Urban Pathways

Kathmandu

POLICY ENVIRONMENT PAPER

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Urban Policy Paper on "Evaluating the Effect of Policies, Vehicle Attributes and Charging Infrastructure on Electric Vehicles Diffusion in Kathmandu Valley, Nepal"

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Abstract: This research presents a rigorous study of electric vehicles growth in Kathmandu Valley of Nepal based on the public response to various issues, prospects, and policies related to electrical vehicle growth in Nepal. Two surveys were carried out to take data from the public response to EVs, which are presented and explained in this paper. Study of public response to EV policies, both in current state and in utopian consumer preferred policy states has been carried out and compared in this research. Furthermore, the system dynamics analysis and EV growth projection of same two sets of data obtained from these surveys using two software tools, viz VENSIM-PLE and MATLAB are done and presented herewith. In addition to this, the change in level of CO_2 emission with EV growth, their sensitivity analysis to different related variables, etc are also included in this paper. Summing up, this paper shows a projection of EV growth in Kathmandu valley under different policy status and the related effects of EV growth using System Dynamics programming and simulation tools for result validation.

Key words: System Dynamics Method, Electric Vehicles Forecasting, Electric Vehicles, VENSIM-PLE, MATLAB

1. Introduction

The global shifting away from petroleum fuels and towards more renewable energy sources has resulted in a significant progress in favor of vehicle electrification. The development of electric vehicles (hereinafter EVs) is an emergent solution to green the existing transportation systems and to reduce the issues of climate change. Also, motivated by the increasing environmental concerns and the available resource limitations of oil, the automobile industry has continued to develop different alternative fuel vehicles. Out of all the potential solutions that do not utilize petroleum, battery electric vehicles (hereinafter BEVs) are among the widespread and most popular option these days. One of the main advantages of BEVs is that these vehicles have zero emissions (generating no greenhouse gases or pollutants) and contains less moving parts which results lesser maintenance and operating costs/expenses. Hence, BEVs help contribute to cleaner air and they are better for the environment. Also, these vehicles run on electricity, which can be generated through sustainable, renewable, and environment friendly resources.

The Nepalese government has been determined to promote EVs as long-term clean transportation alternatives (National Transport Policy, 2001), with the aim of utilizing hydropower potential of Nepal. In the initial stage of EV diffusion, there are various factors that prevent people accepting EVs, such as long charging duration, short driving range and higher price. Government with supporting policy plays a significant role to address those challenges. For example, in the short term period, governments can offer economic incentives such as subsidies and tax reduction to narrow the price gap, and support technological investment to promote the development of charging infrastructure. In the long term, government can continue to invest in power train technologies to improve the performance of EVs. This research focuses on examining the role of government policies and the development of infrastructure in the EV promotion in Nepal, rather than the exact prediction of the future EV population.

In the fight against air pollution and greenhouse gas emissions, the electrification of the transport sector is an important step as it would greatly improve the air quality. And in fact, switching to electric vehicles has also been a core target of the Ministry of Forests and Environment since 2015, when Nepal's

Nationally Determined Contribution was established. Also, it can significantly reduce the carbon-dioxide emissions in Kathmandu which constitutes of 37.37% of national carbon-dioxide emissions per year.

There are very few researches conducted in Nepal or in the capital city which examines the influence of policies for the promotion of EVs and estimate the growth in a different scenario. In this context, a study on EV development might shed new light on the dynamics of EV adoption and tackle the barriers it faces in its implementation. The study will ultimately provide policy recommendations for the promotion EVs in Kathmandu Valley with the realization of potential benefits. This study focuses on electric two wheelers, four wheelers and three wheelers (named safa-tempos) as total electric vehicles operating in Kathmandu Valley. Geographically, this analysis covers only the case in Kathmandu valley. However, numerous expansions of electric three wheelers have occurred in different cities of Nepal till now. All vehicles registered in the Bagmati Zone of Nepal are assumed to be used in Kathmandu valley which is a reasonable assumption because other districts in this zone are hilly areas and largely un-motorable (Dhakal, 2006).

The second section of this paper describes briefly the development of mathematical model used for this study using software like VENSIM-PLE and MATLAB for validation of results obtained from two different approach of development the system dynamics model. These two software work on slight variation of same model, i.e. system dynamics model of EV growth. The third section describes the research methodology, providing the information of the flow of research progression in brief. The fourth section discusses the results obtained and also discusses on the importance and prospects of the research. The later sections focus on the conclusions of this paper and policy recommendations.

2. Model Formulation and Tools

Vensim is a visual modeling tool that allows conceptualizing, document, simulating, analyzing and optimizing models of dynamic systems. Vensim PLE (for Personal Learning Edition) is a configuration of Vensim that are designed to make it easier to learn system dynamics. Vensim PLE provides a simple and flexible way of building simulation models from causal loop or stock and flow diagrams. A system dynamics model including the emotional and policy-bound public response and aspects of EV growth based on this has been developed and incorporated in this software.

MATLAB is a 4th generation, high-performance language for technical computing. It integrates computation, visualization and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. They are used to perform modeling and analysis of dynamic systems, using simulation to validate theory and test hypotheses, questioning and confirming simulation result, focusing on fundamental principles. As opposed to Vensim, which used graphical block diagrams to model a real-life system, MATLAB uses direct mathematical models prepared by the authors in the form of computer programming/codes.

