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# Life Cycle Cost & Social Impact Analysis of Electric Vs. Diesel Bus: A Comparative Case Study of Saja Yatayat vs. Sundar Yatayat

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**Abstract**
The pressure for the environment protection with in the concept of sustainable development in Nepal is constantly raising. This is also reflected in the transportation sector of Nepal. The topic of electric mobility often discussed. Government of Nepal is planning to purchases 200 electric buses in the Kathmandu valley. The transportation sector is considered as significant source of the air pollution of the Kathmandu. Using of Eco-friendly transportation system has the potential impact for improving the environment and the greenhouse gas emission.

In this paper, I make an effort to compare the comparative life cycle cost analysis and social impact analysis of two public buses with the consideration of time value of money and environmental impact for the Kathmandu valley. For the compression I took two public buses, one is diesel bus i.e. Saja Yatayat, one of the most popular diesel public buses in the Kathmandu valley for public transportation and another one is Sundar Yatayat which is an emerging electric bus in the public transportation in the Kathmandu valley. Life cycle cost analysis is a decision-making tool that can be effectively used to establish the economic feasibility of a project. Use determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain, and finally dispose of an object or process. when each is equally appropriate to be implemented on technical grounds. In the case of the electric vehicle many benefits are still not well understood and still it is omitted from only on the basis of the life cycle cost-benefit analysis. The benefits related to human health, air quality and the environmental, economic growth, and the grid resilience. So, this paper focused in theses sector. The total sum life cycle cost including social cost and environmental of Diesel bus is NPR 25.90 Million where as for the electric bus is NPR 25.2 million for the same 12years time.However, the acquisition cost and the operating costs of the electric vehicles generate a certain cost structure that is different compared to the diesel vehicles. The aim of this paper is to highlight the possibility of using life cycle cost analysis to quantify the support for the acquisition of electric buses against diesel buses.

**Keywords**
Life Cycle Cost Analysis, Social Impact Analysis, sustainability Transportation, Diesel Bus, Electric Bus

## 1. Introduction

### 1.1 Background

With the increasing rate of pollution in Kathmandu, there may come a time when one has to mandatory put protective glasses and layered masks before leaving the house to shield themselves from lethal gases and dust in the air. To avoid such a situation, it is crucial to start taking preventive steps now and one possible choice can be electrification of transport vehicles. All forms of transportation including two-wheeler and four-wheeler private vehicles as well as public buses can be replaced with renewable energy-run electric vehicles. Moreover, since Nepal has a comparative advantage in terms of production of hydroelectricity, it has a huge potential to replace fossil fuel in upcoming days. The nature of the fossil fuel, as the name suggests, fossil, which takes millions of years to get replenished in abundance. The rate of consumption of the fuel is just making its way higher than the rate of productions, which inevitably

will reach on a point where it will be exhausted with no more fossil fuels to satire the demand.

Nepal has no known deposits of oil, gas, or coal except for some lignite deposits. Biomass, oil products, coal, hydro, and electricity are its main sources of primary energy. The largest share of energy consumption goes to the residential sector. The share of industry and transport is now small, but these sectors are growing fast. From 1990 to 2014, total final energy consumption rose from 106 kilotons of oil equivalent (ktoe) to 665 ktoe for the industry sector, and from 111 ktoe to 858 ktoe for the transport sector.[1]

Electrified vehicles have been widely recognized as a viable solution for overcoming environmental pollution and oil depletion. An electric vehicle is an alternative fuel automobile that uses electric motors and motor controllers for propulsion, in place of more common propulsion methods such as the internal combustion engine. The issue of economic viability of diesel bus and electric bus is often discussed. A pre-feasibility study report by Global Green Growth Institute (GGGI) claims theta switching the electric bus has more operational, maintenance and financial advantages than the diesel bus in Nepal despite of higher initial investment in the electric bus.

