions. Additionally, the impact of government policies on the adoption of EVs is analysed. Projections for future trends in the EV market are made up to the year 2030. The analysis concludes that the primary obstacles hindering the market penetration of EVs include the prevailing market conditions, technological limitations, and social challenges. Recommendations are provided to address these challenges, aiming to enhance the market growth and performance of EVs, thereby contributing to a more sustainable future.
Keywords: **Environment, Electric Vehicles, Market Penetration and Sustainable Future**

INTRODUCTION :

The global consciousness surrounding energy conservation and environmental sustainability has intensified in recent years. Activities conducted by humans that lead to greenhouse gas emissions have severely affected the environment. For centuries, the automotive industry has predominantly utilized internal combustion engines (ICEs) to power vehicles, which depend on fossil fuels and release detrimental emissions. Conversely, electric vehicles (EVs) have been developed, presenting numerous benefits in comparison to ICE vehicles. EVs are characterized by their rapid acceleration, improved energy efficiency, and the capacity to significantly lower greenhouse gas emissions and air pollutants, as they generate no emissions during operation.

Electric vehicles (EVs) can be broadly classified into four categories: battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). BEVs operate exclusively on electric motors that derive their energy from batteries. In contrast, HEVs and PHEVs utilize internal combustion engines (ICE) in conjunction with electric motors. FCEVs, while also employing electric motors, are powered by a fuel cell stack. This paper is dedicated exclusively to the discussion of BEVs, and the term "EVs" within this context refers specifically to BEVs.

When comparing the powertrains of internal combustion engine (ICE) vehicles with those of electric vehicles (EVs), it is evident that EVs utilize systems that exhibit enhanced energy efficiency, primarily due to the reduction of energy waste through regenerative braking technology. This technology allows the vehicle to recover kinetic energy during braking, which is then converted back into electrical energy to recharge the batteries via the motors. Additionally, EVs do not draw energy while at rest, in stark contrast to ICE vehicles that consume fuel during idle periods. Moreover, the design of EVs negates the necessity for a gearbox, as electric motors are capable of generating peak torque across a wide range of speeds. This design choice not only minimizes energy loss but also reduces vehicle weight, thereby improving energy efficiency. Research has extensively documented

Industrial Engineering Journal
ISSN: 0970-2555
Volume: 54, Issue 1, January:2025

the environmental benefits of EVs, revealing that they emit 30-80% less greenhouse gas over their entire life cycle compared to ICE vehicles. As a result, EVs are increasingly viewed as a promising alternative to traditional ICE vehicles, with the potential for widespread adoption in the near future. Recent policy initiatives aimed at promoting EV market penetration have further facilitated their growth in the automotive sector.

In 2017, the global sales of electric vehicles (EVs) surpassed the 1 million mark, indicating a significant growth of 54% compared to the sales figures from 2016. China has emerged as the leading market for EVs, contributing to more than half of the total global sales. As depicted in Figure 1, cumulative global EV sales exceeded 3 million units in 2017, with China responsible for 40% of this total. The United States follows as the second largest market for EVs. These data points highlight the rapid expansion of the EV market on an international scale.

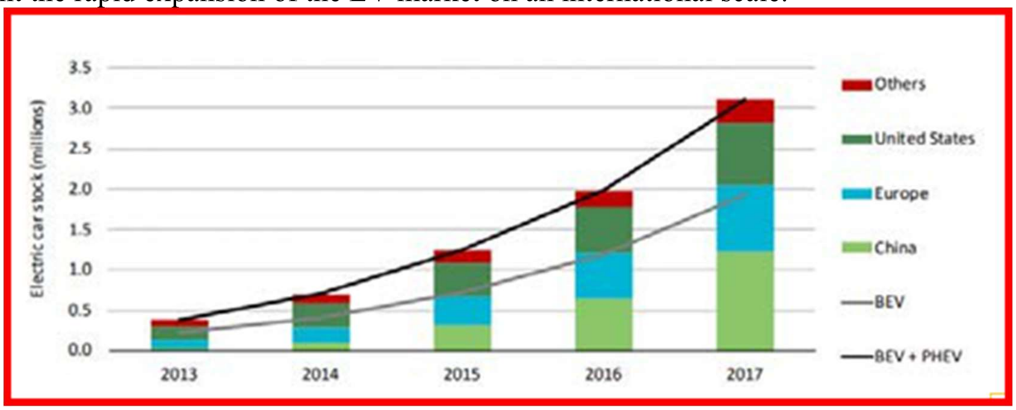

Figure- 1

The electric vehicle (EV) sector is experiencing growth; however, several obstacles impede its market expansion. These include the high initial purchase price, restricted driving range, insufficient charging infrastructure, and prolonged charging durations. Additionally, the energy storage systems (ESS) associated with EVs encounter issues related to safety, cost, and the management of energy storage and delivery. The current advancements in energy storage technology for EVs are significantly shaped by these challenges. This paper aims to review and analyze the various challenges and factors influencing the market growth and penetration of EVs. The objectives of this study include identifying the multifaceted challenges and forecasting future trends in the EV market.

