**International Journal of Engineering and Technical Research (IJETR)**
**ISSN: 2321-0869 (O) 2454-4698 (P), Volume-11, Issue-12, December 2021**

# Challenges and barriers for sustainable use of electric vehicles in Nepal

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**Abstract - With the depletion of the fossil fuels especially petrol and diesel, there is no other alternative than to shift the transport sector to alternative fuels. In this regards, Electric vehicle is one of the upcoming technologies with the potential to phase out the IC engine vehicle. In addition to the alternative to the fossil fuels, the electric vehicle has an added advantage of reducing the green house gas emission. Looking at this the Government of Nepal has developed various plans and policies regarding the promotion of electric vehicle like SNDC and SDG-7. The study aims to determine the major challenges and barriers for the promotion of the electric vehicle for the sustainable use in Nepal. In present context around 1.9 million tonnes of CO2-eq is emitted from the vehicles used in Nepal. While the small passenger transports like tempo and e-rickshaw are dependent on electricity, most of the passenger and freight vehicles is completely dependent on fossil fuels for energy generation. While cost of the electric vehicle is the major concern from the users point of view, managing the electric supply for the charging along with the management of energy flow from the grid is major concern for the decision makers.**

**Key words: Electric vehicle, Transportation, Emission, Challenges**

## 1. INTRODUCTION

The first electric vehicle was built by Frenchman Gustav Trauve in 1881. It was a tricycle powered by a 0.1 HP dc motor fed by lead-acid batteries (M. Ehsaani, 2005). In the meantime, gasoline vehicles were invented. Both the gasoline and EV had a competition for about 20-30 years. After that advancement of Internal Combustion Engine, its reliability, range, speed, cheap gasoline surpassed EV and hence development of EV remained disturbed until the invention of Chips and advancement in battery technology. So, nowadays due to that reason EV has emerged as competitive player with advanced gasoline powered vehicles. It seems that in future due to increased gasoline price and environmental concern electric vehicles will be number one again. Many countries already announced in the development of EV and cutting gasoline engines production plan also shows the bright future. It is even more relevant for Nepal because of possibility of tremendous renewable energy source i.e., hydropower.

Electric vehicles depict most reliable solution for the future in road transportation field, taking into consideration the interest in reducing greenhouse gas emissions (GHGs), as well as air and sound pollution (J. Brady et. al., 2011).In 2015, "Paris declaration on Electro-Mobility and Climate Change and Call to Action" has been adopted due to its contribution in less GHGs emission. This declaration has as a main objective reducing global warming with more than 2 degrees. This goal is achievable if electric vehicles represent 35 % from the total number of vehicles sold until 2030 ( Lewish et. al., 2021). In order to reach this target, a decrease in the acquisition price of the electric vehicles is mandatory until it reaches a level closer to that of the internal combustion engine vehicles. Nowadays, the most expensive part of an electric vehicle is the battery, which represents 25 -50 % of the price of the electric vehicle, depending of the technology used (Nykvist, 2015).

Geographically, Nepal is a midsize country with poor quality road infrastructure and variable terrain are challenges for EV. Tremendous hydro power potentiality and surplus electricity in near future is strong point for sustainable EV use. Governmental rules/regulations are inadequate in different dimensions for the sustainable EV use in Nepal. The study is both qualitative and quantitative. The analysis of current legal aspects and possible improvement, environmental impacts, social aspects etc. generally are qualitative analysis while comparative economic analysis, pollution analysis, gradeability analysis may ask for quantitative analysis. Similar studies in national and international practice will be done to get the result realistic and implementable for Nepal. The introduction of EVs in Nepal has aimed to reduce environmental pollution from combustion vehicles. Vehicles that run on combustion fuels to power the engine are significant components of polluting the environment due to the harmful waste gases produced, such as carbon dioxide. Major countries globally, for this reason, are pushing to have electric vehicles as the standard form of transport means to be used rather than gasoline engine powered vehicles. Following the same trend, EVs in Nepal are also being promoted.

