Global Green Growth Institute

Accelerating Implementation of
Nepal's *Nationally Determined Contribution*

Investment Projects for Electric Mobility

December 2018

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Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
BMTA	Bangkok Mass Transit Authority
BRT	Bus Rapid Transit
BSEB	Battery-Swapping Electric Buses
BYD	Build Your Dreams
CAPEX	Capital expenditure
CREF	Central Renewable Energy Fund
CO_2eq	Carbon dioxide equivalent
DC	Direct Current
DOTM	Department of Transport Management
EGAT	Electricity Generating Authority of Thailand
EM	Electric Mobility
EU	European Union
EV	Electric Vehicle
EVAN	Electric Vehicle Association of Nepal
FAME	Faster Adoption and Manufacture of Electric Vehicles
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse gas
GGGI	Global Green Growth Institute
GMW	Gayam Motor Works
GON	Government of Nepal
GW	Giga Watt
HOV	high-occupancy vehicle
ICE	Internal Combustion Engine
IFC	International Finance Corporation
INR	Indian rupees
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
KfW	Bank aus Verantwortung
KMC	Kathmandu Metropolitan City

KMUTT	King Mongkut's University of Technology Thonburi
KSUTP	Kathmandu Sustainable Urban Transport Project
KRW	Korean Won
kWh	kilo Watt hour
MGCF	Mongolia Green Credit Fund
MOF	Ministry of Finance
MOFE	Ministry of Forests and Environment
MOPIT	Ministry of Physical Infrastructure and Transport
MOU	Memorandum of Understanding
MT	Million tons
MW	Mega Watt
NDC	Nationally Determined Contribution
NEA	Nepal Electricity Authority
NPR	Nepali rupees
NTBS	Nepal Trolley Bus Service
OPEX	Operational Expenditure
PM	Particulate matter
SME	Small and Medium Enterprise
SDG	Sustainable Development Goals
SP	Singapore Power
TCO	Total Cost of Ownership
TDF	Town Development Fund
UNCTAD	United Nations Conference on Trade and Development
USAID	United States AID
USD	US dollars
VAT	Value Added Tax

Exchange rate:
USD 1 = INR 65.21
USD 1 = NPR 103.6

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Executive Summary

Working under the overall direction of the Ministry of Forests and Environment and in partnership with the Ministry of Physical Infrastructure and Transport, the Global Green Growth Institute (GGGI) launched the Electric Mobility Program in 2017, to support a transition towards clean and sustainable transportation in Nepal. Under the program, which supports implementation of Nepal's *Nationally Determined Contribution* (NDC) by boosting the adoption of electric vehicles in Nepal, this *Investment Projects for Electric Mobility* was produced.

Overall, these investment projects seek to provide investors with investment-ready opportunities in the clean energy and clean technology space. Most projects offer the possibility of solid financial performance, as well as environmental and social benefits.

The Need for Greater Investment in Electric Mobility

Fossil fueled-transport systems are generating pollution, trade deficit and geo-strategic risk.

The transport sector of Kathmandu has been expanding. This increase exerts significant stress on the environment as air quality continues to deteriorate. Particulate matter concentrations in Kathmandu, for example, are 3 times here than World Health Organization standards, and during 1995-2013, greenhouse gas emissions quadrupled nationally to 3170 kt. Additionally, petroleum imports are a significant portion of the trade deficits in Nepal, amounting to NPR 165 billion (USD 1.6 billion) in 2018, some 15% of the total trade deficit.

Electrification of the transport sector would provide multiple benefits, such as decreased emissions, improved air quality, and increasing energy security. Since 2016, significant gains have been made in electricity generation and distribution in Nepal, and more improvements are expected. Similarly, new hydropower facilities are expected to come online over 2018-2019, helping to ensure that the increased demand resulting from the gradual electrification of the transport sector can be met.

To advance electric mobility, the Government of Nepal has put in place supportive policy and fiscal incentives.

The Government of Nepal has put in place a policy framework to support sustainable and electric transport including Nepal's *Nationally Determined Contribution*, the Sustainable Development Goals, the *National Transport Policy* (2001) and the *Environment Friendly Transport Policy* (2015). A supportive fiscal environment is also now in place. The Ministry of Finance reduced customs duty on private electric vehicles to 10% and public vehicles to 1%, which is significantly lower than the 80% and 5% levied on fossil fuel vehicles respectively. In addition, Nepal Rastra Bank has set monetary policy that increased loan-to-value ratios (loan limits) for electric vehicles to 80% compared to only 60% for fossil fuel vehicles. However, subsidies and credit lines dedicated for electric vehicles are yet to be introduced in the country.

With the adoption of the *National Action Plan for Electric Mobility*, the Government of Nepal starts to operationalize policy intentions.

The Ministry of Forests and Environment and Ministry of Physical Infrastructure and Transport, supported by the Global Green Growth Institute, have been working to implement an Electric Mobility Program to achieve transport sector targets outlined in Nepal's *Nationally Determined Contribution*. A key deliverable of this program was the establishment of a *National Action Plan for Electric Mobility*, which was completed in mid-2018, and launched officially by Prime Minister K.P. Sharma Oli in October 2018. The action plan outlined a number of key actions to advance electric mobility, including initial project ideation. Through consultation with 21 stakeholders, financial and technical assessments and modelling, these project ideas were then developed into the seven project concepts which comprise this report on *Investment Projects for Electric Mobility*.

Designing and Building an Electric Mobility Ecosystem in Nepal

Achieving electric mobility goals and targets requires building an electric mobility ecosystem.

An electric mobility ecosystem comprises four essential components, including a) vehicle manufacturing and technology provision; b) financing; c) infrastructure development; d) and transport operators. Each component of the ecosystem has its own opportunities and risks. The common success factor for all components is to ensure that bankable business models can be developed. An ecosystems approach helps to improve adoption of electric vehicles by ensuring that enabling components of the network are in place, including charging infrastructure and power generation and distribution systems, which are essential for adoption. Indeed, research consistently demonstrates that consumer anxiety over drive range and charging station provision is a critical concern.[1] In the case of Nepal, interviews conducted with current and prospective buyers of electric vehicles by GGGI in 2017 showed that Nepali consumers have this same fundamental worry – many cited it as a key reason to *not* purchase.[2]

While Nepal made some early advances in electric mobility, renewed investment and project delivery is needed.

Nepal has also had experiences in operating technologies such as trolley buses and electric three-wheelers, also known as '*safa tempos*', within Kathmandu Valley since the 1970s and 1990s respectively. However, the trolley bus operation was discontinued due to mismanagement in 2011. Private electric cars, however, were recently introduced on the Nepali market, whose sales mainly escalated due to fossil fuel supply disruption in the Nepal-India border during 2015-16. Uptake of private electric vehicles have been growing since and interested public vehicle operators have also surfaced. Sajha Yatayat, a public bus operator, is interested in deploying electric buses and eventually converting its whole fleet to electric. One of the main electric mobility ecosystem components that still needs substantial support is infrastructure.

Growing investments in electric mobility projects across Asia, and globally, can serve as useful models for Nepal's investment projects.

Battery electric buses, trolley buses, battery leasing programs, fossil fuel vehicle conversion to hybrid and fully electric, charging infrastructure, battery recycling plants and financing incentives for electric mobility are projects that are being implemented all over Asia. Cities such as Shenzhen, Bangkok, and Karachi are aiming to introduce or have introduced battery operated buses worth investments of more than USD 600 million. Trolley buses are technologies that have withstood the test of time and are still being operated in cities such as Shanghai and Almaty. Battery leasing is an innovative program that aims to eliminate 60% of the upfront cost of electric vehicle technologies to the consumer. Such a program in Jeju, constituting of 23 swap stations totaling an investment of USD 86 million, provides convenient access to affordable batteries in addition to reducing investment requirements for a consumer. All of these and other projects from across Asia constitute useful models for electric mobility projects and ecosystem design in Nepal.

[1] See for example, Melliger, A et al. 2018. "Anxiety vs reality – Sufficiency of battery electric vehicle range in Switzerland and Finland" in *Transportation Research Part D: Transport and Environment*. Vol. 65, Dec. 2018, p. 101-115.

[2] GGGI 2017. Internal research undertaken by GGGI Nepal.

Investment Projects for Electric Mobility

Through careful design, seven financially, environmentally and socially attractive investment projects for electric mobility have been conceptualized.

These project concepts support investments needed in key components of Nepal's electric mobility ecosystem. Based on financial, economic and technical assessments, the project concepts demonstrate viability. Further full feasibility assessments will need to be undertaken. In partnership with government, banks, entrepreneurs and other industry actors, the following projects were conceptualized:

- *Deploying Midsize Electric Bus Fleet in Kathmandu Valley* - Midsize electric buses are entirely battery powered and can access both larger highways (primary routes) and smaller feeder roads (secondary routes) to service an estimated 600,000 monthly passengers in Kathmandu Valley. If the project can achieve a delivery price of USD 187,796 per bus and assemble an estimated fleet of at least 50 buses, a financially sustainable mobility service model can be successfully established without government subsidy. With a return on investment of around 5.17%, cost recovery on the 50 buses could be achieved after 15 years.

- *Deploying an Electric Trolley Bus System in Kathmandu Valley* - New generation electric trolley buses draw power from overhead lines or catenaries, but also have the ability to go 'off-line' for short stretches of route. They are well suited to Kathmandu's 28-kilometer long ring-road, where a fleet of trolley buses can provide transport services to an estimated 76,800 daily passengers. The infrastructure, including poles, catenaries and bus stations would be developed by the private sector. A fleet of 64 trolley buses, deployed at a per unit cost of USD 144,788, would achieve cost recovered in 10 years. The project would achieve a return on investment of 12.66% for the operator.

- *Upscaling Electric Vehicle Battery Leasing for Three-Wheelers* - 714 electric three-wheelers, called safa tempo, operate in Kathmandu and date to the early 1990s, including outdated lead acid batteries which constrain trip distance and frequency, and generates significant battery waste.

- A battery swap station in Kathmandu that leased and charged 51 lithium ion batteries to safa tempo operators would require an estimated investment of USD 487,452 and generate revenues of USD 84,942 in the first year. A return on investment of 5.28% could be achieved by the station operator.

- *Upscaling and Monetizing Public Access Charging Stations* - Deployment of 10 stations charging stations by the public power utility in partnership with a major retail outlet is a way to expand the number of stations available, enable widespread adoption of private passenger electric vehicles while still achieving financial sustainability. These 10 stations could service an estimated consumer base of 100 drivers daily, generating annual revenues of USD 2.2 M, as well as generate brand value for the retail outlet through association with a high-tech, emerging and sustainable technology. The monetary return on investment would be an estimated 26.05%, however the real value of the project is not in the immediate financial return.

- *Establishing and Valorizing Battery Recycling* - Over 24,000 tons of spent lead-acid batteries are discarded every year in Nepal and because there are no domestic battery recycling facilities in the country, all spent batteries are taken to India. Given that greater adoption of electric vehicles is a policy goal, a robust domestic used battery management solution is needed. A battery recycling facility can be established for an estimated USD 4.9 M investment, and with correct policy support can achieve return on investment of 20%, leading to cost recovery within 3.7 years.

- *Converting Fossil Fuel Taxis to Electric Taxis* - An estimated 10,000 taxis provide transport services across Kathmandu. Due to suppressed fares, high inflation and rising operational costs, many drivers and taxi fleet operators see hybrid-electric taxis as an attractive alternative, due to the significant savings in operations and maintenance that electric vehicles offer. A taxi conversion center in Kathmandu, where conventional taxis can be converted to hybrid, would cost an estimated USD 2.2 M to establish. With adequate commitment from drivers and fleet owners, a revenue of USD 19 M for the sale and installation of required technology could be achieved, leading to an internal rate of rate of 15.01%.

- *Establishing an SME Financing Facility for Electric Mobility* - The cost of capital is high in Nepal, partly due to high inflation. It is also often difficult to access, especially for ventures in electric mobility and transport, which commercial and retail banks tend to view as high-risk. A central fund to provide debt and equity financing to electric mobility start-ups, provide subsidy to private consumers who buy electric vehicles, and develop electric mobility infrastructure would generate multiple benefits. Series A capitalization of the fund could draw on both domestic and international sources, to constitute a total size of NPR 4.6 billion (USD 45 M).

1. Introduction

1.1. Context

The Kathmandu Valley comprises a resident population of some 3.3 million people and a significant share of the vehicles in Nepal.[3] In 2017, approximately 40% of the total national vehicle fleet was registered in the Kathmandu Valley metropolitan area.[4, 5] This metropolitan fleet includes both private and public vehicles, although the share has shifted significantly over time. In 1990, there were around 800 public buses in the metropolitan area, rising to more than 11,000 by 2017 - an annualized growth rate of 11%.[6] However, the number of private vehicles, especially two-wheelers, has been rising much more quickly. As a result, the overall share of public vehicles has decreased from 8% in 1990 to just 2% in 2017 (see Figure 1.1). Within this context, the current supply of public transport remains insufficient. Overwhelmingly, the transport sector in Kathmandu is dominated by diesel and gasoline vehicles. However, electrification of Nepal's transport sector makes good sense for both the medium- and long-term financial, environmental and strategic benefits.

Of principle importance is the air quality and mitigation benefits that transport electrification would bring. Air quality in Kathmandu has worsened dramatically since the 2000s. This is the result of increased fossil fueled vehicles, coupled with the overall geographic structure of the valley, the microclimate and wind flow, and other sources such as brick kilns and reconstruction of buildings and roads, has led to Kathmandu being ranked as one of the world's most air polluted cities in the past few years.[7] Particulate matter (PM2.5) in Kathmandu has climbed to an annual average of 30.40 $\mu g/m^3$. This is three times higher than the standard prescribed by the World Health Organization. As a result, approximately 9,000 premature deaths occur annually in Nepal.[8] In addition, greenhouse gas emissions are rising. In 1995, annual emissions from Kathmandu's transport sector totaled an estimated 716 kilotons, rising more than four-fold to 3170 kilotons in 2013.[9] The Pre-Feasibility Study on Deployment of Electric Bus in Kathmandu Valley, jointly developed by the Ministry of Physical Infrastructure and Transport, Ministry of Forests and Environment and the Global Green Growth Institute, shows the environmental costs of a diesel bus in its 10-year life is around USD 32,000, whereas due to zero tailpipe emissions and lower noise, electric buses on the same route will have no environmental costs.[10] Within this context, electric vehicle, which have zero tailpipe emissions, are an essential component for improving air quality in Nepal's cities.

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[3] Central Bureau of Statistics. 2012. National Population and Housing Census, 2011. National Planning Commission; Ministry of Urban Development. 2017. National Urban Development Strategy. Ministry of Urban Development.

[4] World Bank. 2013. *Urban growth and spatial transition in Nepal*. Washington, DC: World Bank.

[5] According to the DOTM, 37% of vehicles were registered in the Bagmati Zone, which roughly corresponds with the metropolitan area of Kathmandu Valley.

[6] Department of Transport Management. 2017. Vehicle Registration Data.

[7] Zhong, M., Saikawa, Eri., Avramov, A., Chen, C., Sun, B., Ye, W., Keene, W.C., Yokelson, R.J., Jayarathne, T., Stone, E.A., Rupakheti, M., Panday, A.

[8] World Health Organization. 2016. Ambient air pollution: A global assessment of exposure and burden of disease. Retrieved from http://apps.who.int/iris/bitstream/10665/250141/1/9789241511353-eng.pdf

[9] World Bank. 2017. CO2 emissions from transport sector in Nepal.

[10] GGGI. 2017. Pre-Feasibility of Deploying Electric Bus in Kathmandu Valley. Ministry of Forests and Environment. Ministry of Physical Infrastructure and Transport.