ECONOMIC:

The automotive sector faces significant challenges in the widespread adoption of electric vehicles (EVs), necessitating strategic recommendations for their effective market integration. Economic factors represent a primary obstacle to the growth of EVs globally. Even in economically advanced nations, the transition to EVs encounters hurdles that hinder their mainstream acceptance. These economic challenges can be classified into three distinct categories.

E VEHICLE:

The economic viability of the electric vehicle itself presents numerous challenges. The current limitations of EV technology have resulted in various complications, making it difficult for these vehicles to compete with more affordable internal combustion engine (ICE) vehicles. To facilitate the promotion of EVs, collaboration from multiple stakeholders, particularly government entities, is essential. National policies significantly shape the EV market, but they also carry substantial economic implications. For instance, China, as the world's second-largest economy, plays a pivotal role in advancing EV adoption globally. However, as a leading oil producer, the rise of EVs poses challenges to the petroleum sector in China, thereby influencing the broader economy. Despite the lower operational costs of electricity compared to gasoline and diesel, the nascent state of EV technology has resulted in higher initial costs, which can deter potential buyers. The current manual assembly processes and the lack of economies of scale in producing expensive EV components further exacerbate the pricing issue, necessitating higher retail prices to ensure profitability for manufacturers.

BATTERY:

The cost associated with batteries has historically been a matter of concern, independent of their applications. In recent years, there has been a marked reduction in battery prices, coupled with a gradual enhancement in energy density, as illustrated in Figure 2 below. This trend has significantly supported the growth of electric vehicles (EVs) in the market, as evidenced by Figure 1 above. Nevertheless, despite the decrease in battery costs, the challenge of economically manufacturing batteries at scale persists, largely due to the reliance on expensive materials and advanced production processes that contribute to the high costs of batteries for EV applications. Current technological capabilities have not yet achieved the production of high-performance batteries using conventional materials. For electric vehicles, it is imperative that batteries maintain a high energy capacity to ensure extended range

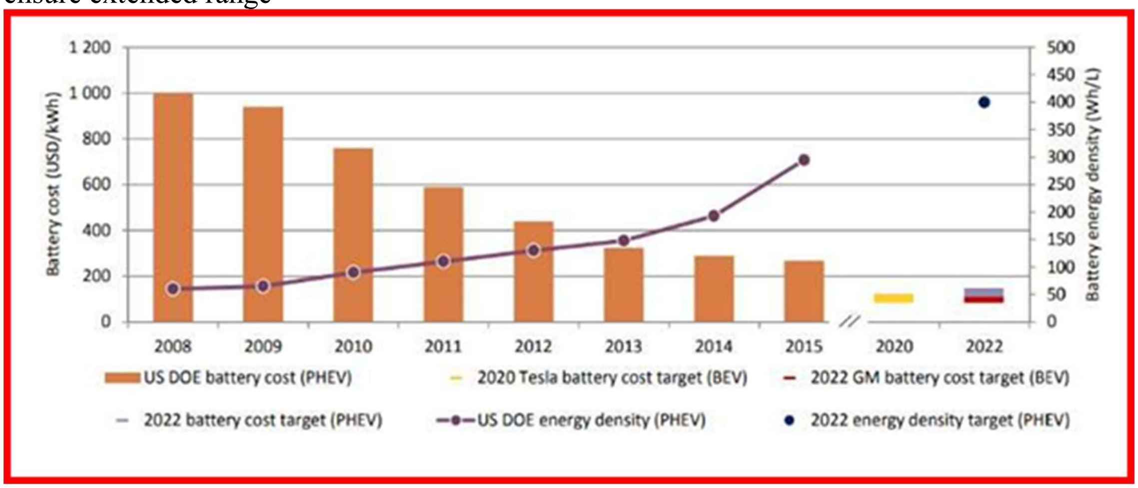

Figure- 2

The development of batteries presents challenges that are strikingly similar to the economic issues confronting electric vehicles (EVs) as previously outlined. According to Li and Ouyang, a reduction in battery costs for EVs could significantly lower overall consumer expenditures, allowing for a greater willingness to pay higher charging prices. The substantial expense associated with batteries is a primary reason why EV prices are expected to remain higher than those of conventional internal combustion engine (ICE) vehicles in the near future, despite the availability of government purchase subsidies in numerous countries. To effectively lower EV prices, it is crucial to enhance and expand production capabilities, thereby increasing the output of EVs and making them more affordable in the marketplace. Research indicates that for EVs to achieve widespread market acceptance without government subsidies, a considerable reduction in battery costs is essential. Furthermore, Adepetu and Keshav contend that the cost of EVs is more critical than their overall performance, asserting that prioritizing cost reduction is more vital than performance enhancement. However, achieving these objectives necessitates a significant boost in EV sales, which appears unlikely given the current state of battery technology.