## 2. PROMOTION OF ELECTRIC VEHICLES

The electric vehicles in the road of Nepal are around 1% in (MFE Report, 2020). With the country's aim to reduce the carbon emission along with increasing the share of the electrical vehicle in overall mix, the government has developed various plans and policies like Sustainable Development Goals-7 goals, Second Nationally determined Contribution, Long term strategy for Net Zero emission, Environment-friendly Vehicle and Transport Policy, National Transport Policy etc.

2.1 Second Nationally Determined Contribution

Goal: Formulation of Long-term low GHG emission development strategy by 2021 to achieve net-zero GHG emission by 2050.

Target:

- In 2025, sales of electric vehicle will be 25% of all private passenger vehicle sales, comprising of two-wheeler and 20% of all four-wheeler public passenger vehicle sales excluding erickshaws and electric tempos. As a consequence, there will be decreased in fossil fuel energy demand from 40 PJ to 36 PJ. This target will mitigate CO2 eq. emission from 2,988 Gg to 2,734 Gg CO2 eq. ·
- By 2030, electric vehicles sales will increase to cover 90% of all private passenger (two wheeler and 60% of four-wheeler public passenger vehicle excluding e-rickshaw and etempos. Thus, mitigation of emission will be from 3,640 Gg CO2 eq. to 2,619 Gg CO2 eq.
- By 2030, develop 200 km of electric rail network to use as public travelling as well as freight transportation

**2.2 Sustainable Development Goals**

Goal: Ensure access to affordable, reliable, sustainable, and modern energy for all

Target:

- By 2030, ensure universal access to affordable, reliable and modern energy services ·
- By 2030, increase substantially the share of renewable energy in the global mix ·
- By 2030, double the global rate of improvement in the energy efficiency
- By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossilfuel technology and promote investment in energy infrastructure and clean energy technology. ·
- By 2030, expand infrastructure and update technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries and small island developing states.

2.3 National Transport Policy (2002)

- Co-operating policies and programs that mitigates emission from the transport sector
- Provisions to restrict polluting vehicles restrict the operation of vehicles in urban core areas and development of cycle tracks
- Provision to exclude heavy tax on non-polluting vehicles
- Formation of Road Transport Authority for road transport management ·
- Incorporation of National Transport Board to coordinate authorities relating to transport

2.4 Environment-friendly Vehicle and Transport Policy (2014)

- Development and extension of environment-friendly and electric vehicles and transportation. ·
- Rules and regulation to allow conversion of technically feasible motor vehicles into electric vehicles. ·
- Aim to achieve exceeding 20% of vehicle fleets to be environmentfriendly vehicles by 2020. ·
- Construction of safe cycle tracks and efficient charging stations for electric vehicles to reduce emission.
- Tax reduction and the provision of flow interest loans for private consumers to purchase environment-friendly vehicles.

## 3. PRESENT STATUS OF TRANSPORT SECTOR

According to the Department of Transportation Management, Nepal more than 3.9 million vehicles have been registered upto Fiscal year 2020/21 and responsible for the emissions of 1.7 million tonnes of Co2-eq (MoPE, 2017). Currently, the annual grate of increase in petrol and diesel imports stands at 12.6% and 14.9% respectively , if this trend continues a large portion of the GDP shall be required for covering the cost of the these imported fuels. The current electricity consumption from transport sector is 2052 mWh. Looking at the energy consumption of the Bagmati province only, the energy consumption in transport sector is around 14 PJ out of which the contribution of the gasoline and diesel is 48.8% and 37.6% respectively. If this trend continues the diesel and petrol consumption in transportation sector of Bagmati province will reach upto

8.8 PJ while the petrol will reach 6.3 PJ by 2050 A.D. The increase in diesel and petrol consumption will further increase the emission released by the electric vehicle and hence directly affect the country target of achieving the net zero emission by 2050 A.D. Based on long term strategy for net zero emission, with existing measures like SDG 7 goals and SNDC in place, the emission from the transportation sector can be reduced by the 26% in 2030 and 41% in 2050. while with additional measures to alternative fuel the emissions can be reduced by 30% in 2030 and 97% by 2050.