Secondly, as a landlocked country without petroleum resources, Nepal must import its fossil fuel needs. Trade deficits have increased by 23% to NPR 713.94 billion (USD 6.9 billion) in the first eight months of the fiscal year 2017/18, mainly due to the rising share of imports from around 70% in 2005/06 to 90% in 2016/17. Total trade deficit is expected to increase to USD 10.3 billion by the end of the fiscal year 2017/18 of which 15% will be due to petroleum imports from India and other countries. Transport sector's consumption of petroleum is the highest in the country. Conversely, with theoretical potential of 83 GW, and 188 hydropower projects with a total capacity of 6.8 GW under construction, Nepal will have excess electricity supply in the next few years.[11] Electrification of the transport sector, therefore, brings substantial financial and strategic benefits linked to energy sufficiency and reducing the national trade deficit.

Within this context, electric mobility presents an attractive option to reduce the national trade deficit and foster long-term domestic sustainable energy solutions. Thirdly, both of Nepal's neighbors, China and India, are rapidly moving towards electric mobility. The Government of India had announced in 2016 that India will aim for 100% EV by 2030. However, realizing the need to develop the necessary infrastructure first, the Government of India has stated that EVs will constitute 30% of the total transport system in 2030.[12] In addition, India put in place the Faster Adoption and Manufacture of Electric Vehicles (popularly known as the FAME scheme) scheme to reduce upfront technology costs to those willing to buy private or public electric vehicles. Similarly, China is gearing towards increasing its EV fleet to 15% by 2025.[13] Primarily, if electric vehicles on the Indian auto market are expected to rise in the next five to ten years, Nepal, which relies on India to supply its market, must necessarily consider the implications of this goal.

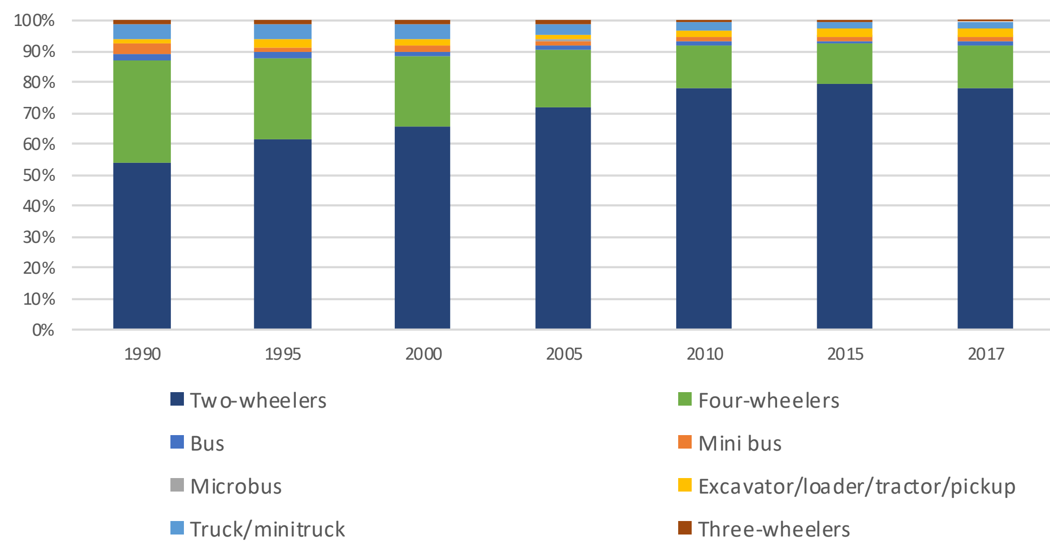


Figure 1.1 Vehicle type by share in the Kathmandu Valley area, 1990-2017[14]

[11] Ministry of Energy, Water Resources and Irrigation. 2018. List of Issued Generation Licenses. Department of Electricity Development. Retrieved from: <http://www.doed.gov.np/construction_license_for_generation.php>

[12] Bloomberg. 2018. India Says Never Targeted 100% Electric Mobility by 2030, Scales Down Aim. Retrieved from: <https://www.bloombergquint.com/business/india-says-never-targeted-100-electric-mobility-by-2030-scales-down-aim>

[13] Bloomberg. 2018. India Says Never Targeted 100% Electric Mobility by 2030, Scales Down Aim. Retrieved from: <https://www.bloombergquint.com/business/india-says-never-targeted-100-electric-mobility-by-2030-scales-down-aim>

[14] For this figure and associated analysis, the vehicle categories 'micro bus', 'mini bus', and 'bus' have been classified as for public transport use. This is an assumption, as the source data does not provide for this criterion.

Cognizant of this need for change, and of the strategic and financial advantages of electric mobility, the Government of Nepal has been building the required policy and regulation to support a widespread switch to electric mobility. Two of the main policies include the National Transport Policy (2001) and the Environment Friendly Transport Policy (2015), with the former setting out broad provisions for sustainable transport and the latter detailing specific targets and directions for fostering the various ecosystem components such as infrastructure, manufacturing, technology. A National Sustainable Transport Strategy (2015), which is yet to be endorsed by the government, sets out a long-term strategic vision for the transport sector and aims to strengthen the economic, social and environmental aspects within the transport sector. Furthermore, Nepal Rastra Bank has increased the loan-to-value ratio for electric vehicles to 80% and the Ministry of Finance has decreased customs duty from 40% to 10% for private electric vehicles and 5% to 1% for public electric vehicles.

While an increasingly robust policy and regulatory framework is in place, much greater attention is needed for implementation. With this in mind, the Government of Nepal and GGGI launched Phase I of the *Electric Mobility Program* in 2017, to support active programming and concrete implementation of national electric mobility goals and targets.

1.2. Government of Nepal's *Electric Mobility Program*

The Global Green Growth Institute is working in partnership with the Ministry of Forests and Environment and the Ministry of Physical Infrastructure and Transport to support the implementation of Nepal's *Nationally Determined Contribution* (NDC) in the transport sector. This work takes place within the umbrella targets and interventions outlined in the NDC including a) having 20% of all vehicles be electric by 2020; b) reducing fossil fuel dependence by 50% by 2050; and c) significantly improving air quality in cities by 2025.

Phase I of this program was implemented over 2017-18, under the overall guidance of the relevant ministries, and the supervision of the National Green Growth Steering Committee, and involved three key deliverables:

1. National Action Plan for Electric Mobility – The Action Plan was developed to support implementation of transport sector targets specified in Nepal's Nationally Determined Contribution (NDC). The NDC outlines a series of 14 targets out of which four are focused on the transport sector. The National Action Plan has assessed barriers to uptake of electric vehicles in Nepal and recommended three key priority actions, which need to be implemented to meet NDC targets. These priority actions are: a) Establish an Electric Mobility Unit to provide oversight to financial and program initiatives; b) Establish a National Program for Electric Mobility to facilitate public and private acquisition of electric vehicles, invest in infrastructure, push for operational progress and refine legislation; and c) Establish a National Financing Vehicle to manage financial support to promote infrastructure, innovation and entrepreneurship for electric mobility.
2. Investment Projects for Electric Mobility – This report presents seven viable project ideas that align with priority Actions 1 and 3 outlined in the National Action Plan for Electric Mobility. These project ideas (outlined in Chapter 4) aids in integrating all components of a sustainable electric mobility ecosystem. The different components of the ecosystem are: i) Policy, ii) Technology, iii) Manufacturing, iv) Operators, v) Financing and vi) Consumers.
3. Pre-Feasibility Study on Deployment of Electric Bus in Kathmandu Valley – This study has assessed the feasibility of an electric bus in one of Sajha Yatayat's routes. Sajha Yatayat is a cooperative currently operating a fleet of more than 48 diesel public buses. Through a Total Cost of Ownership Analysis (TCO), the study assessed the operational, economic, social and environmental costs of operating a diesel bus vs an electric bus. The results show that the BYD K7 bus is 39% cheaper than the current Ashok Leyland Diesel Bus during its 10-year life.

This current investment pipeline for electric mobility projects corresponds to Output 2.

1.3. Goal and objectives of this pipeline

The fundamental goal of this pipeline is to provide concrete investment project opportunities to support implementation of the *National Action Plan for Electric Mobility*.

This current *Investment Plan* builds off the project ideas initially conceived within the scope of the *National Action Plan*. The projects presented in this *Investment Plan* take the initial ideas further, and into more detailed scope, in-terms of partners, beneficiaries, financing, impact and outcome – reflecting further thinking undertaken by the Government of Nepal and GGGI, as well as consultations undertaken with the business and investment communities in Nepal, and internationally. Nonetheless, these project ideas, conceived for bankability and to further the concrete action needed to boost electric mobility in Nepal, require detailed conceptualization and financial analysis.

1.4. Stakeholder engagement and consultation

As for the development of the *National Action Plan*, development of this pipeline has followed a participatory, consultative process. This process, outlined below, has involved feed in and contributions from government officials, non-government organizations, academics, transport operators and business representatives. A preliminary customer outreach activity was also carried out to assess demand and acceptance of various electric mobility services available in Kathmandu.

Development of the pipeline was carried out through a blended consultation process that first sought to generate initial project ideas and recommendations; and the second sought to flesh out and finalize short-listed project ideas. Project bankability was also determined for all relevant project ideas.

A validation meeting was held with the Ministry of Physical Infrastructure and Transport and the Ministry of Forests and Environment to present the final set of projects under the pipeline.

A total of 21 consultations were carried out with stakeholders ranging from businesses to financing institutions and government bodies. The stakeholders consulted are part of the various electric mobility ecosystem components discussed in Chapter 2. Table 1.2 shows that among the stakeholders consulted, technology and infrastructure are the main components being focused on by electric vehicle dealers namely, Sipradi Trading, CIMEX, Agni Energy and Electric Vehicle Association of Nepal. Technology is also a big focus group for Tailg, Eco Infinity and Asian Batteries that are producing electric three-wheeler, importing electric two-wheelers and manufacturing lead-acid batteries for vehicles catering to two- to four-wheelers, respectively. The Electric Vehicle Association of Nepal is an umbrella organization that currently provides oversight to the Clean Locomotive Entrepreneurs Association and Nepal Electric Vehicle Charging Stations, which is currently involved in operating electric three-wheelers "*safa tempos*" and upgrading battery systems from lead-acid to lithium-ion. The Alternative Energy Promotion Center has been involved in carrying out developing financing policies, disseminating technology and developing infrastructure.

Local financing institutions such as the Town Development Fund and the Nepal Investment Bank Ltd are in the process of being accredited to the Green Climate Fund and are looking to invest in the electric mobility sector by leveraging funds accessed through GCF. In addition to that, local venture capitals were also consulted to gauge interest and appetite in investing in innovative electric mobility initiative.

Table 1.1 Activity timeline

Component	Activities	Time Period
Stakeholder Mapping	Stakeholder Mapping – Primary and secondary stakeholders for electric mobility were identified	March 2018
Key Informant Interviews	Priority stakeholders for electric mobility were identified, and first round consultations were implemented using key informant interviews	April. – June. 2018
Consumer Interviews	Current and prospective consumers of both electric car and electric motorbike were interviewed using a structured questionnaire focusing on demand for the different projects trying to understand demand	Oct. 2017
Project Ideation	Initial project ideas were gathered from consultations and subject to review and consideration on several factors	July 2018
Preparation of Pipeline of Projects	Draft pipeline was developed, with consideration on project bankability. Business representatives were consulted on demand for specific technologies and its viability in Kathmandu.	June – Sept 2018
Validation Meeting	Final pipeline was presented to the	October. 2018

Table 1.2 List of stakeholders and respective electric mobility components

Stakeholder Name	Policy	Technology	Infrastructure	Manufacture	Operator	Finance
GOVERNMENT BODIES						
Alternative Energy Promotion Centre	√	√	√			√
Town Development Fund						√
Ministry of Physical Infrastructure and Transport	√					
BUSINESSES AND BUSINESS GROUPS						
Sipradi Trading (Tata representative in Nepal)		√	√			
CIMEX (BYD representative in Nepal)		√	√			
Agni Energy (Mahindra representative in Nepal)		√	√			
Electric Vehicle Association of Nepal		√	√	√	√	√
Mahanagar Yatayat					√	
Panchakanya Charging Station			√			
Safa Charging Station			√			
Shree Bha Charging Station			√			
Sarathi Cab					√	
Everest Cab Services					√	
Tailg		√		√		
Eco Infinity		√				
Asian Batteries Pvt Ltd.		√		√		
FINANCING INSTITUTIONS						
Nepal Investment Bank Ltd						√
NMB Bank						√
Central Renewable Energy Fund						√
Business Oxygen						
Dolma Foundation						
M&S Next Venture Corp						

NO HORN
TOYOTA
SUZUKI
Mahindra
tourister

2. Building an Electric Mobility Ecosystem for Nepal

2.1 A system of connected components

As is the case for many countries, Nepal is starting to build out its electric mobility ecosystem. Early progress in this field, as explored in Chapter 1, yielded mixed, but overall positive results. These early investments in electric mobility, both in public transport services (trolley buses and electric three-wheelers or *safa tempos*), were isolated projects and not part of a wider effort at building an ecosystem for electric transport.

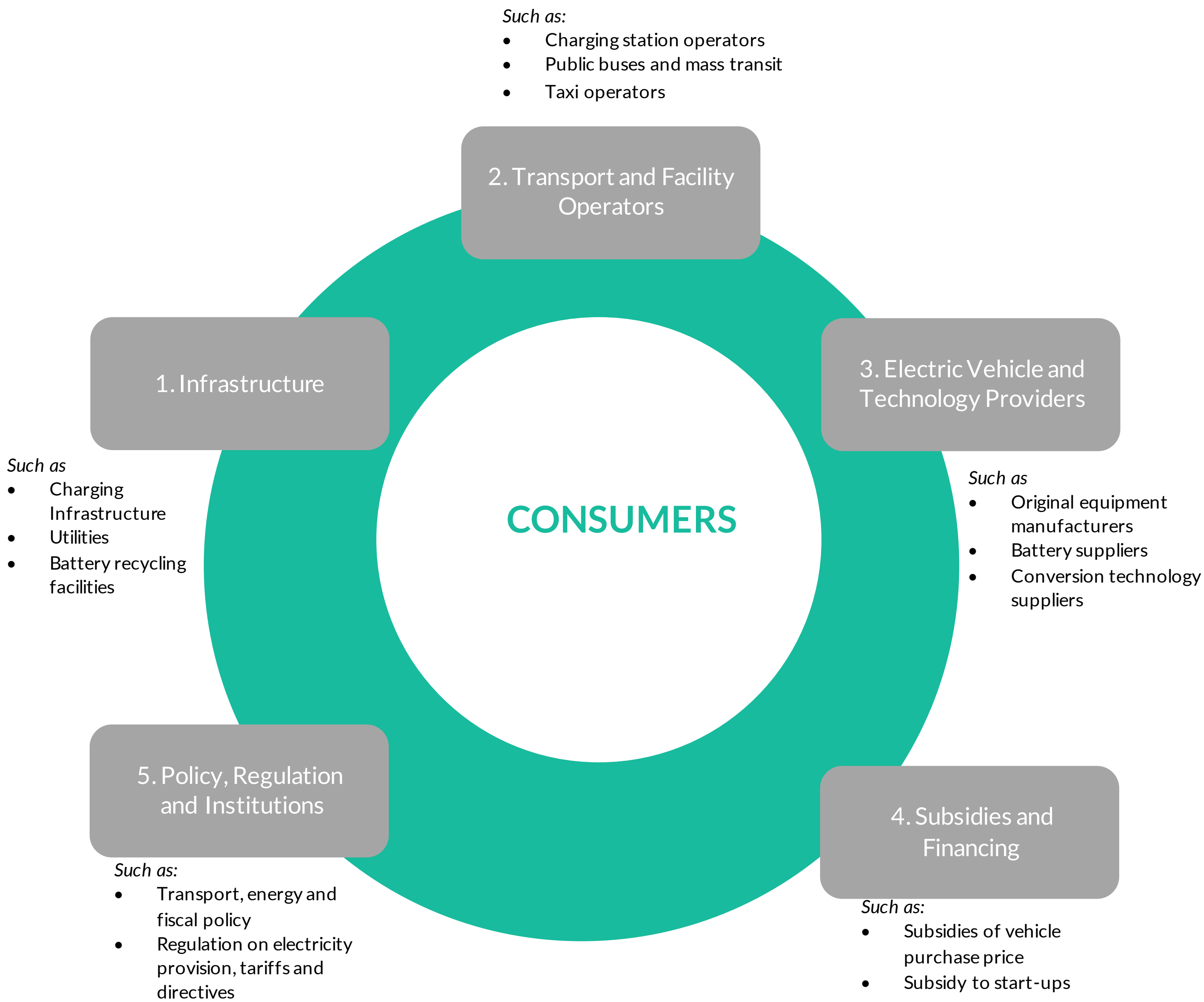
Since then, rapid progress in the field has led to the emergence of an ecosystems approach to electric mobility, namely by the European Union. Such an approach seeks to build a well-balanced and functioning network of electric mobility components, including transport policy, vehicle manufacturing, technology provision, financing, infrastructure development and transport service provision, as outlined in Figure 2.1 below. [15] Each component of the ecosystem has its own opportunities and risks. As the EU has noted, on key common success factor for most comwponents is to ensure that bankable business models can be developed. The development of such models for Nepal is the broad purpose of this *Investment Pipeline* (see Chapter 1).

