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Conversion of Maruti Gypsy into Electric Vehicle: A Comparative Study on Different Scenarios

by

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A THESIS

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DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

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The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis entitled **"Conversion of Maruti Gypsy into Electric Vehicle: A Comparative Study on Different Scenarios"** submitted by Kishor Dulal, in partial fulfillment of the requirements for the degree of Master of Science in Renewable Energy Engineering.

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ABSTRACT

Government of Nepal has been investing a huge amount in imports of ICEVs that has been provided to its higher ranked officials as facility. There is significant cost involved in operation of those vehicles. Government investments on import and operations can be limited if vehicles like Maruti Gypsy can be converted to EVs using readily available conversion kits. Maruti Gypsy is primarily selected for low Gross Vehicle weight and is available in hard and soft body versions. With the rise in production of electricity in Nepal, EV usage is important in terms of energy security. With the conversion kits vehicles that have been unserviceable or soon be dumped can be utilized as part of special facility than investing on new ones for government officials.

Among the imported petrol, transportation sector alone consumes 96% of it, which is threatening in terms of energy security. It also compared capability of current conversion effort done by Nepali Army whose maximum speed is limited to 54 kmph and max distance of 60 km. To overcome these limitations new EV conversion kit has been considered for this study where the battery technology utilizing Lithium were found effective to traditional lead acid battery that was used previously.

This study is carried out with comparison of different scenarios such as using EV conversion kit, continuing operation with petrol and selecting new EV as facility to government officials. With NPV comparison for different investment options considered, utilizing EV conversion kit seems marginally feasible than petrol operation and 100% feasible than new EV for the study period of 8 years. The conversion system cost seems lowering day by day and due to reduction of price of lithium-based batteries making this option more feasible. If mass conversion is done on all 146 Maruti Gypsy vehicles considered it is found that CO production will reduce by 5114 kg, HC by 306.6 kg and NO_x by 220.75 kg.

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ABBREVIATIONS

CO	Carbon Monoxide
EV	Electric Vehicle
GoN	Government of Nepal
ICEV	Internal Combustion Engine Vehicle
MCM	Monte Carlo Method
MCS	Monte Carlo Simulation
MOF	Ministry of Finance
NA	Nepali Army
NEA	Nepal Electricity Authority
NO2	Nitrogen dioxide
NOC	Nepal Oil Corporation
NPC	National Planning Commission
NPV	Net Present Value
PM	Particulate Matter
WECS	Water and Energy Commission Secretariat

LIST OF SYMBOLS

A	Ampere	[A]
Ah	Ampere Hour	[Ah]
F	Force	[N]
C_{RR}	Coefficient of Rolling resistance	
Wh	Watt Hour	[wh]
P	Power	[w]
V	Velocity	[m/s]

CHAPTER ONE: INTRODUCTION

Nepal has heavily relied on imports of automobiles, particularly internal combustion engine vehicles (ICEVs). It is found that Nepal imported a total of 3.2 million vehicles from 1989 to 2017 in the last three decades (New Business Age, 2019). However, there has been a notable increase in the import of electric vehicles (EVs) in recent years, primarily due to tax incentives proposed in recent government budgets. Before the COVID-19 outbreak and the implementation of new vehicle taxation policies, the country witnessed a significant annual growth in registered vehicles, posing a threat to foreign reserves and the overall economy. It is evident that in the coming years, our scrapyards will be filled with inoperable ICEVs. Government offices have traditionally procured ICEVs, offering them as privileges to high-ranking officials. Nevertheless, the automotive industry's global trend emphasizes a shift towards cleaner energy, driven by concerns about environmental pollution caused by fossil fuels used in ICEVs. EVs have been established as the most feasible solution to meet the criteria for clean energy in the automotive sector.

Given the endeavors to replace ICEVs with EVs, it is evident that we will inevitably burden the national economy. Numerous countries have initiated the conversion of ICEVs to EVs using readily available conversion kits in the market. The advancements in battery technology have been remarkable in recent years, making EV conversion a feasible solution for developing nations like Nepal to reduce investments in vehicles provided as special privileges to officials.

1.1 Background

Electric Vehicle Conversion kits are readily available in the Nepali market and can also be purchased online from neighboring nations such as India and China. There have been instances of ICEV to EV conversions in Nepal as well. Recently, the Nepali Army converted a Maruti Gypsy into an EV using a conversion kit. The Nepali Army has been using two variants of the Maruti Gypsy, namely the MG 413W and MG 410, for the past two decades. These variants of the Maruti Gypsy have been allocated to higher-ranking officials as privileged vehicles. Similarly, the Armed Police Force (APF) and the Nepal Police also utilize the same vehicle. A significant portion of the budget is allocated as capital budget each year to regularly replace old vehicles. Among the vehicles provided as privileged vehicles, the MG 413W variant of the Maruti Gypsy, which has a very low Gross Vehicle Weight (GVW) of 1650 Kg, was chosen for the conversion using conversion kits.

The electric car industry has already been impacted by lithium-ion batteries, and the use of these batteries to the conversion market will undoubtedly transform it as well (Greg Albright, 2012). In order for the conversion technology to be fleet scalable for this study, we will take into account the widely accessible conversion technologies. This scalability will in reducing the net foreign deficit resulting from regular import of the vehicle used for the higher rank government officials which may be nominal to total import but is notable in terms of transportation-based import.

1.2Problem Statement

The provision of car facilities to Gazette officials at the first-class equivalent and higher has required a considerable investment. There is a provision for shuttle bus services to other officers and employees of GON offices, which undoubtedly requires significant expenditure and ongoing operating and maintenance costs. The geopolitical and economic situation for a country like Nepal, which depends on its only two neighbors for the purchase of vehicles and gasoline, constantly places its transportation industry at high risk from the perspective of energy security, so alternatives must be taken into consideration. In order to make the best use of the resources that are already available, it is proposed that this research look at alternatives that have already been attempted at the micro level. To meet the aforementioned criteria, in which converted EVs that are currently either producing more pollution or being dumped at yards will replace the monthly expense of fuel.

1.3 Objectives

The main objective of this study is to conduct techno-economic analysis of conversion of ICE powered vehicle to EV.

The main objective of research will be met by obtaining following specific objectives.

(i) To study currently converted EVs and evaluating their performance.

(ii) To study and analyze EV conversion additional EV conversion options available.

(iii) To perform financial feasibility of mass conversion based on different practical and applicable scenarios and to evaluate environmental benefits.

1.4 Scope and Limitations of Work

The study will make it easier to use the resources that are available by building on the current policy that permits the conversion of ICE-based vehicles to EVs. If this study can establish and demonstrate the financial and environmental benefits that converted EVs offer, it may offer insight into using off-road junkyard vehicles to create a functional vehicle. The main drawback is the small number of studies that have been done on conversion as well as the scant national data on conversion of passenger cars or other vehicles. The study will look for foreign data accessible from conversion, if possible, as well as the conversion carried out by Nepali institutions up to this point in order to get over these constraints.

Furthermore, the major limitations that are associated to this study is as follows:

(i) The power calculated for the design was limited due to which the test result is also affected.

(ii) The power of motor was limited due to the budget constraint.

(iii) The battery selection was limited to lead acid battery due which the true potential of converted EV cannot be ascertained which was also due to budget constraint.

CHAPTER TWO: LITERATURE REVIEW

2.1 Power Ratings Calculations for Vehicle Dynamics

Notable vehicle parameters such as gradient resistance, aerodynamic drag, rolling resistance must be considered while determining a vehicle's power ratings. As an example, the method of selection for motor rating of an electric automobile with a total weight of 450 kg has been taken into consideration (T. Porselvi, 2017).

Net force required for vehicle to drive is given by equation 2.1 below,

$$F_{TOT} = F_{GR} + F_{RR} + F_{AD} \tag{2.1}$$

where,

F_{TOT}=Sum of all the forces acting against the motion of the vehicle

F_{GR}= Force of resistance due to gradient

F_{RR}= Force of resistance against rolling

F_{AD}=resisting force caused by aerodynamics and shape of vehicle

Sum of tractive forces that the motor output must be overcoming to move the vehicle is denoted by F_{TOT}.

2.1.1 Gradient Resistance

When climbing travelling up or down on a slope or on a flyover a resistance is offered to the vehicle movement which is called as gradient resistance (F_{GR}).

It acts due to the component of its self-weight which tries to drag the vehicle down ward while the drive is intended upwards. The angle between the ground and slope of the path is represented as α, which is shown in Figure 2.1. It should be duly noted that this force acts to negate the forward moment in uphill movement and acts to assist in downward movement where this component adds to the driving force. So, while moving up more force and torque on the wheels are needed whereas while moving downwards less drive or energy is required.

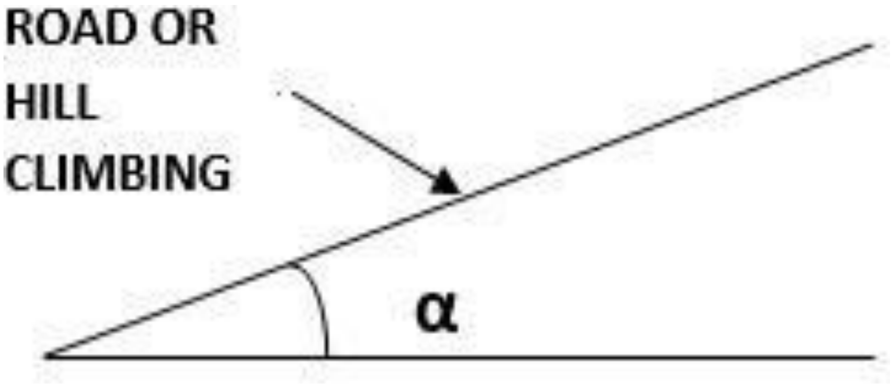


Figure 2.1 Inclined Surface

The gradient resistance can be calculated using the formula given by equation:

$$F_{\mathrm{GR}} = + M \times g \times sin\ \alpha \tag{2.2}$$

Let's use an electric automobile that travels on a level route as an illustration.

Therefore,

Slope (α) =0^{o}.

F_{GR}= 450*9.81*sin 0^{o} = 0 N.

For this instance, power required to overcome resistance offered by the gradient is zero. Hence it is neglected while evaluating power.

2.1.2 Rolling Resistance

As the vehicle tires are in touch with the surface of the ground they are standing, it offers a resistance to movement which is called rolling resistance. This force resisting the rolling of vehicle is given by the formula 2.2 below:

$$F_{RR} = C_{RR} x\ M\ x\ g$$

(2.3)

where,

C_{RR} = Coefficient for rolling resistance

M = mass (kg)

g = gravitational acceleration = 9.81 m/s^2

Considering black topped surface,

C_{RR} = 0.01 (T.Porselvi, 2017)

M= 450 kg (given as example)

Therefore, F_{RR}= 0.01×450×9.81=44.145 N

Power needed to beat the rolling resistance of 44.145 N is:

P_{RR}= F_{RR}×V/3600= 44.145×100/3600= 1.226 kW

Where, V=velocity (in kmph)

2.1.3 Aerodynamic drag

The resistance force offered by force of viscosity acting on the vehicle is termed as aerodynamic drag. It is mainly dependent on shape of the vehicle designed or considered for the conversion in this case.

Aerodynamic drag can be calculated using formula 2.4 as shown below

$$F_{AD} = 0.5 \times C_A \times A_f \times \rho \times * (Vt + Vo)^2 \tag{2.4}$$

where,

C_A = Coefficient of aerodynamic drag

A_f = total area of contact

ρ = the density of air

V_0 = velocity at time 0 and V_t is velocity at time t

The three main forces that act on a moving object at a constant speed are inertial force and aerodynamic force and force due to inclination. For the purposes of this example, let's assume that the amount of power required to overcome aerodynamic drag and other resistive forces is about 1.3 kW is about. As a result, the vehicle's total tractive power requirements are given by,

P_{TOT}= 1.226 kW+1.3 kW= 2.526 kW.

In reality, we don’t select an electric motor with this rating of 2.526 kW power. We should consider these losses due to transmission from electric motor to the wheel. Thus, the mechanical power output (P_{TR}) necessary for driving the vehicle is given by the equation 2.5 below:

$$P_{TR} = P_{TOT} / \eta \tag{2.5}$$

Where, η= efficiency of the gear system used.

Considering the transmission system efficiency to be 0.85, the mechanical power output required is:

$P = P_{TOT} / \eta = 2.526/0.85=2.97= 3$ kW

In order to select a power rating for a 450 kg electric vehicle, a motor with a power rating of 3 kW must be selected. This is how the power rating required to drive an EV under a certain load calculation is done (T.Porselvi, 2017).

2.1.4 Inertial Force

The rate of Change of velocity is called as acceleration. This is one of the important components of vehicle dynamics that needs to be considered for conversion. Inertial force is given by the equation 2.6 below (Singh, 1993).

$$\mathrm{FA} = M \times a \tag{2.6}$$

where,

F_A = the Force due to the acceleration

a = is the acceleration due to gravity

M =is the mass of the vehicle

2.1.5 Additional Conversion Calculation

The followings are the basic calculations used in conversions to determine electrical and other essential parameters.

Torque calculation for minimum force required

$$Torque = F_{TOT}\ x\ W_R \tag{2.7}$$

where,

W_R is the wheel radius

(i) The battery power rating watt hour is given by equation 2.7 below:

$$Ah\ x\ V = Wh \tag{2.8}$$

where,

Ah = Ampere hour

V = Voltage

Wh = Watt hour

(ii) By using the battery of provided watt hour capacity, the vehicle can travel a distance which is given by the formula 2.8 given below:

$$d = Wh/F_{TR} \tag{2.9}$$

where,

d = distance travelled in one full charge

F_{TR}= Total Tractive forces needed to drive the vehicle.

(iii) The charging time for batteries are related to the battery charging system’s capability associated with it.

$$\mathrm{T = Ah/A} \tag{2.10}$$

where,

Ah = Ampere hour rating of battery

A = Current in amps (charger)

2.2 EV Components and its Function

As seen in Figure 2.1, a series of safety devices connect the LiPo battery pack to the controller, which acts as the electric automobile system's heart and brain. The 400A automotive grade fuse with a fully clear cover helps to contain sparking in the event of a blown fuse from an excessive current.

The isolation switching for the low current side is provided by the high current relay. The driver can easily access the emergency push button, which enables them to shut off the relay whenever necessary. It is not necessary to use a soft start circuit to avoid or reduce high inrush current because the controller has internal protection. Additionally, the cable itself is automotive grade and able to meet the wiring requirements for electric vehicles.

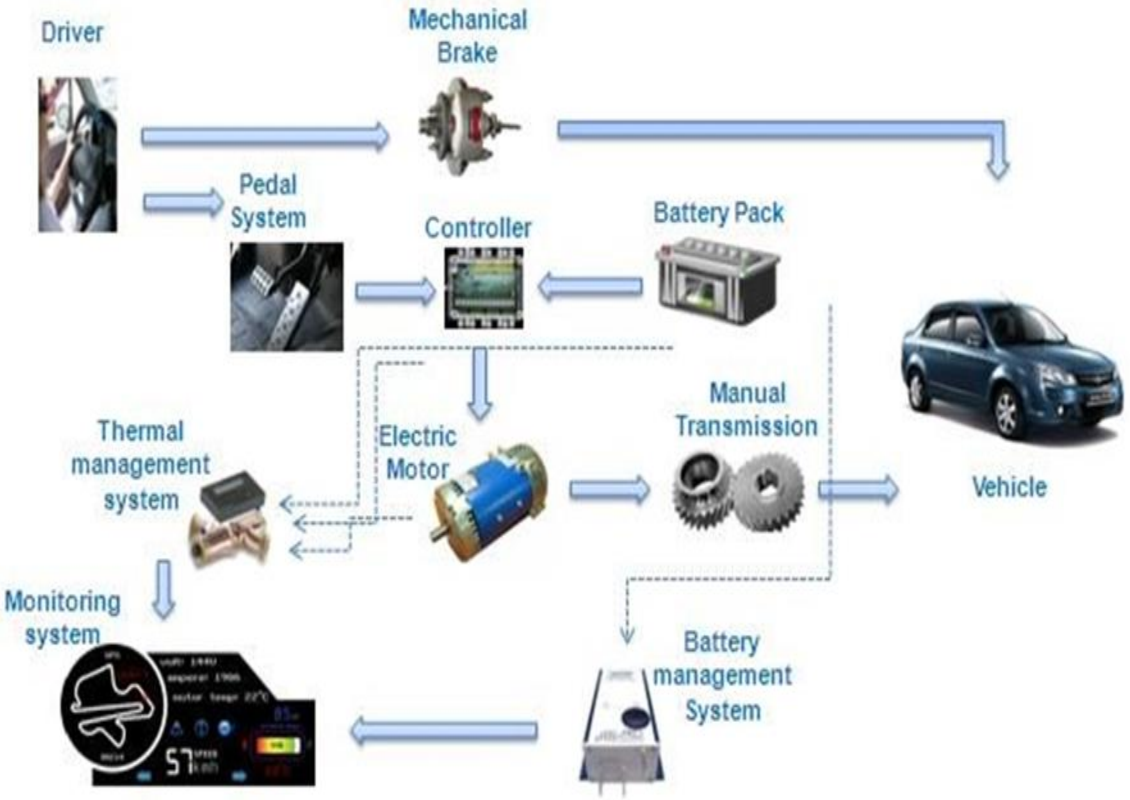


Figure 2.2 Basic Components of EV

The controller uses the Pulse Width Modulation (PWM) technology to convert the battery's DC power to three phases of AC. Three high current cables link the controller to the induction motor. Additionally, two quadrature encoders for phases A and B installed on the motor shaft are used to capture the rotor position of the motor in order to accomplish precision control.

The quadrature encoder's simultaneous detection of motor speed and direction serves as the main feedback signal for the motor control algorithm. By pressing the foot throttle, the controller generates low voltage input and uses it to drive the induction motor up to the desired speed. The maximum throttle voltage and the maximum throttle resistance must match the controller's specifications. The maximum voltage for the throttle is typically 5 VDC, and the maximum resistance is 5 k ohm.

