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Study on economic plausibility of electric vehicle charging stations in Nepal

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Abstract

Nepal is targeting to produce 15,000 MW of electrical energy by 2030 and there shall be abundant energy in the country. Electric Vehicle (EV) charging stations can play a vital role in consumption of the electricity generated within the country and this can be achieved by adequately installing EV charging stations in different regions across the major highways Nepal so that the EVs can access them easily. This study compares petrol and diesel engine vehicles with an EV (Nissan Leaf) on the cost of energy consumption per kilometer to determine the economic prospect of EVs in Nepal. The total number of EV charging stations required was calculated based on the charging requirements (considering a discharge of 65%). The vehicles were compared based on the energy cost incurred per kilometer factor for a range of 20,000 kilometers. Furthermore, the payback period for setting up an EV charging station was determined based on the charging stipulations for the EVs, cost incurred and the total revenue in a year. Wherever relevant, the data were adopted from other countries due to insufficient data from Nepal. Results suggest that, setting up a total of 64 EV charging stations shall yield a peak power demand of 17.5 MW. Additionally, Nissan leaf (EV in our study) is found to be the best alternative costing 2.4 Nepalese Rupees (NRs) per kilometer compared to that of petrol and diesel engine vehicles with the cost of 11.2 and 8.7 NRs per kilometer respectively. Also, the return on investment for setting up a single charging station has been determined within a payback period of 3 to 4 years. This study is one of its first kind to determine the prospect of EV charging stations in Nepal and could offer valuable information to control fossil fuel import in the future.

Keywords: Nepal; Electric vehicle; Electric vehicle charging station; Energy consumption; Economic feasibility

1. Introduction

It is evident that Nepal is planning to produce more than 15000 MW of electricity by 2030 so as to increase the electrification in urban and rural parts of Nepal. This has brought about tensions regarding the surplus electricity in the coming years [1]. It is also important to consider that the major economic hubs in the world are moving in the direction of replacing the Internal Combustion Engine (ICE) vehicles and making usage of electric vehicles in the future [2]. Similar is the case with Nepal, as the country is reliant upon automobile manufacturers such as India, Germany, Japan and China for the import of the vehicles. The aforementioned countries have plans to replace all the ICE vehicles with electric vehicles (EVs) as soon as the upcoming decade. The total number of registered vehicles in Nepal was 198343 in 2013-14 [3]. In Nepal, transport sector consumes about 63% of total imported petroleum fuel and most of this fuel is consumed by vehicles in Kathmandu valley [4]. In 2012, the valley consumed 46% of the total petrol and 16% of the total diesel sales in Nepal, which were largely consumed in the transport sector [5].

This study is aimed towards predicting the number and position of EV charging stations in order make those accessible and finding the effect in the overall fuel-energy mix scenario of Nepal. Not only that, we have compared the petrol and diesel engine vehicles with an EV (Nissan leaf) based on the energy cost per unit distance factor, and suggested the best solution. Last but not the least, we have calculated the pay-back period (PBP) for setting up an EV charging station for Nepal by making some assumptions on setting up cost along with profit and expenses incurred throughout the year.

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2. Method

2.1. Number and location of EV charging stations

We have based the study on Charging Station Selection server (CSS) algorithm which is used in order to trace the location of the vehicle instantaneously and also for tapping the area covered by the vehicle. In addition to that, it suggests the vehicle with all the charging stations nearby, within that range of area. Also, the server makes contact with all the vehicles, so as to predict the amount of traffic for proposing the optimum charging station to the vehicle requiring charging. Not only that, in case of heavy congestion in the roads, alternate path is put forth by the CSS. By using the CSS, the driver can choose the best charging type, which in turn shall block the slot in the promptest manner [6,7].