An ecosystems approach helps to improve adoption of electric vehicles by ensuring that enabling components of the network are in place. Indeed, research consistently demonstrates that consumer anxiety over drive range and charging station provision is a critical concern.[16] In the case of Nepal, interviews conducted with current and prospective buyers of electric vehicles by GGGI in 2017 showed that Nepali consumers have this same fundamental worry – many cited it as a key reason to *not* purchase.[17]

More broadly, building an electric mobility ecosystem generates a range of positive feedback loops. Consumers see electric buses on the roads and are encouraged to purchase electric cars for private consumption. Finding charging stations integrated into major public car parks, consumers realize the convenience of switching to electric. Adequate power demand planning helps to ensure the stability of supply. Building recycling facilities for used batteries helps to ensure that negative externalities of a widespread switch to electric vehicles are minimized and reassures consumers. All these and other positive feedback loops can be obtained, strengthening the electrification of the transport sector.

An ecosystem approach also simply helps to minimize gaps between services and infrastructure needs and ensure the development of a holistic system. Social safeguards need to be built into individual components and the ecosystem, to ensure inclusiveness. As such transport issues related to gender, affordability and accessibility, especially for passengers with disabilities, the elderly, pregnant women and passengers with children, should be fully integrated throughout the ecosystem. Figure 2.1 outlines the essential components of an electric mobility ecosystem. The system draws on work supported by the European Union and lays the conceptual foundation of the selected project concepts in Chapter 4.

[15] European Union. 2016. eCo-FEV D502.3 Potential Business Model.
[16] See for example, Melliger, A et al. 2018. "Anxiety vs reality – Sufficiency of battery electric vehicle range in Switzerland and Finland" in *Transportation Research Part D: Transport and Environment*. Vol. 65, Dec. 2018, p. 101-115.
[17] GGGI 2017. Internal research undertaken by GGGI Nepal.



Source: Adapted from a study by the European Union (2016)[18]

Figure 2.1 Components of an ecosystem for electric mobility

[18] European Union. 2016. eCo-FEV D502.3 Potential Business Model.

The ecosystem is comprised of the following key components:

1. **Infrastructure** – including charging stations, battery recycling facilities, transport facilities and systems such as trolley bus catenaries, stations, bus lanes, and monorail infrastructure.
2. **Transport and Facility Operators** – Private and public entities managing the provision of transport and related services to the public, primarily. This may include bus and taxi operators, as well as operators of charging facilities and stations.
3. **Electric Vehicle and Technology Providers** – Importers and distributers of electric vehicles, as well as local parts and vehicle manufacturers, and technology providers, including batteries and conversion technologies.
4. **Subsidies and Financing** – Including subsidies and credit schemes offered to consumers to increase purchasing of electric vehicles, and financing to entrepreneurs (such as transport operators), as well as broader incentives to support electric mobility.
5. **Policy, Regulation and Institutions** – Includes policy across the transport sector, as well as supporting and enabling sectors such as the energy and manufacturing sectors; as well as fiscal and customs policy on the import of vehicles, and associated practices in key institutions.

These four components of the ecosystem are in turn supported by and built around a) consumers and their needs; and b) policy and regulations:

a. **Consumers –** Private consumers of electric vehicles for personal use, as well as corporate consumers and government bodies that may purchase electric vehicles.

b. **Policy and Regulation –** Including national policy and strategic priorities for the transport sector; air quality standards, emissions standards and wider operational standards and directives for transport operators (for example bus fare regulation); as well as energy policy.

2.2. The electric mobility ecosystem in Nepal

The components of Nepal's electric mobility ecosystem are in various states of advancement. In particular, the policy and regulatory space has become increasingly well built. A number of vehicle manufacturers have entered the domestic market, and charging infrastructure is starting to be developed. Transport operators are starting to show interest in integrating electric vehicles into their fleets. Consumers, overall, remain hesitant to invest in electric vehicles due to the higher price point, relative to conventional vehicles, and lack of charging infrastructure for inter-city routes. These trends and other aspects are explored in more detail below.

INFRASTRUCTURE: Some progress has been made, especially in terms of charging infrastructure

Infrastructure development is a prerequisite of market and service delivery development in a country. For electric vehicles, development of charging infrastructure, whether fast charging, slow charging or battery swapping, should be a priority. The development of such infrastructure supports market expansion.

In Nepal, investment in public-access charging infrastructure has started. CIMEX, a local supplier, has obtained exclusive rights to distribute BYD products in Nepal, and has begun importing BYD electric cars and energy storage products. The company, in collaboration with the National Electricity Authority (NEA) has installed five charging stations in January 2018, in a move to support awareness of electric vehicles. They have plans to install a total of 10 charging piles at the end of 2018. NEA, the only electric utility in Nepal is interested in collaborating with other companies willing to install charging stations and is keen on developing a charging network in the country.[19] Development of charging stations requires access to land. NEA's access to land in major parts of Kathmandu paired with its interest of utilizing these lands to develop charging stations is a positive step towards infrastructure development in the country. In addition to this, KIA has installed one charging station in Kurintar, on the way to Pokhara.

[19] Online Khabar. 2018. Nepal Electricity keen on setting up nationwide EV charging station network: Ghising. Clean Energy Wire (CLEW), Germany.

Infrastructure, besides charging stations, is also essential in effective operation of electric mobility services. For example, a trolley bus service would require overhead catenaries, and conversion services would require a conversion facility. There is much scope to build more extensive and tailored infrastructure systems.

INFRASTRUCTURE: The sector is supported by ongoing progress in power generation, transmission and management

Over 2016-18, Nepal benefited from improvements in power management, especially in Kathmandu, leading to a reduction in power cuts and load shedding. Such stability improves the viability of electric vehicles in Nepal. With a number of hydropower facilities under development, the federal government projects an energy surplus by 2019, primarily during the summer and monsoon, when river water levels are high and production soars[20]. Indeed, Nepal's hydroelectric potential is immense, with an estimated 83,000 MW of energy in the country's rivers. Only a fraction of this is being captured currently.

The following hydropower facilities are expected to come online over the next 5 years:

- Upper Tamakoshi Facility – Dolakha District – Expected output: 456 MW – Coming online 2019.
- Kulekhani 3 Facility – Makwanpur District – Expected output: 14 MW – Coming online 2019
- Upper Trishuli 3A – Rasuwa District – Expected output 60 MW – Coming online 2019

OPERATORS: Transport operators are interested in going electric, but struggle with financing.

Since the 1970s, Nepal transport operators have launched four main operations. The first was an electric trolley bus system developed in the 1970s, with support from the Government of China. Altogether 32 trolley buses operated during 1975 – 2009. Nepal Trolley Bus Service (NTBS), a branch of the Nepal Transport Corporation, operated these trolley buses until 2001. Improper management resulted in the dissolution of the operator in 2001 and the trolley bus service came to a halt. After 18 months, Kathmandu, and Bhaktapur municipalities decided to revive the trolley bus line. However, as these buses failed to attract customers, substantial losses accrued, due to which the two municipalities opted out of the plan. In 2009, Kathmandu Metropolitan City ceased the trolley bus operation as it faced chronic losses.[21]

The second initiative involved electric three-wheelers in Nepal. Private operators have been running these three wheelers, also known as *safa tempos*, in primary, secondary and tertiary routes within Kathmandu Valley. The safa tempos were first manufactured and operated in 1993, with funding from USAID, which attracted the attention of individual private sector investors. By 2011, a total of 714 safa tempos were plying the streets of Kathmandu. The number, however, has not increased after 2011 as the federal government banned the production of additional three-wheelers due to congestion.

The third initiative has been led by the public bus transport cooperative operator, Sajha Yatayat, with technical support from the Global Green Growth Institute. In partnership with the Institute, Sajha Yatayat is looking to deploy 2-4 electric buses in Kathmandu. CIMEX, the BYD importer in Nepal, will support the procurement of the buses, which Sajha Yatayat will operate. Beyond these initial buses, Sajha Yatayat has also committed to taking its entire fleet electric over the upcoming several years.

The fourth initiative involved the procurement of five BYD C6 electric buses, allocated to the Lumbini Development Trust, for operation, by the Asian Development Bank. These buses will provide transport from the Lumbini International Airport into Lumbini city, when the international airport opens. Charging stations have been established in Lumbini accordingly.

OPERATORS: Transport service providers are expected to provide socially inclusive services

Transport is essential to people's access to education, work and public services. Cognizant of this, the Government of Nepal articulates a socially inclusive vision for its transport system, as follows: "*Transport system should not exclude or impose any sort of discrimination to any section of society (especially children, women, elderly, physically challenged, and other marginalized peoples) particularly in terms of accessibility and ease of usage. There should not be any physical or institutional barrier to use transport infrastructure and services.*" (National Sustainable Transport Strategy, Draft-2015).

[20] Spotlight Nepal. 2018. "Nepal to export electricity to India from next fiscal year" in *Spotlight Nepal*. Published Aug. 15 2018 at https://www.spotlightnepal.com/2018/08/15/nepal-export-electricity-india-next-fiscal-year/

[21] Smith, F. 2018. Kathmandu-Bhaktapur Trolley Bus. The Nepali Times.

As a result, the development of electric mobility service operators should aim to further this agenda by improving affordability, accessibility and safety through technical and financial solutions. Currently in Nepal, there is a 50% discount for transportation applied for disabled persons. Additionally, seats are to be reserved for disabled persons, pregnant women, travelers with small children and the elderly where the transportation vehicle has a capacity of 15 or more.[22] Similar measures should be promoted and preserved in the shift towards sustainable transport. A World Bank (2013)[23] study on gender and transport in Kathmandu also recommended inclusive planning processes for transport, and promotion of 'Safer Transport for All' campaigns and measures to ensure personal safety of all travelers, particularly young women who reported to feel most unsafe on overcrowded vessels.

There are also opportunities in transport related investment projects to further the Government of Nepal's efforts towards gender equality in the labor market, capacity building and education by promoting equal opportunities for men and women in the sector's value chains.

TECHNOLOGY: Local manufacturing has been restrained, but may pick up

Manufacturing of EVs began in 1993 when the Global Resources Institute initiated assembly of eight battery operated three-wheelers in Kathmandu. On the strength of this, and recognizing the business opportunity of local production, five manufacturers namely, Nepal Electric Vehicle Industry, Electric Vehicle Company, Green Electric Vehicle, Green Valley and Bagmati Electricals produced a total of 714 electric three-wheelers, or safa tempos, from 1996-2011, an average of 47 a year. Most of these safa tempos are still deployed on the streets of Kathmandu.[24]

The initial pilot of eight vehicles involved importing all parts required to produce the electric three-wheelers. However, in 2000, four years after the beginning of private sector manufacturing, local industry began manufacturing the required parts for the safa tempos, increasing production of vehicles and holding down cost. As a result, in 2011, the central government moved to restrict three-wheeler registration, citing issues of congestion on the smaller tertiary routes that safa tempos tend to ply. Since 2011, the total number of registered safa tempos in Nepal has remained fixed at 714. In this way, the industry was a victim of its own success.

The second manufacturing experience is more recent, involving electric two-wheelers and rickshaws. Tailg is a Chinese company, producing electric scooters and electric bicycles in China for both domestic and international sale. The company is expanding heavily and is seeking to increase international production and sales of its products.[25] As part of this, Tailg Nepal has established an assembly unit in Gothatar, on the outskirts of Kathmandu. As of October 2017, the company has assembled and sold 22 electric rickshaws and is still in the process of an assembly system for electric scooters.[26] Both these examples demonstrate scope for development of the local electric vehicle manufacturing industry.

TECHNOLOGY: Domestic technologies and platforms are nascent

Different technology and services are gradually being developed in Nepal to facilitate cleaner modes of transport. The first technology that was introduced in Nepal was trolley buses that utilized direct electricity lines to power their system, hence not requiring backup services. In 1993, lead-acid battery operated safa tempos were introduced in the streets of Kathmandu. Currently, the private operators of safa tempos are in the process of replacing their lead-acid batteries with lithium ion batteries. However, private operators are hesitating to make the switch due to the high cost of lithium-ion batteries (around NPR 1 M = USD 9,633). Electric vehicles with lithium-ion batteries have also been introduced by manufacturers such as Mahindra, KIA and BYD. So far, around 500 Mahindra electric cars and 77 Kia Soul have been sold in Nepal.[27] The recent Nepal Automobile Dealers Association's auto show, in 2018, brought three new electric vehicle options in the limelight. The Tata Tigor, Hyundai Ioniq and Renault ZOE were showcased to customers previously who had very limited options. The drive range of these EVs ranges from 100 km per charge for Tata Tigor to 400 km per charge

[22] Australian Himalaya Foundation. 2016. *A Report on Disability in Nepal*. Accessed at https://www.australianhimalayanfoundation.org.au/wp-content/uploads/2017/08/2016_Nepal_Disability_Report.pdf
[23] World Bank. 2013. *Gender and Public Transport. Kathmandu, Nepal*. Washington, DC.
[24] Global Resources Institute. 2006. Electric Vehicles in Kathmandu. Global Resources institute (GRI). http://www.grilink.org/ktm.htm-
[25] China Daily. 2017. "TAILG plugs right into Belt and Road opportunities", in China Daily. Accessed at http://usa.chinadaily.com.cn/epaper/2017-05/09/content_29267407.htm
[26] Following phone interviews with Tailg Nepal representatives undertaken by GGGI
[27] Kathmandu Post. 2018. EVs see great interest from customers at NADA

for Renault ZOE, making them ideal for travel within Kathmandu and outside, respectively.