To ensure lightness and durability, the induction motor is placed on the transmission box using a specially manufactured aluminum connection plate. The induction motor's starting torque is sufficient to turn the front wheel or rear wheel and propel the vehicle forward.

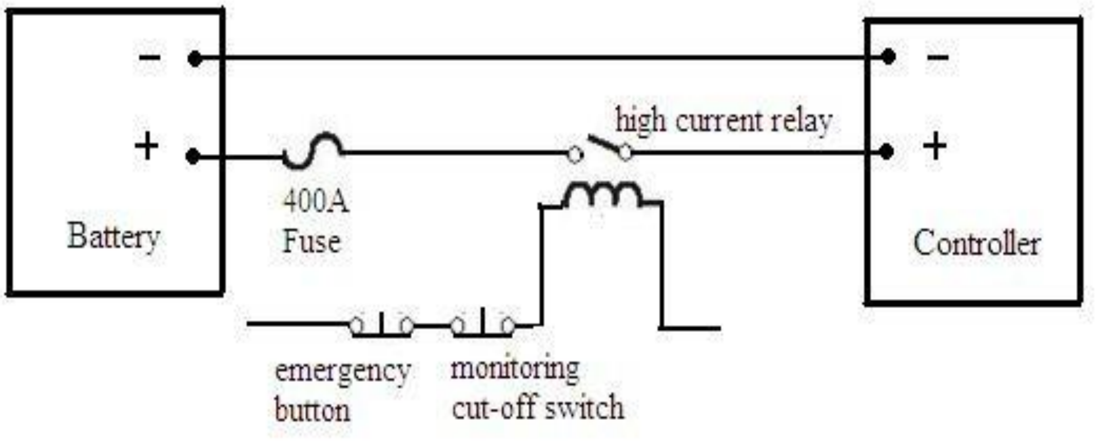


Figure 2.3 Controller to battery wiring diagram

2.3 Investment Criteria: NPW or NPV

We will first briefly discuss the fundamental process for using the net-present-worth criterion to evaluate and compare various investment projects.

2.3.1 Evaluating a Single Project

The details of evaluating a single project are divided into following major steps:

Step 1: Determine the interest rate that the firm wishes to earn on its investments. The interest rate you determine represents the rate at which the firm can always invest the money in its investment pool, the value of capital available for lending and investing. This interest rate is often referred to as either a required rate of return or a minimum attractive rate of return (MARR). Usually, this selection is a policy decision made by top management. It is possible for the MARR to change over the life of a project, but for now we will use a single rate of interest when calculating PW.

Step 2: Estimate the service life of the project.

Step 3: Estimate the cash inflow for each period over the service life.

Step 4: Estimate the cash outflow for each period over the service life.

Step 5: Determine the net cash flows for each period (Net cash flow = Cash inflow - Cash outflow).

Step 6: Find the present worth of each net cash flow at the MARR. Add up these present-worth figures; their sum is defined as the project's NPW.

Step 7: In this context, a positive NPW means that the equivalent worth of the inflows is more than the equivalent worth of the outflows so that the project makes a profit. Therefore, if the PW is positive for a single project, the project should be accepted: if it is negative, the project should be rejected. Present-Worth Analysis accepts the project that results in the smallest PW of costs or the least negative PW (because you are minimizing costs rather than maximizing profits) (Park, 2013).

2.4 Fuel Facility provided to Government officials

GoN has set a restriction on the facilities provided to its personnel in order to cut down on operating costs and organize these benefits. This was set to limit the exploitation of government resources and control the limited budgets available to be utilized in other productive sectors (Ministry of Finance , 2019).

Table 2.1 Fuel Facility provided to officials of GoN

S. N	**Authorized Official**	**Fuel per Month (In Liters)**	**Engine Oil and Brake Oil Per Quarter (In Liters)**
1	Minister/ Constitutional Authority	According to Law in function	”
2	Secretary /Specific Category	100	5
3	Joint-Secretary	70	5

2.5 Fuel Import Pattern of Nepal

Huge amount has been spent each year on import of fossil fuel mostly for vehicles in Nepal. The trend of fuel import seems to rise each year according to import of vehicles. More alarming is that all these fuels have been imported for sectors that have less effect on national GDP and ultimately on national economy. As, this research is focused on petrol-based vehicles major focus is on the import and utilization of petrol imported which has been increasing at an alarming rate from 2069 to 2079 B.S. (NOC, 2022).

Table 2.2 Fuel Import Pattern of Nepal (in kL)

Fiscal Year	**Petrol**	**Diesel**	**Kerosene**	**ATF**	**LPG IN MT**
2078/79 (2021-22AD)	736276	1723557	17340	157128	536028
2077/78 (2020-21AD)	591700	1696202	23584	72264	477752
2076/77 (2019-20AD)	512128	1473536	18924	137424	449063
2075/76 (2018-19AD)	566827	1714917	25004	200108	429609
2074/75 (2017-18AD)	488675	1588869	22337	197220	370560
2073/74(2016-17AD)	407270	1319873	19607	164836	312928
2072/73(2015-16AD)	240386	785685	14194	83819	214194
2071/72 (2014-15AD)	287473	921714	19653	141404	258299
2070/71 (2013-14AD)	253381	808567	18409	125678	232660
2069/70(2012/2013A)	223087	721203	24065	115896	207038

Fig 2.4 below depicts import trend of petrol of Nepal which has been in rise at a uniform rate. In total 77,36,27,600 liters of petrol were imported last fiscal year. The figure also signifies that there has been tremendous amount of petrol vehicle being imported along with petrol based 2 wheelers.

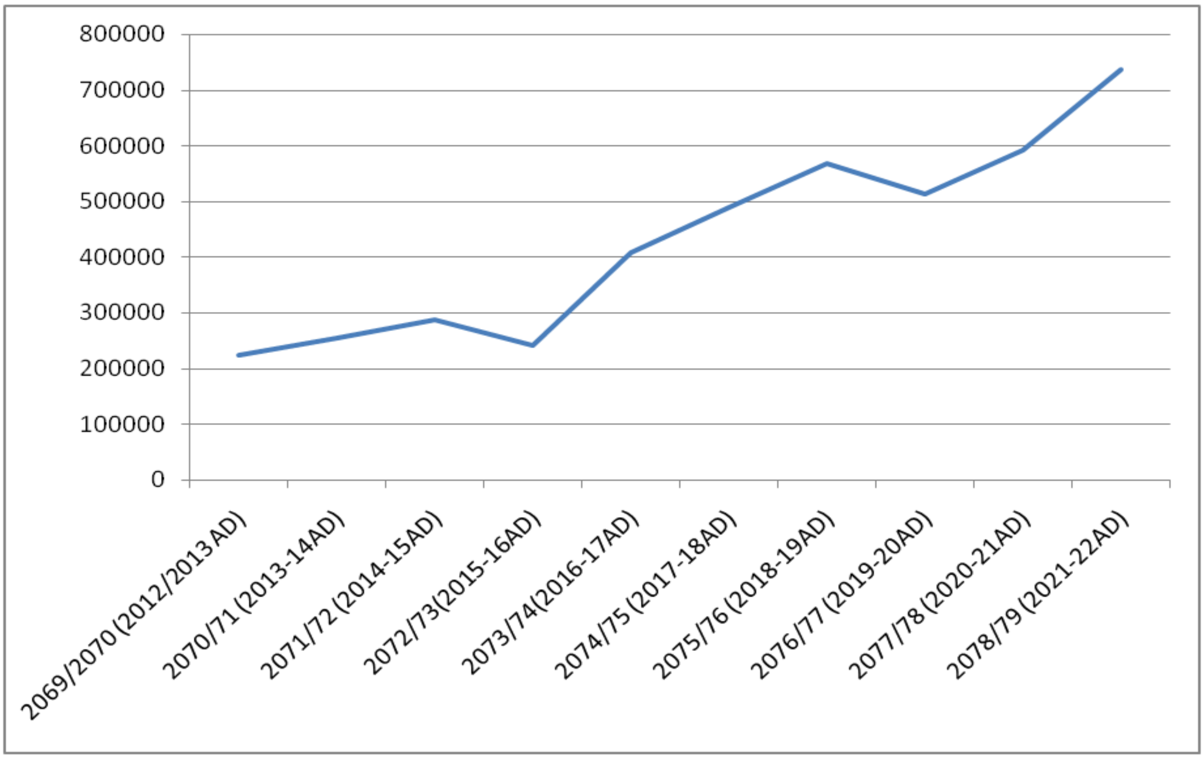


Figure 2.4 Fuel Import Pattern of Nepal

2.6 Imported Petrol Utilization in Nepal by Sectors

Petrol imported in Nepal Mostly has been utilized in transportation sector which accounts to 96% whereas other important sectors like industry have nominal use of petrol (NEIS, 2019).

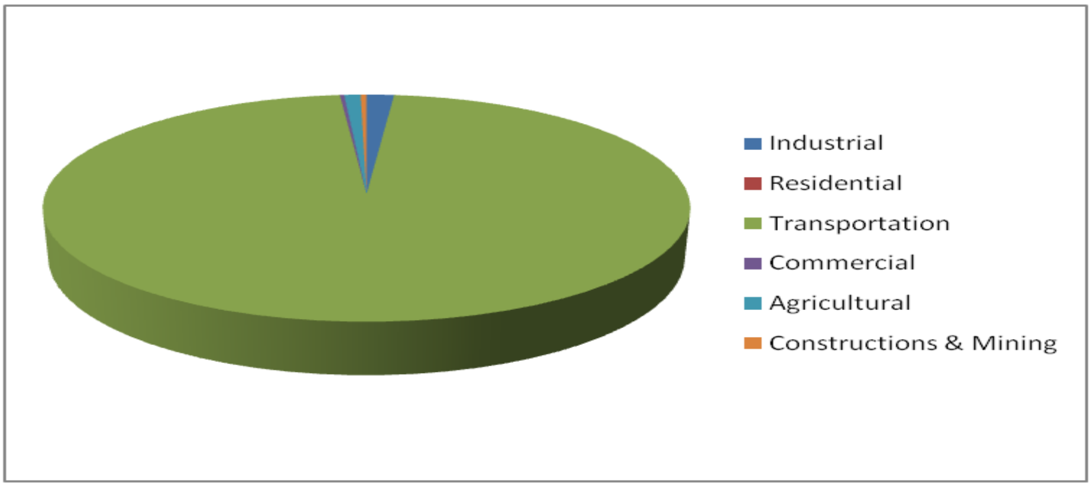


Figure 2.5 Petrol Utilization by Sectors

2.7 Electricity Production in Nepal and Pricing

In the hydroelectricity sector, NEA and IPPs have been collaborating to create projects that will eventually be incorporated into the national grid. Even though we now have a 10000 MW export agreement with India, the current PPA projects we have applied for will provide 11739.8 MW, while the PPA projects we have completed have a total capacity of 6366.1 MW, which suggests we will have excess energy soon. It follows that based on the generation; the price of electricity will be lower provided the energy is surplus (NEA, 2022)

Even if oil prices rise globally, if Nepal produces 20% of its total capacity during the next ten years, its GDP will increase by a minimum of four times (Herath Gunatilake, 2020). It is obvious that increasing hydropower acts as insurance against rising oil prices.

Table 2.3 NEA Projects and Future Capacity of Electricity

S.N.	**Status**	**Numbers**	**Capacity (MW)**
1	Projects Operating Smoothly	132	1531.8
S.N.	**Status**	**Numbers**	**Capacity (MW)**
2	Projects Being Constructed	141	3280.9
3	Projects under Different Stages	84	1553.4
	PPA Concluded Projects	**357**	**6366.1**
4	PPA Applications	269	11739.8
Total		**626**	**18105.9**

2.8 Comparison of Lithium Battery to Lead Acid Battery

The table 2.4 below aims to compare different important parameters related to battery technologies that can be the base of their choice in conversion of ICEV to EV. This section aims to highlight the features and characteristics like Energy density, Specific Energy, maintenance cost, life cycle, efficiency etc. for the different types of batteries that can be used in conversion. The comparison with assist in determining the right kind of battery technology needed for EV conversion process (Greg Albright, 2012).

Table 2.4 Battery Technology Comparison

Parameters	**FLA (Flooded Lead Acid)**	**VRLA (Valve Regulated Lead Acid)**	**Lithium Ion**
Energy density (Wh/L)	80	100	250
Specific Energy (Wh/kg)	30	40	150
Regular maintenance	Yes	No	No
Initial Cost ($ per kWh)	65	120	600
Life Cycle	1,200 @ 50% DOD (Depth of Discharge)	1,000 @ 50% DoD	1,900 @ 80% DoD
Charging Window	50%	50%	80%
Sensitivity to the temperature	Degrades significantly above 25°C	Degrades significantly above 25°C	Degrades significantly above 45°C

Parameters	**FLA** **(Flooded Lead Acid)**	**VRLA** **(Valve Regulated Lead Acid)**	**Lithium Ion**
Efficiency	100% @20-hr rate 80% @4-hr rate 60% @1-hr rate	100% @20-hr rate 80% @4-hr rate 60% @1-hr rate	100% @20-hr rate 99% @4-hr rate 92% @1-hr rate
Increments Voltage	2 V	2 V	3.7 V

(Greg Albright, 2012)

It's worth noting that the different chemistries in this table have distinct usual state of charge windows. This means that in order for a lead acid system to have the same amount of available energy as a lithium-ion system, the lead acid system's nameplate energy capacity must be greater.

Given the evident disparities in the technical and economic features of the various battery types, the "best" choice for which battery type to utilize is application dependent.

2.8.1 Cycle Life Comparison

Lithium-ion batteries have a substantially longer cycle life cycle than lead acid batteries in deeper discharging situations. The disparity grows worse as the ambient temperature rises. Each chemical's cycle life can be extended by limiting the depth of discharge (DoD), discharge rate, and temperature, although lead acid is mostly having significant higher sensitivity to each of these characteristics.

Figure 2.6 compares the cycle life of a lithium-ion battery pack with an AGM type VRLA battery in a temperate zone (with an average temperature of 77°F). The graph depicts various lead acid DoD% because depth of discharge impacts cycle life. As can be seen, the AGM pack's depth of discharge must be limited to 30% in order for a lithium-ion battery's discharge depth of 75% to live as long. To attain equal life, the AGM type battery's capacity needs to be 2.5 times that of the lithium-ion battery.

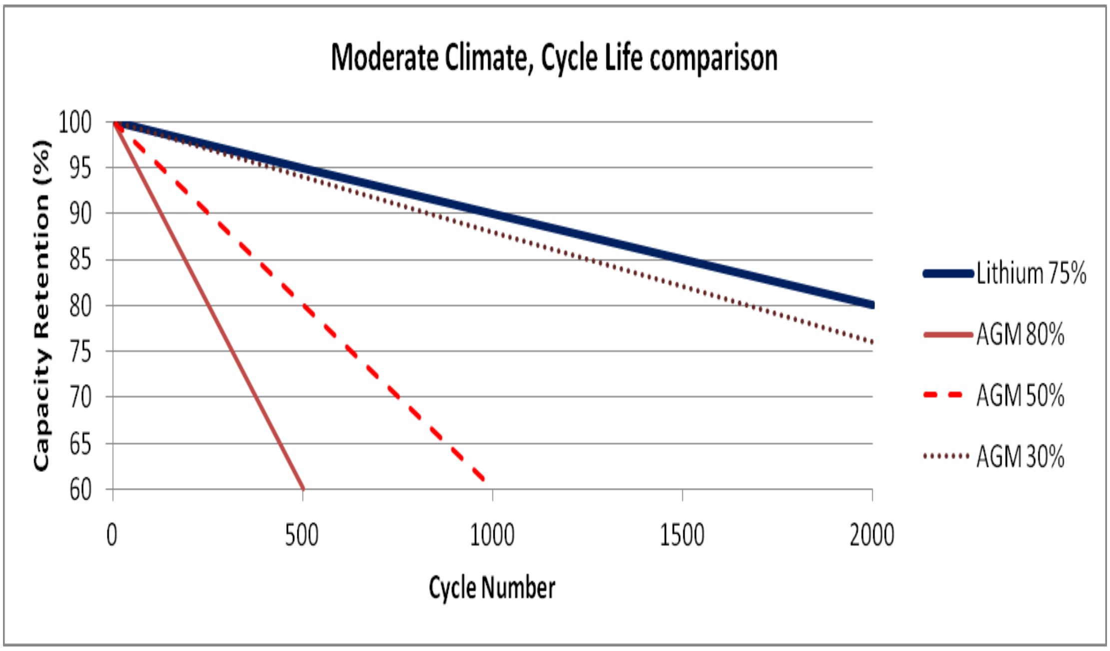


Figure 2.6 Life Cycle Comparison in Moderate Climate (Greg Albright, 2012)

The difference between lithium-ion and lead acid is made worse in warmer locations where the average temperature is 92°F. Lead acid (both VRLA and flooded) loses half of its moderate climate rating in terms of cycle life, but lithium-ion remains stable up to temperatures that routinely reach 120°F.