## 1.2 Rationale

Nepal has no proven sources of fossil fuels, the dependency of these fuels with India (or China for that matter) may continue perpetually. A sustainable alternative is required to reduce the GHG emissions from the transportation sector of Nepal. One of such alternatives could be electric vehicles. Fuel scarcity is a reality Nepalis are all too familiar with in 2015; Nepal faced fuel scarcity like never before, which left the country crippled for weeks. The country still reels under pressure to maintain smooth supply of petroleum products and the government is yet to find a concrete solution to this threatening problem. Many short-term solutions have been proposed but a permanent long-term solution is yet to be found.

During 2016-17, Nepal imported 407 million liters of gasoline (petrol), 1.32 billion liters of diesel, 19 million liters of kerosene, 184 million liters of aviation fuel, 36 thousand liters of furnace oil and a large amount of Liquefied Petroleum Gas (LPG). The burning of these fuels produces a significant amount of GHGs, and transportation sector contributes to the highest level of GHG emissions.[2]

Last year, Number, a crowd-sourced global database, ranked Kathmandu the third most polluted city in the world, and the Environment Performance Index listed Nepal among the top four worst performers in protecting human health and environment from degrading air quality. In the face of steadily deteriorating environmental conditions, could not have been better timed.

## 1.3 Problem Statement

Residents of Kathmandu by now know that they breathe some of the dirtiest air in the world. But unlike elsewhere, that awareness has not created the public opinion pressure to act. Up to 35,000 Nepalis lose their lives annually due to diseases caused by air pollution. One in every 10 people in Kathmandu suffers from chronic lung diseases like COPD, bronchitis and emphysema. The average life expectancy of Nepalis is reduced by over two and one-half years because of air pollution. Recent advances in electric transport provide the solution. What is sorely lacking in Nepal is political will, long-term commitment and strategic planning for electric mobility.[2]

Rapid increase in vehicular traffic, poor traffic management, Nepal's fleet of sub-standard vehicles and low-quality fuel, as well as ineffective control of emissions have been the major contributors to the country's escalating air pollution problem. As a result, negative health impacts to the residents of urban areas, along with the attendant problems of productivity loss and increased health expenses are on the rise. Those who suffer most from the impacts of air pollution are children, youth, and elderly people. Poor air quality has also had an adverse impact on the economy through the negative impacts of pollution on tourism. By consuming such fuels in the transport sector, the nation is not only diminishing its foreign currency reserve but is also inflicting detrimental effects on public health through the resultant air pollution.

## 1.4 Objectives

Main objective

To examine life cycle cost analysis of electric vs diesel bus

Specific objectives:

- To determine total cost of ownership of public electric bus and public diesel bus
- To compare government policy in public diesel vehicle and public electric vehicle
- To quantify the societal benefits of the electric public bus

### 1.5 Limitations

- The project is comparison on public transportation sector focusing the bus
- The study site in this research covers only for Kathmandu valley
- For the calculation of total cost of ownership following assumptions was taken.
  - Life time of vehicle was taken as 12 years
  - Interest rate for bank was 10

## 2. Literature Review

### 2.1 Transportation

Transportation, the movement of goods and persons from place to place and the various means by which such movement is accomplished. The growth of the ability and the need to transport large quantities of goods or numbers of people over long distances at high speeds in comfort and safety has been an index of civilization and in particular of technological progress. [3]

### 2.2 Sustainable transportation

A sustainable transportation system is one that: · Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations. Sustainable Transport is sometimes known as Green Transport and it is any form of transport that does not use or rely on dwindling natural resources. Instead, it relies on renewable or regenerated energy rather than fossil fuels that have a finite life expectancy. For this reason, it is said to have a low or a negative effect on the environment since it makes use of energy sources that are sustainable.[4]