The SD methodology is mainly used for studying and managing complex feedback systems, such as energy, economics and other social systems. The main idea of SD theory is that the whole system is composed of multiple subsystems, the relationship between the systems or various factors are interconnected, which makes the whole system a feedback system. Feedback, also called causal loop, refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. The causal loop diagram may be used to illustrate a system's feedback. Suppose, the EV demand have positive effect on the number of charging stations. That in turn affects the EV demand via the attractiveness function since increasing the number of charging stations enhances the attractiveness of EV from consumers' perspective. Contrariwise, negative feedback has a reciprocal effect on the system. For example, if the number of produced EV increases, then inversely, the price of these vehicles will fall. Falling price leads to greater demand and so to higher production rate. It means that there is a reciprocal relation between the number of the produced EVs and their prices.

System dynamics model uses the concept of feedback to represent the behavior of the complex nonlinear system. In the system dynamics methodology, a problem or a system is first represented as a causal loop diagram.

3. Methodology

The data on electric vehicles were collected from the Department of Customs and Transport Management Office, Province number 3 of Nepal (which includes Kathmandu valley). It is the main and reliable sources of information. These data are used to realize current situation of Electric Vehicle mix and total number of electric vehicles.

The diffusion model of the Nepalese market based on the model of Struben and Sterman (Struben and Sterman, 2008) was built with modification to include more causal strips affecting EV population in Nepalese context. Struben and Sterman emphasize a broad boundary of alternative fuel vehicle transition, "including attributes, driver experience, word of mouth, marketing, learning through R&D and experience, innovation spillovers, and infrastructure" (Struben and Sterman, 2008). However, they did not consider the effect of policies, which is a key factor in Nepalese EV promotion. In our research, we focus on key factors like government policies, charging infrastructure and vehicle attributes. Moreover, the model has also considered consumer preferences. Primary data has been obtained from field visit/questionnaire survey to estimate parameters of EV attributes, charging infrastructure facility and government policy. The methodology adopted in this study is as shown in the following figure.

For the evaluation of the effect of policies and to calculate parameters for consumer preferred policy of the model, a survey was conducted in Kathmandu in March and April 2019. The survey had three parts. The first part contained questions on demographics, driving experience, as well as questions on attitudes, knowledge and preferences in relation to purchasing and driving EVs in best case. The second part was with reference to description of each policy. The third part was about resale value of EVs and hindrances while buying an EV. Participants were asked to provide weights to their willingness to purchase EVs under five categories (Taxation, Purchase Price, Charging Infrastructure, Operation and Maintenance, Environmental Emissions) which were presented in a random order.

Review of literature provided the ideas of for the survey questionnaire which are generally relating to the public's response to easy taxation, purchase subsidy, environmental impact of EVs, ease in operation and maintenance of EVs, their willingness to recommend EV to someone else based on these qualities of EV, and in addition to these, the survey collected their expectations in these fields to evaluate the nature of development of EVs in Kathmandu Valley.

As stated earlier, this study collected primary data from three surveys, the first one to understand the consumer preference of electric vehicles policy, taking responses of consumers about their willingness to consider getting an EV if the government policies were exactly as they preferred it. The second survey was conducted based on a more relevant policy status or current policy status of EVs in Nepal and public response to these were recorded. The third survey was promoter survey, which recorded the response of EV promoters and marketing companies regarding their notion on current EV policies in Nepal.

Problem formulation, literature review, secondary data collection and interpretation, model development in VENSIM-PLE, primary data collection/questionnaire survey, data analysis, attractiveness factor and importance factor, determination of probability of purchase, result validation using MATLAB, determining final results and discussions are the stages of methodology in this research.

Furthermore, the block diagram below illustrates the detail flow of the study. The equation 1-6 (Struben and Sterman, 2008) quantifies the survey parameters into the simulation block parameters and hence they are put to determine the number of EVs at the end of the year. The causal loop updates the value of such parameters and they estimate the number of EVs at the end of the next year which continues up to the years of study period or simulation time. This flow has been elaborated by the block diagram and equations in the later portion of this section.

Current EVs (V) accumulate new EV sales (S) and EV discards (G) in equation 1. EV discards (G) are age dependence due to limited EV service life, which is assumed to be 10 years (Yu, Yang et al., 2018).

$$dV/dt=S-G \tag{1}$$

New EV sales (S) are determined by the potential demand (D), willingness to consider (W), and probability of purchase (P) in equation 2. The probability of purchase (P) has been calculated from questionnaire survey.

$$S=D*W*P \tag{2}$$

Consideration stage is a diffusion process of consumers' willingness to consider EVs (WtC), which equals the consideration rate. EV purchase behavior is the combination of emotional acceptance and rational choice (Rezvani, Jansson et al., 2015).