Apart from development in hardware, Nepal has also made some progress in developing software, such as ride-hailing apps called Tootle and Sarathi. Tootle was introduced in early 2017 with the intention of connecting customers with two-wheeler owners willing to offer rides inside Kathmandu Valley. This ride-sharing app is designed in such a way that consumers pay significantly lower (NPR 214 for a 10 km ride) with Tootle, as opposed to a local taxi which charges more than NPR 400 for the same distance. In addition, consumers don't have to go through the same hassles of commuting in crowded public transportations.

Another technology that is in the process of being developed is Sarathi. Similar to ride-hailing services provided by Uber and OLA, Sarathi aims to provide mobility solutions by offering ride leasing, booking, car rental and car sharing services to the population of Kathmandu. Sarathi began its operations in 2017 and is currently working with 40 taxis catering to approximately 500 customers per day. They aim to improve the financial and social conditions of drivers by increasing access to financial services and building their capacity on communication and technology. With 100% metered rides and 24 hours service, Sarathi is systematizing taxi services in Kathmandu, along with providing convenient rides to the consumer. Sarathi is one of the businesses participating in the Rockstart Impact accelerator program, which is working to bridge the gap between entrepreneurs and impact investors.[28]

There have been various activities in Nepal initiating talks about installing monorails, metro, BRT, electric ropeway, etc. Among these, cable car is a technology that was installed in Chitwan District in 1998. A total investment of NPR 430 M (USD 4.1 M) was made by a private company called Citawon Co-E Group through financing from local banks. The cable car caters to more than 7000 devotees every day going to and back from the Manakamana Temple. Currently, the fare is such that locals are charged NPR 50 per person, whereas devotees from elsewhere have to pay NPR 640 per person. This success of cable cars has prompted the private sector to recently develop another cable car system in Chandragiri.

FINANCING: Financing remains limited, undermining growth

Although battery costs have decreased rapidly since 2009, batteries are still major cost components escalating the initial cost of EVs. Financial incentives are important in introducing and deploying EVs in a country.[29] Investment in new transport technologies, such as EVs, and associated infrastructure in Nepal is limited due to high acquisition costs and absence of incentives, such as subsidies, that aid uptake of clean technologies. However, different fiscal measures have been introduced through the Ministry of Finance and the Nepal Rastra Bank to increase electric vehicle uptake in the country. NRB increased provisions of loan-value ratio for private electric vehicles to 80% in 2017, encouraging private vehicle operators to increase adoption of EVs. Import duty of electric vehicles was decreased from 40% to 10% for private transport in 2016 in an effort to sway interests of private sector consumers (c.f. import duty is 1% for electric vehicles for public transport). In addition, Ministry of Finance decreased the import duty of electric public vehicles to 1% to encourage the public sector in adopting this technology.

Increasing interest from the private sector in importing and distributing electric vehicles, especially electric two- and three-wheelers, have also been observed. Companies such as Tailg, Asta Automobile, BG Video and Electronics as well as SLR Techno & Trade are importing two-wheelers, both electric scooters and motorbikes, from Japan, India and China. In addition, Mahindra and Kia and BYD are the other three players in the electric vehicle distribution field in the country.

CONSUMERS: Consumer awareness is growing slowly, but proactive promotion is needed

As indicated earlier, based on interviews undertaken by GGGI with both current and prospective consumers of electric vehicles in Kathmandu, anxiety over the provision of public access charging stations remains central and inhibits the market. At the same time, vehicle manufacturers and distributers in Nepal are hesitating to invest themselves, preferring instead to offer charging stations at their central service center, rather than for general public access. Moreover, electric vehicles are largely seen as a luxury good, due to their high cost relative to other vehicles on the market.

Overall, knowledge of electric vehicles is not widespread in Nepal. While some consumers have excellent

[28] New Business Age. 2018. Impact Investing: Contributing to Economic Growth. Accessed online at: <http://www.newbusinessage.com/MagazineArticles/view/2018>

[29] IEA. 2017. Global EV Outlook 2017: Two million and counting. Clean Energy Ministerial. Electric Vehicles Initiative.

knowledge of the advantages and disadvantages of electric vehicles, most consumers are unaware or are misinformed. As such, the market could benefit from widespread promotion of electric vehicles, and the clear setting out of the benefits of switching to electric.

POLICY: A relatively robust policy and regulatory landscape has been built

Specific policies being implemented in other parts of the world include waiving regulations that limit the availability of license plates for clean technologies, providing access to urban areas that are restricted for ICE, waiving usage fees in certain portions of the road network, increasing access to charging infrastructure and parking spaces and providing access to high-occupancy vehicle (HOV) lanes.[30] Since the EV market is at a very nascent stage in Nepal, supporting policies are broader in scope and are yet to be properly implemented. A summary of the EV policy landscape in Nepal is presented below.

Owing to the increasing pollution levels and the recent fuel supply disruption, activities to introduce electric vehicles, including scooters, three-wheelers and four-wheelers have been escalating in Nepal. Robust policies and regulations have been introduced to create a favorable environment for uptake of electric vehicles in the country. Policies such as the National Transport Policy (2001) and the Environment Friendly Transport Policy (2015) encourage a wider shift to sustainable transport services, which include targets of increasing environment friendly vehicles such as EVs, adding infrastructure required to facilitate efficient operation of these vehicles and encouraging manufacture of these vehicles. In addition, various strategy documents have been introduced, such as National Sustainable Transport Strategy (Draft-2015), National Urban Development Strategy (2017) and National Energy Strategy (2013) that outline various provisions for adopting electric vehicles. Making a policy statement, the National Planning Commission of Nepal became the first government body to purchase an electric car in January 2018.[31]

[30] IEA. 2017. Global EV Outlook 2017: Two million and counting. Clean Energy Ministerial. Electric Vehicles Initiative.

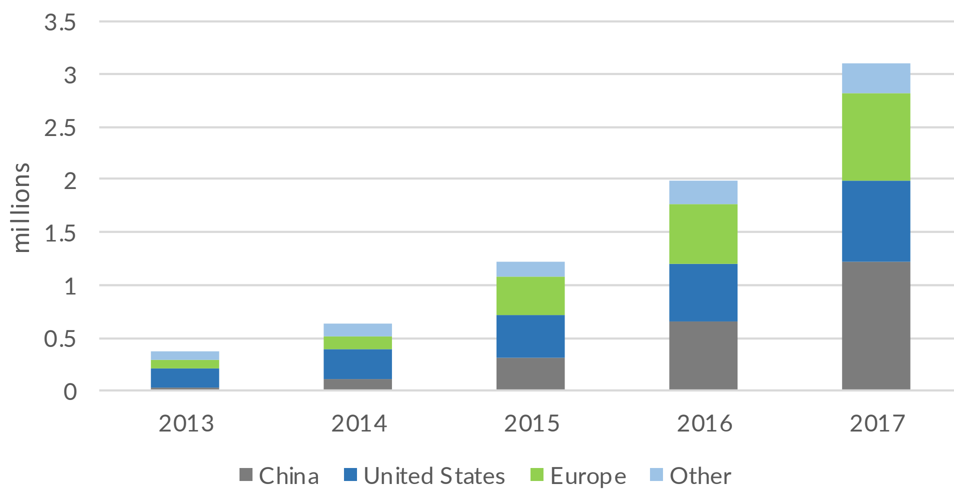
[31] Onlinekhabar. 2018. Nepal's first govt-procured electric car is a policy statement: Planning Commission Vice-Chair Wagle. Accessed online at: < http://english.onlinekhabar.com/nepals-first-govt-procured-electric-car-is-a-policy-statement-planning-commission-vice-chair-wagle.html>

3. Selected Electric Mobility Investments in Asia

3.1 Global trends towards an electric future

Overall, a switch towards electric mobility can be globally. While the overall market share of electric vehicles in most markets remains small, it's growing steadily. In Norway, for example, electric vehicles hold a 40% market share, the highest globally, followed by Iceland at 11.7%, Sweden at 6.3% and China at 2.2%.[32] Norway's global lead is due to advanced and generous subsidies and other support. Similarly, the number of electric vehicles in circulation continues to climb, from less than 0.5 million in 2013, to over 3 million today. Much of this growth has taken place in China.

Within Asia, China, India, Thailand, Japan and Korea are all increasingly investing in electric mobility, with China the regional lead by far. In 2017, China had 1.2 million electric vehicles on its streets, compared to just 0.2 million in Japan (see Figure 3.1). China and India have visions of increasing the share of EVs in their fleet to 15% by 2025 and 30% by 2030 respectively. In addition, battery prices have decreased by 80%, from USD 1000/kWh to USD 209/kWh between 2010-2017, making EVs more lucrative globally.



Source: Using data from the IEA, 2018.[33]

Figure 3.1. Number of electric cars in circulation globally

[32] International Energy Outlook. 2018. *Global EV Outlook 2018*.

[33] International Energy Outlook. 2018. *Global EV Outlook 2018*.

It has been estimated that the battery prices will continue to decrease to USD 70/kWh by 2030, which will increase investor confidence in the electric mobility space. Beyond electric passenger vehicles, operators, utilities and governments are investing heavily. Selected key investments are outlined in the next section

3.2 Selected electric mobility investments in Asia

Battery electric buses

Battery electric buses are rapidly becoming the most common form of public transport system in the world. The global electric bus population doubled in 2016, when compared to that in 2015. China is increasingly becoming the world leader in transforming its public bus fleet to electric, as its electric bus stock increased to 343,500 units in 2016, which was 99% of the electric buses in the world.[34] With companies such as Build Your Dreams (BYD) that has become world leader in electric vehicle manufacturing, China is leaping forward in-terms of meeting its targets of reducing GHGs and air pollution. Other developing countries in Asia, such as Pakistan, Sri Lanka and Thailand are either conducting feasibility studies or piloting electric buses to introduce a full fleet.

When compared with diesel buses, although the acquisition cost of electric buses is higher, their life-time operation and maintenance cost is significantly lower. The maintenance cost of battery electric buses is generally observed to be around 50% of that of diesel buses. However, this depends on availability of service centers and spare parts. The annual maintenance savings of a battery electric bus is around USD 4,800 more than that of a diesel bus.[35]

Project: Establishment of City-Wide Electric Bus Fleet
Place: Shenzhen, China
Date: 2011 – 2017
Investment size: USD 37,8 billion
Ecosystem component: Transport operator; manufacturing; infrastructure
Summary: Shenzhen has more than 16,000 electric buses with BYD making 80% of its new buses. Shenzhen has been known to be the first in the world to have a city-wide all electric bus fleet.[36] Investment on these buses were made easier by introducing subsidy of USD 150,000, which is almost half of the price of the bus. Build Your Dreams (BYD) is the world's largest Chinese automobile manufacturer, headquartered in Shenzhen, China, which had initiated the process of piloting electric buses in the city. With expertise in manufacturing monorails, buses, forklifts, trucks and rechargeable batteries, BYD has been able to make a strong market hold in over 50 countries in the world.

Project: Deploying Electric Buses in Bangkok
Place: Bangkok, Thailand
Date: 2018
Investment size: NA
Ecosystem component: Manufacturing, Operator, Technology
Amongst the numerous initiatives taking place in Bangkok, Edison Motors, a Korean bus manufacturer has introduced five electric buses, one on each of the five routes identified jointly with King Mongkut's University of Technology Thonburi (KMUTT), Bangkok Mass Transit Authority (BMTA), the Thailand Research Fund and Electricity Generating Authority of Thailand (EGAT). These buses are being tested to assess the capacity of their battery to withstand high temperatures and local traffic conditions. BMTA plans to bid on 35 electric buses upon successful completion of these tests. Edison Motors has recently entered into partnership with four Thai automatic companies to scope start local manufacturing opportunities.[37]

Project: Establishing an Electric Bus Fleet in Karachi
Place: Karachi, Pakistan
Date: 2018 - present
Investment size: USD 600 M
Ecosystem component: Financing, Operator, Technology
Karachi, Pakistan – A Chinese company called Eco-Bus has offered to invest in and operate 2000 electric buses in Karachi, Pakistan. Currently, Eco-Bus has provided two electric buses for piloting purposes. Once the viability of

[34] IEA. 2017. Global EV Outlook 2017: Two million and counting. Clean Energy Ministerial. Electric Vehicles Initiative.
[35] GGGI. 2017. Low Carbon Buses for Amman, Jordan. Grutter consulting.
[36] The Straits Time. 2018. Shenzhen leads the way in switch to electric buses. Accessed online at < http://www.straitstimes.com/asia/east-asia/shenzhen-leads-the-way-in-switch-to-electric-buses>
[37] Pressreader. 2017. Edison Motors lays electric bus groundwork. Accessed online at: < https://www.pressreader.com/thailand/bangkok-post/20171222/281998967821193>

these buses has been assessed, Eco-Bus will invest USD 600 M to purchase and operate 2000 buses along with construction of 500 charging stations within the city.[38]

Trolley buses

Trolley buses are safe and environment friendly electric vehicle options that have been adopted in many parts of the world since the end of the 19th century. Since then, more than 370 cities around the world have up to 40,000 trolley buses in service at one point in time. Countries such as Russia, Canada, Ecuador, Mexico, New Zealand, China, Greece and 40 more countries have installed a trolley bus system. The trolley bus is a proven technology that minimizes pollutants, noise and destruction of urban areas. The trolley buses can be implemented in only 15% of the cost of implementing an urban rail system.[39] When compared to the operations of a hybrid and a Plug-in hybrid bus, operating at an annual distance of 80,000 km, the trolleybus has 81% and 54% more OPEX savings per annum, respectively. Similarly, the marginal abatement cost (USD/tCO_2) of a trolley bus is 64% higher than a hybrid bus and 56% lower than that of a plug-in hybrid bus.[40]

Trolleybus maintenance costs are considered higher (10-30%) in parts of Europe due to high frequency of failures and unavailability of spare parts in the market, whereas operators in China report maintenance costs to be 30% lower than that of a diesel bus. Annual maintenance cost of infrastructure has been estimated to be 0.5% of CAPEX.[41]

Project: Shanghai Trolleybus System
Place: Shanghai, China
Date: 1914- present
Size: NA
Ecosystem component: Operator, Technology
Shanghai, China - Trolley buses in Shanghai, China was introduced in 1914, which operated from the Dongxinqiao Bridge to Zhengjiamu Bridge.[42] This was one of the oldest trolley bus systems in the world. In 1994, the Shanghai trolley bus system comprised of 900 vehicles plying in more than 20 routes, largest operation in the world. The number of trolley buses declined to as low as 150 units in 2012, due to reconstruction and widening of the roads, after which more trolley buses were added to reach 300. The new buses that were added were the dual-mode trolley buses that ran up to 10 km "off-wire" or on battery. Out of the 13 lines trolley buses are operating in, line 71 is the longest route in Shanghai (17.5km) catering to a daily passenger number of about 50,000 every day.[43]

Project: Trolley buses in Kazakhstan
Place: Almaty, Kazakhstan
Date: NA
Size: NA
Ecosystem component: Technology, Infrastructure
Almaty, Kazakhstan – There are 8 trolley bus routes, which are in full operation in Almaty, Kazakhstan. A total of 195 trolley buses were bought from one of China's electric vehicle manufacturing company called San Bao. These buses have 36 batteries and can run up to 10 kilometers without the electric lines. The trolley bus infrastructure was developed during the Soviet times and is still in operation.[44]

Battery leasing programs

Sustainability of electric vehicles depends largely on activities that decrease cost of batteries and increase accessibility to charging or battery swap stations. Battery swapping schemes, being introduced in many countries around the world, provide support to consumers in lowering battery replacement costs, in addition to increasing opportunities for long distance travel. Countries which lack basic EV infrastructure, such as charging stations, are best positioned to adopt battery swapping programs, that reduce maintenance cost for users, while providing the same benefits in-terms of drive range.