INFRASTRUCTURE

The classification of electric vehicle (EV) charging infrastructure based on accessibility includes three main types: public, semi-public, and private. Public charging infrastructure is accessible to all individuals and is generally located in public parking spaces. In contrast, semi-public charging infrastructure is limited to designated groups. Private charging infrastructure is typically installed in personal garages or residences. As shown in Figure 3, the prevalence of private charging infrastructure has exceeded that of public infrastructure, primarily due to its greater accessibility and the preferences of EV users. Nonetheless, it is important to emphasize the essential role that public charging infrastructure plays in facilitating the widespread adoption of EVs and in alleviating users' range anxiety.

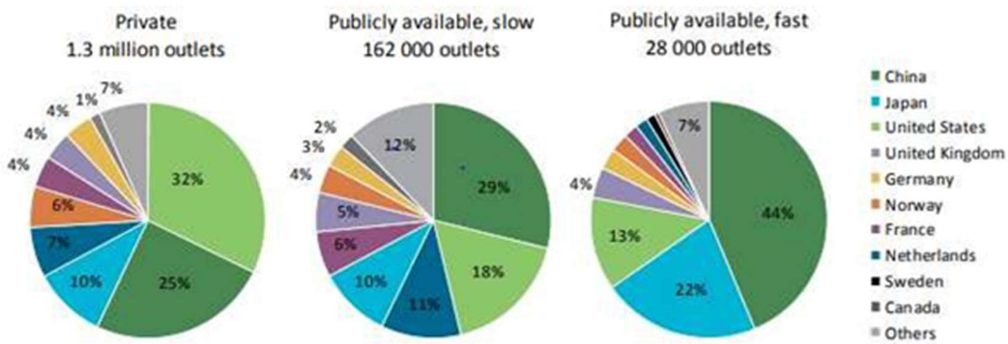

Figure- 3

The infrastructure for charging electric vehicles (EVs) can be categorized into three distinct types based on their accessibility: public, semi-public, and private. Public charging stations are universally accessible and are commonly found in public parking facilities. In contrast, semi-public charging stations are designated for use by specific groups of individuals. Private charging stations are typically installed in personal garages or residences. As depicted in Figure 3, the number of private charging stations has outstripped that of public stations, primarily due to their enhanced accessibility and the preferences of EV owners. However, it is crucial to acknowledge the significant role that public charging stations play in promoting the widespread adoption of EVs and in mitigating range anxiety among users.

The interplay between subsidies and construction incentives is critical in the development of charging infrastructure. The pricing structure, along with subsidies for both construction and operational costs, is directly proportional to the profitability of charging stations. However, various factors such as charging demand, geographical positioning, and the density of electric vehicles (EVs) create complex interactions that influence profitability. For example, the revenue generated and the number of charging units is significantly affected by the level of charging demand, which in turn impacts the capital expenditure required for establishing charging infrastructure. Research indicates that for charging stations to maintain profitability, they must be strategically situated in urban centres, as rural locations often yield insufficient demand to support financial viability. While urban installations provide enhanced accessibility for EV users, they typically incur higher rental costs. To mitigate range anxiety among EV users, it is essential to establish charging facilities in both urban and rural settings. Evidence from Stuttgart reveals that charging stations are underutilized and economically unviable due to their high concentration in a single area, leading to investor reluctance in funding public charging projects. Furthermore, at this nascent stage, policymakers and investors recognize the absence of a robust business model for public charging infrastructure, which significantly affects their investment choices. Ultimately, the number of EVs is the most critical determinant of charging demand and the overall profitability of charging infrastructure; a higher EV population correlates with increased demand for charging services, thereby enhancing the financial sustainability of these facilities.