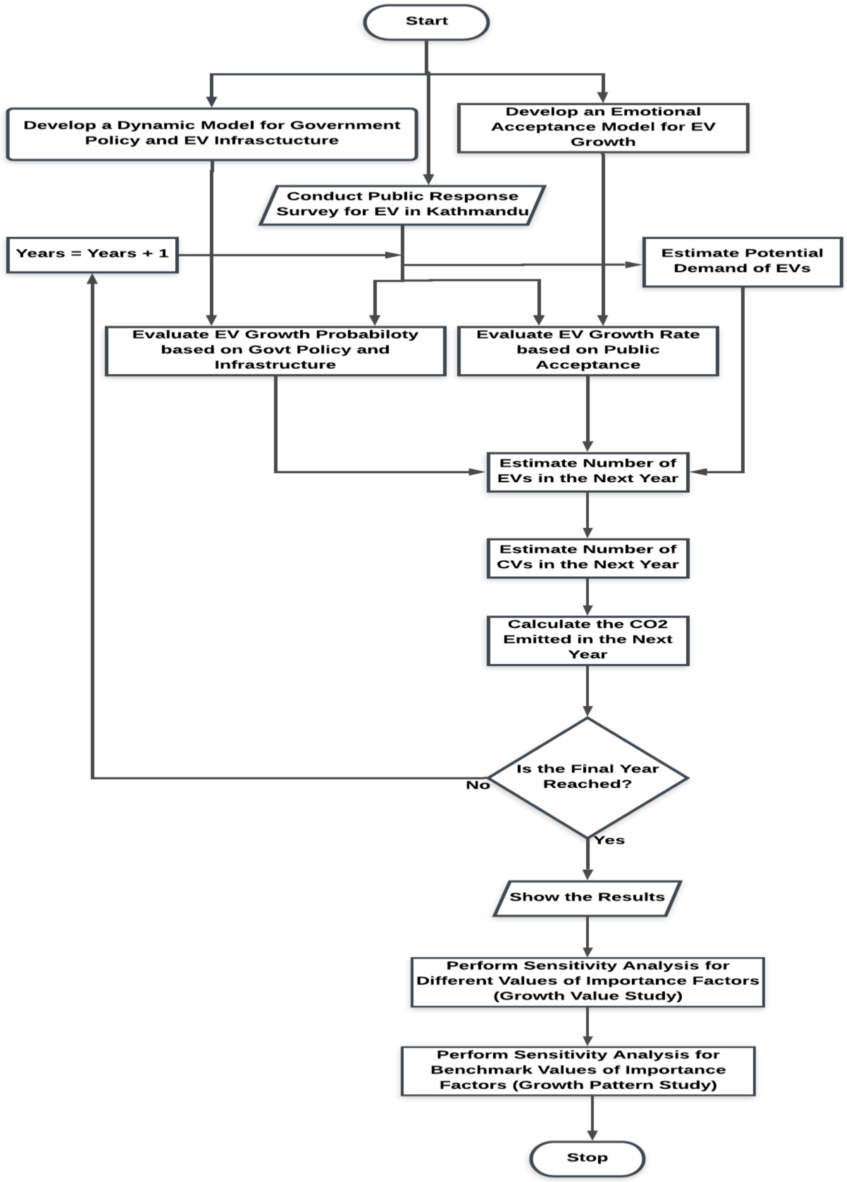

Figure 1 Methodology

Through the consideration stage, we can obtain WtC (W), which captures the cognitive, emotional acceptance of EVs. An increase of WtC (W) is a function of the total social exposure (τ) and decay rate (φ), as shown in Equation Willingness to Consider is the function of the total social exposure (τ) and decay rate (ϕ).

$$dW/dt=\tau(1-W)-\phi W \quad (3)$$

Equation 4 refers to Struben and Sterman's model. The total social exposure (τ) comes from marketing, word of mouth of EV drivers, and word of mouth of other vehicle drivers. The marketing effectiveness of EVs is dominated by the government and enterprises at the initial stage of EV penetration. The second term represents the influence of the word of mouth of EV drivers. Here, q_1 and W_1 are the contact effectiveness and willingness to consider of the EV drivers. V/N is the EV market share. The last term is the word of mouth of other vehicle drivers. Here, q_2 and W_2 are the contact effectiveness and willingness to consider of other drivers, respectively. (1-V/N) is the market share of other vehicles. Similarly, q_1, W_1 and q_2, W_2 has been calculated based on the survey response. Contact effectiveness is fraction of survey from the related population whereas willingness to consider has been calculated from the analysis of the response from public during survey.

Total social exposure (τ) is given as:

$$\tau = \lambda + \left(q_1 * W_1 * \frac{V}{N} \right) + \left(q_2 * W_2 \left(1 - \frac{V}{N} \right) \right) \quad (4)$$

Willingness to Consider will decrease without enough social exposure of EVs. When the total social exposure (τ) is infrequent, willingness to consider decays rapidly. The loss of willingness to consider (ϕ) is defined in Equation 5 (Struben and Sterman, 2008). When WtC decays at a rate of 50%, $\tau^*$is the reference total social exposure.

The decay rate (ϕ) is given as:

$$\phi = \frac{1}{1 + \exp\left(-2 \left(1 - \frac{\tau}{\tau^*} \right) \right)} \quad (5)$$

Although consumers are willing to take EVs as a serious choice in the first stage, they would still make a comparison between EVs and CVs in the purchase stage, rather than directly choose vehicles among others. Attractiveness factor has been calculated from survey from general public and importance factor has been calculated from promoters.