## 4. CHALLENGES AND BARRIERS

Regarding the Electric vehicle charging infrastructure, the academic debate especially on Electric Vehicle Charging Station (EVCS) deployment issues is attracting more and more attention on a worldwide level. During the last decade, EVCS planning problems have been adequately examined and are still catching the interest of both practitioners and researchers. These studies adopt various techniques and methods for locating the stations, thus composing a multispectral body of literature. Despite their differences, all the EVCS locating approaches have in common that they propose a system of EV charging networks after taking into consideration technical and geographic resources, aiming to facilitate EV users with the lowest energy consumption possible ( Yang et. al, 2016). Most of the studies have incorporated optimal roll-out strategies through taking into account demand and supply data. For example, Oda et al., 2018 adopted a mixed method that incorporated queuing theory and cost–benefit analysis for both mitigating the congestion related to quick charging stations and examining the need for installation of new. Another study carried out by Pagani et al., 2019, used an agent-based simulation framework along with a georeferenced model of the built infrastructure, aiming to identify the charging behavior of individual EV users as well as the deployment of the EVCSs. When it comes to the supply side allocation, though, many scholars have followed optimization methods, such as integer programming ( Chen et. al., 2013) , genetic algorithms ( Alegre et. al., 2017), particle swarm optimization, etc. ( Zhang et. al., 2019) to determine the positions of the EVCSs. Bouguerra and Layeb employed five Integer Linear Programs based on weighted set covering models, resulting in optimal infrastructure schemes that could be adopted by stakeholders and policy-makers. Maximal covering model was also used in a study conducted by Frade et al., aiming to define both the number and the capacity of the new stations. There are still more studies have taken place in this area, some papers develop a framework for assessing entire areas instead of individual points, thus formulating spatial models ( Zhang et. al., 2019). Csiszár et al., 2019 used weighted multicriteria methods to evaluate areas and allocate charging stations within an area applying a hexagon-based approach and using a greedy algorithm. In the same direction, Namdeo et al., 2014 developed a methodological framework for multidimensional spatial analysis that combines socioeconomic traits and trip characteristics for prioritizing the demand-based public charging stations. Another research by Victor-Gallardo et al., 2019, employed a method that considers supplying charging stations in metropolitan areas and providing their availability in routes connecting distant places, while ensuring the technical feasibility of these locations. Costa et al., 2019, proposed the mapping of well-suited sites for EVCSs by using GIS analysis in combination with knowledge from a survey conducted with local EV experts. Zhang et al., 2019, formulated a spatial methodology that takes into account a variety of positive and negative factors related to walkability in order to determine optimal position of the charges. There are few researches done in Nepal about different aspects of EV use. Government of Nepal, Ministry of Forest and Environment published a paper in March 2021 about the Electric Mobility, but it focuses on environmental aspects as a target in future theoretically. Adhikari et. al, 2020 explains about few barriers in EV use in Nepal and lacks to integrate for the sustainable EV operation in ground reality. The major challenge and barriers for the sustainable use of electric vehicle

- Electric vehicles should be suitable to operate techno-financially, environmentally as a sustainable means of transportation. The technical parameters like charging infrastructures (fast charging) for EV, grade ability, ground clearance should be assessed extensively. Financial and environmental analysis with other transportation means, policy level barriers and their solution, social as well as sustainable issues should be carefully addressed for electric vehicles in case of Nepal. These factors should be studied and solved with vigorous studies, surveys, interviews and with practical research.
- To reduce the dependence of fossil fuel and to reduce GHG emission, it has been suggested that renewable energies, particularly biofuel, may be adopted (Ong et.al., 2014). The International Energy Agency has

projected that biofuels may supply up to 27% of the world's energy demand for transportation sector by 2050, reducing CO2 emissions by around 2.1 GT/year (Technology Transfer, 2011). However, the use of biofuel is not without its challenges. Depending on the feed stocks being utilized, biofuel production may interfere with human food production and land uses, and furthermore, it has not reached sufficient technological maturity to produce economical and efficient bio fuels. This has resulted in, as yet, low adoption of biofuels as alternative energy sources (Bio-fuels for transport, 2018).