### 2.3 Life-cycle cost analysis

Life-cycle cost analysis (LCCA) is a decision-making tool which can be effectively used to establish the economic feasibility of a project. Employed it for the energy infrastructure of Indonesia on a time scale indicating a positive move towards transportation sector sustainable development. Use of alternative fuels other than fossil ones needs urgent promotion. Many debates have been held and views expressed on the topic of post diesel mobility and much research and testing are being conducted worldwide exploring the alternative mechanisms for vehicle transportation. Although there is no doubt that electric mobility will lead to lower local emissions, and is accepted as an environmentally friendly practice compared to diesel-based mobility, there have been concerns over energy security, as well as the environmental pollution caused by the fossil fuels used for transportation. Energy security can be enhanced by promoting more usage of renewable energy. One of the significant causes of the slow pace of adoption is the economics involved.[5]

### 2.4 Total Cost of Ownership

A Total Cost of Ownership (TCO) analysis shows a clear picture of what is the real cost of purchasing a given asset. It includes all costs involved in the purchase of the property but it also adds maintenance, upgrade and operational costs that occur during its lifetime. This tool is particularly useful to evaluate different options when a company wishes to make a certain investment. It helps the company to make an informed decision about whether to buy, lease or look for other options. Present value (pv) is often included in these analyses, since some expenses are paid a few years after the purchase is made and the only way to compare between different options is to discount all future values to present time.

### 2.5 Social impact analysis

A social impact analysis (SIA) aims to predict the positive or negative impact that development or land use change may have on people's way of life, their culture, or their community. The SIA process also encourages applicants to mitigate, minimize or resolve any negative outcome of development and enhance public benefit, which in turn will better inform decision making within Council

## 3. Introduction to case area

A good public transport system is supposed to make efficient use of urban space and provide well-organized and affordable mobility, but a major cause of concern in developing countries like Nepal is that while urbanization continues to happen rapidly, the modal share of public transport remains stagnant. Despite the massive rise in Kathmandu's population in the past few years, public vehicles are still far fewer in number to ensure a comfortable, hassle free ride to commuters on a daily basis. There are no well-defined schedules, and the vehicles are generally poorly maintained, lack cleanliness, and are overcrowded and uncomfortable. Which is the main reason to increase a large no. of private vehicle in Kathmandu valley.Though the study area is Kathmandu valley, i choose the ring road of Kathmandu valley to analysis the total life cycle cost of the two buses cause it is the most vibrant and used road in Kathmandu valley to link three district of the valley