Probability of Purchase/attractiveness of vehicle is function of:

$$P = \beta_p * a_p + \beta_v * a_v + \beta_c * a_c \quad (6)$$

Beta factors are called as importance factors and a_p, a_v, and a_c are called as attractiveness factors which has been calculated based on our questionnaire survey from EV promoters and general public respectively.

4. Results and Discussion

The causality strip of Growth of EVs as obtained from the study in VENSIM-PLE is shown in figure 2. As seen here, the growth of EV over the course of 180 months (15 years) has reached to around 1.1 million. The smooth S-curve suggests that there is no abrupt rise or fall in number of EVs. Similarly, the number of high potential costumers has decayed for around 20-30 months, and after that, it has stabilized to a small number. A similar rise in probability of purchase as in number of EVs could be seen in the graphs. The probability also stabilizes after a certain period of time, suggesting that there is no additional change in people's views on EVs since its number has already saturated. It also suggests that there will be very less additional EVs after that period of time. Figure 2 and 3 are the evaluations of the two types of policy scenario which shows that the second survey has effective policies for EV development which are explained in recommendations section of this paper.

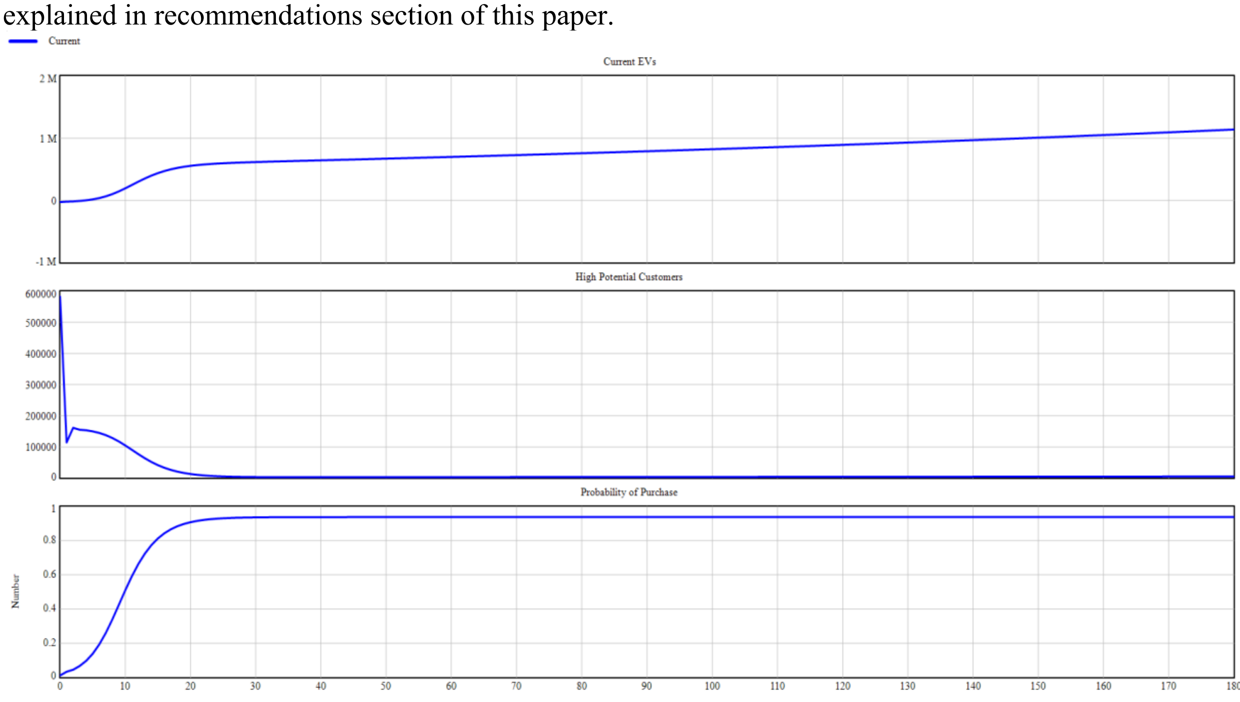

Figure 2 Growth of EVs in VENSIM-PLE Based on First Survey

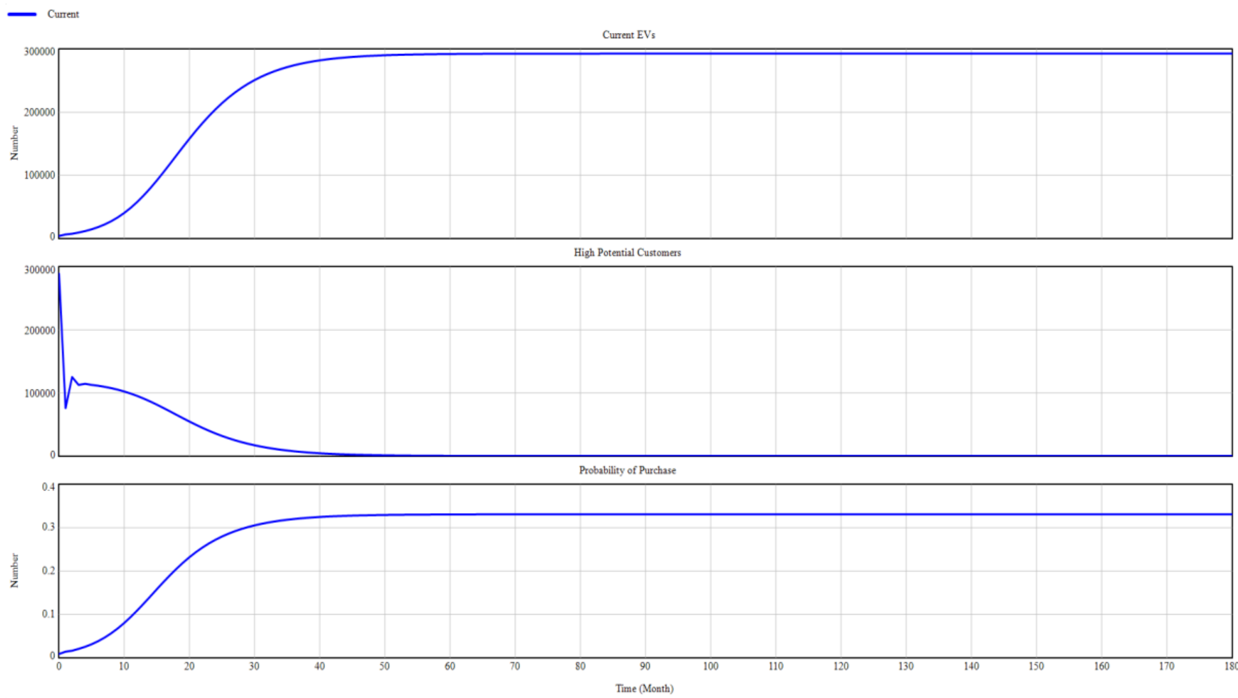

Figure 3 Growth of EVs in VENSIM-PLE Based on Second Survey

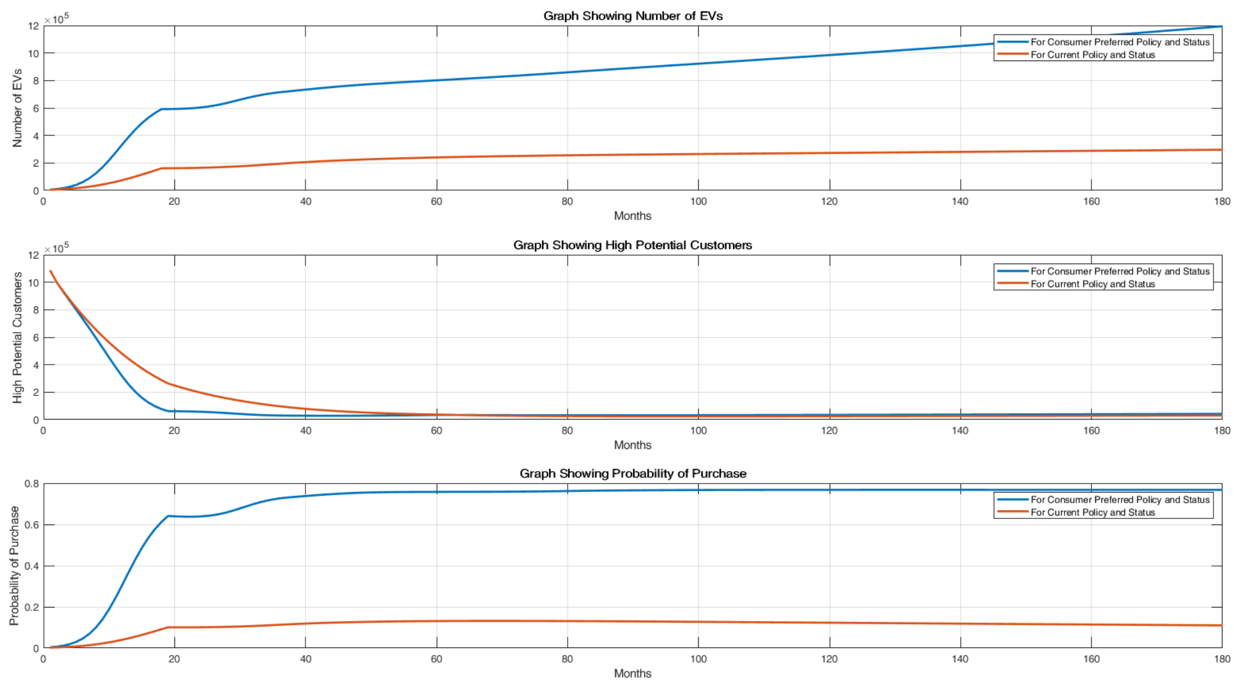

Figure 4 Growth of EVs in MATLAB Based on Both Surveys

The causality strip of Growth of EVs as obtained from the study in VENSIM-PLE is shown in Figure 2 and 3. As seen here, the growth of EV over the course of 180 months (15 years) has reached to around 1.1 million and 0.3 million respectively for first and second surveys. The smooth S-curve suggests that there is no abrupt rise or fall in number of EVs. Similarly, the number of high potential costumers has decayed for around 20-30 months, and after that, it has stabilized to a small number. A similar rise in probability of purchase as in number of EVs could be seen in the graphs. The probability also stabilizes after a certain period of time, suggesting that there is no additional change in people's views on EVs since its number has already saturated. It also suggests that there will be very less additional EVs after that period of time.