The economic landscape of charging infrastructures is influenced by a variety of indirect factors, including the technologies associated with the charging infrastructure, advancements in electric vehicle (EV) technologies, developments in battery technologies, the psychological aspects and behaviours of EV users, and relevant government policies. The interplay between direct and indirect factors is crucial, as their effects on charging infrastructures are evident. For example, the geographical placement and availability of charging stations are influenced by the driving range of EVs, which is contingent upon the technologies employed in both EVs and batteries. Furthermore, improvements in EV technologies can extend driving ranges, thereby facilitating greater market penetration by alleviating concerns related to range anxiety. It is also recognized that increasing the density of charging stations can mitigate range anxiety. Additionally, the characteristics of charging infrastructure technology directly impact charging durations, which in turn affects the number of EVs in circulation. Moreover, the relationship between EV and battery technologies is significant, as the driving range of EVs is linked to the cost-effectiveness of charging infrastructure. In conclusion, comprehensive research and analysis are essential to enhance the economic viability of charging infrastructure, thereby promoting its installation and expansion through practical solutions aimed at improving economic performance. The market penetration of EVs can be further advanced by developing charging infrastructures that are responsive to demand.

TECHNOLOGY:

From a technological standpoint, the integration of electric vehicles is challenged by several factors. A significant issue is the energy storage system, which is integral to the functionality of electric vehicles, as it stores and provides the necessary power. The hurdles in the manufacturing and development of these energy storage systems are considerable. The availability of raw materials poses a significant challenge in the production of energy storage systems for electric vehicles. These systems must utilize high-grade materials to ensure they perform effectively and operate safely, minimizing risks such as corrosion and explosion.

The design of a modern electric vehicle system aims to efficiently handle all potential energy resources based on their availability [14]. A critical concern regarding current energy storage systems is their size and financial implications. It is noteworthy that around one-third of the total cost of an electric vehicle is attributed to the energy storage system. The high expense of this system is influenced by various components, such as material costs, packaging, power conversion, replacement, operational expenses, maintenance, and labour.

The use of Li-ion batteries has been increasing in popularity and has become the dominant battery technology for the automotive industry [39]. For a smooth operation, every energy storage system needs to be protected and maintained. Electric vehicles that are equipped with Li-ion batteries are faced with safety and cost issues that are related to thermal effects in the batteries [40]. In electric vehicles, the Li-ion batteries need to be protected from overcharging and over discharging. This is because it is proven that when the Li-ion battery is over discharging, high rates of heat generation and electrochemical reaction occur and thus the batteries are prone to an increase in temperature [41]. The increase in temperature within the Li-ion batteries is the main cause of safety issues such as swelling, thermal runaway, electrolyte fire and explosions [42]. Therefore, the application of Li-ion batteries within electric vehicles still require further analysing and understanding of the thermal effects in the batteries under different conditions.

The adoption of lithium-ion (Li-ion) batteries has surged, establishing them as the predominant battery technology within the automotive sector. To ensure optimal performance, it is essential to implement protective measures and maintenance protocols for every energy storage system. Electric vehicles utilizing Li-ion batteries encounter safety and cost challenges associated with thermal dynamics. Specifically, these batteries must be safeguarded against both overcharging and over-discharging, as excessive discharge can lead to significant heat generation and heightened electrochemical reactions, resulting in elevated temperatures. Such temperature increases are critical contributors to safety hazards, including battery swelling, thermal runaway, electrolyte combustion, and potential explosions. Consequently, a comprehensive analysis and deeper understanding of the thermal behavior of Li-ion batteries under varying conditions remain imperative for their application in electric vehicles.

INFRASTRUCTURE:

One of the primary obstacles hindering the integration of electric vehicles (EVs) into the current market is the insufficient availability of public charging infrastructure. Unlike traditional vehicles that rely on fuel, EVs depend on energy storage systems, such as batteries, which necessitate recharging. This requirement, in turn, demands additional energy to be supplied from the existing power grid and power generation facilities. Consequently, it is imperative to harness renewable energy sources, such as wind and solar power, to meet this demand. The cost of charging may be affected by the technologies employed in both the power grids and the charging infrastructure. Furthermore, advancements in charging technology can influence the duration of charging sessions, thereby impacting the overall adoption rate of EVs.

SOCIAL:

The social dimension of electric vehicles (EVs) significantly influences economic development, as it encompasses the indirect elements that deter potential consumers from embracing EV technology. These elements typically involve advancements in EV technology, psychological influences, regulatory frameworks, and consumer behavior [9]. The successful integration of EVs into the market presents a socio-technical challenge, reliant on the interplay between consumer attitudes and the operational efficacy of the vehicles [50]. Psychological influences encompass consumers' perceptions regarding costs and benefits, their openness to new technologies, and the impact of social factors [9]. A notable psychological concern among EV users is range anxiety, which refers to the persistent fear of becoming stranded due to a depleted battery, stemming from the vehicle's limited driving range [51,52]. A research team conducted an investigation into the barriers to EV adoption, utilizing a mixed-methods approach that included a survey of nearly 5,000 participants, semi-structured interviews with experts from approximately 200 organizations, and eight focus groups across 17 cities in the Nordic region [53].