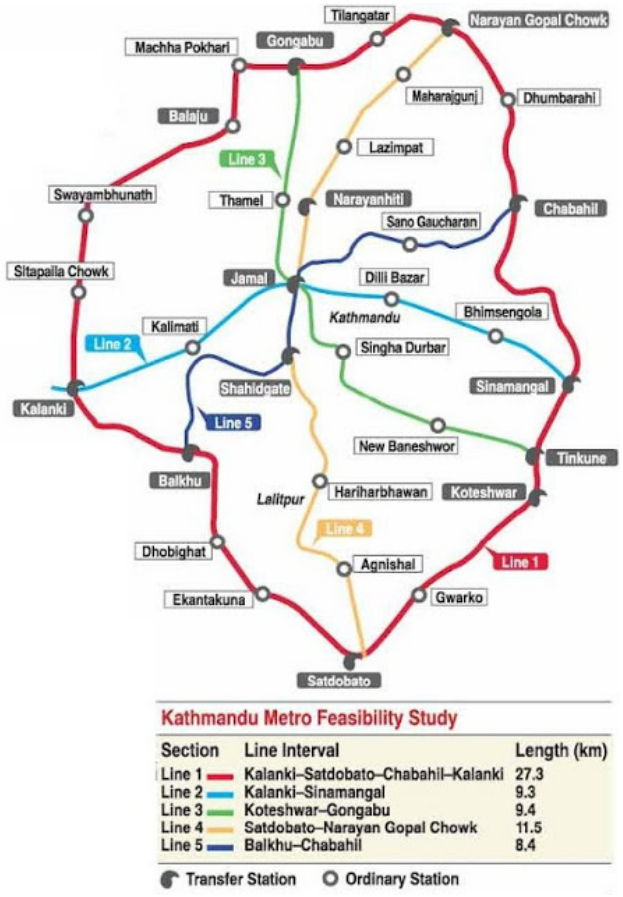


**Figure 1:** ring road map

### 3.1 Public electric bus in Kathmandu

A private transport service company has launched the operation of two public electric buses on the Ring Road route of Kathmandu .This is the first time that the electric buses are available to the public after the shutdown of the government-run trolleybuses more than a decade ago.The company also introduced a smart card and announced that a passenger would get 20 per cent discount on the fare if paid by the card. Each bus costing Rs 15.5 million has 60 seats. The Yatayat, the public transport company operating the buses, has acquired permission to operate the vehicles on the Ring Road for now.

## 4. Methodology

The study area of propose research work was Kathmandu valley. Which is located in Baghmati zone of central Nepal. Sajha Yatayat and Sundar Yatayat are providing mobility in public transport sector. Although sajha Yatayat have boarded its services through Nepal, Sundar Yatayat is new in transportation field and currently is providing service in ring road. So, for similar comparative analysis same route is taken for both the transportation. Total length of ring road is 27 km and in average 4 trips is covered by each vehicle The LCCA of any vehicle can be computed by calculating the TCO with respect to the time value of money; the initial purchase price of the vehicle including freight charges; the depreciation costs of the vehicle over its economic life; alteration and replacement costs; operation costs; maintenance costs; financing costs including interest; costs associated with taxes; and insurance costs. It explains the various components of TCO and highlight the significance of each one. Their work also explores the totality of TCO. They developed a segmented TCO model for alternative vehicle technologies, together with the external costs associated with the vehicle use and ownership. The societal perspective was also considered, whereby the cost to society due to the effect of technology was computed. This was termed as the total cost for society (TCS). The final TCO model was obtained by integrating various costs (purchase cost, operational costs, non-operational costs, and external costs of pollution) with respect to the time value of money. The basic assumptions that were made for this study were for the purpose of estimating various infrastructure-related costs, such as the cost of bus procurement, the cost of diesel, the cost of operation and maintenance, cost of bus

replacements and the cost of electricity.

## 5. Findings

### 5.1 Total Cost of Ownership of Sajha Diesel Bus Vs Sundar Elecric Bus

Total ownership costs involve all the foreseen and unforeseen cost while buying vehicle. Sajha Yatayat is continuously providing services to the local public since decade while Sundar Yatayt is a new in transportation field. Sajha bus is running 76 diesel bus while Sundar Yatayat is running two electric vehicles. While comparing only the purchasing price of the vehicle, Sajha Bus seems to be more economical as compared to Sundar Electrical Bus as purchasing price of Sundar electric Bus is 46.13 times than that of Sajha Diesel Bus. But while comparing overall ownership cost associated with two vehicle, Sundar Electric Bus was found more feasible than that of the Sajha Diesel Bus. The co-Oweship cost of Sajha Diesel Bus and Sundar Electric Bus is shown in Table 1 and Table 2 Respectively