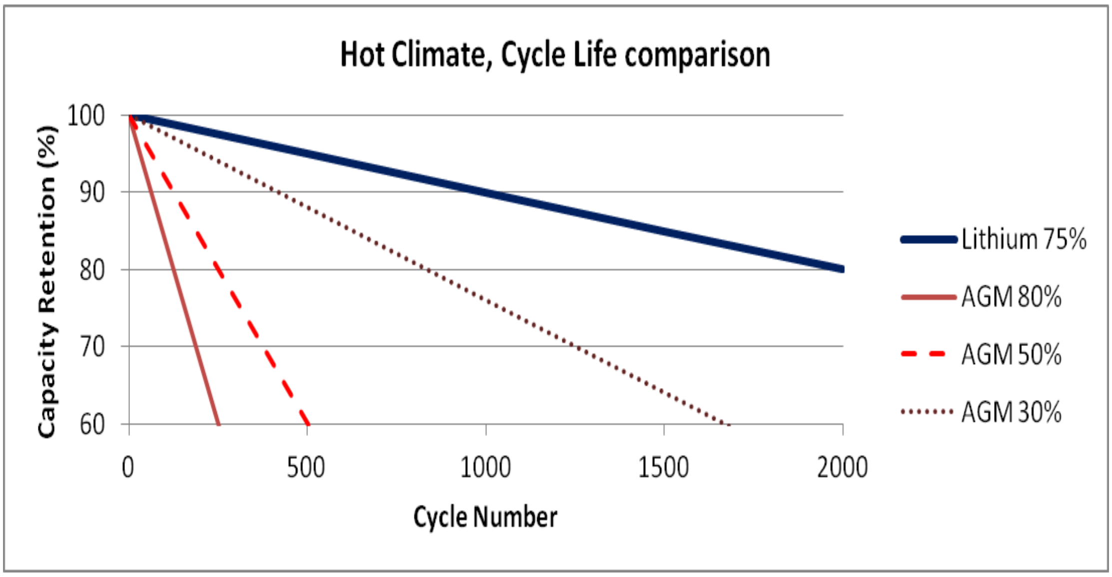


Figure 2.7 Life Cycle Comparison in Hot Climate (Greg Albright, 2012)

2.8.2 Performance Rate

How long a system will take to discharge a battery is a crucial factor to take into account when choosing a lead acid battery's capacity. Lead acid battery have less capacity available from the shorter the discharge period.

If a 100Ah VRLA battery is depleted during a four-hour period, it will only produce 80Ah. In comparison, even after a 30-minute discharge, a 100Ah lithium-ion system will accomplish over 98Ah. Because of this feature, lithium-ion batteries are ideal for applications where full discharge of battery occurs in less than eight hours, as demonstrated in Figure 2.8.

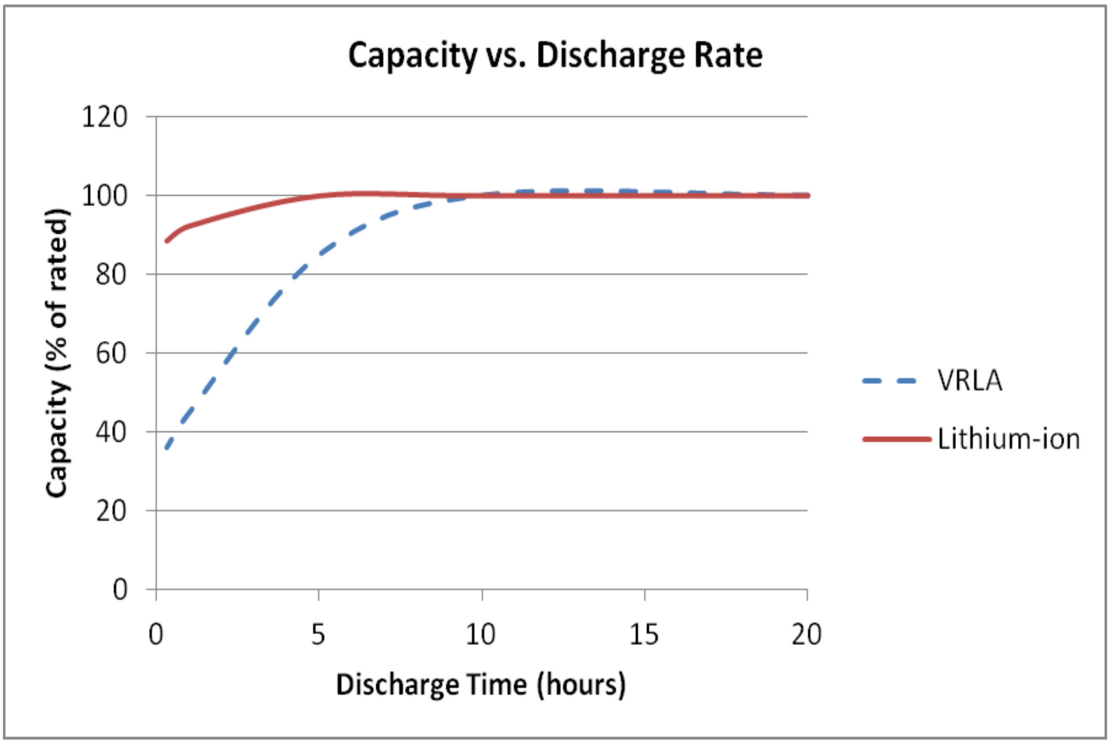


Figure 2.8 Capacity vs Discharge Rate (Greg Albright, 2012)

2.8.3 Cold Weather Performance

Because the rate of discharge affects lead acid performance, two distinct rates have been demonstrated for the VRLA battery. In cold weather situations, both lead acid and lithium-ion lose capacity, although as shown in Figure 8, lithium-ion loses much less capacity as the temperature goes into the -20°C region.

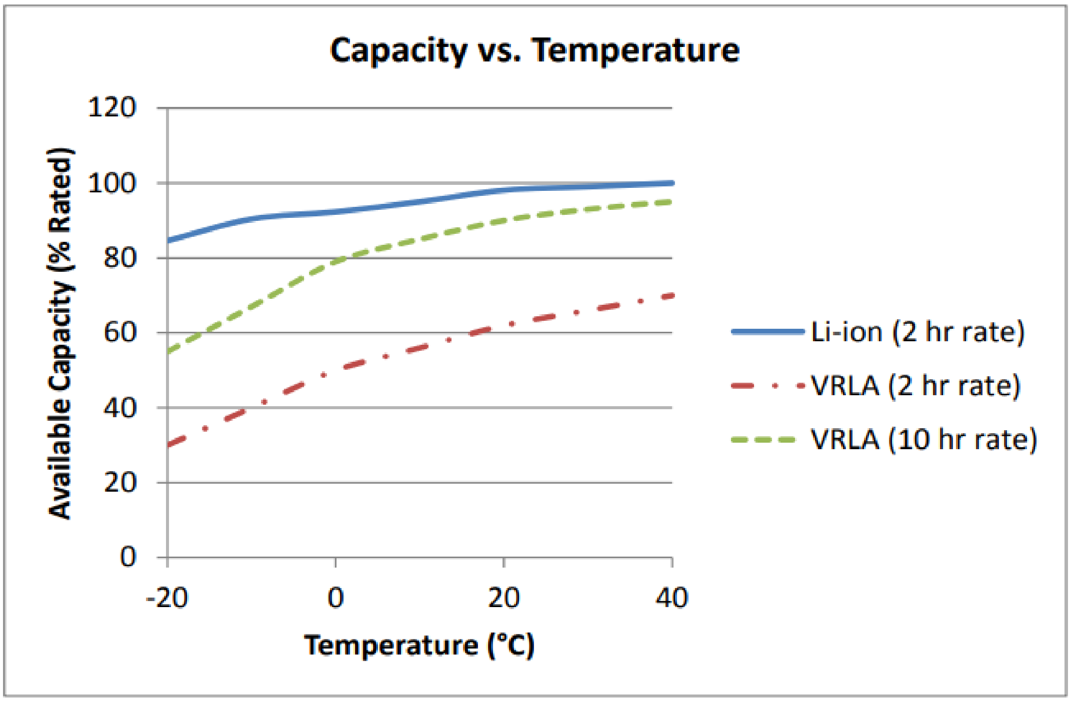


Figure 2.9 Capacity Vs Cold Temperature (Greg Albright, 2012)

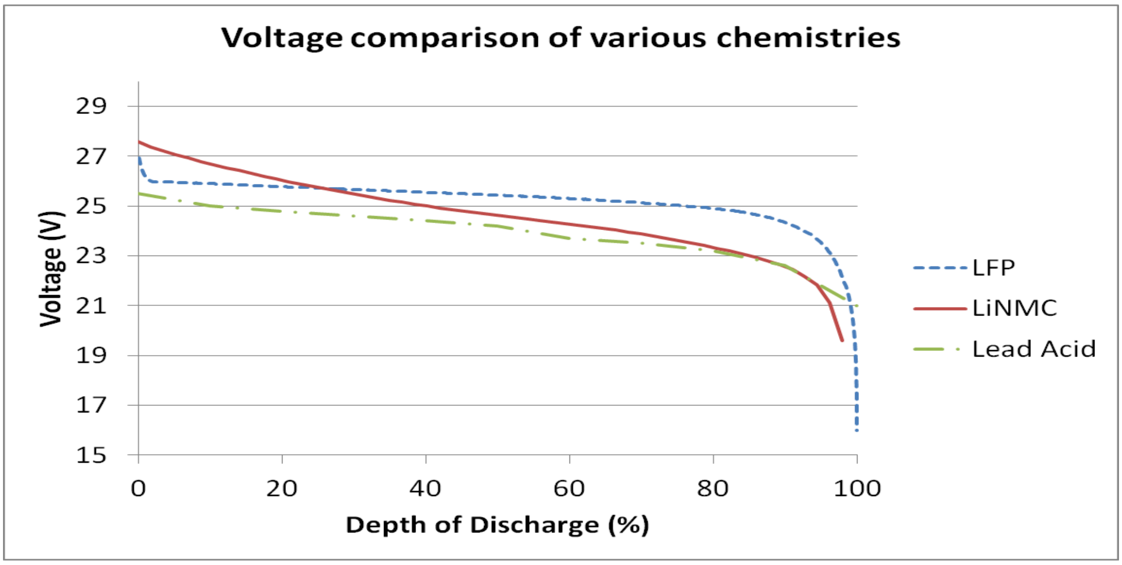
2.8.4 Environmental Impact

Lead acid batteries perform poorly in terms of environmental friendliness when compared to lithium-ion batteries. Lead acid batteries require many times rawer material than lithium-ion batteries for the same amount of energy storage, and the mining process has a substantially bigger negative impact on the environment. The lead processing industry consumes a lot of energy and emits a lot of pollutants. Despite the fact that lead is exceedingly hazardous to human health, the manufacturing techniques and battery packaging significantly limit the risk to humans. In the United States, approximately 97% of lead acid batteries are recycled, which has a significant environmental advantage. Lithium presents its own set of environmental challenges (Greg Albright, 2012). The major components of a lithium-ion battery require the mining of lithium carbonate, copper, aluminum, and iron ore. Although lithium mining requires a significant number of resources, lithium is only a minor component of the battery cell by mass, therefore the environmental implications of aluminum and copper are significantly bigger. The lithium-ion recycling industry is still in its infancy, but because cell materials have exhibited great recovery and recyclability, lithium-ion recycling rates are expected to rival lead acid (Greg Albright, 2012). Lithium has various environmental challenges of its own. Lithium carbonate, copper, aluminum, and iron ore must be mined to make the main parts of a lithium-ion battery. Although lithium mining uses a lot of resources, it makes up a very small mass percentage of the battery cell, so the environmental effects of aluminum and copper are considerably more important. Although the lithium-ion recycling sector is still young, it is anticipated that lead acid recycling rates will soon be surpassed by lithium-ion rates due to the excellent recovery and recyclability of the cell ingredients (Greg Albright, 2012).

2.8.5 Voltage Comparison

The voltage range of each chemical is critical in deciding whether lithium-ion and lead acid batteries can coexist in a given electrical system. Three battery packs, referred to as "24V" batteries in Figure 2.10, are compared. Technically, the nominal voltage of the LiNMC (Lithium Nickel Manganese Cobalt Oxide Battery) is 25.9 volts, while that of the LFP (Lithium Iron Phosphate) is 25.6 volts.

The graph's conclusion is that lithium-ion and lead-acid systems are in good accord throughout the most of ranges of voltage, but any electrical system would have to have capability to handle lithium-ion's greater charging voltage in order to operate at its best. The majority of battery charge controllers and discharge inverters for renewable energy sources can be switched between lithium-ion and lead-acid batteries. Manufacturers of charge controllers, inverters, and lithium-ion battery manufacturers can help ensure system compatibility. (Greg Albright, 2012).



2.10 Voltage Comparison with Depth of Discharges (Greg Albright, 2012)

2.9 Crystal Ball

Crystal Ball is a simple simulation program for analyzing the risks and uncertainties associated with spreadsheet models of Microsoft Excel. This Spotlight provides a quick summary of how Crystal Ball is utilized (it can take a few minutes). Excel models usually are deterministic, which implies that the given inputs are constant (one value per cell). At any given time, we can only see singular result. If we desire to see different outcomes and results, we must manually edit the model's inputs. Simulation is a method for swiftly generating and analyzing a large number of alternative outcomes. Excel cannot execute simulations on its own; instead, an add-in tool such as Crystal Ball is required.

Time Series Forecasting, Monte Carlo Simulation, Optimization and Real Option Analysis, Hypersonic Strategic Finance Planning, and other main features of the CB are listed below (Frost, 2023).

i. Account for input variability in product results.
ii. Optimize process parameters.
iii. Pinpoint critical quality factors.
iv. Reduce adverse outcomes.
v. Assess risk

2.10 Conversion Options Considered

Today there are various conversion options available in the market among them few notables have been selected that can match basic technical requirements of converted EV parameters and the requirement based on the fuel facility provided to government officials above first class.

2.10.1 Loop moto- Electric Car Conversion Kit (E vehicle Info, 2022)

The business sells a small-scale electricity-based powertrain that includes lithium-ion based battery, a battery management system (BMS), and other add-ons required to convert conventional automobiles to electric ones. Honda City, Hyundai Verna, Honda Civic, Honda Amaze and Hyundai Accent are just a few of the vehicles for which the company has got its ARAI certification. The company also provides conversion kits for the Hyundai Accent, Honda Amaze, Maruti Suzuki Dzire, Maruti Suzuki Swift, and, Maruti Suzuki Wagon R. The business provides specialized options for converting any kind of car. The lithium-ion battery has a 7.8kwh intelligent battery management system and LiFePO4 technology. This kit comes with battery that has a 180 km range per charge. The conversion kit includes a 15 kW 3-phase AC motor, 3.3 kW AC charger, and gearless gearbox. The top speed, according to the business, is 80 km/h (E vehicle Info, 2022).

2.10.2 E-Trio- Electric Car Conversion Kit (E vehicle Info, 2022)

The company's efforts to convert the current ICE (diesel/petrol) vehicles into electric vehicles have received permission from the Automotive Research Association of India (ARAI). Automobiles including the Maruti Dzire, WagonR, and Alto have been converted by E-trio. and also offers the EV-150 and EV-180 types of conversion kits. Maruti Alto, WagonR, and Dzire can allegedly be transformed into an electric vehicle within 48 hours, according to the business. ICE automobiles can be converted to electric vehicles using the EV-150 and EV-180 electric vehicle conversion kits. It is the only retrofitting start-up business in India to have its conversion kits approved by the government. The conversion kits include an E-Trio-designed gearbox, a Lithium-ion battery, motor, traction controller, onboard charger, and auxiliary components. the company also modifies the suspension to adjust the extra weight. Battery ranges from 150km to 180 km.

2.10.3 Bharat Kit (E vehicle Info, 2022)

Bharat Kits is a Hyderabad-based firm that works on retrofitting sedans and hatchbacks. It was founded in 2016. The business sells both adapted autos and conversion kits. For converting Swift Dzire, alto, and WagonR, the company has also been certified by ARAI and ICAT. The battery, battery controller, motor, gearbox, DC-DC, on-board charger, instrument cluster, AC full kit, charging gun, vacuum pump, and kit gear selector are some of standout features of the Kit Bharat electric car conversion kits. The business sells a special LiFePO4 battery with a one-time charging range of 80 kilometers. The battery takes roughly four to five hours to fully charge. With it, it can reach a top speed of 80kmph.

The package includes a well-organized battery management system as well as a battery controller. The conversion package includes a 15kW motor. The battery capacity varies depending on the car model. The battery capacity for the hatchback is 12kwh, while the sedan battery capacity is 15kwh.

2.10.4 Rexnamo Electro-Electric Car Conversion Kit (E vehicle Info, 2022)

For the past ten years, Rexnamo Electro has sold conversion kits and refitted electric vehicles. The company also converts and restores old vehicles like Honda Citys, Volkswagens, Old BMWs, Contessas, and Lancers. The conversion kits have an 88 kmph top speed and an 80 km driving range on a single charge.

2.11 Emission from Gypsy Vehicles

For Gypsy MG410 model and MG413 model they fall into the category of pollution range of equipment with GVW below 3500 kg. Table 2.5 below shows emission limit for those vehicles. The unit for measurement is given in g/Km for Carbon monoxide (CO), Hydrocarbon (HC) and Nitrogen oxide (NO_x) (Car Trade Tech, 2010) .

Table 2.5 Petrol Vehicles Emission Standards (GVW ≤ 3500 kg), g/Km

Year	Reference	CO	HC	HC+NO_x	NO_x
1991	–	14.3–27.1	2.0–2.9	–	
1996	–	8.68–12.4	–	3.00–4.36	
1998	–	4.34–6.20	–	1.50–2.18	
2000	Euro 1	2.72–6.90	–	0.97–1.70	
2005	Euro 2	2.2–5.0	–	0.5–0.7	
2010	Euro 3	2.3	0.2	–	0.15
		4.17	0.25		0.18
		5.22	0.29		0.21
2010	Euro 4	1	0.1	–	0.08
		1.81	0.13		0.1
		2.27	0.16		0.11

2.12 Study Gaps

Several studies have been done in past on EVs and feasibility study on their applications as well. But there are few studies that perform financial analysis on EV Conversion Kits comparing the cost to facilities given to the Government officials of Nepal. There has not been enough practice to utilize conversion kits to transform ICEVs to EV. In Nepali

Army (NA) few conversion efforts have been conducted to look for feasibility of conversion.

In this study, conversion efforts made by NA will be analyzed technically and financially to suggest a new conversion kit. As of now there are several commercial conversion kits available but the one with best technical and financial applicability will be chosen to replace the facility given to the government officials by GON using the NPV method. Secondary data regarding the conversion options and the limitations of conversion done on Maruti Gypsy will be thoroughly analyzed to look at better battery alternatives as well as system alternatives.

CHAPTER THREE: RESEARCH METHODOLOGY

The research methodology outlines all of the precise procedures employed to carry out the investigation. The choice of a suitable methodology and the applicability of such approaches to solving the identified research problem are key factors in the accomplishment of research projects. It essentially outlines the procedures for gathering data and analyzing that data to find the answer to a research question. The goal of this research is to find ways to fix the problems with the EV conversion model that has been put in place and to investigate other use cases for the Maruti Gypsy.