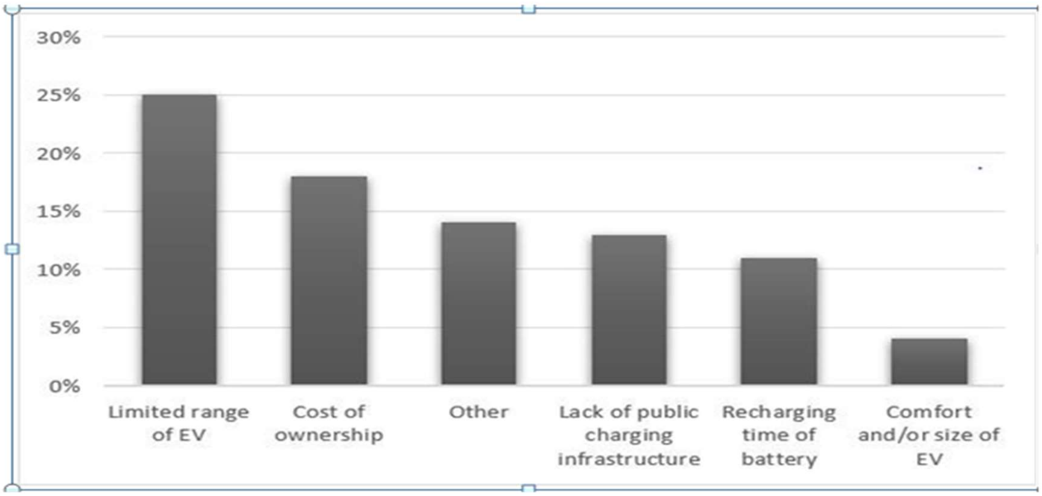

Figure- 4

ENVIRONMENTAL:

Transitioning from internal combustion engine (ICE) vehicles to electric vehicles (EVs) plays a crucial role in enhancing environmental quality. EVs are considered to be environmentally sustainable since they operate on battery power, thereby eliminating tailpipe emissions. Conversely, the burning of petroleum in ICE vehicles releases toxic substances into the air, posing risks to both human health and ecological systems. However, the process of generating electricity for EV charging is not without its own environmental consequences, as it can produce greenhouse gas emissions that contribute to global warming.

GOVERNMENT POLICIES:

In response to the pressing need for governments and industries to mitigate the effects of accumulated greenhouse gas (GHG) emissions, as well as the recognition of the advantages offered by electric vehicles (EVs), a series of new policies aimed at promoting EV adoption have been established. Nations including the United States, Norway, China, Germany, and Brazil have initiated strategies categorized into three main areas: incentives, regulations, and subsidies, all designed to facilitate the integration of EVs into the market. Absent these supportive measures, the majority of consumers would likely refrain from purchasing EVs, primarily due to their significantly higher costs compared to internal combustion engine (ICE) vehicles and the insufficient availability of charging infrastructure. For instance, the U.S. Department of Energy has established over 17,000 charging stations as part of the EV Project and the ChargePoint America initiative. Additionally, the Idaho National Laboratory has utilized this newly developed network of charging stations to assess the engagement and utilization of EVs across various states.

FUTURE TREND:

Electric vehicles (EVs) are anticipated to play a pivotal role in the future of transportation, as evidenced by their rapidly expanding market share, driven by significant investments in recent years. The promotion of EVs for widespread adoption is expected to lead to a substantial increase in their uptake, facilitated by a decrease in costs resulting from economies of scale. This heightened demand will likely attract further investment in the research and development of EV technologies, thereby expediting the global transition to electric mobility. The International Energy Agency (IEA) has forecasted a rise in the global stock of EVs from 3.7 million in 2017 to 13 million by 2020, ultimately reaching 130 million by 2030. Concurrently, EV sales are projected to grow at an average rate of 24% throughout this period, increasing from 1.4 million in 2017 to 4 million by 2020, and eventually achieving 21.5 million by 2030

CONCLUSION AND RECOMMENDATIONS:

This study examines the various challenges and opportunities associated with the mass market deployment of electric vehicles (EVs). The challenges identified can be categorized into four primary domains: economic, technological, social, and environmental. Economic challenges are particularly significant, as the high purchase price of EVs has hindered widespread adoption. The low rate of EV uptake has led to substantial initial investments and diminished profitability for public charging infrastructure, adversely affecting its economic viability and sustainability. In terms of technological challenges, the production of energy storage systems for EVs remains economically unfeasible, and the thermal instability of lithium-ion batteries under extreme conditions has yet to be resolved. Additionally, the energy density of existing battery technologies is considerably lower than that of conventional fuels, which restricts driving range. There is also a pressing need for advanced renewable energy technologies to generate sufficient electricity for the power grid to meet the growing demand for charging. From a social perspective, range anxiety has contributed to negative societal perceptions of EVs, primarily due to their limited range, extended charging times, and inadequate charging infrastructure. While EVs are characterized by zero tailpipe emissions, they still face environmental challenges, including greenhouse gas emissions associated with electricity generation for battery recharging. Furthermore, the manufacturing and disposal processes of batteries at the end of their life cycle can lead to significant environmental pollution.

The development of charging infrastructure for electric vehicles (EVs) is a significant concern that warrants attention. It is essential for governments to collaborate with private entities to enhance the availability of public charging stations. This can be achieved by offering incentives and subsidizing the operational and maintenance costs associated with these infrastructures. Furthermore, rather than merely increasing the number of charging stations, it is crucial to conduct thorough research on the charging habits of EV users to identify optimal locations for these facilities. Comprehensive studies on the economic aspects of charging infrastructure are necessary to facilitate its expansion and effectiveness, providing practical solutions to enhance its financial viability. Additionally, standardizing the technological integration between EVs and charging stations is vital for promoting the widespread adoption of electric vehicles. For instance, implementing a universal charging port that offers high efficiency and compatibility across various manufacturers' vehicles would be beneficial.

REFERENCES:

1. Faizal, M., Chelvan, R.K., Amirah, A. 2017. Energy, Economic and Environmental Impact of Wind Power in Malaysia. International Journal of Advanced Scientific Research and Management, 2, Pp. 81-87.

2. Faizal, M., Fong, L.J., Chiam, J., Amirah, A. 2017. Energy, Economic and Environmental Impact of Hydropower in Malaysia. International Journal of Advanced Scientific Research and Management, 2, Pp. 33-42.

3. Faizal, M., Ateeb, S. 2018. Energy, Economic and Environmental Impact of Palm Oil Biodiesel in Malaysia. Journal of Mechanical Engineering Research and Developments, 41, Pp. 93-95.

4. Faizal, M., Ang, W.Y., Amirah, A., Tan, Y.H. 2019. Energy, Economic and Environmental Impact of Sugarcane Bagasse in Malaysia. International Journal of Advanced Scientific Research and Management, 4, Pp. 104-110.

5. Faizal, M., Wardah, Y.H., Husna, M.A., Amirah, A., Tan, Y.H. 2018. Energy, Economic And Environmental Impact Of Waste-To-Energy In Malaysia. Journal of Mechanical Engineering Research and Developments, 41, Pp. 109-113.

6. Marshall, B.M., Kelly, J.C., Lee, T.K., Keoleian, G.A., Filipi, Z. 2013. Environmental assessment of plug-in hybrid electric vehicles using naturalistic drive cycles and vehicle travel patterns: A Michigan case study. Energy Policy, 58, Pp. 358–370.

7. Jaunky, V.C. 2011. The CO2 emissions-income nexus: Evidence from rich countries. Energy Policy, 39 (3), Pp. 1228–1240.

8. Sadorsky, P. 2014. The effect of urbanization and industrialization on energy use in emerging economies: Implications for sustainable development. American Journal of Economics and Sociology, 73 (2), Pp. 392–409.

9. Zhang, Q., Li, H., Zhu, L., Campana, P.E., Lu, H., Wallin, F., Sun, Q. 2018. Factors influencing the economics of public charging infrastructures for EV – A review. Renewable & Sustainable Energy Reviews, 94, Pp. 500–509.

10. Kihm, A., Trommer, S. 2014. The new car market for electric vehicles and the potential for fuel substitution. Energy Policy, 73, Pp. 147–157.

11. Peng, T., Ou, X., Yan, X. 2018. Development and application of an electric vehicle's life-cycle energy consumption and greenhouse gas emissions analysis model. Chemical Engineering Research and Design, 131, Pp. 699–708.

12. He, F., Wu, D., Yin, Y., Guan, Y. 2013. Optimal deployment of public charging stations for plug-in hybrid electric vehicles. Transportation Research Part B: Methodological, 47, Pp. 87–101.

13. Global EV Outlook. 2016. International Energy Agency, Paris.

14. Hannan, M.A., Hoque, M.M., Mohamed, A., Ayob, A. 2017. Review of energy storage systems for electric vehicle applications: Issues and challenges. Renewable & Sustainable Energy Reviews, 69, Pp. 771–789.