[38] Pakistan Today. 2017. Plying of modern electric buses in Karachi augurs well: governor. Accessed online at: < https://www.pakistantoday.com.pk/2017/10/28/plying-of-modern-electric-buses-in-karachi-augurs-well-governor/>.
[39] Trolley Motion. n.d. Arguments Pro Trolleybus. Accessed online at: < http://www.trolleymotion.eu/www/index.php?id=3&L=3>
[40] GGGI. 2017. Low Carbon Buses for Amman, Jordan. Grutter consulting.
[41] GGGI. 2017. Low Carbon Buses for Amman, Jordan. Grutter consulting.
[42] Global Times. 2016. Shanghai's classic trolley buses and trams are on a resurgence. Accessed online at: < http://www.globaltimes.cn/content/970005.shtml>
[43] Wikipedia. 2017. Trolleybuses in Shanghai. Accessed online at:< https://en.wikipedia.org/wiki/Trolleybuses_in_Shanghai>
[44] China Central Television. 2015. China made trolley bus welcomed in Almaty. Accessed online at: < http://english.cntv.cn/2015/11/25/VIDE1448427362956912.shtml>

China, for example, aims to add 12,000 charging/swap stations by 2020.[45] Together, the State Grid Corporation of China and China Southern Power Grid have installed over 800 battery-swapping stations for electric buses.[46] The Niti Aayog in India has also strongly recommended that the Indian Government install battery swap stations specifically for 2- and 3-wheelers.[47] Advantages of battery swapping include short wait time and optimization of battery life due to regular battery maintenance in swapping stations. However, the initial construction cost of a battery swapping facility is higher compared to that of the AC Plug-in charging and DC Fast Charging Stations.[48]

Project: Installation of battery swap stations
Place: Nanjing, China
Date: 2015 - present
Size: NA
Ecosystem component: Infrastructure, Operator
Ziv Av Engineering is a company that was commissioned to install 7000 battery swapping stations for electric buses in Nanjing, capital of Jiangsu province in China in 2015. A company named Bustil owns the franchise for charging and swapping batteries in Nanjing. Currently, one swapping station in Nanjing has the capacity to swap approximately 72 batteries per day, where a battery swap takes around 8-10 minutes. These battery swap stations are also equipped with two charging facilities in which a bus can be fully charged in about 4 – 6 hours.[49]

Project: Battery swap program by Gayam Motor Works
Place: India
Date: 2015 - present
Size: NA
Ecosystem component: Manufacturing, Infrastructure, Technology
There are more than 600,000 electric rickshaws using lead-acid batteries in India, which need to be replaced twice a year. To address this problem, Gayam Motor Works developed lithium-ion three-wheelers, known as SmartAuto, in India in 2015. In addition, recognizing the lack of charging infrastructure to ease e-rickshaw operations, GMW introduced battery swap stations that supports three-wheeler operators in reducing their operation and maintenance costs. These lithium-ion batteries can be fully charged in three hours and provides a drive range of about 110 km per charge. One clear advantage to this battery swap program is that consumers can buy the vehicles without the battery, which significantly lowers the initial investment. According to GMW, the cost of a SmartAuto, without a battery, is lower than the cost of a diesel three-wheeler.[50]

Project: Battery Lease Business in Jeju Island
Place: Jeju Island, South Korea
Date: 2015 - present
Size: USD 85.4 million
Ecosystem component: Operator, Technology, Financing
The Seguipo city in Jeju Island operated 23 Battery- Swapping Electric Buses (BSEB) in 2016. The battery charging efficiency of the system is around 95% and one battery is swapped in an average time of one minute. The company that is operating this battery-swapping station is called Begins, which has installed fast and slow charging stations as well. The total investment cost of KRW 96.6 billion including government subsidy of KRW 26.4 billion and private investment of KRW 70.2 billion was estimated for construction of battery leasing stations. [51]

Project: Lithion Power Battery Swapping Stations
Place: Delhi, India
Date: 2018 – present
Size: USD 1 billion
Ecosystem component: Technology, Financing, Operator
Delhi, India – A Delhi based company called Lithion Power has plans to invest approximately USD 1 billion to expand their battery swapping

[45] CISION. 2017. China EV Charging Station and Charging Pile Market Report, 2017-2020. PR Newswire
[46] IEA. 2017. Global EV Outlook 2017: Two million and counting. Clean Energy Ministerial. Electric Vehicles Initiative.
[47] NITI Aayog. 2017. India Leaps Ahead: Transformative Mobility Solutions for All. Rocky Mountain Institute.
[48] Fang, S-C. K, B-R. Chung, C-Y. 2017. Battery-Swapping Electric Bus Transportation System: Comparison with an All Plug-In System. Energies;10:890
[49] Li. Yanying. 2016. Infrastructure to facilitate usage of electric vehicles and its impact. 6th Transport Research Arena April 18-21, 2016. Transport Research Procedia 14: 2537-2543.
[50] Hasnie, S. Gayam, R. 2017. Battery swapping can propel India's electric car revolution. Asian Development Blog. Accessed online at: <https://blogs.adb.org/blog/battery-swapping-can-propel-india-s-electric-car-revolution>
[51] IEA. 2015. EV Battery Leasing Business in Jeju. Begins Accessed online at: <https://www.iea.org/media/workshops/2015/towardsaglobalevmarket/B.4Begins.pdf>

stations to other areas in Delhi to cater to demands from electric vehicles ranging from public vehicles such as three-wheelers, e-rickshaws and two-wheelers. Lithion Power is working towards creating a battery bank of more than one million batteries by 2021. As of February 2018, the company owns 5 battery swapping stations in Delhi and charges on an average of INR. 75-300 (USD 1.2 – 4.6)[52] depending on the size of the battery. A single battery runs on an average of 70-100 km per charge.

Vehicle conversion

It is a well-known fact that electric vehicles are less lucrative due to high initial costs. However, high economic, environmental and energy costs of a fossil fuel vehicle have prompted many consumers to debate whether they should make the switch to battery electric vehicles. The option of going electric has been identified to be made affordable by conversion technologies that are emerging in the market. This technology can minimize negative impacts of fluctuating fossil fuel prices and provide better income security to public vehicle operators. In developed countries like America where high-end electric vehicles have a comparatively big market, these conversion technologies cost 30% of that of the cost of an electric vehicle in 2009.[53] However, in developing countries like India where alarming pollution trends have prompted a few developers to design, the cost of these technologies has gone down to about 0.1% of that of similar hybrid vehicles.[54]

A major limitation of these conversion technologies has been the use of led-acid batteries, which although provide greater customization option, have shorter life than lithium-ion batteries.

Project: Altigreen Drive Electric
Place: Bangalore, India
Date: 2013 - present
Size: USD 3.5 million
Ecosystem component: Technology, Manufacturing
Altigreen Propulsion Labs, India – The conversion technology developed by Altigreen Propulsion Labs in India offers improvement in fuel efficiency by about 30% and cuts down tailpipe emissions by as much as 20%. The plug-in system called HyPixi ranges in cost from INR 60,000 – 80,000 (USD 920 – 1227)[55] depending on the type of vehicle being converted. This technology can be applied in a range of vehicles from two-wheelers to 16-wheeler trucks.[56] At this stage, Altigreen has raised about USD 3.5 million from angel investors to develop the HyPixi technology and is looking for more funding, essentially to continue with improving the product and for R&D purposes. Currently, Altigreen is only selling the HyPixi to corporate fleet owners and has plans to sell to individual customers once their service centers and installation network is in place.[57]

Project: Revolo hybrid technology
Place: Pune, India
Date: 2010- present
Size: NA
Ecosystem component: Technology, Manufacturing
KPIT, India – KPIT Technologies in India has introduced pure electric and hybrid conversion technologies, known as Revolo, for vehicles ranging from buses to taxis. This technology was first conceived in 2010 when KPIT was a software company. KPIT then joined hands with Bharat Forge Ltd., manufacturer of auto parts, to train its mechanics to carry out the simple process of installing the hybrid technology. Revolo has a unique architecture which allows it to operate on a lower voltage. It also does significant regeneration to have the maximum possible range with the smallest possible battery. The system is modular and designed for Indian conditions.

Project: Converting 7000 taxis in Beijing to electric
Place: Beijing, China
Date: 2018
Size: USD 1.3 billion
Ecosystem component: Technology, Operator
Beijing, China – China has a bigger market in electric vehicle conversion technologies

[52] Exchange rate: USD 1 = INR 65.21
[53] Berman, B. 2009. Top 7 Issues for an Electric Car Conversion. Hybridcars.
[54] The Economic Times. 2018. Want to save 30% on fuel costs? Altigreen holds the key. ET Rise.
[55] Exchange rate: USD 1 = INR 65.21
[56] The Economic Times. 2018. Want to save 30% on fuel costs? Altigreen holds the key. ET Rise.
[57] The Better India. 2018. This Startup Can Reduce Your Vehicle's Fuel Consumption by 25%! Accessed online at: <https://www.thebetterindia.com/126966/startup-can-reduce-vehicles-fuel-consumption-25/>

especially because of its aggressive policies towards reducing fossil fuel vehicles. Beijing is one such city where 70,000 fossil fuel taxis are being converted to battery based electric taxis. The cost of converting its total fleet has been estimated to be around CNY 9 billion (USD 1.3 billion). However, since the technology is expensive, taxis operators such as Caocao are hoping to receive subsidies through the government.[58]

Charging infrastructure

Charging infrastructures are critical components of Electric Mobility. At the end of 2017, the share of publicly accessible slow and fast chargers was the greatest in China: 41% and 74%, respectively compared to countries around the globe. IEA specifies that construction of charging infrastructure is highly dependent on the country's policy that includes clear deployment targets and has a clear direction on funding mobilization.[59]

Project: Installation of charging stations
Place: Singapore
Date: 2018 - present
Size: NA
Ecosystem component: Infrastructure, Financing, Operator
A ride-hailing company called Grab has recently partnered with Singapore Power (SP) to increase the number of electric vehicles in its fleet. SP is in the process of installing and operating fast charging stations to cater to the growing demand. By the end of 2018, SP expects to install and operate 30 charging stations, which has been targeted to grow to 500 by 2020. Although the pricing structure has not be determined yet, SP has confirmed that price will be based on the type of chargers: AC and DC, specifically.[60] [61]

Project: Installation of Charging Stations
Place: China
Date:
Size: USD 4.1 billion (till April 2018)
Ecosystem component: Infrastructure, Financing, Operator
The State Grid Corporation has been the largest utility service provider to install and operate charging stations in China. Till April 2018, the Corporation has invested more than 28 billion RMB (USD 4.1 billion) to build more than 5700 charging stations and 56,000 charging piles.[62] Furthermore, the Corporation is looking to construct a total of 120,000 fast charging stations and 500,000 public stations by 2020.[63]

Project: Promoting EV Purchases, Charging Network
Place: Thailand
Date: 2015 - present
Size: USD 607,671 (Phase V – 2018)
Ecosystem component: Infrastructure, Operator
The government of Thailand is aiming to increase its total EV fleet to 1.2 million and install 690 charging stations by 2036. Through the Energy Conservation Fund, the Energy Policy and Planning Office has provided USD 1.5 million to government agencies, state-owned enterprises and private firms to construct public charging stations. It dispersed its 5th round of support worth USD 607,671 in March 2018 to install 31 public EV charging stations. The fund provides 30% subsidy to private investors, 1.8 million baht (USD 54,690) and 190,000 baht (USD 5,772 0 as subsidy for quick-charging and standard charging stations developed by the government agencies, as well as 1 million baht (USD 30,383) to state enterprises. Till date, the fund has provided support for installation of 150 charging stations around the country.[64]

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[58] World Economic Forum. 2017. 70,000 Beijing taxis are being converted to electric power. Accessed online at: <https://www.weforum.org/agenda/2017/03/beijing-is-converting-its-fleet-of-70-000-taxis-to-electric-power>
[59] IEA. 2018. Global EV Outlook.
[60] Channel NewsAsia. 2018. Singapore's largest electric vehicle charging network to have 500 charging points island-wide by 2020. Accessed online at: < https://www.channelnewsasia.com/news/singapore/singapore-s-largest-electric-vehicle-charging-network-to-have-10445736>
[61] Techcrunch. 2018. Accessed online at: < https://techcrunch.com/2018/08/23/southeast-asias-grab-plans-electric-vehicle-push/>
[62] State Grid EV Services. 2018. The Development Status, Planning and Prospect of Charging Infrastructure in China. Accessed online at: <https://event.buhlergroup.com/fileadmin/uploads/buhler/The_future_of_mobility/Photos/Presentation_PDFs/Development_Status__Planning_and_Future_Prospects_of_Charging_Infrastruc....pdf>
[63] National Development and Reform Commission (NDRC) (2015, October 9). Guide to the development of electric vehicle charging infrastructure. National Development and Reform Commission, National Energy Bureau, Ministry of Industry, Information, and Technology, and Ministry of Housing and Urban-Rural Development; www.ndrc.gov.cn/ zcfb/zcfbtz/201511/t20151117_758762.html
[64] Piyachart Maikaew and Yuthana Praiwan. 2018. Powering the EV surge. Bangkok Post. Accessed online at: < https://www.bangkokpost.com/business/news/1414335/powering-the-ev-surge>

Battery recycling plants
Currently there are a few different methods being employed for battery recycling, which include, pyrometallurgical, hydrometallurgical and physical processes. However, these processes decrease the value of products that can be recycled. Although it is costlier and lacks regulatory standards, physical separation is a key method that needs to be integrated to maximize the residual value of batteries.[65] Battery recycling plants are all over the world, however, proper safety measures are not employed in many developing countries, leading to lead exposure.

Project: Lead-acid battery recycling in India
Place: India
Date: 2018
Size: USD 0.97 M
Ecosystem component: Technology, Operator
There are a few major players in India, such as Hindustan Zinc, SesaSterlite and Hindalco, that recycle lead-acid batteries. For a 40 MT/Day recycling capacity, the total cost of construction and operation of a lead-acid battery recycling plant is estimated at INR 696 Lakhs (USD 0.97 M). This project will yield a return of 32%.[66]–

Project: Environment Protection Law
Place: China
Date: 2015 - present
Size: N/A
Ecosystem component: Policy
In 2017, 30-40% of the spent lead-acid batteries were recycled by smelting companies without a certificate, causing environmental and health hazards. A new law for environment protection was passed in 2015 after which the Ministry of Environmental Protection has been strictly monitoring disposal of spent batteries and its waste and is expected to curb emissions of lead waste by 2020. [67]

Financing initiatives
National financing vehicles are emerging financing bodies that gain access to and manage environmentally friendly and sustainable investments. The Global Green Growth Institute has estimated that in the next 15 years, a total of USD 93.1 trillion will be required for infrastructure development and low carbon transitions. In such a scenario, National Financing Vehicles develop a pool of investment by reaching out to multilateral and bilateral aid, private sector investments, capital markets and the national budget through which local priority development projects can access financing.[68] The fiscal incentives discussed below are those that are dedicated to electric mobility and broader energy and green growth related projects.