3.1 Conversion of Maruti Gypsy done by NA

NA has converted Maruti Gypsy Vehicle No BA. 1. JHA. 6262 which has been running smoothly till date. The following table shows the details of the converted vehicle. Specification of Maruti Gypsy are given in APPENDIX A.

Table 3.1 Details of Converted Vehicle

Registration no	BA 1 JHA 6262
Conversion Date	2077
Body/Chassis	Maruti Gypsy 413W
Motor Controller	Kelly, KAC96501-8080I, 200A, 24-96 V
Motor Specification	7.5KW Three phase AC Induction Motor
Battery pack	72V, 200AH Lead Acid Battery (6x12V,200AH)

The vehicle's mechanical system was modified to meet the needs. The elimination of the engine, transmission, and other auxiliary systems resulted in a significant weight reduction. However, using a lead acid battery increased the weight of the car. Along with the battery, motor and the rear axle assembly adds weight to the vehicle, raising its overall weight and ultimately reducing the traction force needed to move it.

Only few mechanical systems were removed and major systems of the vehicle has been kept as it was in the vehicle previously. The details of all the mechanical systems and their treatment have been shown in the table below.

Table 3.2 Mechanical Details of Conversion

Gear System	Forward, Reverse and Neutral
Transmission system	Rear axle replaced by new axle with mounted three phase
Induction motor	Engine, Gear box, rear axle and propeller shaft removed during conversion
Suspension System	Originally fitted suspension
Braking System	Originally fitted with void of vacuum booster
Steering System	Originally fitted with void of hydraulic
Charging System	Onboard Solar Panel along with Single Phase AC, 50hz

3.1.1 Design Configuration of Converted EV

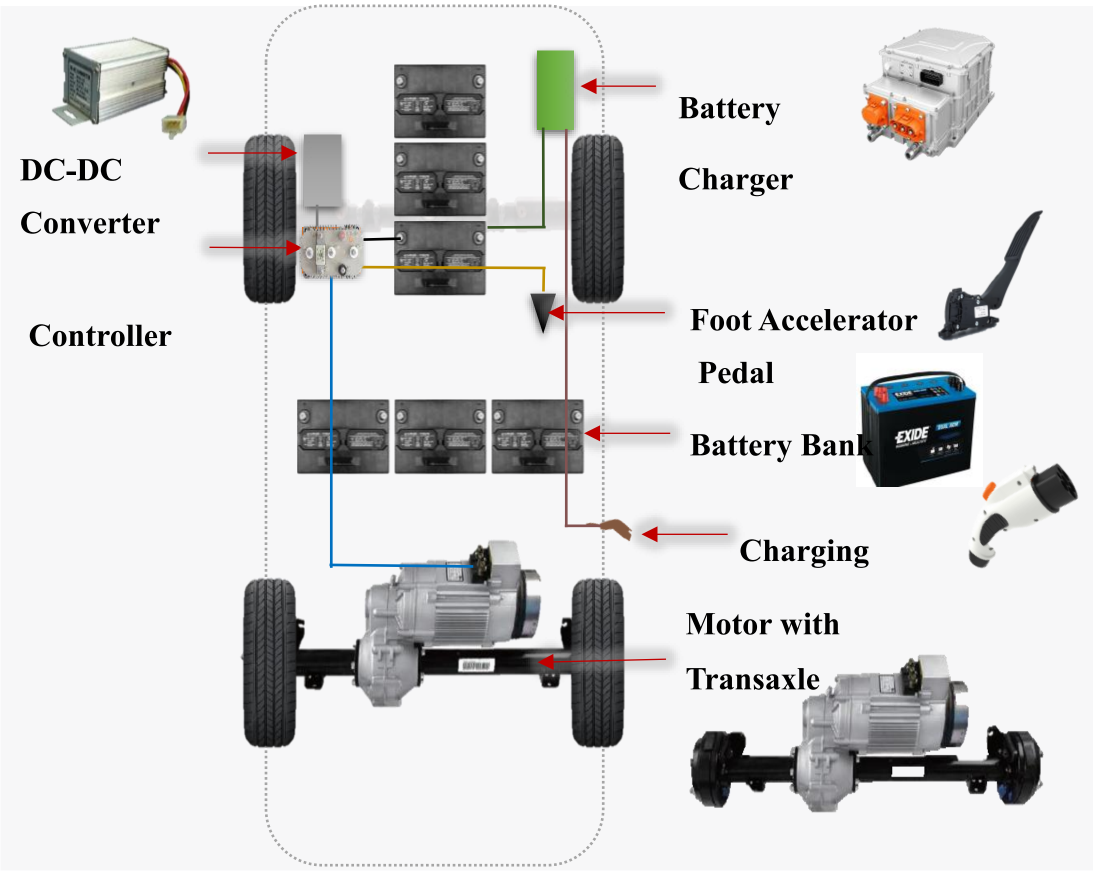


Figure 3.1 Design Configuration of Converted EV

3.1.2 Weight Treatment for Conversion

All unnecessary components from the vehicle to accommodate EV components altogether 316.55 Kg of weight were reduced. Details of the components and their respective reduced weights are shown in the table below.

Table 3.3 Weight Reduction Table

S. N.	Component/Assy	Weight (Kg)
1	Radiator	4.650
2	Rear Propeller Shaft	3.650

3	Front Propeller Shaft	3.300
4	Air Cleaner Set	1.900
5	Gear Box	28.400
6	Auxiliary gearbox	26.600
7	Fuel Tank	6.750
8	Silencer	18.400
9	Rear axle assembly	58.900
10	Mounting Cable and others	14.150
11	Engine Weight	89.100
12	Fuel	40 (Approx)
13	Battery	10.750
14	Coolants	10(Approx)
Total Weight Reduced		**316.55**

Despite the reduced weight of removal some more weight was added due to the EV components which sum about 440 Kg.

Table 3.4 Weight Addition Table

S. N	Component/Assy	Weight
1	Battery	317.700
2	Drive Motor	37.300
3	Controller	3
4	Rear Axle	32

5	Cables/Wires/ Clamp	15
6	Battery Charger	5
7	Battery Brackets	30
Total Weight Added		440 Kg

Due to additional load present vehicle weight was increased by 123.45 Kg. Development stages of EV conversion is shown APPENDIX C.

Figure 3.1 Final View of Converted Electric Vehicle

3.1.3 Calculations for Converted EV

To drive a vehicle, certain resistance needs to be overcome by electric vehicle. The forces that come into play are given by equation 2.1.

$$F_{TOT} = F_{GR} + F_{RR} + F_{AD}$$

where,

F_{TOT}= Sum of all the forces acting against the motion of the vehicle

F_{GR}= Force of resistance due to gradient

F_{RR}= Force of resistance against rolling

F_{AD}=resisting force caused by aerodynamics and shape of vehicle

Sum of tractive forces that the motor output must be overcoming to move the vehicle is denoted by F_{TOT}.

(i) Rolling Resistance

Rolling resistance is the resistance offered to the vehicle due to the contact of tires with road. The formula for calculating force due to rolling resistance is given by equation 2.3 from previous section.

$$F_{RR} = C_{RR} x\ M\ x\ g$$

where,

C_{RR}= Coefficient of rolling resistance

M= mass in kg

g= acceleration due to gravity= 9.81 m/s^2

For the application considered, C_{RR}=0.01 for black topped pitch (Singh, 1993).

M= 1585Kg+123.45Kg ≈ 1710 Kg

Therefore,

F_{RR}= 0.01*1710*9.81=167.75N

(ii) Gradient Resistance

The vehicle's gradient resistance is the resistance it faces when climbing a hill or flying over a bridge, or when traveling downhill. The angle formed by the ground and the path's slope is denoted as α.

The formula for calculating the gradient resistance is given by equation 2.2 from previous section.

F_{GR}=+ M*g*sin α

For Kathmandu City assuming 0º

Therefore, the angle α =0º

F_{GR}= 1775*9.81*sin 0º = 0N.

(iii) Aerodynamic Drag

Aerodynamic drag is the resistive force offered due to viscous force acting on the vehicle. It is largely determined by the shape of the vehicle. The formula for calculating the aerodynamic drag is given by equation 2.4 from previous section.

$$F_{AD} = 0.5 \times C_A \times A_f \times \rho \times * (Vt + Vo)^2$$

Whereas in this case,

C_A= Coefficient of aerodynamic drag, taken as 0.5 (Singh, 1993)

A_f = Area under contact of fluid i.e., air = 2m^2 (Maruti Gypsy 413 Hard Top with dimensions is shown is APPENDIX A)

ρ= density of air=1.2 kg/m^3

V_0 = velocity at time 0

V_t =velocity at time t= 54 Kmph (15m/s), considered design parameter

Computing these values we get,

F_{AD}=135N

Therefore, total tractive power required to move the vehicle is evaluated as

P_{TOT} = (167.75+ 135) N × 54/3600=4541kW=4.5 kW

However, an electric motor with a power rating of 4.678 kW should not be chosen. Power transmission losses to the wheel must be considered. As a result, equation gives the mechanical power output (P_{TR}) required to drive the vehicle is evaluated using equation 2.5.

$$P_{TR} = P_{TOT} / \eta$$

where,

η= efficiency of the transmission gear system.

Let us consider the efficiency of the transmission system to be 0.85. Therefore, the mechanical power output required is:

P_{TR} = P_{TOT} / η= 4.5/0.85=5.34kW <7.5 kW

Thus, for an electric car of 1710 kg we chose 7.5kW EV conversion kit with full accessories. The selection was limited mainly due to financial reasons and import of goods were also restricted at that period.

(iv) Inertial Force

For designed speed of 54 kmph the acceleration is calculated using equation 2.6

$$FA = M \times a$$

Using the formula, $a=(V_t-V_0)/t$,

a = (V1 -V0)/t = (15-0)/25=0.6m/s2 (assuming 25 Secs to reach the highest Velocity of 54 kmph i.e.,15m/s)

So, F_A= 1710×0.6=1026N

(v) Torque Calculation

Wheel diameter (W_D) =15''=0.381m

Wheel radius (W_R)=0.1905m

Motor Speed (N)=2880 rpm (Company, 2019)

So, the rated Torque of motor= $P*60/2\pi N$=24.86 Nm

The Gearing ratio gives net rated torque(τ_R)=49.73*4=99.47Nm (Gearing ratio of Motor with axle attachment) (Chauhan, 2015).

(vi) Minimum Torque required

Minimum Torque required is basically the torque on wheels needed to drive the vehicle which can be calculated using equation 2.6 from previous section.

Torque (τ_{min})= F_{TOT} x W_R=(F_{RR}+F_{GR}+F_{AD}) W_R=(167.75+0+135)×0.1905=57.67Nm

For normal running the torque is sufficient but for inclinations the speed has to be reduced sufficiently so that there is minimum drag effect.

(vii) Additional Conversion Calculation

The followings are the basic calculations used in conversion.

The watt hour of the battery is given by equation 2.7.

Ah x V=200×12×6=14,400Wh

where,

Ah = Ampere hour

V = voltage of each battery

Wh = power rating in watt-hour

The distance that can be travelled using this battery is given by equation 2.8.

d=Wh/F=14400/302.75= 47.56 Km

Hence d=47.75Km

Solar charging during runs and regeneration factor also added the distance due to which max distance attained on single charge is 60 Km.

The charging time of the lead acid battery is given by

T=Ah/A =200Ah/30A=6.66 (Based on Discharge 6-8 hours)

3.1.4 Motor Selection

Due to their flux-weakening capabilities, induction motors are easy to operate, robust, and require little maintenance. The breakdown torque of these motors limits their constant power area. They are inefficient and have low power factors at high speeds (Sreedhar Madichetty, 2021).

Due to limitations of budget and time Induction Motor has been selected for the conversion with capacity of 7.5 kW.

3.1.5 Specification of Converted EV

From the calculation and the test runs final specification of EV of converted Maruti Gypsy is given in table 3.5 below.

Table 3.5 Specification of Converted EV

Vehicle Model	Maruti Gypsy MG413W
Type	Line AC and solar chargeable battery powered electric vehicle

Full Charge Km	60 km
Full Charging Duration	6-8 Hours (Approx.)
Battery Pack	6 Pcs (12 V, 200 Ah Lead Acid Battery)
Motor	7.5 KVA Three phase AC Induction Motor
Controller	Kelly, KAC96501-8080I, 200A, 24-96 V
Top Speed	54 Kmph
Gear System	Forward, Reverse and Neutral
Conversion Cost	NRS. 7,50,000.00
EV Conversion Duration	Magh 2076 – Baishak 2077 (4 months)

3.2 Comparison of Conversion Kits

Based on the Model of the vehicle and the driving requirements of government officials the Loop moto- Electric Car Conversion Kit is selected basically for the following features:

Table 3.6 Comparative Chart of Conversion Kits

Kit Type	**Loop moto-electric Conversion Kit**	**E Trio Kit**	**Bharat Kit**	**Rexnamo Electro-Electric Car Conversion Kit**
Range (1 Charge)	180 Km	150 Km & 180 Km	80 Km	80 Km
Top Speed	80 Km/Hr		80 Km/Hr	88 Km/Hr

Kit Type	**Loop moto-electric Conversion Kit**	**E Trio Kit**	**Bharat Kit**	**Rexnamo Electro-Electric Car Conversion Kit**
Motor	15 kW 3phase AC		15 kW 3phase AC	
Battery	LiFePo4 With BMS	Li-ion	LiFePo4 With BMS	
Battery Capacity	17.8kWh		15 kWh	
Cost Per Kit (NPR)	4,80,000 to 8,00,000	6,40,000	8,00,000	3,84,000 to 9,12,000

3.3 Comparison of New EV For Study

For this study 2 Chinese EV and one Indian EV is taken into consideration for the analysis of different alternatives or scenarios. Table 3.7 below shows the basic parameters of these EV readily available in Nepali market along with their price which would be used in our simulation in crystal ball.

Table 3.7 New EVs in Nepal for Comparative Study

Vehicle	**DERRY EV 7**	**THEE GO E8**	**MAHINDRA e2o Plus**
Battery Capacity (kWh)	17KWh	14.8 KWh	19KWh
Seating Capacity	5	5	4
Top Speed	70 Km/h		80 Km/h

Vehicle	DERRY EV 7	THEE GO E8	MAHINDRA e20 Plus
Charging Duration (Hrs)	5.5 Hrs	5 Hrs	6-8 Hrs
Range (Km)	175 Km	150 Km	140 Km
Ground Clearence	170 mm	170 mm	170
Cost	19,50,000	21,94,500	31,00,000

3.4 Operational Costs Associated with Maruti Gypsy

Maruti Gypsy yearly costs around NRs 1,95,000 per annum for operation based on the facility fuel and other expenses associated (EMESC,2022).

Table 3.8 Operational cost of Maruti Gypsy

S. N	Item	Total Cost (NRs)	Remarks
1	Servicing Cost	20000	Fuel as per MOF Expenditure Directive 2077
2	Fuel	147000	Fuel as per MOF Expenditure Directive 2077
3	Coolant/Antifreeze	1500	Service Manual
4	Pump Servicing and Fuel System Maintenance	25000	Data from EMESC
5	Miscellaneous maintenance	1500	Data from EMESC

Operational cost only includes the cost related to Fuel System, Cooling System and Engine System related verifiable cost so that comparison with the fuel-based vehicle is more logical and reasonable. Cost related to other common systems like steering system, transmission system etc. is not considered as they are used by both converted EV and original Vehicle.

3.4.1 Distance Calculation for Comparison of Scenarios

Fuel facility per Month = 70 Liter

Total fuel per year= 70*12= 840 Liter

Total Distance = Total fuel* Mileage =840 *10 km=8400 km

Distance per month = 700 km

Distance Per Day = 700km/25= 28 km (Assuming min 5 days a month holiday)

Based on this distance compared to the fuel facility provided to first class officers of GoN, it is evident that if EV conversion has distance capacity of minimum 80 km on 1 charge cycle, then with one charge it can operate for 3 official days.

3.5 Financial Analysis

Financial analysis assesses the stability, viability, and profitability of a business or any project. In this project financial study is conducted to compare the Net Present Value (NPV) of the investment made on conversion kits and new EV over a period of 8 years. Similarly, as a part of the financial analysis payback period computation of the new EV along with petrol operation to test the scenarios are also carried out.

3.5.1 Net Present Value (NPV) Analysis

NPV calculates the current valuation of a future stream of cash flows that an investment will unfold. A stipulated time frame and a discount rate, equal to the minimum acceptable rate of return is taken as reference for the NPV calculation. An investment with positive NPV is generally considered good to invest. However, in this thesis, there is not any cash inflows associated over the life of these kits, there are only cash out flows chiefly on three overheads viz: Cost of Installation, Cost of Operation and Cost of Maintenance. So, a comparative study of the NPV is necessary.

The total cost during every year is recorded and totaled. Later on, all the total cost is discounted to the year 1 to calculate the NPV. The cost of installation depends upon the preference of the user and the maintenance cost is associated with the typical product and its usage. In this thesis, the cost of installation for the respective kits are referenced on the basis of the current market price. The maintenance cost is used on the basis of the EMESC maintenance record. The cost of operation for EV is taken as on basis of the mileage of fuel given to officials as special provision.

A : Monthly Minimum Charge (NPR.)

B : Energy Charge (NPR. /kWh)

The formula to compute the NPV is given below:

$$\boldsymbol{NPV = \sum_{t=0}^{n} \frac{R_t}{(1+i)^t}} \tag{3.1}$$

Where:

R_t : Net Cash inflow/outflows during a single period

i : Discount rate of return

n : Total number of periods

t : t^{th} period

3.6 Sample Size for Calculations

For the study among 179 Vehicles Available in Nepal Army Vehicle inducted 146 vehicles inducted after 2001 has been considered for evaluation. Details of the vehicle considered are shown in APPENDIX D.