**Table 1:** ownership cost analysis of sajha yatayat

TOTAL COST OF OWNERSHIP ANALYSIS FOR SAJHA YATAYAT

| SN | Component | Value in NRS | Remarks |
|---|---|---|---|
| 1 | PW of initial cost of diesel bus | ₹ 3,336,000.00 | |
| 2 | PW of Different costs | | |
| a | Bill book Renew cost | ₹ 5,450.95 | Total cost 800 factored by (P/A;10%;12) |
| b | income tax | ₹ 57,235.01 | Rs 8400 factored by (P/A;10%12) |
| c | Fitness +pollution | ₹ 4,676.58 | (RS 300+35) each 6 months |
| d | Route Permit | ₹ 10,554.01 | Rs 500 each 4 months i.e. thrice a year |
| e | Engine oil + servicing | ₹ 1,130,261.21 | Rs 40000 for every 3 months i.e. 4 times a year |
| f | Energy Cost | ₹ 10,115,599.29 | Per day travel =125 km, mileage 3km/liters. Therefore 1208 liters per month (diesel price=Rs 98/liters) = Rs123480 |
| h | PW of all costs | ₹ 11,323,777.05 | |
| 3 | Annual cost with interest | ₹ 1,661,915.06 | (A/P;10%12) of h |
| 4 | Annual Charge without interest | ₹ 943648.09 | h/12 |
| 5 | Difference in annual charge with and without interest | ₹ 906,996.59 | 3.-4 |
| 7 | PW of interest cost | ₹ 6,179,995.25 | 5 is factored by (P/A, 10%12) |
| 8 | Annual financing charge | ₹ 166,191.51 | 10% of annual cost |
| 9 | PW of Annual financing charge | ₹ 1,132,377.71 | |
| 10 | Net present worth of financing | ₹ 7,312,372.95 | 7+9 |
| 11 | Bus replacement cost | ₹ 1,062,952.41 | PV of cost of vehicle deposited at 0 time to get 3336000 at the end of 12 years |
| 12 | Total cost of ownership | ₹ 21,749,156.96 | sum of PW of initial investment, Pw of annual cost + present worth of financing cost and bus replacement cost |

Sundar electric Bus has to pay all the annual charges except fitness and pollution charges. Also, Sundar Electric Bus has to pay only half of the income tax as compared to the Sajha Diesel Bus.

**Table 2:** ownership cost analysis of sundar yatayat

TOTAL COST OF OWNERSHIP ANALYSIS FOR SUNDAR YATAYAT

| | Component | Value in NRS | Remarks |
|---|---|---|---|
| 1 | PW of initial cost of electric bus | ₹ 15,500,000.00 | |
| | pw of charging station | ₹ 1,000,000.00 | One charging station costs 20 lakhs (used for 2 buses) |
| 2 | PW of Different costs | | |
| a | Bill book Renew cost | ₹ 5,450.95 | Total cost 800 factored by (P/A;10%;12) |
| b | income tax | ₹ 31,945.53 | Rs 4200 factored by (P/A;10%12) (half than Ics) |
| c | Fitness +pollution | ₹ - | |
| d | Route Permit | ₹ 10,554.01 | Rs 500 each 4 months i.e. thrice a year |
| e | Minimum maintenance | ₹ 56,513.06 | RS 2000 each 3 months |
| f | Energy Cost | ₹ 1,393,817.20 | RS 4.5/km (125 km per day, therefore Rs 16312 per months) |
| g | Battery maintenance | ₹ 800,000.00 | |
| h | PW of all costs | ₹ 2,298,280.76 | |
| 3 | Annual cost with interest | ₹ 337,303.30 | (A/P;10%12) of h |
| 4 | Annual Charge without interest | ₹ 191523.40 | h/12 |
| 5 | Difference in annual charge with and without interest | ₹ 184,084.59 | 3.-4 |
| 7 | PW of interest cost | ₹ 1,254,295.64 | 5 is factored by (P/A, 10%12) |
| 8 | Annual financing charge | ₹ 33,730.33 | 10% of annual cost |
| 9 | PW of Annual financing charge | ₹ 229,828.08 | |
| 10 | Net present worth of financing | ₹ 1,484,123.71 | 7+9 |
| 11 | Bus + charging station replacement cost | ₹ 5,257,408.49 | PV of cost of vehicle deposited at 0 time to get 3336000 at the end of 12 years |
| 12 | Total cost of ownership | ₹ 25,278816.68 | sum of PW of initial investment, Pw of annual cost + present worth of financing cost and bus replacement cost |