A similar strip of the same study performed in MATLAB™ has been shown in Figure 4. This graph also shows that the number of electric vehicles has reached around 1.2 million in 15 years of time based on the first survey and settled at around 0.3 million in the same time based on the second survey. The decay in high potential consumers is less steep than that obtained in results from VENSIM-PLE model. This is because of the discards of electric vehicles and conventional vehicles included in MATLAB™ are more rigorous than that in VENSIM-PLE. The MATLAB™ program uses data of number of vehicles saved in an array and uses the previous values from certain time in history to reduce them as discards. The first instance in which this discard has come in effect, we can see the step-like change in the curve (at around 18 months).

Similarly, for both of these cases, the study of CO_2 emission has been done based on yearly emission of a CV and net carbon footprint of EVs. For the rise and changes in number of EVs and respective number of CVs, the net CO_2 emission was computed and is shown in the following figure (Fig. 5) along with respective EV and CV market shares.

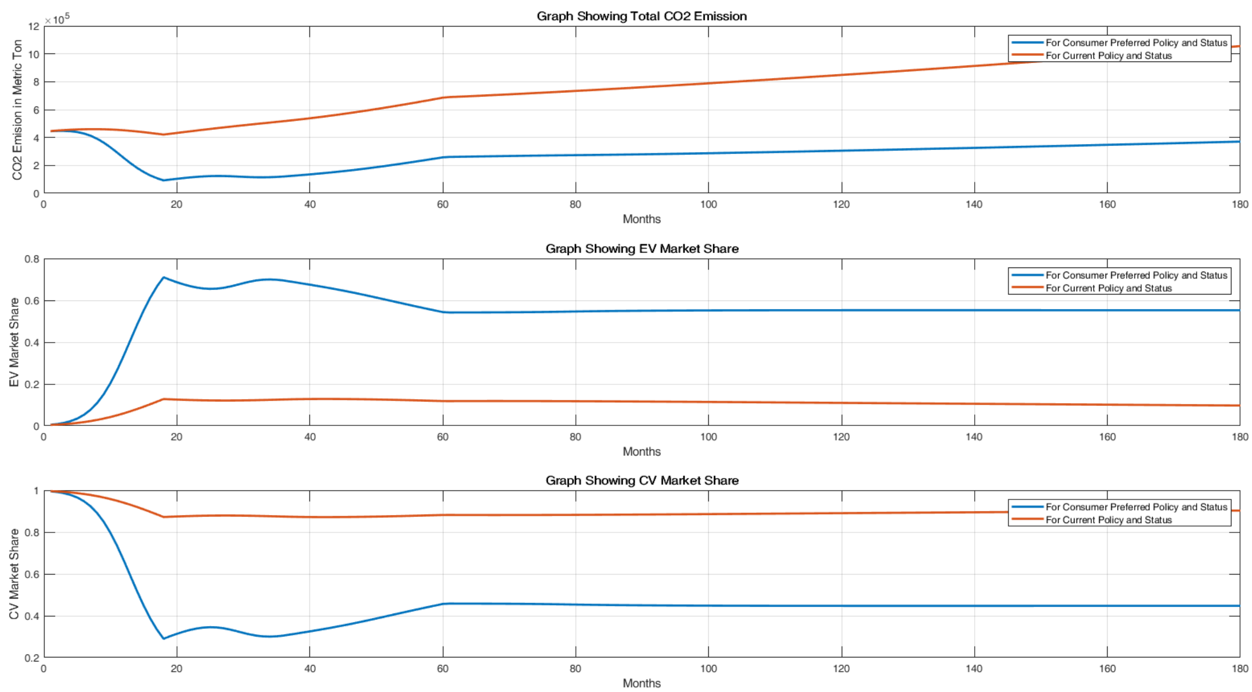

Figure 5 Graph Showing CO_2 Emission and EVs and CVs Market Share

This graph shows that the net CO_2 emission at any time depends on the number of EVs and its market share. However, these results have only been obtained in MATLAB as VENSIM-PLE could not provide the appropriate tools for this computation.

Since the EV change depends on the importance and attractiveness factors of policies and vehicle attributes, the sensitivity analysis of such case is also necessary. Hence the sensitivity analysis was performed, which provided the information on the factors, policy, attributes, or infrastructures that affect the EV growth. Figure 6 shows these sensitivities.