Project: Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME)
Place: India
Date: 2015 - present
Size: USD 42.3 M (incentives disbursed till November 2018)
Ecosystem component: Financing
The FAME scheme in India, a type of National Financing Vehicle, came into operation in April 2015, with the aim of supporting development of electric vehicle markets and EV manufacturing ecosystems in India. It is designed such that all businesses can apply for subsidies for all electric vehicle types, including two-wheelers, three-wheelers, four-wheelers, commercial vehicles and buses. A total of 90,000 hybrid or battery electric vehicles have received subsidies under this scheme since 2015. In addition to financing transport vehicles, FAME provided approximately INR 155 Crores (USD 23.8 M)[69] during 2015-2016 for development of charging infrastructure and implementation of pilot projects as well as technological development projects.[70] Phase I of the scheme has provided total incentives of INR 2.2 billion (USD 34 M) to 191,589 vehicles, which has contributed to a total of 61 M kgCO_2 reduction is scheduled to end on 31st March 2018.[71] Mahindra, an electric vehicle manufacturer in India for example, has also been receiving subsidy under the FAME scheme since 2015. A total of INR 124,000 (USD 1901) is being provided to all models of

[65] IEA. 2018. Global EV Outlook.
[66] Entrepreneur India. n.d. Lead Battery Recycling. Accessed online at: <https://www.entrepreneurindia.co/project-and-profile-details/Lead%20Battery%20Recycling>
[67] Sun, Z., Cao, H., Zhang, X., Lin, X., Zheng, W., Cao, G., … Zhang, Y. (2017). Spent lead-acid battery recycling in China – A review and sustainable analyses on mass flow of lead. Waste Management, 64, 190–201.
[68] Global Green Growth Institute. 2017. Building National Financing Vehicles. Accessed online at: <http://report.gggi.org/2016/wp-content/uploads/2017/06/National_financing_vehicles.pdf>
[69] Exchange rate: USD 1 = INR 65.21
[70] Government of India. 2016. Fame India Scheme. Ministry of Heavy Industries & Public Enterprises. Press Information Bureau, Government of India.
[71] The Economic Times. 2017. Hybrid, e-vehicles continue to attract incentives under FAME. Accessed online at: <https://economictimes.indiatimes.com/industry/auto/news/passenger-vehicle/cars/hybrid-e-vehicles-continue-to-attract-incentives-under-fame/articleshow/60815243.cms>

Mahindra REVA electric vehicles, which is almost 15% less than the original purchase price of the new e_2o Plus model.[72]

Project: Financial incentives to EVs
Place: China
Date: 2016 - present
Size: NA
Financial incentives in China – China has implemented various financial incentives to boost sales of electric vehicles. One of the tools they widely used in 2016 are subsidies worth USD 15,000 per vehicle. However, this was slashed in 2017 to make way for EV manufacturers to utilize the EV carbon credit quotas being offered. In addition to this, six cities in China provide license plates for EVs free of cost, and without having to go through the hassle of waiting, compared to long queue and high cost for the fossil fuel vehicle license.[73]

Project: Financial incentives for EVs in Japan
Place: Japan
Date: 2016 - present
Size: NA
Ecosystem component: Financing
Japan has introduced many fiscal incentives since the 1990's to promote electric vehicles. A new financing scheme was introduced in 2016 whereby a maximum subsidy of USD 7,700 was be provided to cars based on the drive range of the vehicle. In addition to that the Japanese government has also waived different taxes, such as the tonnage tax, and reduced the annual automobile tax by 50% for EVs.[74]

Project: Access to Clean Energy Fund
Place: India
Date: 2018-present
Size: USD 120 million
Ecosystem component: Financing
The off-grid energy sector in India has inadequate access to financing. To mobilize resources for this sector, GGGI is working together with the National Bank for Agriculture and Rural Development (NABARD) and the Ministry of Environment, Forests and Climate Change to secure funding of USD 50 million through GCF. Out of the total USD 120 million, USD 70 million has been committed by Indian Renewable Energy Development Agency Limited (IREDA), which is also the executing agency. Through this fund, domestic financial institutions can be encouraged to finance off-grid energy projects.[75]

Project: Mongolia Green credit Fund
Place: Mongolia
Date: 2018
Size: USD 50 million
Ecosystem Component: Financing
Mongolia Green Credit Fund, Mongolia – The Mongolia Green Credit Fund was established through collaboration between the Ministry of Environment and Tourism, Ministry of Finance, Mongolian Bankers Association and the Global Green Growth Institute. The board members of this fund constitute of the government counterparts, banks, GCF and investors. A total of USD 50 million is being raised for the fund, out of which USD 40 million is estimated to come from GCF. The rest will be invested by 10 banks that are part of the Mongolian Bankers Association. The MGCF aims to provide credit for energy efficiency and green development related projects.[76]

[72] National Automotive Board. n.d. FAME India: National Mission on Electric Mobility. Department of Heavy Industry. Government of India.
[73] Financial Times. 217. Subsidies help China sell the most electric cars. Accessed online at: https://www.ft.com/content/18afe28e-a1d2-11e7-8d56-98a09be71849
[74] Rikki Gibson. 2018. What Can We Learn From Japan About EV Adoption? Fleetcarma: A Geotab company. Accessed online at: https://www.fleetcarma.com/can-learn-japan-ev-adoption/
[75] GGGI. 2017. Areas of overlap with the International Solar Alliance.
[76] GGGI. 2017. Mongolia seeks to strengthen partnerships to scale up sustainable finance. Accessed online at: <http://www.ipsnews.net/2017/09/mongolia-seeks-to-strengthen-partnerships-to-scale-up-sustainable-finance/>

4. Electric Mobility Project Concepts

4.1 A viable, bankable ecosystem

The project concepts presented in this chapter constitute key components of Nepal's electric mobility ecosystem, spanning infrastructure, operators, vehicle and technology providers, and financing (see Table 4.1). What follows is a brief introduction to the parameters utilized in selecting and designing these project ideas.

Project concepts draw on the *National Action Plan for Electric Mobility*. This plan identifies key barriers to greater adoption of electric mobility, and lays out actions to overcome these barriers, including specific project ideas. All projects in the plan were ideated in collaboration with a range of stakeholders and designed to respond to particular pain points and requests which stakeholders expressed, ensuring that proposed ideas were demand driven.[77] As such, these project ideas constitute a long-list of needs. In preparing this *Investment Pipeline*, project ideas from the *Action Plan* were subject to further review, analysis and in-depth discussion with key stakeholders and partners from across government and private sector. These assessments primarily explored technical and commercial viability. Based on these assessments, a short list of seven project ideas was prepared.

Table 4.1 Overview of Project Ideas

Project Idea	Ecosystem Component
Midsize Electric Bus Fleet	Operators
Electric Trolleybus System	Operators; Infrastructure
Electric Vehicle Battery Leasing for Three Wheelers	Infrastructure
Public Access Charging Stations	Infrastructure
Battery Recycling Facility	Technology; Infrastructure
Converting Conventional Taxis to Electric	Technology; Operators
Financing Facility for Electric Mobility	Financing

[77] Government of Nepal. 2018. National Action Plan for Electric Mobility.

Shortlisting of project ideas involved consideration for the following parameters:

- **Ecosystem balance** – The project ideas seek to provide a balance of solutions across the major components of Nepal's nascent ecosystem
- **Policy alignment** – The project ideas were assessed for compatibility with major policy positions of the federal government
- **Investor appetite** – Each project idea was reviewed with active transport investors and entrepreneurs to gauge potential appetite
- **Contextual viability** – Project ideas accommodate the specific ground realities of Kathmandu as a city, and Nepal as a country
- **Technology viability** – Linked to the above point, the viability of the proposed technology and its market fit were a key concern in the assessment and design of project concepts
- **Commercial viability or bankability** – Proposed projects (with the exception of the fund) were all expected to be financially sustainable and profitable, to ensure bankability.
- **Scalability and replicability** – Project concepts can be upscaled or expanded, as well as replicated into other cities of Nepal

The concept of bankability deserves closer attention. As noted in Chapter 2, bankability is key to an effective electric mobility ecosystem. All components of the ecosystem, to be successful, must present clear business models with returns on investment which are commercially attractive. This contributes to the long-term financial sustainability of projects.

For the projects that follow, once overall technical viability is satisfied (see the parameters above), financial and economic analyses are carried out to determine the project's return on investment (see Figure 4.1). In particular, projects were reviewed for profitability, using the internal rate of return as the primary indicator. All projects have an internal rate of return that is commercially competitive, though some more than others. In the projects that follow, the internal rate of return varies from 55.7%-20.3%. As second metric of commercial viability was also used to assess project concepts – cost recovery, or the number or years needed until capital expenditure is recovered. For the projects that follow cost recovery varies from 1 - 15 years. Detailed analyses of economic and financial viability for all projects are included in Annex 2.

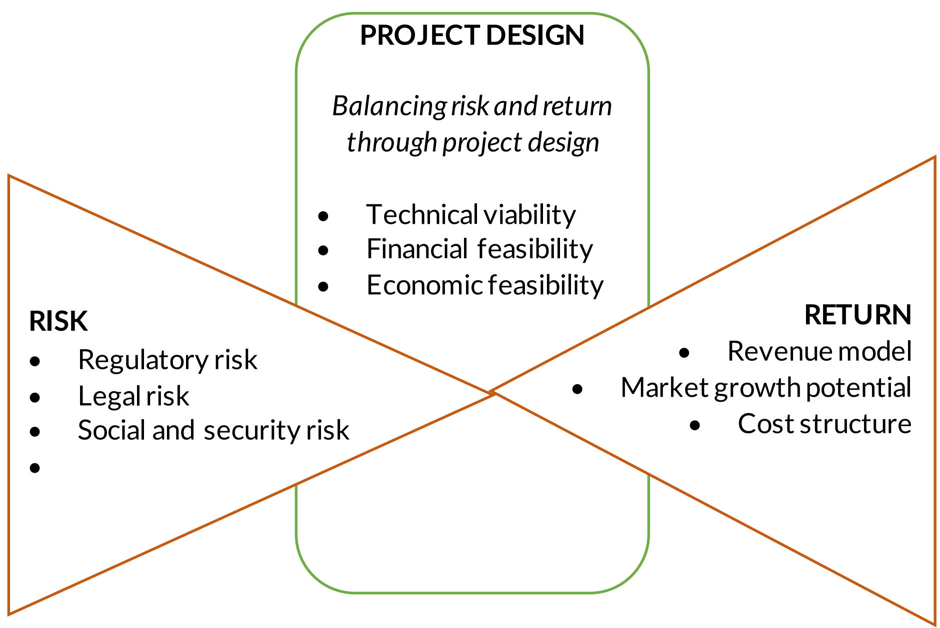


Figure 4.1 Project bankability

Fundamentally, bankability is achieved through minimizing risk and maximizing return., as part of the project design process, and comprises the following components:

Risk

- **Regulatory risk -**The regulatory environment of EV in Nepal has been well designed and implemented. Regulations are in place and permitting requirements are outlined properly. Usually projects have problems when it comes to regulatory aspect due to political issues and undefined regulations. In the case of Nepal, EV has been successfully implemented which will be easier assess.
- **Legal risk -** Businesses that enter the country would need to address necessary legal risks on setting up a business in the country context. Understanding are the limitations in terms of ownership in equity, land acquisition and taxation.
- **Social and security risk -** The social and security risk plays an important role into the assessment because of its power to stop and delay projects. Usually this risk is overlooked and the reason why many businesses experience losses and usually ends up in a bad relationship between stakeholders. This also creates an implication to other development within the area.

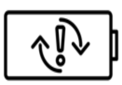
Return

- **Revenue model -** The revenue model and expenses are important factors to assess the financial feasibility of the project. However, many financially feasible projects are stall or fail due to the inadequate qualification of potential risks which show up as costs, and ruin profitability. The revenue model needs to adequately and conservatively assess demand, and structure products and services that meet demand in a financially profitable way.
- **Market growth potential -** Investors seek projects that can demonstrate potential market growth. The introduction of a new technology to a new market will have higher initial investment cost. As a result, the market growth potential needs to be considered in order to attract and reassure investors that investment costs are worthwhile.
- **Cost structure –** All costs need to be quantified as early in project design as possible. Operational and capital costs are typical. In addition, risk usually has a cost in terms of delays and unexpected expenses, which is why it's best to assess financial feasibility once all risks have been identified. These risks should be costed and infused to the financial model. The revenue model for a project needs to be carefully designed to ensure that costs are covered, and target investment returns are achieved

4.2 Projects

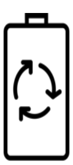
Deploying a Midsize Electric Bus Fleet in the Kathmandu Valley

Deploying an Electric Trolleybus System in the Kathmandu Valley



Upscaling Electric Vehicle Battery Leasing for Three Wheelers

Upscaling and Monetizing Public Access Charging Stations



Establishing and Valorizing Battery Recycling

Converting Fossil Fuel Taxis to Electric Taxis

Establishing a SME and Consumer Financing Facility for Electric Mobility


बाहिर
न्यूरोड गेट-रत्नपार्क
पुरानो बसपार्क-शहिदगेट
त्रिपुरेश्वर-माईतिघर
नयां बानेश्वर
साझा यातायात
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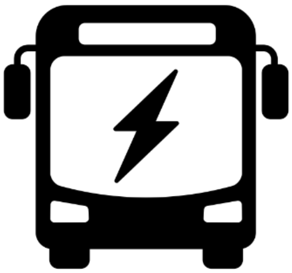
4.2.1 Deploying a Midsize Electric Bus Fleet in the Kathmandu Valley



CAPEX	NPR	1,138 M	USD	10.9 M
OPEX	NPR	1,164 M	USD	11.2 M
LIFE	YEARS	16		
COST RECOVERY	YEARS	15		
NPV	NPR	395 M	USD	3.8 M
IRR	%	5.17		

Demand for public transport outstrips supply, especially in the mid- to high-quality segment. Midsize electric buses are entirely battery powered. They can seat between 20-30 passengers and are 8 meters long, allowing them to access both larger highways (primary routes) and smaller feeder roads (secondary routes) to service an estimated 600,000 monthly passengers in Kathmandu Valley. If the project can achieve a delivery price of USD 187,796 per bus and assemble an estimated fleet of at least 50 buses, a financially sustainable mobility service model can be successfully established without government subsidy. With a return on investment of around 5.17%, cost recovery on the 50 buses could be achieved after 15 years. The project would provide inclusive, low-carbon mobility across the Kathmandu metropolitan region, supporting livelihoods, jobs and the local economy, reducing greenhouse gas and particulate matter pollution, and reducing dependency on imported fossil fuels.

1. The case for electric bus transport

Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020. According to a KfW estimate, there are currently around 2500 electric vehicles operating in Nepal, some of which are public transport.[78] The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[79]

Fiscal and monetary policy increasingly favours electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles. Similarly, value added tax (VAT) on electric buses are refundable. The Nepal Reserve Bank has also increased its loan limit to 80% for electric vehicles, compared to 65% for fossil fuel vehicles, recognizing the higher price tags on electric vehicles.

Beyond development, fiscal and monetary policy are the robust strategic benefits for Nepal of 'going electric'. Nepal's hydropower potential has been identified at 83,000 MW, of which 42,000 is commercially exploitable, and only 995 MW has been installed (some 2% of commercially exploitable potential). Hydropower generation has been estimated to grow substantially as 188 plants with a total capacity of 6,848 MW are under various stages of construction. This increase in supply can be used to electrify the transport sector in the country. On the other hand, as a land locked country without any domestic fossil fuel resources Nepal is obliged to import all its fossil fuels, creating both political dependency and risk, undermining broad national goals of self-sufficiency, and creating significant trade deficit. Thus, switching to electric mobility would increase the energy security of the country.

A pre-feasibility study undertaken by GGGI in 2017 revealed that deploying an electric bus in Kathmandu Valley is cheaper by 24-39% over the life of the bus than deploying a similar fossil fuel model. In terms of operating and maintenance costs alone, an electric bus is 60% cheaper to operate and maintain. This means that the financial advantages of switching to electric increase with every year the bus can be operated.