At the end of 12 years both the Bus has to be replaced and for that certain sum of money is discounted and invested at zero time such that at the end of 12 years it replaces Bus. Detail calculation associated with above table is attached in Annex I. As the purchasing price of electric bus is high, its bus replacement cost is also high. Despite of high initial cost and high bus replacement cost, for the span of 12 years, total ownership cost of electric vehicle was found more as compared to the diesel bus only by 35 lakhs because of less energy cost. As life of the vehicle is taken as 12 years in many literature same is considered for my study. But is the life of the vehicle is considered as 12 years (As Sundar Yatayat claims its Bus has life over 12 years), Yundar Yatayat Bus will have less Ownership Cost as compared to Sajha Yatayat Bus. Figure 6.1 shows the clustered column chart plotted against different cost associated with electric vehicle and diesel vehicle. Blue is for the Sajha Diesel Bus while, orange is for Sundar Electric Bus. If we join mid-point of each column for Sajha diesel bus and Sundar electric bus, shape of the curve is concave upward for the Sundar Electric Bus while Concave downward for the Sajha Diesel bus.

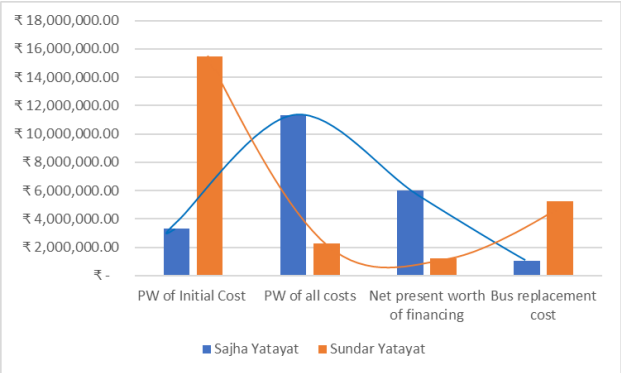


**Figure 2:** total ownership cost of diesel bus vs. electric bus

## 5.2 Quantifying the societal benefits of the electric vehicle

Electric public bus reduces operational emission. The energy source is cleaner and cheaper than oil. Even when the electricity comes from the dirtiest coal dominated grid electric bus still produce less global warming pollution than their conventional counterpart. In the case of the public transportation in the Kathmandu valley, public transportation is not handled by any government sector, it is majorly based on the private sector. Public transport is quite cheap and we can get almost any place of the valley using the public vehicle. But the only problem with them is the crowd. The public vehicles are mostly crowded and much more inconvenient during the office hours. Also, traffic jams are another sort of problem with public vehicles. Private motor vehicles are no more a luxury. They have become a compulsion for daily use thanks to poor public transportation infrastructures in Kathmandu valley. Life cycle cost analysis is a decision-making tool that can be effectively used to establish the economic feasibility of a project. Use determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain, and finally dispose of an object or process. when each is equally appropriate to be implemented on technical grounds. In the case of the electric vehicle many benefits are still not well understood and still it is omitted from only on the basis of the life cycle cost-benefit analysis. The benefits related to human health, air quality and the environmental, economic growth, and the grid resilience. So, my study in the social impact will focused in theses sector. Assessing the value of these benefits provides guidance for policy makers to determine the incentives and investment levels that accurately reflects the full value of electric vehicle to society.

### 5.2.1 Fuel Savings

Using the excel sheet and net present value formula, based the life cycle cost analysis of Sajha Yatayat and Sundar Yatayat,

- the total fuel cost of Sajha yatayat for 12 years is Rs.10115599.29
- total fuel cost of Sundar Yatayat for 12 years is Rs.1393817.20
- fuel saving form Sundar Yatayat is Rs 8721782.09 in 12 years

### 5.2.2 Operations and Maintenance

Using the excel sheet and net present value formula, based the life cycle cost analysis of Sajha Yatayat and Sundar Yatayat

- the total maintenance cost of Sajha Yatayat for 12 years is Rs.1130261.21
- the total maintenance cost of Sundar Ytayat for 12 years is Rs.56513.06
- total saving form maintenance for Sundar Yatayat is Rs 1073748.15 in 12 years

### 5.2.3 Health Impacts cost

To determine the avoided health cost from the diesel bus I used the data from National Academy of Sciences publication, Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use. The estimates in this study relied on the GREET model developed by Argonne National Laboratory and sponsored by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. The National Academy of Sciences study employed this model to estimate emissions per vehicle mile traveled and determine health damages from non-greenhouse gas emissions.