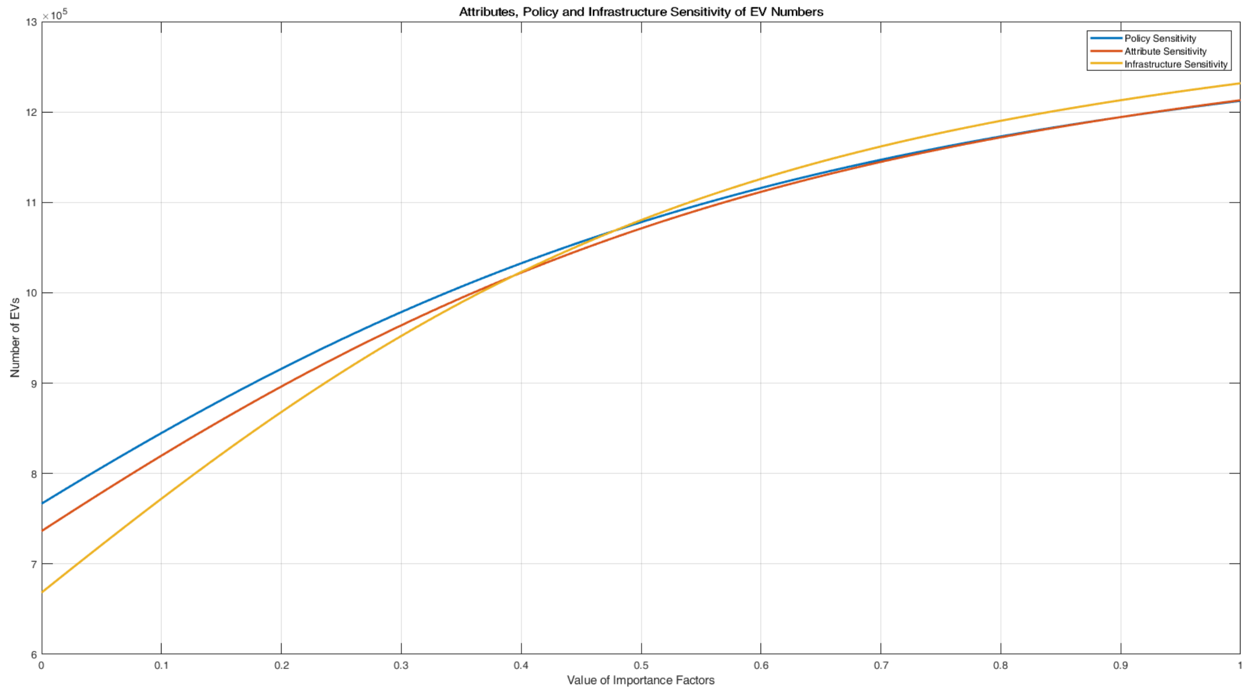

Figure 6 Sensitivity Analysis

From this graph and using mathematical calculations, the sensitivity of EV growth due to EV infrastructure changes is the highest, hence providing the information that the government should build policy in developing EV infrastructure among key factors such that more diffusion occurs in Kathmandu Valley. Following the infrastructure factor, the attribute factors affect the growth next. Hence, if we prioritize the EV policy reforms based on this sensitivity, better result could be obtained in short time as inferred by this analysis.

5. Conclusion

Based on the results obtained, it is clear that if the government policy is made according to consumer preference of Kathmandu valley, the growth of EVs could be achieved very easily in a short period of time. As seen on the results obtained based on the first survey, the number of EVs in Kathmandu valley could be around 1,100,000 (According to VENSIM-PLE Model) to 1,200,000 (According to MATLAB™ Model) if the government promulgates and maintains the policy preferred by the potential EV customers. The customer preferred policy consists of number and location of charging stations to be equal to number of fuel stations and their locations at present, continuation of present import tax rates and road taxes and price of EVs to be 25% less than that of ICE vehicles.

Similarly, based on the results obtained by using the present scenario i.e. if we keep up with the current policy Nepal Government has on EV and let the number of electric vehicles grow naturally for the next fifteen years, the number of EVs will grow to no more than 290,000 (According to VENSIM-PLE Model) or 300,000 (According to MATLAB™ Model) in the same time. This result is only around 25% (According to MATLAB™ Model) to 26.36% (According to VENSIM-PLE Model) of the results obtained when the government policy same as it is at present.

The CO_2 emission analysis showed that the emission will be 10.5e5 at the end of 15 years if we let the growth of EVs happen according to current policy status, and it will be 3.9e5 at the end of the same time period of we let the policies change according to consumer preference.

The study concludes that the positive changes in government policies, vehicle attributes and charging stations during the period will drastically increase number of electric vehicles.

Also, from the sensitivity analysis, it is seen that the vehicle infrastructure such as charging stations, maintenance stations, etc should be paid more attention to since EV growth is highly sensitive to those factors.

6. Policy Recommendations

Based on review of the results obtained from two different customer surveys, developer/promoter survey, System Dynamics Study in VENSIM-PLE and its validation in MATLAB™, the study provides some policy recommendations that support the increase in market share of EVs in Kathmandu valley up to 1.1 million within 15 years. They are as follows:

1. The national and local government needs to provide appropriate condition for charging infrastructure, such as provide public land and financial support, look for public private partnership model such as for EV infrastructure i.e. charging infrastructure. Also, the number of charging stations should be at least equal to the number of fuel stations with fast charging facility in Kathmandu Valley.

2. It is required to carry out capacity building activities for drivers and mechanics that support the O&M facilities. Awareness rising is also required for the consumers in terms of choice of EVs over CVs, considering lower life cycle cost of EVs although it has higher upfront cost.

3. There shall be no or very little taxation during the import of EV for their promotion up to 15 years. Taxation plays a very important role on EV purchase. It implies that consumer oversees the purchase costs which are to be made lower than that of CVs for attraction of potential consumers. From survey purchase costs should be at least 25% less than of CVs according to consumer preference. Along with the results obtained from the survey and the model for EV diffusion, the general public understanding and analysis also says the same. Currently, the government purchase/import tax on CV is roughly 248%. But with reduced purchase/import taxation will lead to increased consumer interest and willingness to consider buying an EV instead of a CV in future.