- There are few works going on about the studies for certain factors for sustainability of EV. Studies highlighted many concerns, such as poor distance range, lack of recharging networks, long charging times, expensive purchase price, fuel cost, as well as brand and model availability.
- The changing time of the electric vehicle is still more than the refueling time. Even with the IC engine vehicle , the queue in the refueling station is increasing. Hence , with EV the concern regarding the queue in charging station is one of the major challenge. Also, with large amount of EV connected to grid at once can cause the grid instability
- The feasibility and the locations of the charging stations along with skilled man power and safety concern during the charging and maintenance of the electric vehicle.
- EVs are a fair bit more expensive than ICE vehicles at the moment for a variety of reasons (car companies trying to recoup research and development costs, lack of meaningful government incentives to encourage uptake, costly battery packs), which is a barrier for a lot of consumers. The resale of the IC vehicle for the promotion of the EV vehicle in itself creates the management and logistic issue. The discussion so far suggested the different approach, methods, practices of charging station infrastructure all around the world but the ground reality of Nepal seems different than many theories proposed by literatures. The terrain, vehicles per person, income level of public, future vehicle forecast, mobility rate, employment and business areas, tourist areas etc. asks for formulation of country specific charging infrastructure model for Nepal.

## 5. CONCLUSION

The study presents the framework for the challenges and barriers for the sustainable use of electric vehicle in Nepal. Various plans and policies of the Government of Nepal along with various commitment made by the country in various national and international platforms have been thoroughly reviewed. The trend of fuel use increasing at an alarming rate which has created burden on country 's economy whereas there is surplus production of the electricity which during off peak period are being wasted. Hence the Government of Nepal has Prepared different plans for the promotion of EV vehicles.

The plan developed by the Government are still to come to full effect with only about !% of the vehicles in Nepal being electric vehicle while utilizing around 2,052 mWh annually. The study has listed out several barriers for the promotion and sustainable use of electric vehicle. Although it is not possible to rank these barriers , the general perception based on the various literature and documents is that the major influencing factor is high cost of electric vehicle along with its repair and maintenance cost, followed by lack of sustainable charging solutions for the users while maintaing the electricity supply for charging is the major concern for the decision makers. As there are is no alternative to reduce the consumption of fossil fuels, the promotion of electric vehicle for sustainable use in Nepal is a most. In this respect, the finding off the study develops the framework for accessing the barriers and potential solutions of regarding the promotion of electric vehicle. The information thus can be utilized by the decision makers to develop sustainable plan for the [promotion of electric vehicles in Nepal.The transition to EV is still a daunting task in case of Nepal and hence proper planning and execution along with further study regarding the challenges and barriers of ground root level is requires.

## REFERENCES


1. A. S. Silitonga, H. H. Masjuki, H. C. Ong, A. H. Sebayang, S. Dharma, F. Kusumo, J. Siswantoro, J. Milano, K. Daud, T. M. I. Mahlia, W.-H. Chen, and B. Sugiyanto, ''Evaluation of the engine performance and exhaust emissions of biodiesel-bioethanol-diesel blends using kernelbased extreme learning machine,'' Energy, vol. 159, pp. 1075–1087, Sep. 2018.
2. Alegre, S.; Míguez, J.V.; Carpio, J. Modelling of electric and parallel-hybrid electric vehicle using Matlab/Simulink environment and planning of charging stations through a geographic information system and genetic algorithms. Renew. Sustain. Energy Rev. 2017, 74, 1020–1027. [CrossRef]
3. B. Nykvist, M. Nilsson, 2015, Rapidly falling costs of battery packs for electric vehicles (Nature Climate Change, vol 5) p 329
4. Bardach, Eugene (2011). *A Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving'*. CQ Press College.