15. EIA. 2015. International Data and Analysis: China, Pp. 1–36.

16. Ji, Q., Fan, Y. 2016. How do China's oil markets affect other commodity markets both domestically and internationally. Finance Research Letters, 19, Pp. 247–254.

17. Kroll, J., Kooy, A., Seebacher, R. 2010. Torsional Vibratiion Damping for Future Engines. Symp. A Q. J. Mod. Foreign Lit.

18. Sapinski, B., Snamina, J.J. 2017. Automotive vehicle engine mount based on an MR squeeze-mode damper: modeling and simulation. Journal of Theoretical and Applied Mechanics, Pp. 377.

19. Boulanger, A.G., Chu, A.C., Maxx, S., Waltz, D.L. 2011. Vehicle Electrification: Status and Issues. Proc. IEEE, 99 (6), Pp. 1116–1138.

20. Sullivan, I.S.J.L., Simon, C., Institute, T.R. PHEV marketplace penetration: an agent based simulation. University of Michigan.

21. Hidrue, M.K., Parsons, G.R., Kempton, W., Gardner, M.P. 2011. Willingness to pay for electric vehicles and their attributes. Resource and Energy Economics, 33 (3), Pp. 686–705.

22. Armstrong, A.R., Robertson, A.D. 2002. Time to recharge. Chem. Br., 38 (2), Pp. 38–41.

23. Hilson, G. 2008. A load too heavy': Critical reflections on the child labor problem in Africa's small-scale mining sector. Children and Youth Services Review, 30 (11), Pp. 1233–1245.

24. Li, Z., Ouyang, M. 2011. The pricing of charging for electric vehicles in China—Dilemma and solution. Energy, 36 (9), Pp. 5765–5778.

25. Adepetu, A., Keshav, S. 2017. The relative importance of price and driving range on electric vehicle adoption: Los Angeles case study. Transportation (Amst)., 44 (2), Pp. 353–373.

26. Gnann, T., Stephens, T.S., Lin, Z., Plötz, P., Liu, C., Brokate, J. 2018. What drives the market for plug-in electric vehicles? - A review of international PEV market diffusion models. Renewable & Sustainable Energy Reviews, 93, Pp. 158–164.

27. Morrissey, P., Weldon, P., O'Mahony, M. 2016. Future standard and fast charging infrastructure planning: An analysis of electric vehicle charging behaviour. Energy Policy, 89, Pp. 257–270.

28. Schroeder, A., Traber, T. 2012. The economics of fast charging infrastructure for electric vehicles. Energy Policy, 43, Pp. 136–144.

29. Li, Z., Ouyang, M. 2011. The pricing of charging for electric vehicles in China-Dilemma and solution. Energy, 36 (9), Pp. 5765–5778.

30. Burnham, A., Dufek, E.J., Stephens, T., Francfort, J., Michelbacher, C. 2017. Enabling fast charging – Infrastructure and economic considerations. Journal of Power Sources, 367, Pp. 237–249.

31. Wirges, J., Linder, S., Kessler, A. 2012. Modelling the development of a regional charging infrastructure for electric vehicles in time and space. European Journal of Transport and Infrastructure Research, 12 (4), Pp. 391–416.

32. Bakker, J. 2011. Contesting range anxiety: The role of electric vehicle charging infrastructure in the transportation transition. Eindhoven University of Technology, 18.

33. Gay, D., Rogers, T., Shirley, R. 2018. Small island developing states and their suitability for electric vehicles and vehicle-to-grid services. Utilities Policy, 55, Pp. 69–78.

34. Ji, Z., Huang, X. 2018. Plug-in electric vehicle charging infrastructure deployment of China towards 2020: Policies, methodologies, and challenges. Renewable & Sustainable Energy Reviews, 90, Pp. 710–727.

35. Wu, T., Ma, L., Mao, Z., Ou, X. 2015. Setting up charging electric stations within residential communities in current China: Gaming of government agencies and property management companies. Energy Policy, 77, Pp. 216–226.

36. Feng, W., Figliozzi, M. 2013. An economic and technological analysis of the key factors affecting the competitiveness of electric commercial vehicles: A case study from the USA market. Transportation Research Part C: Emerging Technologies, 26, Pp. 135–145.

37. Wirges, J., Linder, S., Kessler, A. 2012. Modelling the development of a regional charging infrastructure for electric vehicles in time and space. European Journal of Transport and Infrastructure Research, 12 (4), Pp. 391–416.

38. Philipsen, R., Brell, T., Brost, W., Eickels, T., Ziefle, M. 2018. Running on empty – Users' charging behavior of electric vehicles versus traditional refuelling. Transportation Research Part F: Traffic Psychology and Behaviour, 59, Pp. 475–492.