4. Reduction of yearly taxes on EVs (to almost zero) compared to the taxes on CVs, mainly on road tax, pollution tax, etc, leads to an increase in the number of EVs. Also, the government needs to put a preference to use the amount generated from fuel tax to invest in electric transportation, mainly e-public transportation and necessary charging infrastructure.

5. Environmental taxes should be eliminated for EVs.

6. There should be reduced road tolls and no driving restrictions.

7. Appropriate policy reforms regarding insurance of EVs are suggested.

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References

[1] Aryal, B., Baral, A., and Parajuli, R. Bottlenecks in the Proliferation of Electric Vehicles in Nepal. Martin Chautari: Electric Vehicle Promotion Project. January 1999

[2] Berckmans, G., Smekens, J., Lieselot, O. N., Mierlo V.J., (2017). "Cost projection of state of the art lithium-ion batteries for electric vehicles up to 2030." *Energies* **10**(9): 1314.

[3] Burke, A. F. (2007). "Batteries and ultracapacitors for electric, hybrid, and fuel cell vehicles." *Proceedings of the IEEE* **95**(4): 806-820.

[4] CBS (2012). National Population and Housing Census 2001, *Central Bureau of Statistics*, Government of Nepal.

[5] Customs, D. o. (2075). Department of Customs, Foreign Trade Statistics, FY 2075/76, FY 2074/75, FY 2073/74, FY 2072/73, FY 2071/72 Kathmandu, Department of Customs.

[6] Dhakal, S. (2006). Urban transportation and the environment in Kathmandu Valley, Nepal: Integrating global carbon concerns into local air pollution management, Institute for Global Environmental Strategies.

[7] Gross National Happiness Commission, G. o. B. (2013). Eleventh Five Year Plan Volume I: Self Reliance and Inclusive Green Socio-Economic Development. Thimpu, Bhutan, Gross National Happiness Commission. **I**.

[8] Group, W. B. (2017). Nepal Country Economic Memorandum, Climbing Higher: Towards a middle-income country, Kathmandu, *World Bank Group.*

[9] Helveston, J. P., Liu, Y., Feit, M.E., Fuchs, E.,Klampfl, E., Michalek J, J., (2015). "Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the US and China." *Journal of Transportation Research Part A: Policy and Practice* **73**: 96-112.

[10] JICA, S. (2012). Data Collection Survey on Traffic Improvement in Kathmandu Valley. 2nd Workshop.[Presentation Slides].

[11] Li, W., Long, R., Chen, H., (2016). "Consumers‟ evaluation of national new energy vehicle policy in China: An analysis based on a four paradigm model." *Energy Policy* **99**: 33-41.

[12] Maharjan, S. (2002). Electric vehicle technology in Kathmandu, Nepal: a closer look at development, *Massachusetts Institute of Technology*.

[13] Maryani, A., Wignjosoebrotoa, S., Partiwia G.S.,(2015). "A system dynamics approach for modeling construction accidents." *Journal of Procedia Manufacturing* **4**: 392-401.

[14] NPC (2017). Nepal‟s Sustainable Development Goals Status and Roadmap: 2016-2030, National Planning Commission of Nepal

[15] Rezvani, Z., Jansson, J.; Bodin, J., (2015). "Advances in consumer electric vehicle adoption research: A review and research agenda." *Transportation research part D: transport and environment* **34**: 122-136.

[16] Shakya, S. R. (2018). Analysis of low carbon development strategies: role of transport sector electrification and carbon tax in Nepal. Sperling, D. (1995). Future Drive: Electric Vehicles and Sustainable Transportation. Washington, DC: Island Press Corporation, N. O. C (2013). *Annual Report*. Kathmandu, Nepal, Nepal Oil Corporation Pokharel, G. R. (2018). *Moving Towards Electromobility for Energy Security and Prosperity*.

[17] Wang, Ning., Tang, L.,Pan, H., (2018). "Analysis of public acceptance of electric vehicles: An empirical study in Shanghai," *Technological Forecasting and Social Change*, Elsevier, vol. 126(C), pages 284-291.

[18] Struben, J. & J. D. Sterman (2008). "Transition challenges for alternative fuel vehicle and transportation systems." *Environment and Planning B: Planning and Design* **35**(6): 1070-1097.

[19] Zhang, X.(2018). "The current dilemma and future path of China‟s electric vehicles." *Sustainability* **6**(3): 1567-1593. Huizhong P., Wang, N., Tang, L., (2018). "Analysis of public acceptance of electric vehicles: An empirical study in shanghai."

[20] Paudel, Sushil (2019), "*Evaluating the Effect of Policies, Vehicle Attributes and Charging Infrastructure on Electric Vehicles Diffusion in Kathmandu Valley, Nepal*", Thesis Submitted To Department Of Mechanical Engineering In Partial Fulfillment Of The Requirements For The Degree Of Master Of Science In Renewable Energy Engineering, Tribhuwan University, Institute of Engineering, Pulchowk Campus, Nepal