5. Bouguerra, S.; Bhar Layeb, S. Determining optimal deployment of electric vehicles charging stations: Case of Tunis City, Tunisia. Case Stud. Transp. Policy 2019, 7, 628–642. [CrossRef]
6. Browne, D.; O'Mahony, M.; Caulfield, B. How should barriers to alternative fuels and vehicles be classified and potential policies to promote innovative technologies be evaluated? J. Clean. Prod. 2012, 35, 140–151. [CrossRef]
7. Bührs, Ton; Bartlett, Robert V. (1993). Environmental Policy in New Zealand. The Politics of Clean and Green. Oxford University Press. ISBN 0-19-558284-5.
8. Chen, T.; Kockelman, K.; Khan, M. Locating electric vehicle charging stations. Transp. Res. Rec. 2013, 2385, 28–36. [CrossRef]
9. Cláudia A. Soares Machado, Harmi Takiya, Charles Lincoln Kenji Yamamura, José Alberto Quintanilha and Fernando Tobal Berssaneti , 2020, "Placement of Infrastructure for Urban Electromobility: A Sustainable Approach" sustainability, MDPI
10. Costa, E.; Vanhaverbeke, L.; Coosemans, T.; Seixas, J.; Messagie, M.; Costa, G. Optimizing The Location Of Charging Infrastructure For Future Expansion Of Electric Vehicle In Sao Paulo, Brazil. In Proceedings of the IEEE International Smart Cities Conference (ISC2), Casablanca, Morocco, 14–17 October 2019; pp. 632–637. [CrossRef]
11. Csiszár, C.; Csonka, B.; F´´oldes, D.; Wirth, E.; Lovas, T. Urban public charging station locating method for electric vehicles based on land use approach. J. Transp. Geogr. 2019, 74, 173–180. [CrossRef]
12. EnjianYao, Chunfu Shao, Fanglei Jin, Long Pan, Rui Zhang, 2020, " Battery electric vehicles in China: ownership and usage"
13. Environmental Management. Life Cycle Assessment; Principles and Framework: Geneva, Switzerland, 2006; ISO 14040.
14. Environmental Management. Life Cycle Assessment; Requirements and Guidelines: Geneva, Switzerland, 2006; ISO 14044
15. Farla, J.; Alkemade, F.; Suurs, R.A.A. Analysis of barriers in the transition toward sustainable mobility in the Netherlands. Technol Forecast Soc Chang. 2010, 77, 1260–1269. [CrossRef]
16. Frade, I.; Ribeiro, A.; Gonçalves, G.; Antunes, A. Optimal location of charging stations for electric vehicles in a neighborhood in Lisbon, Portugal. Transp. Res. Rec. 2011, 2252, 91–98. [CrossRef]
17. Fuad Un-Noor, Sanjeevikumar Padmanaban, Lucian Mihet-Popa, Mohammad Nurunnabi Mollah and Eklas Hossain, 2017, "A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development" energies, MDPI
18. Gan, L. Globalization of the automobile industry in China: Dynamics and barriers in greening of the road transportation. Energy Policy 2003, 31, 537–551. [CrossRef]
19. Geva-May, Iris; Pal, Leslie A. (1999). "Policy Evaluation and Policy Analysis: Exploring the Differences". In Nagel, Stuart S. (ed.). Policy Analysis Methods. Nova Science Publishers. p. 6. ISBN 9781560726579.
20. Government of Nepal, Ministry of Forest and Environment, Assessment of Electric Mobility Targets for Nepal's 2020 Nationally Determined Contributions (NDC), March 2021
21. H. C. Ong, H. H. Masjuki, T. M. I. Mahlia, A. S. Silitonga, W. T. Chong, and T. Yusaf, ''Engine performance and emissions using Jatropha curcas, Ceiba pentandra and Calophyllum inophyllum biodiesel in a CI diesel engine,'' Energy, vol. 69, pp. 427–445, May 2014.