With regards to the topography in Nepal the mountainous topography has been a barrier in the development of infrastructures and roads and highways in all the parts except for the Terai Belt. Other regions are not so well connected and equipped by means of roads upon which any vehicle could travel with ease. The barrier in the road development is restriction of use of certain vehicles road especially for the electric vehicles. So, the charging station are placed where there is easy mode of roadways for transportation. The charging stations of electric vehicle are placed with regards to the electric vehicle mileage of 120 km upon full charge (Fig. 1). Assuming the charged percentage by users will drop from a full 100% charging to only 65% charging. Then the driving range of the electrical vehicle drops to a driving range of 78 km. Thus, based on this driving range and the performance of the car, the selection of the electrical power station allocation in all the parts of the country is done accounting the movement of the electrical vehicle which

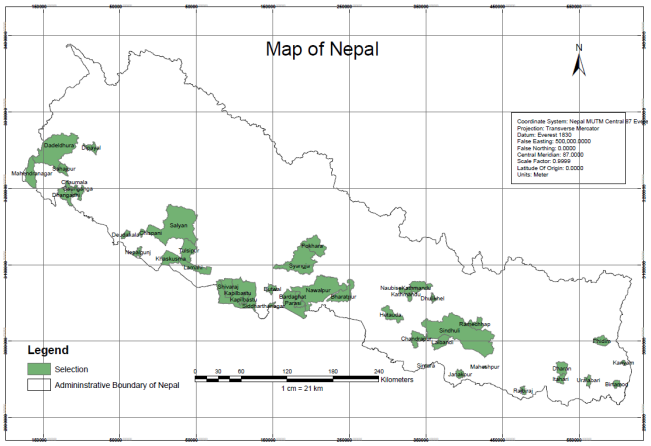

Figure 1: Selected areas for the EV charging stations.

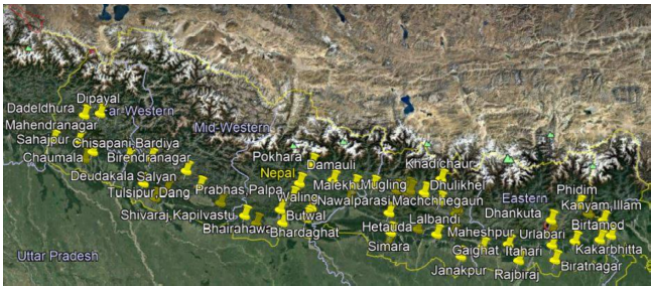

Figure 2: Locations of EV charging stations in Nepal.

could occur along with population density of the place.

The plots were created manually based on the pre-mentioned 78 kilometers distance in major highway (no repetitions allowed).

Based on the pinpoints, which were made taking the major vehicular roads in Nepal into account, we found out that a total of 64 EV charging stations was required at minimum, and the optimum placement of those stations are pinpointed in Fig. 2. Since Kathmandu has the highest population density, an exploded map has been produced for the Kathmandu Valley (Fig. 3).

2.2. Comparison of vehicles in consideration

Three types of vehicles were taken into consideration for comparing in terms of the unit cost incurred per unit kilometer distance. The comparative analysis is presented in Table 1 and Fig. 4.

2.3. Payback Period (PBP) analysis

As per the Electric Vehicles Association of Nepal, there are about 21,000 registered EVs in Nepal. [9] To calculate the PBP for setting up a single charging station, the parameters which were considered are given in Table 2.

Table 1: Comparison of ICE vehicles with Nissan Leaf [8].

Vehicles	price/liter	liter/100 km	price/km
Petrol	112	10	11.2
Diesel	87	10	8.7
	price/kWh	km/24kWh	price/km
EV (Nissan Leaf)	12	121	2.380165