2. Key consumer needs and market challenges

The proposed project responds to the following consumer needs:

- *Clear passenger demand, which is projected to rise* – Given current and projected population increase in the Kathmandu Valley, as well as ongoing urban development and infrastructure investment, including job creation, Kathmandu is expected to remain the primary metropolitan area of Nepal. Demand for transport services at the valley-level will remain robust.
- *General provision of low-quality service* – There is strong consumer appetite for improved services, as the majority of current transport services provided in Kathmandu are low-quality. Overcrowding in vehicles is common, as are poor driving, uncomfortable seating, poor scheduling and unreliable routing.

However, the market is constrained by a range of challenges, as outlined below. The proposed project will carefully respond to and manage these challenges in order to achieve viability.

- *Tightly constrained revenues for bus operators* – The central government regulates transport fares, keeping the minimum fare low at NPR 14 (USD 0.13) for the first 4 km (flat fare) and NPR 27 (USD .25) for a total of 19 km (flat fare). This poses a significant challenge to transport companies, as it depresses revenue and can make it challenging for private companies to simply break even. While electric buses have much lower operational costs than diesel buses, and therefore may achieve operational profitability more easily, high investment costs remain challenging.

[78] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.

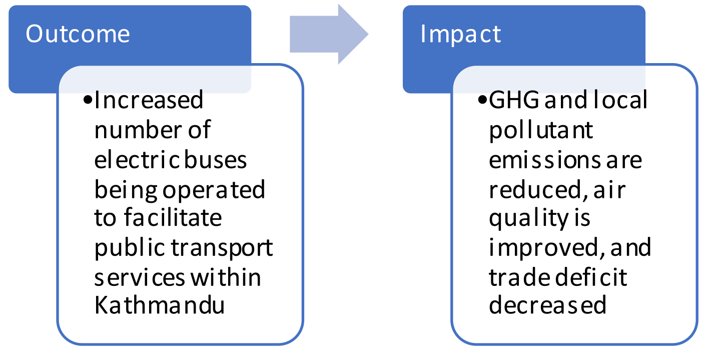
[79] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

- *High upfront costs of vehicle acquisition* – Nepal is land-locked and has limited manufacturing capacity. All electric buses are imported from either China or India. This adds to the cost of acquiring electric buses, and their charging facilities.
- *Uncertainty of business or service model* - To date, there are no solid business models in place to demonstrate to the broader transport market what public bus electric mobility services might look like in Kathmandu. Except for electric tuk-tuks/autorickshaws, there are no electric public transport providers. Other parameters of feasibility are linked to access of vehicles, most appropriate routing, permitting, servicing and maintenance of vehicles, anxiety over drive range, anxiety over battery life and disposal, and cost and supply of electricity.
- *High cost of capital:* Accessing and deploying capital is expensive in Nepal, due to high rates of inflation over 2016-2018. Interest rates of debt hover above 12%. Servicing debt can be difficult, especially in the low-return transport sector. Public funding and low-interest loans are available in theory, as alternatives to commercial debt, but access and mobilization are complicated. Bus operators need support with mobilizing financing for their operations.
- *Need to optimize fleet operations within a competitive market* – Transport operators in Kathmandu are highly competitive, and the local market may suffer distortions from political and government sources. A new entrant in this space will need to ensure that competitive pressures are fully accounted for and suitably addressed. Fleet operations will need to be carefully optimized as a result, including routes and permitting.

3. Proposed mobility service project

The proposed investment project would seek to address the problem identified above. Primarily, this would involve development of a model for operation of mid-sized electric buses in Kathmandu to facilitate public transport services. Such a model may require public investment for infrastructure development.

The proposed project is expected to deliver the following outcome and impact.



Under the right conditions, and with the correct technical support, an electric mobility service could be established and successfully operated. This mobility project would capitalize on a) the strong demand for public transport service in Kathmandu; b) the favourable policy, fiscal and monetary environment for electric mobility in Nepal; c) the high level political and strategic support for electrification of the transport sector in Nepal; d) the willingness of local entrepreneurs to explore mobility ventures.

The proposed project would entail the following components:

- *Design and deployment of vehicle fleet* – Based on initial analysis, a proposed fleet of 50 battery electric mid-size buses (e.g. 8 metre-long, 15-20 seat buses) would be deployed. These may operate on either a) the 27 km ring road that encircles the urban core of the Kathmandu metropolitan region, or b) other arterial and primary roads with strong demand and passenger pools. With reference to the pre-feasibility study developed by GGGI, BYD K7 or similar buses may be acquired from manufacturers of relevant vehicles at reasonable prices. Mid-size buses would be prioritized for their asset cost-revenue ratio, measured against passenger demand, allowing the operator to achieve high-levels of utilization. The project would begin as a pilot initiative, with the introduction of 3-5 vehicles to test viability, then the full fleet would be introduced (per performance); The full fleet of 50 electric buses will cater to some 12,000 passengers per month, with some 6,750 km of route travelled per day. [80]

[80] Based on Sajha Yatayat's daily passenger servicing.

- *Development of supporting infrastructure* – Acquisition and installation of 50 standard charging stations to provide overnight charging services to the fleet of electric buses. These will be located in terminal stations of key routes, or at key points on the ring road.
- *Design and development of business model* - The initial investment (CAPEX) required to purchase 50 buses, in addition to installation of 50 standard charging stations, is estimated at NPR 1,070 million (USD 10.3 million)[81]. Annual maintenance and operating costs per bus is taken as 31.3% of the current maintenance and operating costs of diesel buses in Kathmandu, per earlier pre-feasibility work conducted by GGGI. Since the Nepal Electricity Authority is providing Safa tempos with preferential tariff of NPR 5.4/kWh (weighted average of peak and non-peak), it is assumed electricity tariff will be reduced to the same for electric buses as well.[82] The payback period for this investment will be around 15 years, with rate of return of 5.17%. For a detailed summary of the financial analysis, see Annex 2.
- *Support for capacities and institutions* – Support to private sector institutions in developing business models and carrying out market assessments will be critical in establishing sustainable practices within the transport sector.

In order to operationalize this project, a full feasibility study needs to be conducted, along with stakeholder engagement, capacity building and the brokering of investment. The feasibility study would assess in more detail the components outlined above, with particular attention to financial performance.

4. Scalability and replicability of the project

In 2017, GGGI carried out a pre-feasibility study of deploying a single full-size electric bus in Kathmandu. While the proposed fleet of mid-size buses are different in size, route and diesel consumption characteristics, the 2017 study nonetheless offers useful information. Deploying one full-size electric bus in Kathmandu reduces greenhouse gas emissions by 44-ton CO_2eq per year. A fleet of 50 buses equates to a reduction of 2,187-ton CO_2eq per year. When the resulting improvements in air quality and reduced noise (electric buses are much quieter than diesel vehicles) are monetized for relevant segments of the metropolitan population (social benefit), and the increased energy security of shifting to electric is also monetized (economic benefit), the deployment of 50 electric buses over a 16-year vehicle life is valued at NPR 1.2 billion (USD 12.3 million). Lastly, the monetary value of the environmental benefit is estimated at NPR 3.3 million (USD 32,480) per bus in the 10-year life of the vehicle. This monetary benefit is a result of carbon traded with every ton of carbon saved. There is also the longer-term impact potential of demonstrating fully viable electric bus operation in Kathmandu. With 46,000 diesel buses plying the roads of Nepal, if all vehicles were to progressively switch to electric, the value of that switch is estimated at NPR 154 billion (USD 1.5 billion) during the life of the buses, with a total reduced greenhouse gas emission of 2.0 Mt.

The project can be scaled according to interest and investment appetite beyond the initial fleet of 50 vehicles or replicated into other cities such as Pokhara. There is strong demand from a range of municipalities across the edges of the metropolitan region, to which additional transport services could be extended. Similarly, replicability is high. Nepal has six metropolitan cities, of which two are located within the Kathmandu metropolitan region. The remaining four metropolitan cities would all make sites for replication of this projects.

5. Main Partners

- Sajha Yatayat
- Kathmandu Metropolitan City
- Lalitpur Metropolitan City
- Nepal Electricity Authority
- Department of Transport Management
- Ministry of Physical Infrastructure and Transport

Ministry of Physical Infrastructure and Transport will be the key counterpart for this project.

[81] Acquisition cost of a bus is around NPR 19.4 million (USD 187,796) and installation cost of a charging station is around NPR 1.9 million (USD 18,857).

[82] GGGI. 2018. Pre-feasibility Study.

6. Timeline

Concept

Q4 2018

- MOUs and letters of intent signed
- Initial project design agreed with key stakeholders
- Preliminary discussions with operators and financiers

Design

Q1 and Q2 2019

- Data gathering and surveys conducted
- Assess feasibility
- Model business/service design
- Review and development of design by key partners

Financing

Q3 2019

- Fine tuning of business/service model for financial performance
- Letters of committment obtained
- Letters of intent to deliver from bus manufacturers obtained


परोपकार

4.2.2 Deploying an Electric Trolleybus System in the Kathmandu Valley

CAPEX	NPR	0.3 M	USD	26.4 M
OPEX	NPR	0.5 M	USD	55.7 M
LIFE	YEARS	20		
COST RECOVERY	YEARS	1		
NPV	NPR	47,194	USD	4.8 M
IRR	%	12.66		

Demand for public transport services outstrips supply, especially in the mid- to high-quality segment. New generation electric trolley buses draw power from overhead lines or catenaries, but also have the ability to go ‘off-line’ for short stretches of route. They are well suited to Kathmandu’s 28-kilometer long ring-road, where a fleet of trolley buses can provide transport services to an estimated 76,800 daily passengers. Infrastructure, including poles, catenaries and bus stations would be developed by the private sector. A fleet of 64 trolley buses, deployed at a per unit cost of USD 144,788, would achieve cost recovered in 10 years. The project would achieve a return on investment of 12.66% for the operator. The project would provide inclusive, low-carbon mobility across the Kathmandu metropolitan region, supporting livelihoods, jobs and the local economy, reducing greenhouse gas and particulate matter pollution, and reducing dependency on imported fossil fuels.

1. The case for electric trolley transport

Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020. According to a KfW estimate, there are currently around 2500 electric vehicles operating in Nepal, some of which are public transport.[83] The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[84]

Fiscal and monetary policy increasingly favors electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles. Similarly, electric vehicles are exempt from value added tax (VAT). The Nepal Reserve Bank has also increased its loan limit to 80% for electric vehicles, compared to 50% for fossil fuel vehicles, recognizing the higher price tags on electric vehicles.

This favorable policy environment recognizes the burden that conventional fossil fuel-powered transport places on the trade deficit. Since 1995, increasing demand for transport services has contributed to an increase in petroleum imports by 10% per annum. This has in turn contributed to rising GHG emissions from the transport sector, which has increased by 11% per annum during 1995-2013. This prompts a need to introduce cleaner modes of transport such as trolley buses, that can utilize electricity generated within the country, and contribute to reduced emissions.

Electricity generation in Nepal is steadily improving, as the gap between supply and demand is minimized through the operation of new plants, improved supply management and power imports from India. Construction of the 456 MW Upper Tamakoshi hydropower plant is due for completion by the end of 2018, after which total supply will be almost 1500 MW during the wet season[85] - greater than the peak hour demand of 1300 MW. The surplus energy can be utilized to implement clean transport services within the country. In total, the IFC has estimated Nepal's hydropower potential at 83,000 MW, of which 42,000 is commercially exploitable, and only 802 MW has been installed (some 2% of commercially exploitable potential).

It's also important to note that the government has pioneered electric trolley buses before. In 1975, the Nepal Transport Corporation launched Kathmandu's first trolley bus service using a grant from the People's Republic of China. Thirty-two trolley buses were in service along the 13 km stretch from Kathmandu to Bhaktapur. These were operated by the Nepal Transport Corporation until 2001, and by Kathmandu Metropolitan City (KMC) from 2003 until 2009 when operations finally ceased, due to ongoing issues of mismanagement. In total, the buses were operational for 34 years, and maintained steady ridership, and strong public support.

2. Problem analysis

The proposed project responds to the following consumer needs:

- *Clear passenger demand, which is projected to rise* – Given current and projected population increase in the Kathmandu Valley, as well as ongoing urban development and infrastructure investment, including job creation, Kathmandu is expected to remain the primary metropolitan area of Nepal. Demand for transport services at the valley-level will remain robust. The excess number of passengers in crowded public transport services around ring road[86] is around 76,800 per day.[87]
- *Insufficient quality of service of ring road transport providers* – There is strong consumer appetite for improved services, as the majority of current transport services provided in Kathmandu are low-quality. Overcrowding in vehicles is common, as are poor driving, uncomfortable seating, poor scheduling and unreliable routing. In addition, the passengers travelling into Kathmandu from outside the ring road rely on bus feeder services which tend to be low quality or must content with parking limitations if they drive.
- *Rising commute time due to congestion* – There are increasing issues of traffic congestion due to sustained increases in vehicle numbers. Private four-

[83] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.

[84] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

[85] Department of Electricity Development. 2018. Operating Projects. Accessed online at: <http://www.doed.gov.np/operating_projects_hydro.php>

[86] Kathmandu's ring road is a six lane 27km highway that circumscribes Kathmandu and Lalitpur's metropolitan core.

[87] Calculated with reference to 4% annual population growth rate estimated for Kathmandu, Bhaktapur and Lalitpur during 1991-2011. Adapted from Winrock International-Nepal. 2002. Revival of Kathmandu-Suryabinayak Trolley Bus System. Cemat Consultants Pvt. Ltd.

wheelers and two-wheelers have increased at a rate of 10% and 14% respectively during 1990-2017. 11% of buses and minibuses, on the other hand, have also been added annually, causing traffic congestions.[88] As of 2018, there are 697 vehicles (two- and four-wheelers) per km of road in the Bagmati Zone[89] alone (cf. a density of 80 vehicles/km in 1999[90]). This is 0.6 times higher than vehicle density in Mumbai where vehicle congestion is very high. In the ring road route, on an average, the number of passengers crammed per vehicle type per trip is around 113 in mid-sized buses and 111 in mini-buses, which is 26% and 85% more than the specified capacity respectively. The provision of a transport system would help alleviate this.

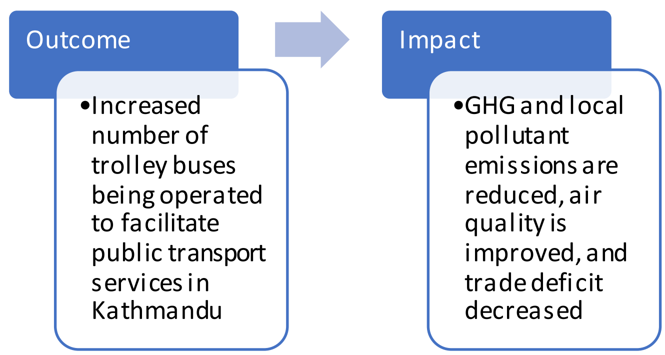
In addition, a number of constraints and challenges would need to be addressed, as outlined below.

- *Uncertainty of political preference* – Both federal and local governments have expressed commitment to introducing transit systems in Kathmandu. In many scenarios, proposed transit systems utilize the ring road, as least partially. However, transit options currently on the table are varied, including monorail, metro/subway and bus rapid transit. It is unclear which option the government would favor.
- *Absence of long-term transport strategy or masterplan for Kathmandu* – Linked to the above point, the Kathmandu metropolitan area lacks a long-term transport master plan, despite contributions from JICA and ADB. The trolley bus proposed has received high level support from the Minister of the Ministry of Physical Infrastructure and Transport, and from municipal leadership. Further support would need to be obtained to ensure consistent buy in on this option.
- *Absence of coordination mechanism across municipalities* – The Kathmandu Valley contains three metropolitan cities, and a further 16 municipalities, in which some 3.5 million people reside.[91,92] To facilitate a transit system that spans the metropolitan area, consensus is required from the three metropolitan cities, namely Kathmandu, Lalitpur and Bhaktapur. Mechanisms to achieve this consensus and coordination are unclear.
- *Absence of strict operational and management apparatus* – Based on reviews undertaken on the first generation of trolley buses operated in Kathmandu, ultimate failure was due to mismanagement. Therefore, one of the key challenges for the installation of a second-generation trolley bus system would be to obtain adequate management systems.
- *Need for clear business model for transit service* – The business model of the transit service is unclear and would need to be carefully designed and bus fares would need to be calibrated. More generally, a range of service or business models would need to be reviewed, and components assessed based on international experiences.