- Quantifying the Societal Benefits of Electric Vehicles by Montréal, Québec [6] shows that the total health cost by diesel bus is 1.38 cents per vehicle mile travelled (VMT).
- As per my life cycle analysis, Sajha and Sundar Yatayat traveled 125km per day.

- So the total distance travelled by Sajha diesel bus is 125 x 348 x 12 = 5220000 km
- Total distance by Sajha diesel bus is =324355.762 miles
- So the total health impact (cost) over the 12 years is 324355.762 x 1.38=447610.95 cents =Rs. 543936.71

#### 5.2.4 Noise pollution cost

Victoria Transport Policy Institute paper [7] shows noise cost for public diesel bus per mile in average is 0.053 U. S. Dollars.

- The total noise cost for per mile of public diesel bus is Rs. 6.44.
- Total distance by Sajha diesel bus is in 12 years is 324355.762 miles
- So the total noise pollution cost over the 12 years is 324355.762 x 6.44 = NRs. 2088851.09

#### 5.2.5 Carbon emission

Life cycle assessment of carbon footprint in public transportation by ching-chih [8] shows total carbon emission by diesel bus per km is 54.6gm. According this paper total carbon emission by diesel bus per km is 54.6gm. GGGI [9] shows carbon tax levied on emissions from the transport sector has been assumed to increase from USD 40 per ton in year 1 to USD 80 per ton in year 10 as most countries around the world imposed carbon taxes in this range.

- Total distance by Sajha diesel bus is in 12 years is = 324355.762 miles = 522000 km
- Total carbon emission by diesel bus in 12 years is =522000 x 54.6 = 28501200 gm=31.42 ton
- The total carbon emission cost for the diesel bus for 12 years =31.42 x 80 = 2513.6 USD = NRs. 1519525.20

**Table 3:** total cost of diesel bus vs. electric bus

| Total Cost of diesel bus vs. electric bus (NPR) | | |
|---|---|---|
| Cost Component | Diesel (Sajha) | Electric (Sundar) |
| Lifecycle Cost | 21,749,156.96 | 25,278,816.68 |
| Social Cost (noise + health) | 2,632,787.8 | - |
| Environmental cost | 1,519,525.20 | - |
| **Total (NPR)** | **25,901,469.96** | **25,278,816.68** |

Calculation of the cost of ownership, societal cost and environmental cost shows the diesel bus is only 0.7 million expensive than the electric bus. But considering the hydro power production of Nepal, Societal and environmental benefit electric public bus is more suitable option for the public transportation than the diesel public bus.

### 5.3 Government Financial Regulation for Public Diesel Vs Public Electric Vehicle

Currently, the Government of Nepal charges 5 % customs duty, 5 % excise duty, 7 % road construction charge and 13 % VAT on Diesel Vehicle which has a carrying capacity of 40 seats or more. On another hand for similar electric vehicle Government is providing subsidy on excise duty and 50 % off on Road Construction Charge only and despite that, both vehicles have to pay equal taxes.

Although the ownership cost of Electric vehicle is lesser than that of the diesel vehicle, by cutting off on different taxes, Government can reduce ownership cost of the electric vehicle substantially such that different private investors get motivated for purchasing Electric Public Buses, thus decreasing fossils fuel consumption, and ultimately reducing fossils fuel dependency. Government of Nepal is charging Custom duty Rs 4 per liters of petrol and Rs 2 per liters of diesel, road maintenance charges Rs 5 per liters for both petrol and diesel, and pollution control charge Rs 1.5 per liters for both petrol and diesel. Thus, Government is imposing a total Rs 11 more on the import of petroleum products. As an electric vehicle reduces pollution that taxes imposed on petroleum products should be invested in the electrical vehicle as incentives.