CHAPTER FOUR: RESULTS AND DISCUSSION

The results that were acquired after the data was processed using the these adopted methodology are reported in this chapter, along with any necessary explanation of the findings. This Chapter also discusses results found with the NPV analysis, payback time, and sensitivity analysis.

4.1 Performance Analysis of Converted EV

The conversion done by NA was a trial of available conversion technology 4 years back. Though it has not been operated more than 40 instances with 1200 Km of run it is noteworthy for analysis and encourage to test currently available technologies to assess their technical and financial feasibility in current context.

4.1.1 Limitation of Power

The converted EV has limitations in terms of motor power as it has limited gradeability compared to other conversion kit available in the market. Figure 4.1 below shows the power requirement for inclined surfaces at different degrees of inclinations for the gross weight of 1710 Kg is used for the evaluation of minimum power requirement evaluation.

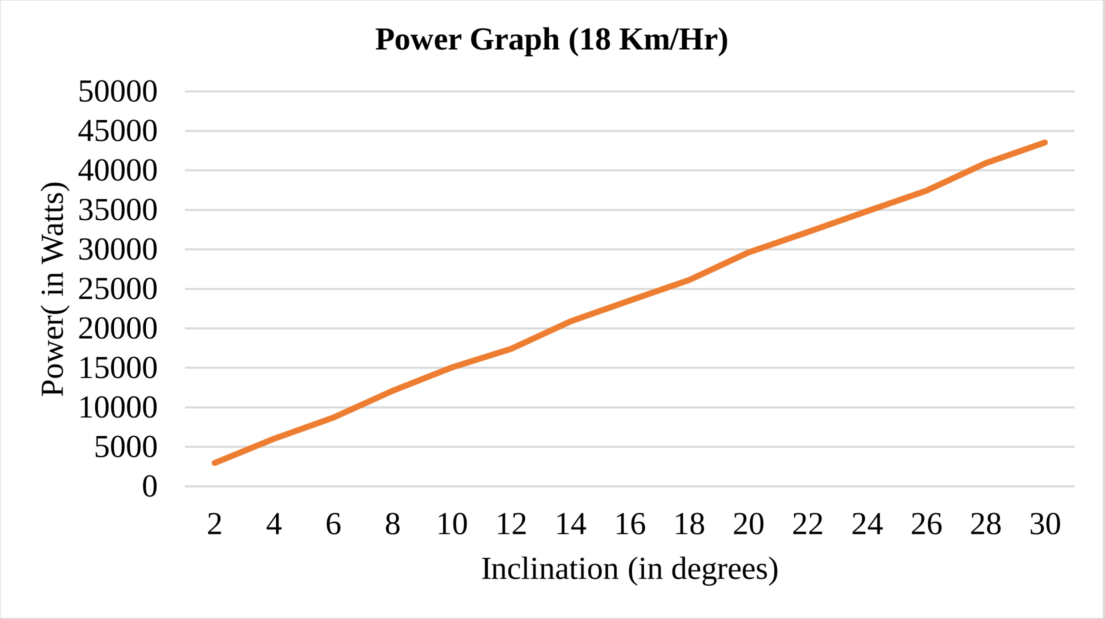


Figure 4.1 Power Vs Inclination (Jhunjhunwala, 2020)

This graph clearly indicates that for the Power of motor 7.5 KW the permitted inclination at 18 Km/Hr (5m/s) is Limited to 5 degrees and with this power to climb 10 degrees the speed has to be reduced by half i.e., 9 Km/Hr (2.5m/s).

4.1.2 Limitation of Battery Technology Used

The conversion of Maruti Gypsy was done using 6, 12V Lead-Acid Battery with each having capacity of 200Ah. $LiFePo_4$ in today's prices seems to be a very viable alternative in terms of following parameters.

(i) **Energy Density (Wh/L):** Lithium batteries have more than 2.5 times better energy density (Greg Albright, 2012).

(ii) **Specific Energy (Wh/kg)**: Lithium batteries have more than 3 times better Specific energy.

(iii) **Cost (per usable KWh per cycle):** Lithium batteries are more than 2.5 times better than lead acid batteries (Power Tech Systems, 2023).

(iv) **Life Cycle:** Lithium batteries have around 2 times more cycle charges at 80% DoD compared to 50% DoD of lead acid batteries (Greg Albright, 2012).

(v) **Sensitivity to temperature:** Lithium-ion batteries are less sensitivity to higher temperature than lead acid batteries (Greg Albright, 2012).

(vi) **Efficiency:** Lithium-ion batteries have better efficiency at all charging and discharging rates than lead acid batteries (Greg Albright, 2012).

4.1.3 Lead Acid Battery Performance

There has been notable but not significant drop in the distance in full charge. Fig 4.1 below represents the current battery capacity in terms of distance on full charge which is based on previous 10 runs.

The graph above is the representation of battery power reduction which has been significant in the third year of conversion. This graph shows that each week the maximum distance is decreasing. As the battery used was lead acid these are the properties inherent of these batteries as explained earlier on figure 2.6.

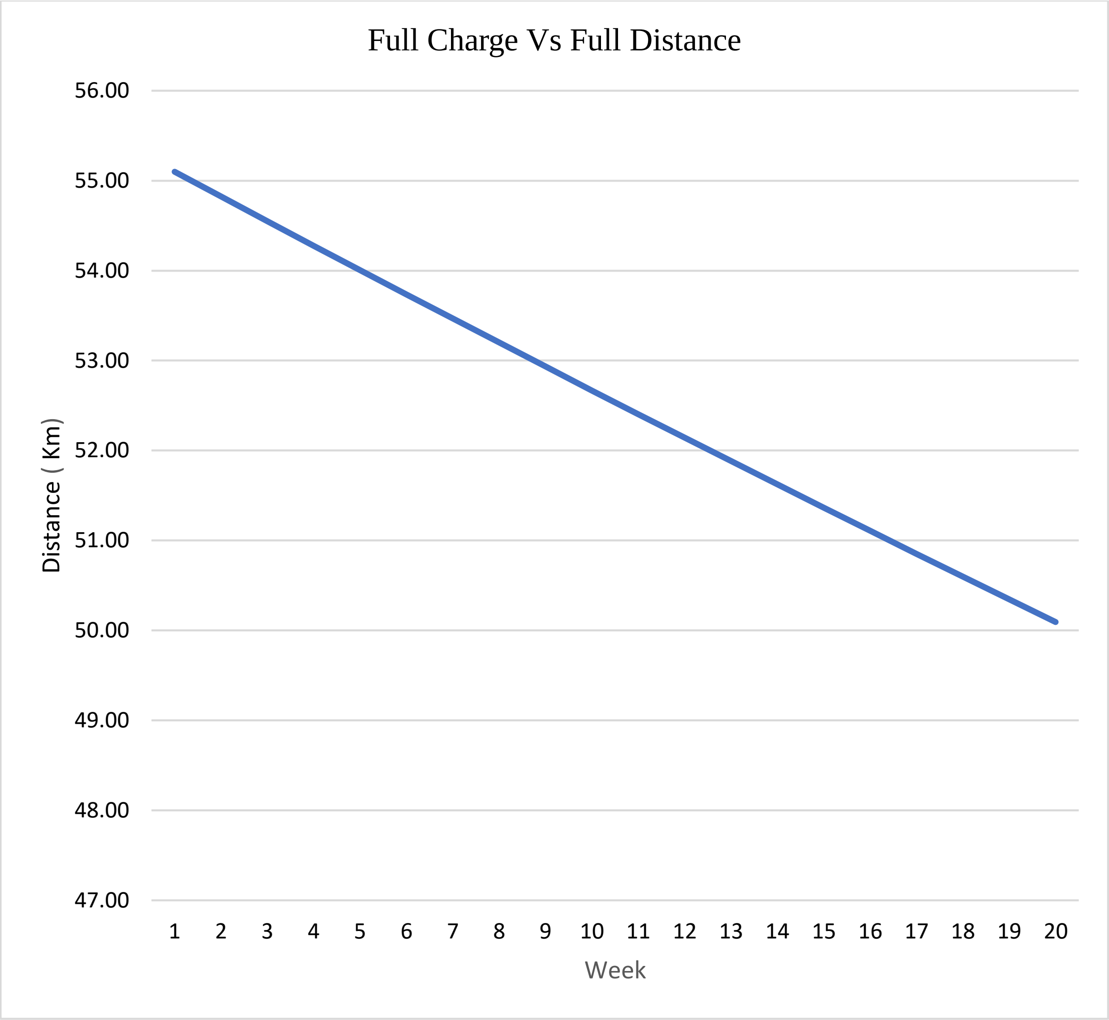


Figure 4.2 Full Charge Vs Distance attained

4.2 Selection of Suitable Conversion System

Conversion done by NA has certain limitation in terms of the battery technology used and the power of the motor selected. The important factors like acceleration force and gradient were overlooked to simplify the conversion. GVW of the vehicle was taken very high but with the introduction of lithium batteries and new conversion kits available right sizing of the system can be done. Fig 4.2 and 4.3 below will show the Force curve and Power curve respectively for Maruti Gypsy considering Lower GVW of 1500 kg.

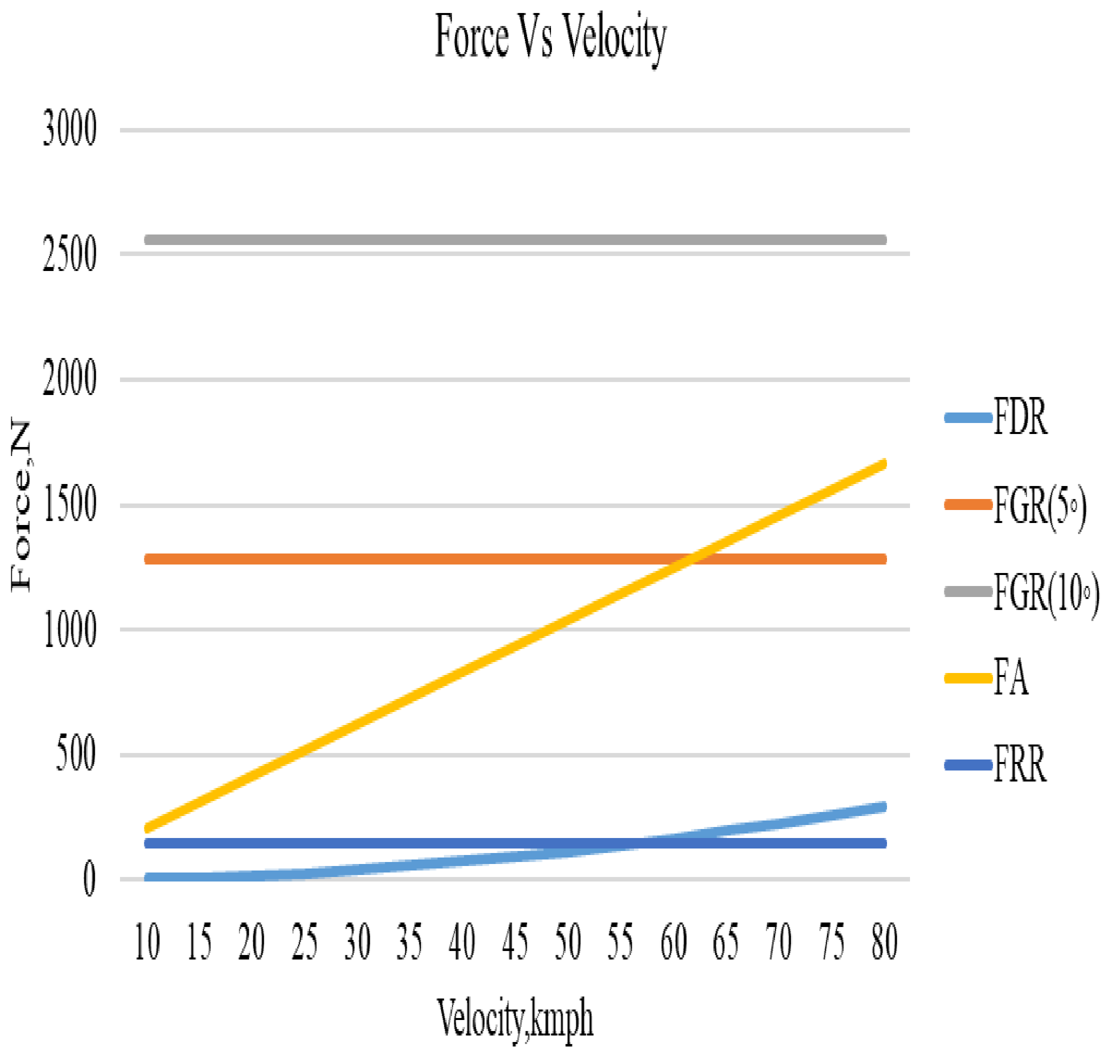


Figure 4.3 Force Vs Velocity Diagram (Jhunjhunwala, 2020)

The above figure clearly shows that higher the gradient the force due to the gradient increases hence more torque is needed on the wheels. Also, acceleration force that is needed has a key effect in terms of force which results in the depletion of battery in EV's so this force cannot be neglected while designing.

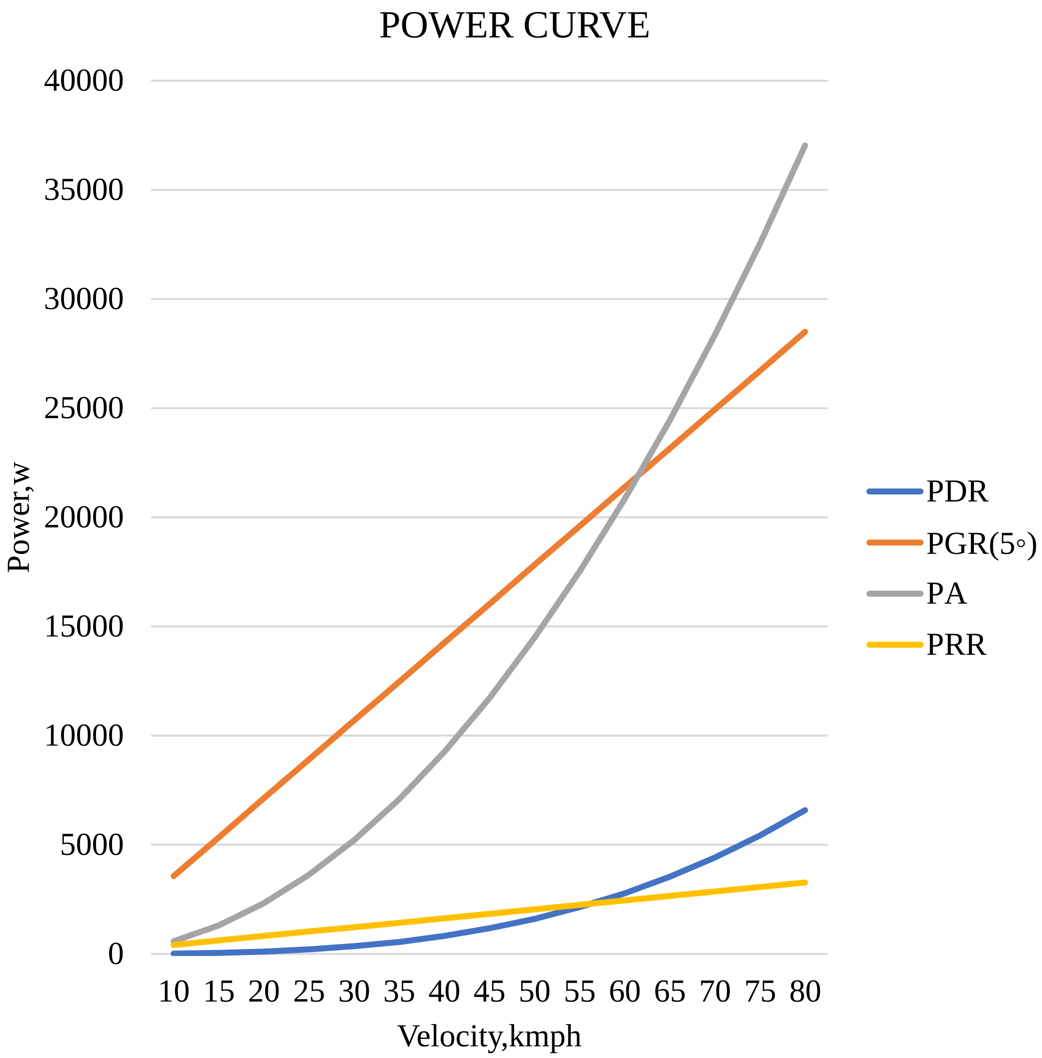


Figure 4.4 Power Vs Velocity Curve (Jhunjhunwala, 2020)

It is also evident from this graph that rate of change of velocity will eventually affect the power characteristics. Even gradient resistance should be considered well based on which the capacity of the motor should be selected. From the figure also it quite evident that we have to consider all these force factors and for the similar max speed of 54 kmph optimized motor size can be evaluated to be 15kW which is 2 times higher than accomplished conversion. Speed limit set for Kathmandu Valley is 50 kmph so selection of new kits can be done based on this as basis of calculation (Nayak Paudel, 2022).

4.3 Assumptions and Facts Collected for NPV Calculation

For the study three scenarios were created so as to test whether EV conversion is feasible or not using the NPV Criterion. All these scenarios have been tested using different assumptions and facts which are discussed in the following section.

(i) For EV Conversion Kits

Table 3.8 below shoes the facts that has been collected for running the simulations average inflation rate was taken from NRB data, rate of electricity from NEA and Cost of maintenance from EMESC.

Table 4.1 Facts Collected for EV Conversion

Factors	Minimum	Likely	Maximum
Average Inflation rate	-3.11%	7.83%	19.81%
Rate of electricity	7.5	10	11
Cost of maintenance	2500	3500	5000

Besides these some assumptions have been made to evaluate the conversion kits which are listed in table 3.9 below. Likely cost is based on the current market value whereas minimum and maximum are all assumed. Also, it is assumed that motor has to be changed at beginning of fifth year.