39. Wright, D.R., Garcia-Araez, N., Owen, J.R. 2018. Review on high temperature secondary Li-ion batteries. Energy Procedia, 151, Pp. 174– 181.

40. Smith, J., Singh, R., Hinterberger, M., Mochizuki, M. 2018. Battery thermal management system for electric vehicle using heat pipes. International Journal of Thermal Sciences, 134 (6), Pp. 517–529.

41. Mahmoudzadeh Andwari, A., Pesiridis, A., Rajoo, S., Martinez-Botas, R., Esfahanian, V. 2017. A review of Battery Electric Vehicle technology and readiness levels. Renewable & Sustainable Energy Reviews, 78, Pp. 414– 430.

42. Ogura, K., Kolhe, M.L. 2017. Battery technologies for electric vehicles. Electric Vehicles: Prospects and Challenges.

43. Shao, M., Deng, J., Zhong, F., Cao, Y., Ai, X., Qian, J., Yang, H. 2018. An all-vanadium aqueous lithium ion battery with high energy density and long lifespan. Energy Storage Mater, Pp. 1–8.

44. Tao, L., Li, J., Zhou, Q., Zhu, H., Hu, G., Huang, J. 2018. Composition, microstructure and performance of cobalt nickel phosphate as advanced battery-type capacitive material. Journal of Alloys and Compounds, 767, Pp. 789–796.

45. Azidin, F.A., Hannan, M.A., Mohamed, A. 2013. Renewable Energy Technologies and Hybrid Electric Vehicle Challenges. Prz. Elektrotechniczny, 89 (8), Pp. 150–156.

46. Li, Y. 2016. Infrastructure to Facilitate Usage of Electric Vehicles and its Impact. Transportation Research Procedia, 14, Pp. 2537–2543.

47. Razeghi, G., Samuelsen, S. 2016. Impacts of plug-in electric vehicles in a balancing area. Applied Energy, 183, Pp. 1142–1156.

48. Motoaki, Y., Shirk, M.G. 2017. Consumer behavioral adaption in EV fast charging through pricing. Energy Policy, 108, Pp. 178–183.

49. Sbordone, D., Bertini, I., Di Pietra, B., Falvo, M.C., Genovese, A., Martirano, L. 2015. EV fast charging stations and energy storage technologies: A real implementation in the smart micro grid paradigm. Electric Power Systems Research, 120, Pp. 96–108.

50. Steinhilber, S., Wells, P., Thankappan, S. 2013. Socio-technical inertia: Understanding the barriers to electric vehicles. Energy Policy, 60, Pp. 531– 539.

51. Nilsson, M. 2011. Electric Vehicles: An interview study investigating the phenomenon of range anxiety. Qual. Interview Study Range Anxiety, Pp. 1–15.

52. Feng, B., Ye, Q., Collins, B.J. 2018. A dynamic model of electric vehicle adoption: The role of social commerce in new transportation Inf. Manag., Pp. 1–17.

53. Noel, L., Zarazua de Rubens, G., Sovacool, B.K., Kester, J. 2019. Fear and loathing of electric vehicles: The reactionary rhetoric of range anxiety. Energy Research & Social Science, 48, Pp. 96–107.

54. Melliger, M.A., van Vliet, O.P.R., Liimatainen, H. 2018. Anxiety vs reality – Sufficiency of battery electric vehicle range in Switzerland and Finland. Transportation Research Part D: Transport and Environment, 65, Pp. 101–115.

55. Clogston, F., Todd, J., Chen, J. 2013. Analysis of the electric vehicle industry. Electric vehicle, 18 (1), Pp. 1–100.

56. Nie, Y.M., Ghamami, M. 2013. A corridor-centric approach to planning electric vehicle charging infrastructure. Transportation Research Part B: Methodological, 57, Pp. 172–190.

57. Funke, S.A., Gnann, T., Plötz, P. 2015. Addressing the Different Needs for Charging Infrastructure: An Analysis of Some Criteria for Charging Infrastructure Set-up BT - E-Mobility in Europe: Trends and Good Practice. W. Leal Filho and R. Kotter, Eds. Cham: Springer International Publishing, Pp. 73–90.

58. Sun, Z., Gao, W., Li, B., Wang, L. 2018. Locating charging stations for electric vehicles. Transp. Policy.

59. Bryden, T.S., Hilton, G., Cruden, A., Holton, T. 2018. Electric vehicle fast charging station usage and power requirements. Energy, 152, Pp. 322– 332.

60. Erbaş, M., Kabak, M., Özceylan, E., Çetinkaya, C. 2018. Optimal siting