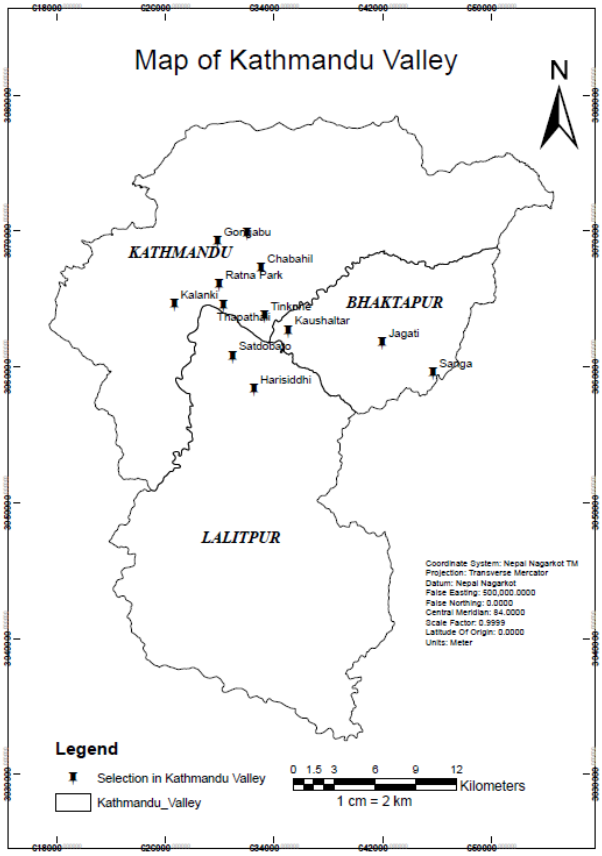

Figure 3: EV charging stations for Kathmandu Valley.

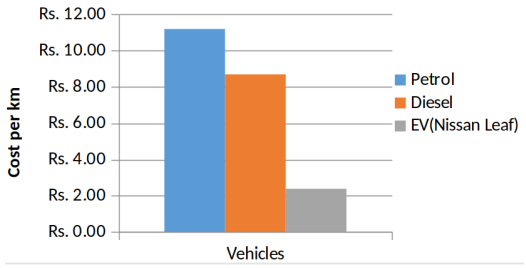

Figure 4: Energy cost per kilometer analysis [5] [9].

Table 2: Basis for calculating PBP of a single EV charging power station [5,9,11].

Parameters	Values
Total number of registered EVs	21,000
Cost per unit electricity	NRs. 5.14
Sale per unit electricity	NRs. 8.14
Distance covered in a year (km)	20,000
Total cost incurred while setting	NRs. 5,00,000
Units for charging	24
Total revenue for one charging (NRs.)	195
Distance covered after 1 charging (km)	121
Total cost for one charging (NRs.)	123
Average Charging period in a year	166
Visiting Electric Vehicles in a year	15
Total visits in an EV station per year	2490
Total Revenue in a year (NRs.)	486447
Total Cost in a year (NRs.)	307166
Maintenance expenses per year	10% of total costs

Table 3: Identified types of EV charging stations.

Capacity	Numbers	Total (in kW)
500 kW	10	5000
350 kW	25	8750
200 kW	12	2400
100 kW	10	1000
50 kW	7	350
Total (in MW)		17.5

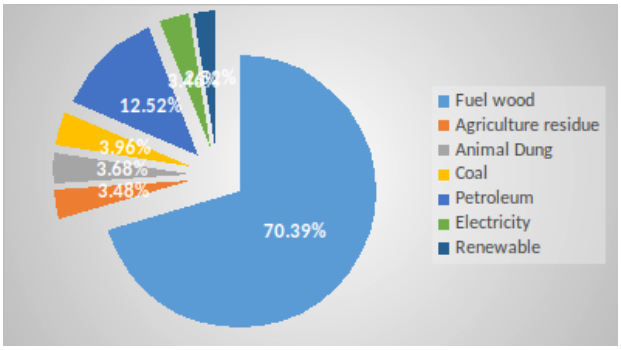

Figure 5: Revised fuel energy mix after addition of EV charging stations.

3. Results and discussion

3.1. Energy analysis

Upon analyzing the total EV charging stations based upon the highway calculation, the total electricity demand raised by the setting up of electric vehicle charging stations: 17.5 MW. Adding of 64 charging stations, and assuming charging station to be in the range of 50kW- 500kW and making below assumptions in the installed capacity of charging stations:

The total electrical load raised by the addition of EV charging stations shall be a total of 17.5 MW at minimum (Table 3). Table 3 does not incorporate the overestimation of the electrical power as a compensation to losses in transmission. Lastly, a fuel-energy mix model was developed for Nepal after incorporating the electrical load from the calculated number and types of EV charging stations (Fig. 5).