Table 4.2 Assumptions made for Conversion

Factors	Minimum	Likely	Maximum
Cost of the conversion kit with BMS	480,000.00	720,000.00	900,000.00
Cost of internal decoration	100,000.00	150,000.00	225,000.00
Cost of wiring	25,000.00	40,000.00	55,000.00
Cost of denting and painting	10,000.00	15,000.00	25,000.00
Cost of new induction motor	1,25,000.00	150,000.00	1,75,000.00
Cost of Battery After 4 Years	8,00,000.00	1,40,000.00	2,40,000.00

(ii) For New EV Purchase

Table 3.10 below shoes the facts that has been collected for running the simulations average inflation rate was taken from NRB data, rate of electricity from NEA and Cost of maintenance from company site of thee Go.

Table 4.3 Facts for New EV

Factor	Minimum	Likely	Maximum
Average Inflation rate	-3.11%	7.83%	19.81%
Rate of electricity	7.5	10	11
Cost of maintenance	2500	3500	5000

Besides these some assumptions have been made to evaluate running cost of EV as listed in table 3.11 below. Likely cost is based on the current market value whereas minimum and maximum are all assumed.

Table 4.4 Assumptions for New EV Purchase

Factors	Minimum	Likely	Maximum
Purchase cost of new E vehicle	2,100,000.00	2,200,000.00	3,000,000.00
Operation and maintenance cost	10000	15000	10000

(iii) For Maruti Gypsy Operation with Petrol

Table 3.13 below shoes the facts that has been collected for running the simulations average inflation rate was taken from NRB data, rate of petrol from NEA and Cost of maintenance from EMESC.

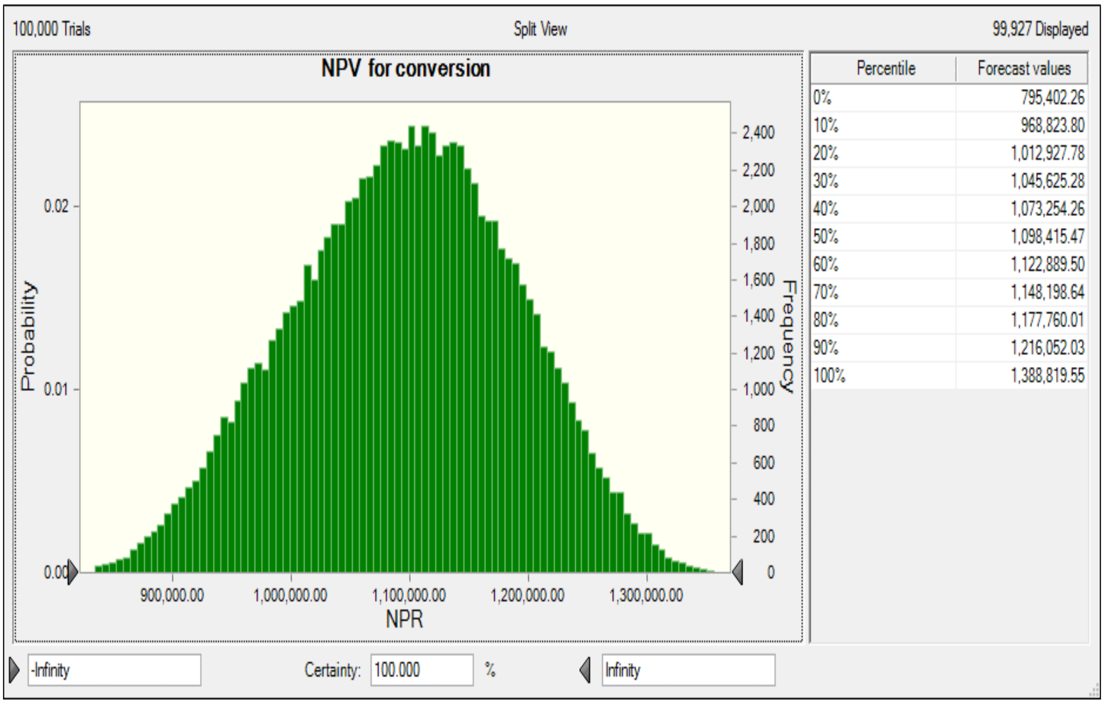
Table 4.5 Facts for Gypsy Operation with Fuel

Factor	Minimum	Likely	Maximum
Average Inflation rate	-3.11%	7.83%	19.81%
Rate of petrol	170	175	177.625
Cost of maintenance	2500	3500	5000

(Shrestha R. , 2021)

4.3 NPV of Current EV Conversion Kit and Proposed Conversion Kit

Several outcomes were estimated using the anticipated NPV values for various combinations of the variables, including installation cost, inflation rate, discount rate, operation cost, and maintenance cost. The Monte Carlo Simulation was run using a crystal ball with a total of 1,00,000 iterations to arrive at the result. The figures below show the NPV values that were computed throughout the iterations. The best-case scenario, where the forecasted NPV value would be least, and the worst-case scenario, where the forecasted NPV value would be greatest, are two distinct values of NPV that are highly interesting to study.



Percentile	Forecast values
0%	795,402.26
10%	968,823.80
20%	1,012,927.78
30%	1,045,625.28
40%	1,073,254.26
50%	1,098,415.47
60%	1,122,889.50
70%	1,148,198.64
80%	1,177,760.01
90%	1,216,052.03
100%	1,388,819.55

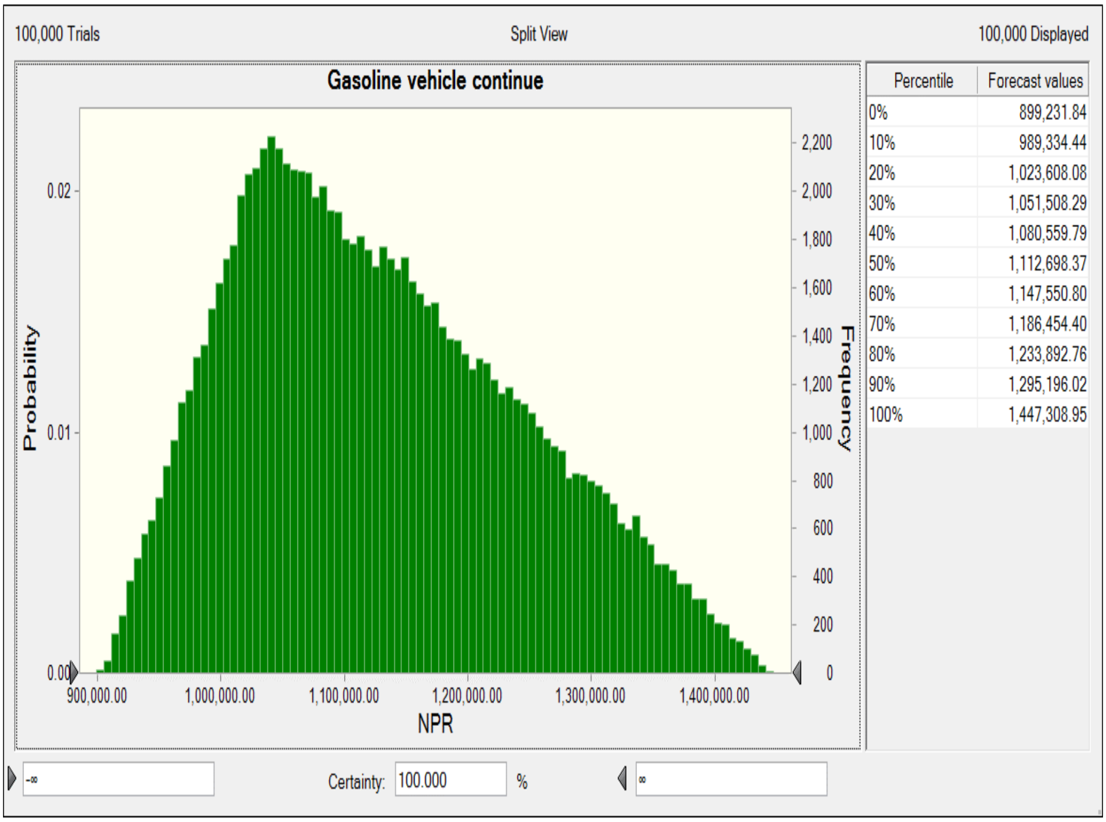
Figure 4.5 NPV for Conversion Kit

The above graphic includes the findings from the trials that were conducted. The observed result distribution resembles a gamma distribution very much. The NPV for the investment in the EV Conversion Kit and its operation and maintenance costs for over the course of years for from the best-case scenario with NPV of NPR 7,95,402.26 to the worst-case scenario with NPV of NPR 13,88,819.55 can be seen clearly. Additionally, according to the percentile table, there is a 10% or lower likelihood that the NPV will fall between NPR. 795402.26 and NPR. 9,68,823.80. The likelihood that the NPV will fall between NPR. 795402.26 and NPR. 1,012,927 grows by up to 20%, and the likelihood that it will fall between NPR. 795402.26 and NPR. 1,045,625 and higher is at least 30%.

Both previous conversion kit and selected EV conversion Kits fall under same price range so single analysis with suffice for them. So, their comparison is better suited with technical analysis than financial.

4.4 NPV of Maruti Gypsy Operation with Fuel

The anticipated NPV values were determined for various combinations of the variables, including installation costs, inflation rates, discount rates, operating costs, and maintenance costs. To arrive at the outcome, a Monte Carlo simulation with a crystal ball was run a total of 1,00,000 times. The following figures show the NPV values that were determined over the iterations. It is highly interesting to notice specific NPV values, such as the worst-case scenario, where the predicted NPV value is highest, and the best-case scenario, where the forecasted NPV value is lowest.



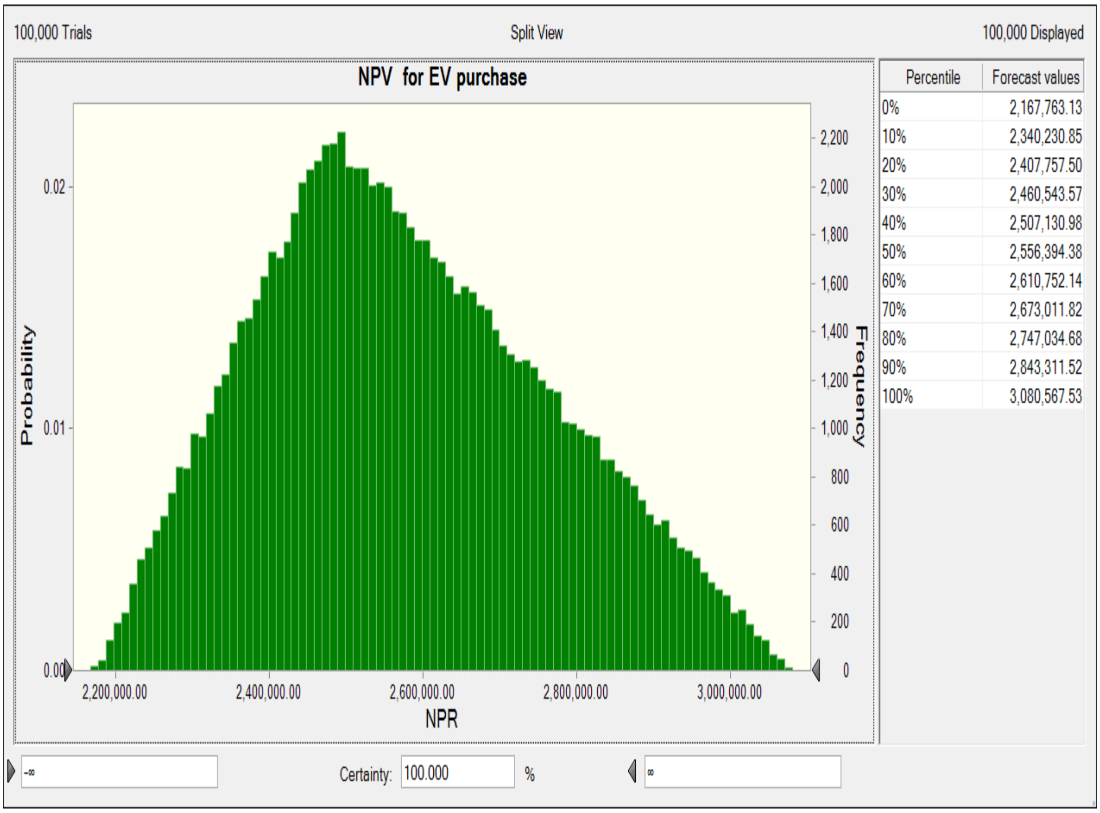
Percentile	Forecast values
0%	899,231.84
10%	989,334.44
20%	1,023,608.08
30%	1,051,508.29
40%	1,080,559.79
50%	1,112,698.37
60%	1,147,550.80
70%	1,186,454.40
80%	1,233,892.76
90%	1,295,196.02
100%	1,447,308.95

Figure 4.6 NPV For Maruti Gypsy Operation

The above graphic includes the findings from the trials that were conducted. The observed result distribution resembles a gamma distribution very much. It is evident that the NPV ranges from 899231.54 in the best-case scenario to 1,447,308.95 in the worst-case scenario for the investment in the Maruti Gypsy and its operation and maintenance costs over the years. Additionally, the percentile chart suggests that there is a 10% or lower possibility that the NPV would fall between NPR. 899,231.54 and NPR. 989,334.44. The likelihood that the NPV will fall between NPR 899231.54 and NPR 1,023,608.08 improves by up to 20%, while the likelihood that it will fall between NPR 903,034.10 and NPR 1,051,508.29 decreases by 30% or less.

4.5 NPV of New EV as substitute to Maruti Gypsy

The anticipated net present values (NPV) for various combinations of the variables, including installation cost, inflation rate, discount rate, operation cost, and maintenance cost, were determined. For the Monte Carlo Simulation, a crystal ball was used to run a total of 100,000 iterations in order to arrive at the outcome. The figures below show the values of NPV that were determined over the iterations. The anticipated NPV value in the best-case scenario, which is where it would be lowest, and the forecasted NPV value in the worst-case scenario, which is where it would be greatest, are two distinct values of NPV that are highly interesting to notice.



Percentile	Forecast values
0%	2,167,763.13
10%	2,340,230.85
20%	2,407,757.50
30%	2,460,543.57
40%	2,507,130.98
50%	2,556,394.38
60%	2,610,752.14
70%	2,673,011.82
80%	2,747,034.68
90%	2,843,311.52
100%	3,080,567.53

Figure 4.7 NPV for new EV Purchase

The aforementioned figure contains information on the study results. A gamma distribution and the observed outcome distribution closely resemble each other. The NPV for the investment in the EV Conversion Kit and its operation and maintenance expenses for over the course of years for from the best-case scenario value of NPR. 2,167,763.13 to the worst-case scenario of NPR. 3,080,567.53 can be seen clearly. Furthermore, according to the percentile chart, there is a 10% or lower likelihood that the NPV would fall between NPR. 2,167,763.13 and NPR. 2,349,230.85. The chance increases up to 20% for the NPV to lie between NPR. 2,167,763.13 to NPR 2,407,757.50. The likelihood is 30% or lower for the NPV to lie between NPR. 2,174,524.23 to NPR 2,463,540.57 and so on.

4.6 Sensitivity

A sensitivity analysis was also performed to understand the output sensitivity of simulation done by CB add-in, NPV with respect to the changes in the input values. The sensitivity data represented in terms of rank correlation obtained during the Monte Carlo Simulation is presented in the table 4.6.

Table 4.6 Rank Correlations of All Scenarios

S.N.	Variables	Correlation rank for various Scenarios		
		Conversion Kit	Petrol Operation	New EV
1.	Cost of Installation	0.953666694		0.999589047
2.	Cost of Fuel/ Electricity	0.039263981	0.999053089	0.018688407
3.	Cost of Maintenance	0.030764661	0.04042498	0.016932855

Above table makes it vivid that the operation cost and the maintenance cost associated has the major impact on Petrol operation of Maruti Gypsy. The cost of the Conversion kit mainly the battery cost embedded in it and recent trends have shown that the cost of Lithium based batteries are coming rapidly down. APPENDIX E shows a quotation of $LiFePo_4$ battery where it is evident that they are becoming cheaper day by day. The cost of the EV itself has major impact on the scenario.

4.7 Comparison of NPV for all Scenarios

The probability scaling from 0% to 100% were shown against the simulated data for NPV for each scenario. Figure 4.4 below demonstrates the new EV cost is significantly more than other options due mostly to its initial expenditure. Given that there is no initial investment required for Maruti Gypsy, it operates with gasoline in a stronger position than new EVs. In terms of investment over the next 8 years, EV conversion appears to be the best choice because of the environmental reasons as well as the it is slightly better at all level of probabilities despite there is provision of change of battery and the motor after 4 years of operation.