**Table 4:** financial regulation chart for diesel bus and electric bus

| Diesel Vehicle | Electric Vehicle |
|---|---|
| Bus>40 seats | |
| Custom 5% | Custom Duty 1% |
| Excise Duty 5% | Excise Duty 0% |
| Road Construction Charge 7% | Road Construction Charge 3.5% |
| VAT=13% | VAT=0% |
| Total =30% | Total =4.5% |

## 6. Recommendation

- Behavior change is important for the transition towards e-mobility. Government should

influence local people to change people's perception towards e-mobility

- Government should Customize regional and city planning, E-mobility has to be better integrated into urban planning
- Unreliability, and loss of time in trip are the major problems people not using public vehicle. So, to overcome this Government should make separate lane for public and private transport such that precious time of the passenger could be saved
- Government should develop charging facilities in start and end stations so that continuous power supply to the Electric bus can be done without compromising the mobility
- Government should make a specific route electric vehicle route and run only electric vehicle to neglect the traffic congestion and fast service
- Appropriate policies and regulations need to be framed for charging infrastructure in public and private places for the electric vehicle which is more sustainable than diesel bus

## 7. Conclusion

Though the initial purchasing price of Electric vehicle is more, when compared total life cost and social cost with diesel vehicle, electric vehicle is found to be more feasible comparing economic aspects. This is due to less fuel cost of the electric vehicle as compared to diesel vehicles. The price of the battery was found more as it is new technology (30 % of the price of the vehicle) but is expected to decrease over the years. As the electric vehicle has to modify as per Nepali standards, Sundar Electric Bus costs have increased substantially. The government of Nepal is, of course, providing certain incentives for an electrical vehicle but is still not enough to promote the electrical vehicle.

## References


[1] Asian Deveopment Bank. Nepal energy sector assessment, strategy, and road map. https://www.adb.org/sites/default/files/publication/356466/nepal-energy-assessment-road-map.pdf, 8 2019. (Accessed on 05/25/2020).

[2] Sonia Awale. Nepal's electric transport future is here — nepali times. https://www.nepalitimes.com/banner/nepals-electric-transport-future-is-here/, 8 2019. (Accessed on 05/25/2020).

[3] Amy Tikkanen. transportation — definition & facts — britannica. https://www.britannica.com/technology/transportation-technology, 9 2019. (Accessed on 05/25/2020).

[4] Michael Evans. Sustainable transport — the earth times — encyclopaedia. http://www.earthtimes.org/encyclopaedia/environmental-issues/sustainable-transport/, 9 2019. (Accessed on 05/25/2020).

[5] Anal Sheth and Debasis Sarkar. Life cycle cost analysis for electric vs. diesel bus transit in an indian scenario. *Int. J. Technol.*, 10(1):105, 2019.

[6] Ingrid Malmgren. Quantifying the societal benefits of electric vehicles. *World Electric Vehicle Journal*, 8(4):996–1007, 2016.

[7] Transportation cost and benefit analysis - noise costs. https://www.vtpi.org/tca/tca0511.pdf, 5 2020. (Accessed on 05/26/2020).

[8] Ching-Chih Chang, Yi-Ting Liao, and Yu-Wei Chang. Life cycle assessment of carbon footprint in public transportation-a case study of bus route no. 2 in tainan city, taiwan. *Procedia Manufacturing*, 30:388–395, 2019.

[9] Gggi-nepal_pre-feasability-of-electric-buses.pdf. https://gggi.org/site/assets/uploads/2018/07/GGGI-Nepal_Pre-Feasability-of-Electric-Buses.pdf, 5 2020. (Accessed on 05/26/2020).