22. Heede R. Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854-2010. Cli. Chang. 2014, 122, 229-241.
23. Ingrid Malmgren, " Quantifying the Societal Benefits of Electric Vehicles", EVS29 Symposium Montréal, Québec, Canada, June 19-22, 2016
24. International Energy Agency, 2015, Energy and climate change (IEA Publishing)
25. J. Brady, M. O'Mahony, 2011, "The potential impacts of electric vehicles" (Elsevier: Transportation Research Part D: Transport and environment, vol 16, issue 2) p. 188
26. Lewis Pickett James Winnett, Dominic Carver, and Paul Bolton, 2021, "Electric Vehicles and Infrastructure" House of commons Library, UK.
27. Madhusudhan Adhikari , Laxman Prasad Ghimire , Yeonbae Kim , Prakash Aryal and Sundar Bahadur Khadka, 2020, Identification and Analysis of Barriers against Electric Vehicle Use.
28. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi (2005), Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, Fundamentals, Theory, and Design, CRC press LLC, New York
29. Namdeo, A.; Tiwary, A.; Dziurla, R. Spatial planning of public charging points using multi-dimensional analysis of early adopters of electric vehicles for a city region. Technol. Forecast. Soc. Chang. 2014, 89, 188–200. [CrossRef]
30. Nur Fatma Fadilah Yaacob , Muhamad Razuhanafi Mat Yazid , Khairul Nizam Abdul Maulud and Noor Ezlin Ahmad Basri, 2020, "A Review of the Measurement Method, Analysis and Implementation Policy of Carbon Dioxide Emission from Transportation" MDPI
31. Oda, T.; Aziz, M.; Mitani, T.; Watanabe, Y.; Kashiwagi, T. Mitigation of congestion related to quick charging of electric vehicles based on waiting time and cost–benefit analyses: A japanese case study. Sustain. Cities Soc. 2018, 36, 99–106. [CrossRef]
32. Pagani, M.; Korosec, W.; Chokani, N.; Abhari, R.S. User behaviour and electric vehicle charging infrastructure: An agent-based model assessment. Appl. Energy 2019, 254, 113680. [CrossRef]
33. Stevens, T. Non-Cost Barriers to Consumer Adoption of New Light-Duty Vehicle Technologies; TØI Report 1329/2014; TØI: Oslo, Norway, September 2013.
34. Technology Roadmap: Biofuels for Transport, US Int. Energy Agency, Paris, France, 2011, p. 56.
35. The world Bank Group. World Development Indicators.2021. Available Online: https:\\data.worldbank.org/.
36. Victor-Gallardo, L.; Angulo-Paniagua, J.; Bejarano-Viachica, R.; Fuentes-Soto, D.; Ruiz, L.; Martínez-Barboza, J.; Quirós-Tortós, J. Strategic Location of EV Fast Charging Stations: The Real Case of Costa Rica. In Proceedings of the IEEE PES Conference on Innovative Smart Grid Technologies, ISGT Latin America, Gramado, Brazil, 15–18 September 2019. [CrossRef]
37. Yang, Y.; Yao, E.; Yang, Z.; Zhang, R. Modeling the charging and route choice behavior of BEV drivers. Transp. Res. Part Emerg. Technol. 2016, 65, 190–204. [CrossRef]
38. Zhang, Y.; Zhang, Q.; Farnoosh, A.; Chen, S.; Li, Y. GIS-Based Multi-Objective Particle Swarm Optimization of charging stations for electric vehicles. Energy 2019, 169, 844–853. [CrossRef]

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