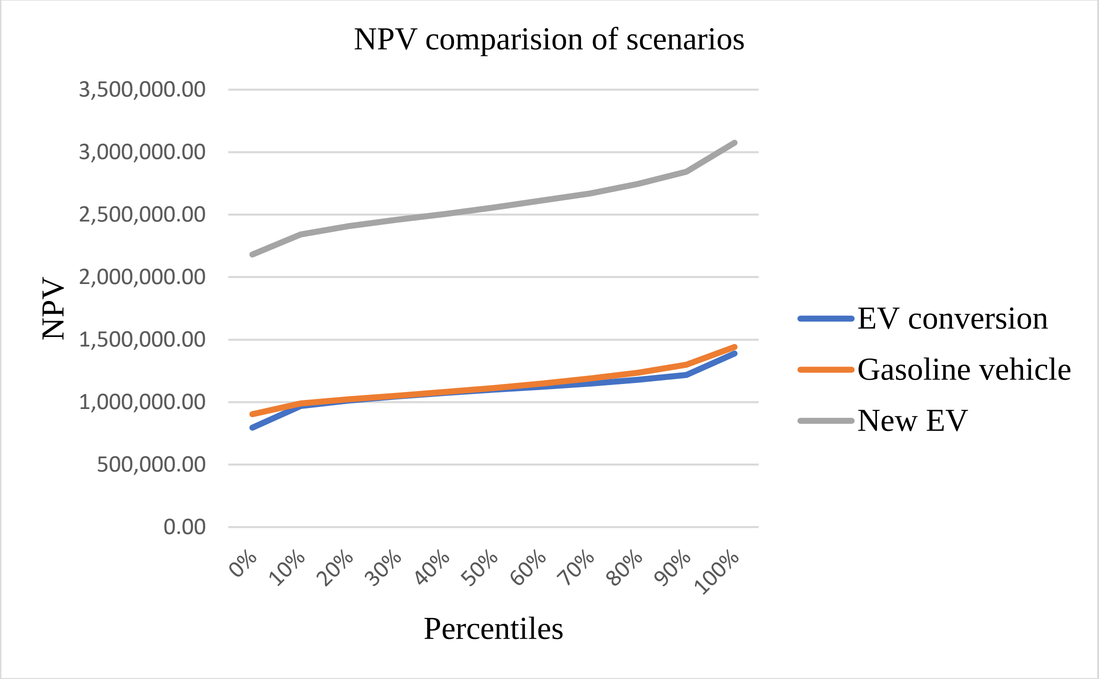


Fig 4.8 NPV for all Scenarios

4.8 Net Environment Benefit from Mass Conversion

Total Distance = 8400 km per vehicle

Considering BS III standards,

NO_x produced per vehicle =0.18 g/km*8400=1512g=1.512kg

NO_x produced by total vehicles =1.512*46=220.752 kg

CO produced per vehicle =4.17 *8400=35028g=35.028 kg

CO produced by total vehicle=146*35.028=5114.08 kg

HC produced per vehicle=0.25*8400g=2100g=2.1 kg

HC produce by total Vehicle =2.1*146=306.6 kg

The above calculation signifies that though the small amount but the environmental effect post conversion cannot be neglected. Though the petrol import will only be reduced by 0.016%, it will have greater value in terms of the positive stride towards the use of hydroelectricity which is going to be surplus in the days to come.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Conclusion drawn from the study are as follows:

(i) The EV conversion of Maruti Gypsy MG 413 has max velocity of 54 kmph and range per charge 60 km but had limitation of torque required against gradient resistance. The force of acceleration was not considered which comes to $0.6 m/s^2$ at the speed of design of 54 kmph.

(ii) The EV conversion of Maruti Gypsy MG 413 was done with lead-acid battery and had limitation that are inherent properties of lead acid batteries that limits the performance of converted EV due to weight added by the battery pack. During the recent trial runs the maximum speed per week has been decreasing in a noticeable rate battery replacement is necessary.

(iii) NPV comparison of EV conversion, operation with petrol engine and New EV has shown that EV conversion is better at all state of probabilities slightly better against petrol-based operation and 100% lesser than the investment on EV considering period of 8 years. Financially current conversion kits can replace the petrol usage effectively based on the study results.

(iv) The NPV is highly sensitive to the cost of Conversion Kits. For petrol-based operation it is highly sensitive to maintenance cost. For new EV it is highly sensitive to cost of EV itself.

(v) If mass conversion is done on all 146 Maruti Gypsy vehicles CO production will reduce by 5114 kg, HC by 306.6 kg and NO_x by 220.75 kg per year.

5.2 Recommendation

(i) A full-scale test of newest kits with Li-ion batteries and minimum power of 15 kW along with reduced GVW of 1500Kg is recommended to access the technical viability in order to evaluate life cycle of conversion kit before carrying out large-scale EV conversion to utilize non-operational and non-efficient government vehicles than salvaging them at significantly low cost.

(ii) A study on shuttle service buses based ICEVs provided by various government offices to be replaced by a converted EV can be performed.

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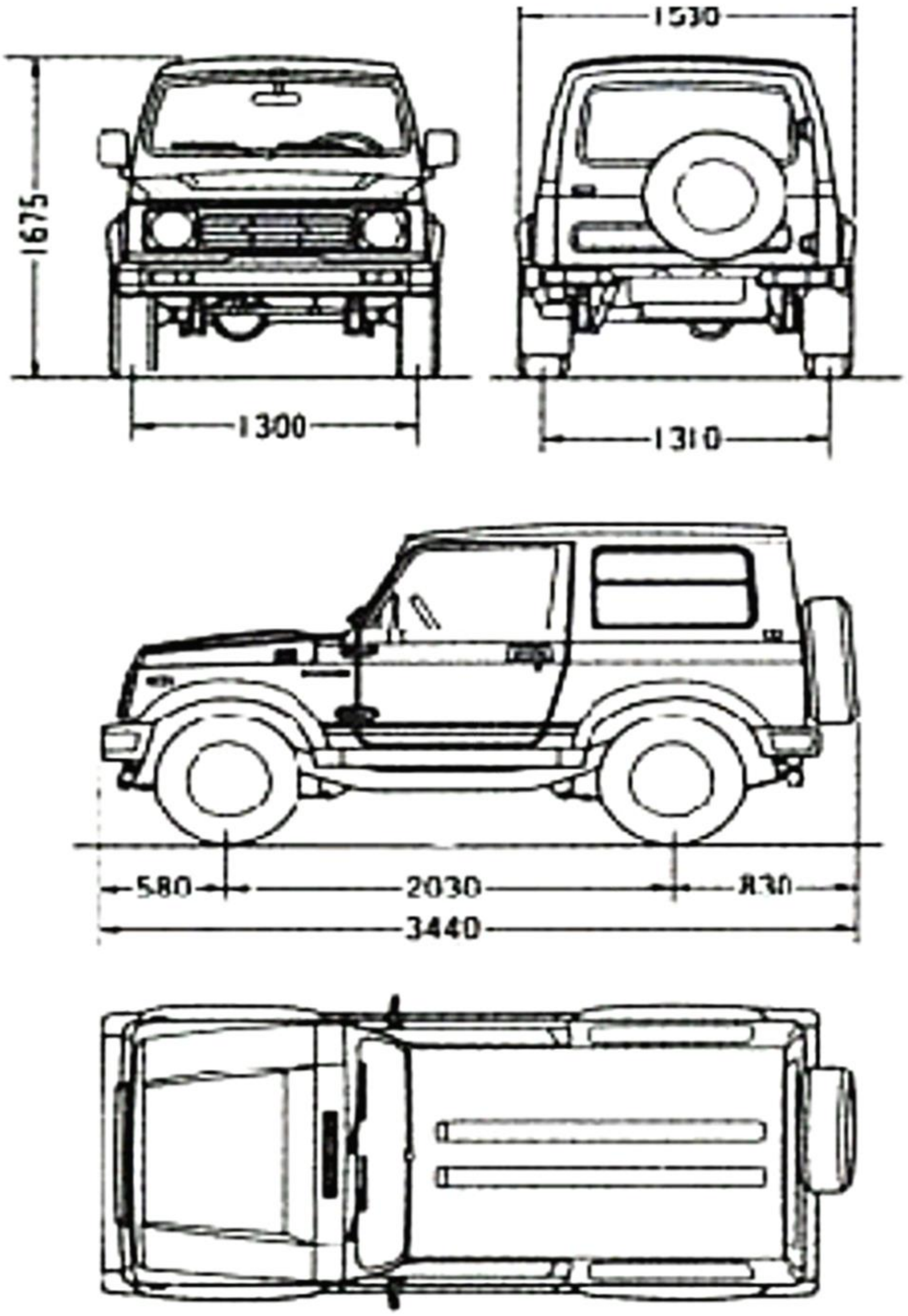
APPENDIX A: VEHICLE DIMENSION

DIMENSIONS OD GYPSY 413 HARD TOP



APPENDIX B: SPECIFICATION

SPECIFICATION OF MARUTI GYPSY 413 SOFT TOP

Fuel Type	Petrol
Max Power	80 bhp @ 6000 RPM
Max Torque	103 Nm @ 4500 RPM
Mileage (ARAI)	11.96
Transmission Type	Manual
No of gears	5 Gears
Drivetrain	4WD / AWD
Cylinders	4, Inline
Turbocharger/Supercharger	No
Valve/Cylinder (Configuration)	4, SOHC
Engine Start-Stop Function	No
Engine Type	G13BB MPFI Gasoline Engine
Engine Description	1.3-litre 80bhp 16V G13BB MPFI Gasoline Engine
No. of Cylinders	4
Valve Configuration	DOHC
Fuel Supply System	MPFI
Super Charger	No
Acceleration (0-100 kmph)	16 Seconds
Drag Coefficient	-
Keyless entry/Push button start	No
DIMENSIONS & WEIGHT	
Length	4010 mm
Width	1540 mm
Height	1845 mm
Displacement	1298
Wheelbase	2375 mm
Ground Clearance	210 mm
Manual Shifting for Automatic	No
Turning Radius (wheel base)	5 meters
Wheel Size	15 Inch
Alloy Wheel Size	-
Wheel Base	2375mm
Front Tread	1300mm
Rear Tread	1310mm
Gross Weight	1585kg
CAPACITY	
Seating Capacity	8
Fuel Tank Capacity	40 litres

No of Seating Rows	2 Rows
COMFORT & CONVENIENCE	
Remote Fuel Lid Opener	Yes
Boot-lid Opener	With Key
Exterior Door Handles	Black
Interior Door Handles	Black
Rear Window Washer	No
Tinted Glass	No
No of Doors	3
Electronically controlled rear view mirror	Black - Driver Only
SUSPENSIONS, BRAKES & STEERING	
Suspension Front	Rear Leaf spring with Double action damper
Suspension Rear	Rear Leaf spring with Double action damper
Front Brake Type	Disc
Rear Brake Type	Drum
Steering Type	Manual
Front Tyres	205 / 70 R15
Rear Tyres	205 / 70 R15
Front Brake Type	Disc
Rear Brake Type	Drum
Tyre Size	205/70 R15
Tyre Type	Tubeless Tyres
Cabin Lamps	Front
Centrally Mounted Fuel Tank	Yes
Kerb Weight	985 kg
MORE INFORMATION	
Country of Assembly	India
Country of Manufacture	India

SPECIFICATIONS OF MARUTI GYPSY 413 HARD TOP

Fuel Type	Petrol
Max Power	80 bhp @ 6000 RPM
Max Torque	103 Nm @ 4500 RPM
Mileage (ARAI)	11.96
Alternate Fuel	Not Applicable
Transmission Type	Manual
No of gears	5 Gears
Drivetrain	4WD / AWD
Cylinders	4, Inline
Turbocharger/Supercharger	No
Valve/Cylinder (Configuration)	4, SOHC
Engine Start-Stop Function	No
Engine Type	G13BB MPFI Gasoline Engin
Engine Description	1.3-litre 80bhp 16V G13BB MPFI Gasoline Engine
No. of Cylinders	4
Valve Configuration	DOHC
Fuel Supply System	MPFI
Top Speed	120 Kmph
Acceleration (0-100 kmph)	16 Seconds
Keyless entry/Push button start	No
DIMENSIONS & WEIGHT	
Length	4010 mm
Width	1540 mm
Height	1875 mm
Displacement	1298
Wheelbase	2375 mm
Ground Clearance	210 mm
Manual Shifting for Automatic	No
Turning Radius (wheel base)	5 meters
Wheel Size	15 Inch
Alloy Wheel Size	-
Wheel Base	2375mm
Front Tread	1300mm
Rear Tread	1310mm
Gross Weight	1620kg
CAPACITY	
Seating Capacity	8

Fuel Tank Capacity	40 litres
No of Seating Rows	2 Rows
DOORS, WINDOWS, MIRRORS & WIPERS	
Boot-lid Opener	Internal
Exterior Door Handles	Black
Interior Door Handles	Black
No of Doors	3
Electronically controlled rear view mirror	Black - Driver Only
SUSPENSIONS, BRAKES & STEERING	
Suspension Front	Leaf spring with Double action damper
Suspension Rear	Leaf spring with Double action damper
Front Brake Type	Disc
Rear Brake Type	Drum
Steering Type	Manual
Front Tyres	205 / 70 R15
Rear Tyres	205 / 70 R15
Front Brake Type	Disc
Rear Brake Type	Drum
Tyre Size	205/70 R15
Tyre Type	Tubeless Tyres
SEATS & UPHOLSTERY	
Seat Upholstery	Fabric
LIGHTING	
Tail Lamps	Conventional
Cabin Lamps	Front
ENTERTAINMENT, INFORMATION & COMMUNICATION	
Kerb Weight	1050 kg
MORE INFORMATION	
Country of Assembly	India
Country of Manufacture	India

APPENDIX C: WORKING STAGES OF CONVERSION

Removal of Non-Essential Components

Removal of rear axle assembly and fixing new one

Preparation of New mounts for Battery

Testing of electrical Systems

Additional Battery Compartment Preparation

Final Demonstration Post Conversion

APPENDIX D: DETAILS OF VEHICLES CHOSEN FOR STUDY

S.No.	Vehicle No.	Manufacture Date	Manufacture Date	FINAL YEAR	Make Country	Make-Type-Model	Engine Type	Condition	Engine No.	Chassis No.
1	BA 1 JHA 9388	2011	2011	2011	India	MARUTI -JEEP-MO-110	Petrol	Operational	G13BBN543062	XMA5EGF41S00255386XDB
2	BA 1 JHA 3224			1993	India	MARUTI -JEEP-MO-650	Petrol	Operational	589547	SJ50-149279
3	BA 1 JHA 4573			1993	India	MARUTI -JEEP-MO-650	Petrol	Operational	643603	JDAJ100G000511099
4	BA 1 JHA 6287	2001	2001	2001	India	MARUTI -JEEP-MO-650	Petrol	Operational		
5	BA 1 JHA 6064	2001	2001	2001	India	MARUTI -JEEP-MO-650	Petrol	Operational	G13BBN114220	MG71IN210361
6	BA 1 JHA 6796	2004	2004	2004	India	MARUTI -JEEP-MO-650	Petrol	Operational		
7	BA 1 JHA 6044	2001	2001	2001	India	MARUTI -JEEP-MO-650	Petrol	Operational		
8	BA 1 JHA 4952	1997	1997	1997	India	MARUTI -JEEP-MO-650	Petrol	Non Operational		
9	BA 1 JHA 4425	1995	1995	1995	India	MARUTI -JEEP-MO-650	Petrol	Operational		
10	BA 1 JHA 3909	1993	1993	1993	India	MARUTI -JEEP-MO-650	Petrol	Operational		
11	BA 1 JHA 4679	6/1/1996	6/1/1996	1996	India	MARUTI -JEEP-MO-252	Petrol	Operational	F10AIN231456	SI41IN177105

12	BA 1 JHA 9390	1/1/2011	1/1/2011	2010	India	MARUTI -JEEP-MO-251	Petrol	Operational	G13BBN543043	XMA5EGF41500-255434
13	BA 1 JHA 7098	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-111	Petrol	Operational	G13BBN230438	MA5EGF41S00229682
14	BA 1 JHA 7103	1/1/2010	1/1/2010	2010	India	MARUTI -JEEP-MO-103	Petrol	Operational	G13BBN232900	MA5EGF41S00225738
15	LU 1 JHA 269	1/1/2010	1/1/2010	2010	India	MARUTI -JEEP-MO-105	Petrol	Operational	483447	245434
16	BA 1 JHA 9380	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-110	Petrol	Operational	J13BBN-544896	MA5EGF41500257240XDB
17	BA 1 JHA 9336				India	MARUTI -JEEP-MO-106	Petrol	Operational		
18	BA 1 JHA 9363				India	MARUTI -JEEP-MO-106	Diesel	Operational		
19	BA 1 JHA 9193				India	MARUTI -JEEP-MO-106	Petrol	Operational		
20	BA 1 JHA 6268	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN128683	MG71IN214707
21	BA 1 JHA 6798	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN170398	MG71IN224258
22	BA 1 JHA 6793	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-102	Petrol	Operational	G13BBN168346	MG71IN223553
23	BA 1 JHA 9394	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	0	0
24	BA 1 JHA 9393	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	0	0

25	BA 1 JHA 9392	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	G13BBN538422	XMA5EGF41S002251283XCA
26	BA 1 JHA 9391	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	G13BBN537061	XMA5EGF41S00249933XBA
27	BA 1 JHA 6804	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168687	MG71IN223662
28	BA 1 JHA 9403	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	G13BBN539720	XMA5EGF41S00252582XEA
29	BA 1 JHA 9395	6/1/2010	6/1/2010	2010	India	MARUTI -JEEP-MO-99	Petrol	Operational	0G13BBTV 538652	XMA 5EGF41500-251549
30	BA 1 JHA 9402	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	0	0
31	BA 1 JHA 9399	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	0	0
32	BA 1 JHA 9398	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	0	0
33	BA 1 JHA 9397	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational	0	0
34	BA 1 JHA 9396	7/1/2011	7/1/2011	2011	India	MARUTI -JEEP-MO-271	Petrol	Operational		
35	BA 1 JHA 9400	6/1/2010	6/1/2010	2010	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN538256	XMA5EGF41500251144XLA
36	BA 1 JHA 9401	6/1/2010	6/1/2010	2010	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBW539118	MASEGF41500-2520268PA

37	BA 1 JHA 7109	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-112	Petrol	Operational	G13BBN231446	MA5EGF41S00229698
38	BA 1 JHA 7108	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-112	Petrol	Operational	G13BBN230668	MA5EGF41S00229685
39	BA 1 JHA 7107	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-112	Petrol	Operational	G13BBN230141	MA5EGF41S00229672
40	BA 1 JHA 7105	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-112	Petrol	Operational	G13BBN232669	MA5EGF41S00229737
41	BA 1 JHA 7104	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-112	Petrol	Operational	G13BBN232339	MA5EGF41S00229724
42	BA 1 JHA 7044	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	213849	22889265
43	BA 1 JHA 7043	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	GB13BBN230438	MA5EGF41S00
44	BA 1 JHA 7042	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN213775	MA5EGF41S00228880
45	BA 1 JHA 7040	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN213340	MA5EGF41S00228874
46	BA 1 JHA 7038	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN213348	MA5EGF41S00228869
47	BA 1 JHA 7037	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN213367	MA5EGF41S00228866
48	BA 1 JHA 6805	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-107	Petrol	Operational	G13BBN170194	MG71IN224254
49	BA 1 JHA 6800	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168538	MG71IN223596