3.2. Economic Analysis

We made comparisons for the energy cost per kilometer for three types of vehicles taken into consideration, i.e., petrol, diesel and Nissan Leaf. The observation is quite clear as it shows the unit cost incurred per kilometer to be the highest for the petrol engine vehicles to be NRs 11.2 per kilometer, followed by the diesel engine vehicle displaying an amount of NRs 8.7 per kilometer, and the EV considered in the study is incurring the least among the three alternatives with a cost per kilometer sum of NRs 2.4 (Fig. 4).

If the total cost for the transportation is considered to be a constant value, for instance, Rs. 5000, the range achieved by all the three types of vehicles is tabulated below. Also, we made some assumptions for unit cost for petrol, diesel and electricity as Rs. 112/liter, Rs. 87/liter and Rs. 12/kWh. The specifications of Nissan Leaf EV was referred as (121 km/24 kWh) with a total discharge of only 20%, whilst the mileage is taken as 20 kilometers per liter (kmpl) for petrol and diesel engine vehicles.

We observed that the amount i.e., Rs. 5000 can be expended for the consumption of 44.64 liters of petrol and 57.47 liters of diesel, whilst 416 kWh of electricity could be consumed (Table 4). Considering the maximum range in a year to be 20,000 kms, then the savings of Rs.39396/- compared to diesel and Rs.64397/- compared to petrol was achieved by the usage of EVs (Table 5). It also conveys a meaning that the extra cost associated with buying an EV could be recovered in a matter of years by fuel saving, also the environmental benefits being a bonus.

Table 4: Mileage comparison for the vehicles.

Fuel/Data	Petrol	Diesel	Electricity
Cost/Liter	Rs. 112	Rs. 87	Rs. 12
Consumption	44.64 liter	57.47 liter	416 kWh

Table 5: Annual cost comparison for 20000-kilometer range for vehicles.

Fuel	Total run (km)	Cost (NRs.)
Petrol	20000	112000
Diesel	20000	87000
Electrical Vehicle	20000	47603

3.3. Payback Period for setting up a single EV charging station

Fig. 6 shows that the estimated Payback Period for an Electric Vehicle Charging Station is 3.8 years. The plot shows the economic feasibility of setting an EV charging station in Nepal. This is referring towards a safe investment if an investor is willing to invest on an EV charging station.

4. Conclusion

The study was done depicting the possibilities of Electric Vehicles Charging Stations in Nepal. The research provides an insight regarding the investment of surplus electricity in Nepal by 2030. Moreover, the environmental goals shall be fulfilled if the promotion of EVs and the charging stations are done in an efficient manner. The study can be extrapolated by enhancing the results with real time data by running sample surveys and in coordination with the concerned authorities with the obtainment of facts, figures and data. Not only the findings can be bolstered by modern time data about the technicalities of the EV charging station, but also the study can be departmentalized for different sources of renewable energies in produced in Nepal such as- wind energy, solar, and mini-hydropower projects. Lastly, the findings can be sharpened using real world data by the collaboration of researchers and engineers from different sectors to come up with a policy to be suggested to the Ministry of Energy, Nepal.

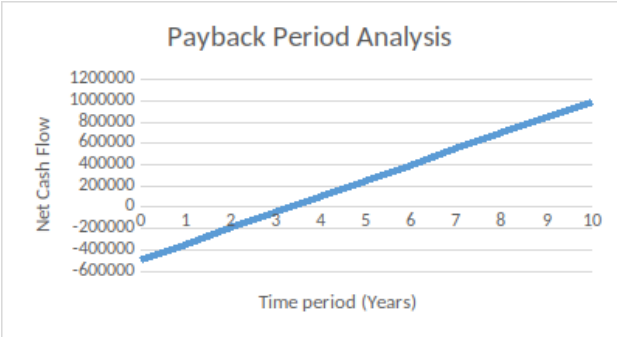

Figure 6: Payback Period analysis.

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