50	BA 1 JHA 6799	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN170440	MG71IN224260
51	BA 1 JHA 6797	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	170369	244256
52	BA 1 JHA 6795	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168532	MG71IN223593
53	BA 1 JHA 6794	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168279	MG71IN223562
54	BA 1 JHA 6792	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168323	MG71IN223545
55	BA 1 JHA 6790	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BNN168113	MG71IN223518
56	BA 1 JHA 6789	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168089	MG71IN223501
57	BA 1 JHA 6787	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168105	MG71IN223490
58	BA 1 JHA 6786	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168048	MG71IN223482
59	BA 1 JHA 6785	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167999	MG71IN223473
60	BA 1 JHA 6784	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167965	MG71IN223465
61	BA 1 JHA 6783	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167889	MG71IN223438
62	BA 1 JHA 6782	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167864	MG71IN233429

63	BA 1 JHA 6781	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167759	MG71IN223420
64	BA 1 JHA 6780	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167667	MG71IN223411
65	BA 1 JHA 6779	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN167827	MG71IN223402
66	BA 1 JHA 6778	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Non Operational	G13BBN166756	MG71IN223177
67	BA 1 JHA 6776	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN165735	MG71IN222849
68	BA 1 JHA 6331	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN128616	MG71IN214565
69	BA 1 JHA 6330	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN128527	MG71IN214648
70	BA 1 JHA 6264	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-251	Petrol	Operational	G13BBN128360	MG71IN214651
71	BA 1 JHA 6261	5/4/2001	5/4/2001	2001	India	MARUTI -JEEP-MO-251	Petrol	Operational	G13BBN109878	MG71IN207693
72	BA 1 JHA 6260	7/1/2001	7/1/2001	2001	India	MARUTI -JEEP-MO-251	Petrol	Operational	G13BBN128115	MG71IN214592
73	BA 1 JHA 5251	6/6/1999	6/6/1999	1999	India	MARUTI -JEEP-MO-107	Petrol	Operational	413BB-643064	JSAFJB33VOO-118578
74	LU 1 JHA 267	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN482881	MA5EGF41S00245569
75	LU 1 JHA 266	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN481952	MA5EGF41S00245303

76	LU 1 JHA 265	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN482927	MA5EGF41S00245499
77	LU 1 JHA 264	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN479552	MA5EGF41S00244731
78	LU 1 JHA 263	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN483173	MA5EGF41S00245561
79	LU 1 JHA 262	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN482588	MA5EGF41S00245222
80	LU 1 JHA 261	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN482940	MA5EGF41S00245538
81	LU 1 JHA 260	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	G13BBN483658	MA5EGF41S00245538
82	LU 1 JHA 259	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-107	Petrol	Operational	G13BBN485260	MA5EGF41S00246030
83	LU 1 JHA 258	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-107	Petrol	Operational	486427	246285
84	LU 1 JHA 257	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	484987	245979
85	LU 1 JHA 255	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	484580	245840
86	LU 1 JHA 254	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	486854	246369
87	BA 1 JHA 6802	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-103	Petrol	Operational	G13BBN168645	MG71IN223632
88	LU 1 JHA 273	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	483451	245425

89	LU 1 JHA 270	1/1/2009	1/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	483322	245142
90	BA 1 JHA 6270	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128718	MG71IN214705
91	BA 1 JHA 7100	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-111	Petrol	Operational	G13BBN231683	229706
92	BA 1 JHA 7097	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN230382	MA5EGF41S00229671
93	BA 1 JHA 9404	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-99	Petrol	Operational	0	0
94	BA 1 JHA 6278	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128217	MG71IN214584
95	BA 1 JHA 6052	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-98	Petrol	Non Operational	G13BBN113878	MG71IN210160
96	BA 1 JHA 6334	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-107	Petrol	Operational	G13BBN124243	MG71IN214567
97	BA 1 JHA 6039	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-98	Petrol	Operational	G13BBN113918	MG71IN210198
98	BA 1 JHA 6259	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN110981	MG71IN208458
99	LU 1 JHA 271	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-105	Petrol	Operational	482818	245507
100	LU 1 JHA 272	5/1/2009	5/1/2009	2009	India	MARUTI -JEEP-MO-103	Petrol	Operational	482310	245377
101	BA 1 JHA 6293	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-110	Petrol	Operational	G13BBN129972	MG71IN207791

102	LU 1 JHA 268	6/1/2012	6/1/2012	2012	India	MARUTI -JEEP-MO-103	Petrol	Operational	G13BBN483203	MA5EGF41S00 245622
103	BA 1 JHA 6333	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128212	MG71IN214566
104	BA 1 JHA 5174	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-253	Petrol	Non Operational	G13BIN595416	MG71IN188154
105	BA 1 JHA 6262	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN109687	MG71IN207617
106	BA 1 JHA 6271	5/1/2001	5/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128211	MG71IN214536
107	BA 1 JHA 353	6/1/1997	6/1/1997	1997	India	MARUTI -JEEP-MO-249	Petrol	Operational	F10AIN-236207	SJ41IN-181969
108	BA 1 JHA 6332	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN218150	MG71IN214539
109	BA 1 JHA 6235	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-100	Diesel	Operational	0	0
110	BA 1 JHA 6038	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-252	Petrol	Operational	G13BBN113030	MG71IN209608
111	BA 1 JHA 4671	0000-00-00	0000-00-00	1996	India	MARUTI -JEEP-MO-250	Petrol	Operational	F10AIN231475	SJ41IN177110
112	BA 1 JHA 6289	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128431	MG71IN214673
113	BA 1 JHA 6788	5/1/2004	5/1/2004	2004	India	MARUTI -JEEP-MO-252	Petrol	Operational	G13BBN168089	MG71IN223501
114	BA 1 JHA 6274	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128529	MG71IN214669

115	BA 1 JHA 9385	1/1/2011	1/1/2011	2010	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN 543038	NASE4F1300-255409
116	BA 1 JHA 6060	6/1/2000	6/1/2000	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN114338	MG712N2L0421
117	BA 1 JHA 6272	0000-00-00	0000-00-00	2014	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128451	MG71IN214647
118	BA 1 JHA 6284	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	128717	214711
119	BA 1 JHA 6063	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-650	Petrol	Operational	13BBNMG134337	MG71IN210290
120	BA 1 JHA 6040	6/1/2001	6/1/2001	2014	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN113867	MG71IN210935
121	LU 1 JHA 256	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	484287	245849
122	BA 1 JHA 6266	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Non Operational	G13BBN128513	MG71IN214623
123	BA 1 JHA 6267	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Non Operational	G13BBN128722	MG71IN214703
124	BA 1 JHA 9405	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN539217	XMA5EGF41500252149XDA
125	BA 1 JHA 6273	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN109813	MG71IW70765
126	BA 1 JHA 7101	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-98	Petrol	Operational	G13BBN232017	MA5FUF229716
127	BA 1 JHA 9389	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-110	Petrol	Operational	G13BBN543019	XMA5EHF41500255434

128	BA 1 JHA 6041	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN113	MG71LN21001
129	BA 1 JHA 6281	0000-00-00	0000-00-00	2001	India	MARUTI -JEEP-MO-251	Petrol	Operational	13BBN128598	MG71IN214665
130	BA 1 JHA 6265	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN124227	MG71IN214564
131	BA 1 JHA 6275	6/1/2000	6/1/2000	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BB4109183	MG711N207261
132	BA 1 JHA 7102	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-276	Petrol	Operational	G13BBN2366	MASEGF/405
133	BA 1 JHA 9386	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN-543207	MASEGF41500-255581
134	BA 1 JHA 6057	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-249	Petrol	Operational	G13BBN 114094	IN210304
135	BA 1 JHA 6285	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-251	Petrol	Operational	G13BBN-128314	MG71I214641
136	BA 1 JHA 5595	6/1/1999	6/1/1999	1999	India	MARUTI -JEEP-MO-111	Petrol	Operational	10ACN249862	SJ41IN199799
137	BA 1 JHA 7041	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN213775	MA5EGF41S00228880
138	BA 1 JHA 7039	6/1/2005	6/1/2005	2005	India	MARUTI -JEEP-MO-253	Petrol	Operational	G13BBN213273	MA5EGF41S00228872
139	BA 1 JHA 6803	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168687	MG71IN223662
140	BA 1 JHA 6801	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168655	MG71IN223630

141	BA 1 JHA 6791	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN168125	MG71IN223526
142	BA 1 JHA 6777	6/1/2004	6/1/2004	2004	India	MARUTI -JEEP-MO-269	Petrol	Operational	G13BBN166505	MG71IN223089
143	BA 1 JHA 6269	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN128723	MG71IN214758
144	BA 1 JHA 9387	2011	2011	2011	India	MARUTI -JEEP-MO-110	Petrol	Operational	G13BBN543173	XMA5EGF41S00255515XDB
145	BA 1 JHA 9376	0000-00-00	0000-00-00	0000	India	MARUTI -JEEP-MO-249	Petrol	Operational		
146	BA 1 JHA 4961	6/1/1998	6/1/1998	1998	India	MARUTI -JEEP-MO-111	Petrol	Operational	F10AIN240434	SJ41IN186644
147	BA 1 JHA 9384	6/1/2010	6/1/2010	2010	India	MARUTI -JEEP-MO-99	Petrol	Operational	GL01K58275	MA1AH4GLKD1K75615
148	BA 1 JHA 6058	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	113947	210371
149	BA 1 JHA 7099	6/1/2006	6/1/2006	2006	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13DBM230279	MA5FUF41500-229693
150	BA 1 JHA 6047	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN109077	MJ71-IN207193C1
151	BA 1 JHA 9378	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-251	Petrol	Operational	GI3BBNS44580	XMA53GF41500256983XDB
152	BA 1 JHA 6053	6/1/1998	6/1/1998	1998	India	MARUTI -JEEP-MO-99	Petrol	Operational	114171(G13 BBN)	210383

153	BA 1 JHA 6292	6/1/2003	6/1/2003	2003	India	MARUTI -JEEP-MO-98	Petrol	Operational	G13BBN128350	MG711N214635
154	BA 1 JHA 9382	6/1/2013	6/1/2013	2013	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN 537728	XMA5EGF41S00250599XDB
155	BA 1 JHA 6065	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	114283	210554
156	BA 1 JHA 6049	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-98	Petrol	Non Operational	C 13BBN 114108	M671-IN 210332
157	BA 1 JHA 9374	6/1/2009	6/1/2009	2009	India	MARUTI -JEEP-MO-98	Petrol	Operational	G13BBN544713	XMA5EGF41S00257089XDB
158	BA 1 JHA 9375	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-111	Petrol	Operational	G13BBN544702	XMA5EGF41SOO 257109XDB
159	BA 1 JHA 9383	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-111	Petrol	Operational	G13BBN 542990	XMA5EGF41S00 255373 XDB
160	BA 1 JHA 4423	6/1/1995	6/1/1995	1995	India	MARUTI -JEEP-MO-98	Petrol	Operational	ELOAIN219169	SJ411N167086
161	BA 1 JHA 5175	6/1/1995	6/1/1995	1995	India	MARUTI -JEEP-MO-107	Petrol	Operational	G 13 BIM595343	MG 71 IM 188116
162	BA 1 JHA 5589	5/16/2002	5/16/2002	2002	India	MARUTI -JEEP-MO-111	Petrol	Operational	F-10 IN-249879	SJ411M199874
163	NA 1 JHA 5582	0000-00-00	0000-00-00	2004	India	MARUTI -JEEP-MO-107	Petrol	Operational	P10A-IN249883	SJA-1IN199809
164	BA 1 JHA 9371	4/5/2011	4/5/2011	2011	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN544276	XMA5GF41S00256690XDB

165	BA 1 JHA 9377	0000-00-00	0000-00-00	2011	India	MARUTI -JEEP-MO-251	Petrol	Operational	G13BBN544528	XMA 5 EGF 41SOO 256959 XDB
166	BA 1 JHA 6055	4/1/2001	4/1/2001	2001	India	MARUTI -JEEP-MO-99	Petrol	Operational	114251	210435
167	BA 1 JHA 9379	5/1/2011	5/1/2011	2011	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BBN544273	XMA 5EGF 41 500-256719XDB
168	BA 1 JHA 6059	0000-00-00	0000-00-00	2000	India	MARUTI -JEEP-MO-98	Petrol	Operational	113878	210160
169	BA 1 JHA 5181	4/1/1998	4/1/1998	1998	India	MARUTI -JEEP-MO-99	Petrol	Non Operational	G13BIN-595460	MG71IN189209
170	BA 1 JHA 7106	4/1/2005	4/1/2005	2005	India	MARUTI -JEEP-MO-98	Petrol	Operational	G13BBN-133900	MASEGF-41500-229738
171	BA 1 JHA 5594	4/1/2011	4/1/2011	2011	India	MARUTI -JEEP-MO-110	Petrol	Operational	FL0-IN-249873	SJ 41 IN-199805
172	BA 1 JHA 6050	6/1/2000	6/1/2000	2000	India	MARUTI -JEEP-MO-99	Petrol	Operational	11493MG69-IN	210164
173	BA 1 JHA 9381	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-99	Petrol	Operational	G13BSN-537-348	MASEGF41500-250247
174	BA 1 JHA 9372	6/1/2010	6/1/2010	2010	India	MARUTI -JEEP-MO-99	Petrol	Operational	G 13 BBN 544465	XMA5E GF41S 00256860XDB
175	BA 1 JHA 5588	6/1/1999	6/1/1999	1999	India	MARUTI -JEEP-MO-98	Petrol	Non Operational	F10IN249856	SS41IN99801

176	BA 1 JHA 4953	6/1/2010	6/1/2010	2010	India	MARUTI -JEEP-MO-98	Petrol	Operational	F10AIN240308	SJ41IN186540
177	BA 1 JHA 9373	6/1/2011	6/1/2011	2011	India	MARUTI -JEEP-MO-99	Petrol	Operational	D1DBBN544581	XMA53GF41S002569XDB
178	BA 1 JHA 6061	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-107	Petrol	Operational	G13B.B.N.114172	M.G.71-I.N.-210397
179	BA 1 JHA 6056	6/1/2001	6/1/2001	2001	India	MARUTI -JEEP-MO-107	Petrol	Operational	G13BBN114349	MG71 IN210458

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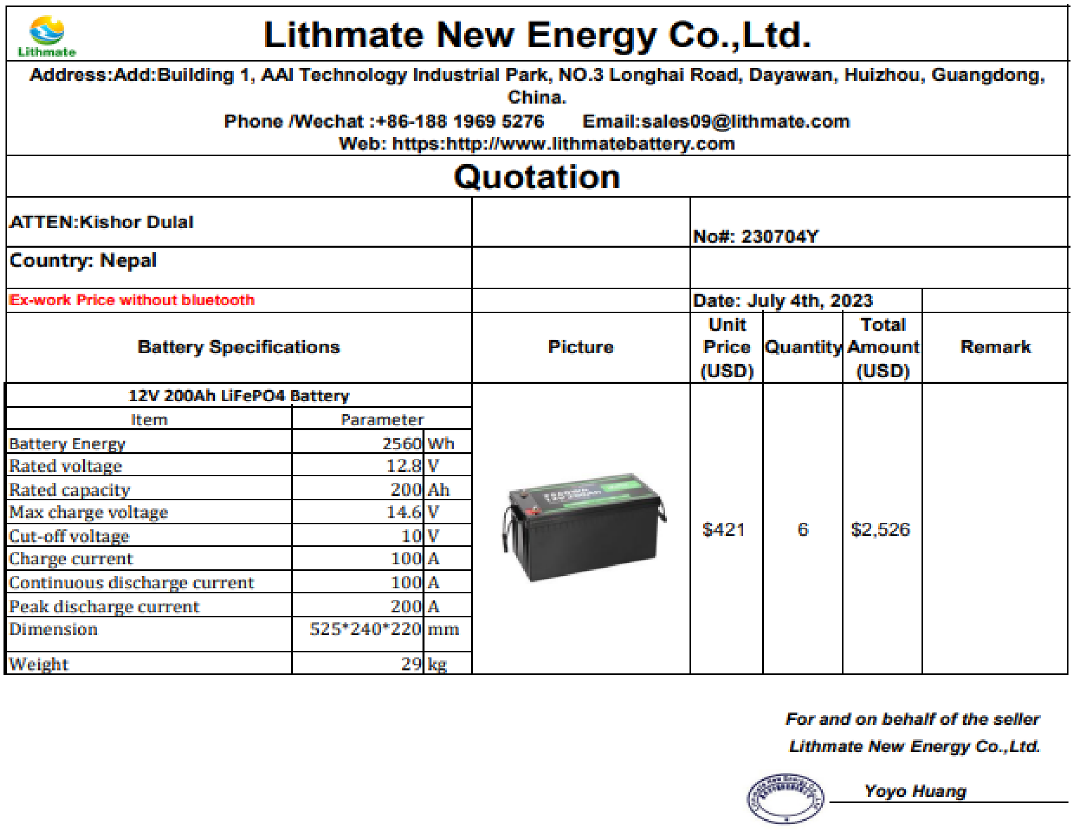

Lithmate New Energy Co.,Ltd.

Address:Add:Building 1, AAI Technology Industrial Park, NO.3 Longhai Road, Dayawan, Huizhou, Guangdong, China.
Phone /Wechat :+86-188 1969 5276 Email:sales09@lithmate.com
Web: https:http://www.lithmatebattery.com

Quotation

ATTEN:Kishor Dulal		**No#: 230704Y**			
Country: Nepal					
Ex-work Price without bluetooth		**Date: July 4th, 2023**			
Battery Specifications	**Picture**	**Unit Price (USD)**	**Quantity**	**Total Amount (USD)**	**Remark**
12V 200Ah LiFePO4 Battery		$421	6	$2,526	

Item	Parameter	
Battery Energy	2560	Wh
Rated voltage	12.8	V
Rated capacity	200	Ah
Max charge voltage	14.6	V
Cut-off voltage	10	V
Charge current	100	A
Continuous discharge current	100	A
Peak discharge current	200	A
Dimension	525*240*220	mm
Weight	29	kg

For and on behalf of the seller
Lithmate New Energy Co.,Ltd.
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