3. Proposed mobility service project

The proposed investment project would seek to address the problem identified above. Primarily, this would involve development a model for the operation trolley buses in Kathmandu, to facilitate public transport services. Such a model will require public investment for infrastructure development and private finance for acquisition of vehicles. The project would also facilitate the broader establishment of trolley bus services and include the associated feasibility and operationalization.

The proposed project is expected to deliver the following outcome and impact.



In early 1999, a team of consultants were commissioned by Winrock International, to undertake an assessment of the possibility of installing a second generation of trolley buses. This report, published in 1999, constitutes the data upon which the components described below are based. Data points from the 1999 report were updated to account for inflation, and to a certain degree population growth, in order to arrive at preliminary rough numbers for viability. The proposed project involves both the a) infrastructure of poles and catenaries; and b) trolley bus vehicles.

- *Infrastructure development and leasing* – Foundational trolley bus infrastructure includes poles and catenaries, and passenger facilities such as bus stops. According to the study by Winrock International, proposed pole distance along trolley routes should be 35 m for straight sections, 30 m for sections with

[88] Department of Transport Management. 2017. Vehicle Registration Data.
[89] One of the 14 zones in Nepal, located in the central region. Kathmandu lies within the Bagmati Zone.
[90] Winrock – PPT KEVA – 2003 seminar
[91] Government of Nepal. 2017. Local Level Authorities (Metropolitan, Sub-Metropolitan, Municipality, Rural Municipality). Accessed online at: http://rapnepal.com/sites/default/files/report-publication/local_govt_of_75_districts23mar2017.pdf
[92] Population growth rate of 5.3% has been taken from MoUD, 2017.

medium curves and 25 m for sections with sharp curves. Along the ring road, the trolley buses could operate on battery (i.e. be off catenary) as the gradient is below 6%. The trolley buses could operate on catenaries once they enter the feeder roads. The proposed mobility project is such that the private sector would be responsible to construct the infrastructure as well as operate the buses. Alternatively, the infrastructure of poles, catenaries and stations could be developed and owned by a consortium of municipalities, including at least Kathmandu Metropolitan City, Lalitpur Metropolitan City and Bhaktapur Metropolitan City. Additional municipalities linked to the system through feeder routes may also participate. The metropolitan consortium would own the assets and rent these to the trolley bus operator Already, in the Kathmandu metropolitan region, asset and infrastructure development and owning boards have been established, as well as metropolitan utilities that operate the infrastructure or assets.

- *Deployment of trolley buses and route planning* – Kathmandu's ring road, which is nearing completion following a rebuild during 2016-18, is 28 km long. It encircles the metropolitan area, running through Budhanilkantha, Bhaktapur, Chapagaun and Chandragiri. Trolley buses are proposed to operate primarily around this ring road. The service would cater to a maximum of 76,800 passengers per day, and buses would undertake 510 trips (both ways). For this, 64 trolley buses will be required, including to operate on parts of ring road the four radial feeder roads (see Figure 4.2).[93] It is proposed that battery trolley buses be introduced in along the ring road and catenaries be installed in the four feeder routes. The start and stop locations for these four routes will be at the end of each of the 4 feeder routes (see Figure below). Since the gradient along the ring road is below 6%[94], the buses can comfortably operate on battery. Four proposed feeder routes and minimum number of stops in each route include a) Budhanilkantha to Bhaktapur (21.6 km) - 24 stops; b) Bhaktapur to Chapagaun (20.7 km) – 20 stops; c) Chapagaun to Chandragiri (21.5 km) – 24 stops and d) Chandragiri to Budhanilkantha (20.5 km) – 30 stops.

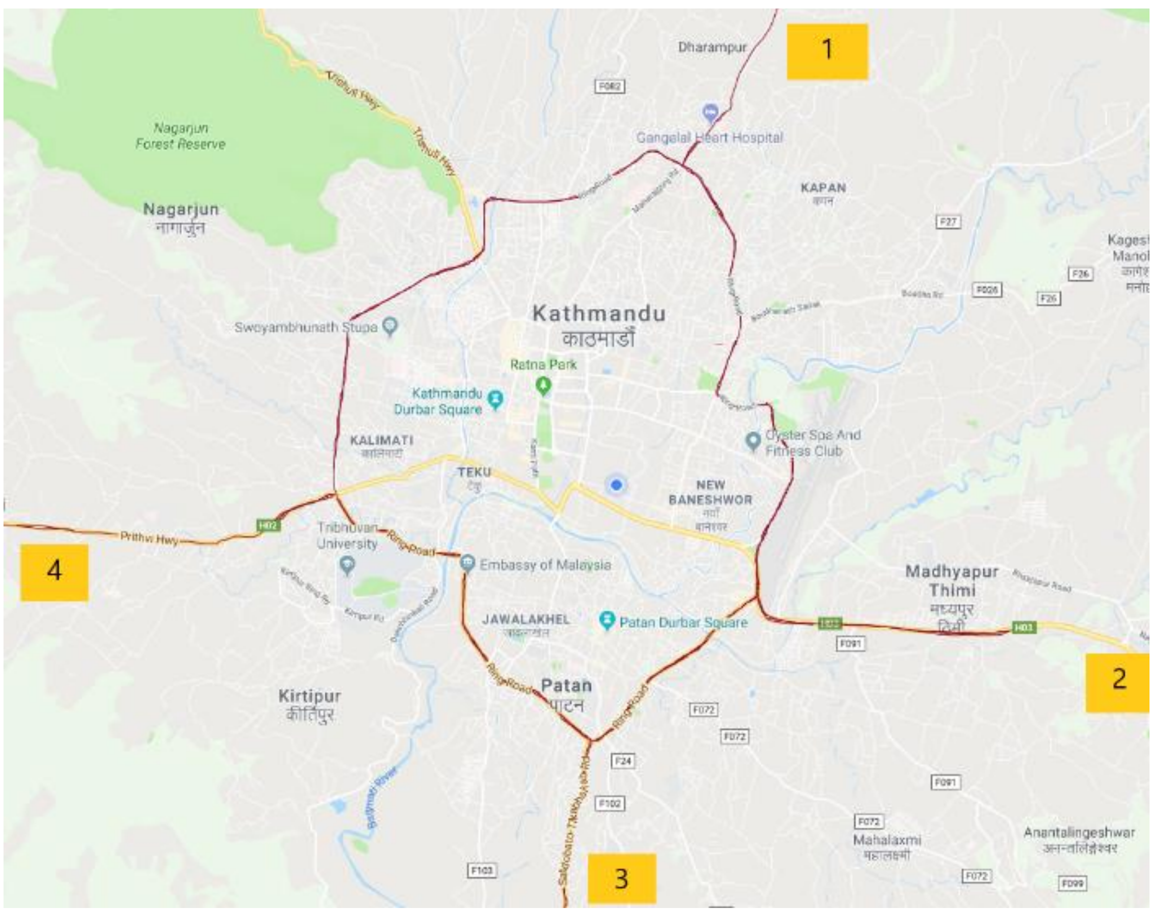
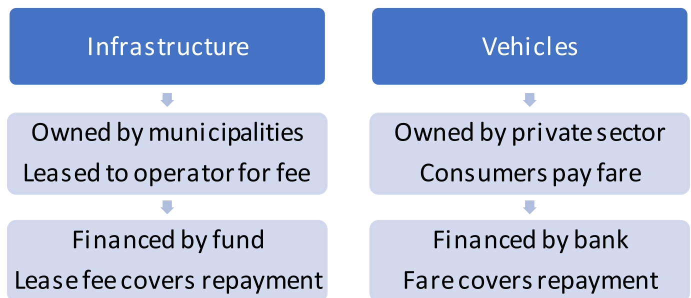


Figure 4.2: Four proposed routes for implementation of trolley bus service

[93] Winrock International-Nepal. 1999. Extending Trolley Bus Services within Kathmandu Valley. Cemat Consultants Pvt. Ltd.

[94] Winrock International-Nepal. 1999. Extending Trolley Bus Services within Kathmandu Valley. Cemat Consultants Pvt. Ltd.

- *Design of mobility service model and financial performance* - The acquisition of the trolley buses will be achieved through a combination of soft loans to the private sector from either bilateral Export-Import Banks, or national funding sources, including domestic retail and/or commercial banks. The infrastructure will be constructed through funding from international funding sources to the private sector or using local municipal capital. Based on initial assessments of financial performance of the operator service model, profitability can be achieved within the first year of operation. Per km investment cost of introducing trolley buses along ring road has been determined at NPR 30.7 million (USD 282,168 per km) by the Winrock International study.[95] Referring to this, the total investment required for implementing trolley bus service along a total of 56 km (excluding overlapping distance) of the four proposed routes is USD 26 million. The cost of the trolley buses themselves is expected to be around NRP 15 M (USD 144,788). The financial internal rate of return which the trolley bus operator may expect is around 12.66%.[96] For equity investments, the rate of return has been estimated at 15.77% (see Table 4.2). For a detailed summary of the financial analysis, see Annex 2.



- *Capacity development and institutional building* – Institutions will be established, and capacity built to ensure delivery of robust services. Given the operational and management challenges that the first generation of trolley buses encountered, this component will be particularly important.

4. Scalability and replicability

Trolley buses, like battery operated buses, have zero tail-pipe emissions. Based on the findings of pre-feasibility analysis carried out by GGGI 2017, deploying a full fleet of 64 trolley buses reduces greenhouse gas emissions by more than 2,816-ton CO_2eq per year. In addition to reducing greenhouse gas emissions, trolley bus will also have tremendous positive impact on air pollution reduction within Kathmandu. With improved mobility services, productivity, growth, and livelihoods are all expected to be positively impacted.

The project can be replicated in other urban areas of Nepal such as Butwal – Lumbini road, according to interest and investment appetite of the respective municipal governments. More generally, GGGI may replicate the model into other countries in GGGI's portfolio.

5. Main Partners

- Kathmandu Metropolitan City
- Lalitpur Metropolitan City
- Bhaktapur Metropolitan City
- Ministry of Physical Infrastructure and Transport

Ministry of Physical Infrastructure and Transport will be the key counterpart for this project.

Table 4.2 Summary of capital and operational expenditure, revenue and return

Capital expenditure (USD millions)	Operational expenditure (USD millions)	Revenue (USD millions)	Project IRR (%)
26.5	55.7	140.4	12.66

[95] Inflation adjusted.
[96] Winrock International-Nepal. 1999. Extending Trolley Bus Services within Kathmandu Valley. Cemat Consultants Pvt. Ltd.

6. Timeline

Concept
Q4 2018

- MOUs and letters of intent signed
- Initial project design agreed with key stakeholders
- Preliminary discussions with operators and financiers

Design
Q1 and Q2 2019

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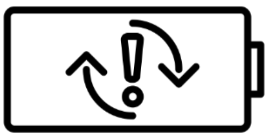
- Assess feasibility
- Model business/service design
- Review and development of design by key partners

Financing
Q3 2019

- Fine tuning of business/service model for financial performance
- Letters of committment obtained
- Letters of intent to deliver from bus manufacturers obtained

4.2.3 Upscaling Electric Vehicle Battery Leasing for Three-Wheelers



CAPEX	NPR	51 M	USD	492,278
OPEX	NPR	30.9 M	USD	229,100
LIFE	YEARS	8		
COST RECOVERY	YEARS	8		
NPV	NPR	-9.2 M	USD	-89,412
IRR	%	5.28		

Electric three-wheelers public tuk-tuks, called safa tempo, operate in Kathmandu and parts of the low-land plains of Nepal. In Kathmandu, these 714 safa tempos use technology that dates to the early 1990s, including outdated lead acid batteries which constrain trip distance and frequency, and generates significant battery waste. A battery swap station in Kathmandu that leased and charged 51 lithium ion batteries to safa tempo operators would require an estimated investment of USD 487,452 and generate revenues of USD 84,942 in the first year. A return on investment of 5.28% could be achieved by the station operator. Adding more batteries to the set and selling electricity back to the grid during peak hours could add to the revenu e stream of the project. The project would extend the provision of inclusive, low-carbon mobility across the Kathmandu metropolitan region, supporting livelihoods, jobs and the local economy, improving operational efficiency and resource use, a nd reducing battery waste.

1. The case for electric three-wheelers (safa tempos)

Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020. According to a KfW estimate, there are currently around 2500 electric vehicles operating in Nepal, some of which are public transport.[97] The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[98]

Fiscal and monetary policy increasingly favors electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles. The Nepal Reserve Bank has also increased its loan limit to 80% for electric vehicles, compared to 50% for fossil fuel vehicles, recognizing the higher price tags on electric vehicles.

Electricity generation in Nepal is steadily improving, as the gap between supply and demand is minimized through the operation of new plants, improved supply management and power imports from India. Construction of the 456 MW Upper Tamakoshi hydropower plan is due for completion by the end of 2018, after which total supply will be almost 1500 MW during the wet season[99] - greater than the peak hour demand of 1300 MW. The surplus energy can be utilized to implement clean transport services within the country. In total, the IFC has estimated Nepal's hydropower potential at 83,000 MW, of which 42,000 is commercially exploitable, and only 802 MW has been installed (some 2% of commercially exploitable potential).

In 1993, electric three-wheelers, called *safa tempos*, were introduced in Kathmandu. These small vehicles are used for public transport and can accommodate around 10-12 passengers. The vehicles typically travel short distances on 17 routes. There are 714 *safa tempos* registered in Kathmandu. This number has been fixed, due to a federal government ban on the registration of new *safa tempos*. The ban was imposed in 2001, supposedly out of concerns over congestion. As electric vehicles, *safa tempos* have zero tailpipe emissions.

Safa tempos operate on technologically outdated lead-acid batteries, most of which were imported. With high quality batteries available, many *safa tempos* can benefit from battery replacement. The proposed project would facilitate such a replacement, through a dedicated battery swap facility. In 2017, EVAN/Shree Eco Visionary Pvt. Ltd launched a small initiative to test the viability of lithium-ion batteries in *safa tempos*. The lithium-ion batteries that have already replaced lead acid batteries in 10 *safa tempos*, provide a drive range of 120 km. Within Kathmandu, the average distance a safa tempo travels in a day is 115 km, which is equal to an average of 9 trips. However, outside of this initiative, *safa tempos* operate on lead acid batteries and the operators complain the current batteries last for a maximum of 8-9 months, incurring battery acquisition cost every year. While many safa tempo operators and owners have expressed interest in switching to lithium ion batteries, most do not due to the high costs associated. As a result, their capacity to provide an optimal electric mobility service remains constrained.

2. Problem analysis

Passenger demand for *safa tempos* remains consistent, particularly for trips between neighbourhoods. Average trip length for *safa tempos* is 30-45 minutes, according to drivers. Preliminary surveys conducted of *safa tempo* ridership around Kathmandu Metropolitan City indicate greater demand than supply. Switching to lithium ion batteries would allow safa tempo drivers to deliver more effectively to this demand, due to the longer drive range of lithium ion batteries.

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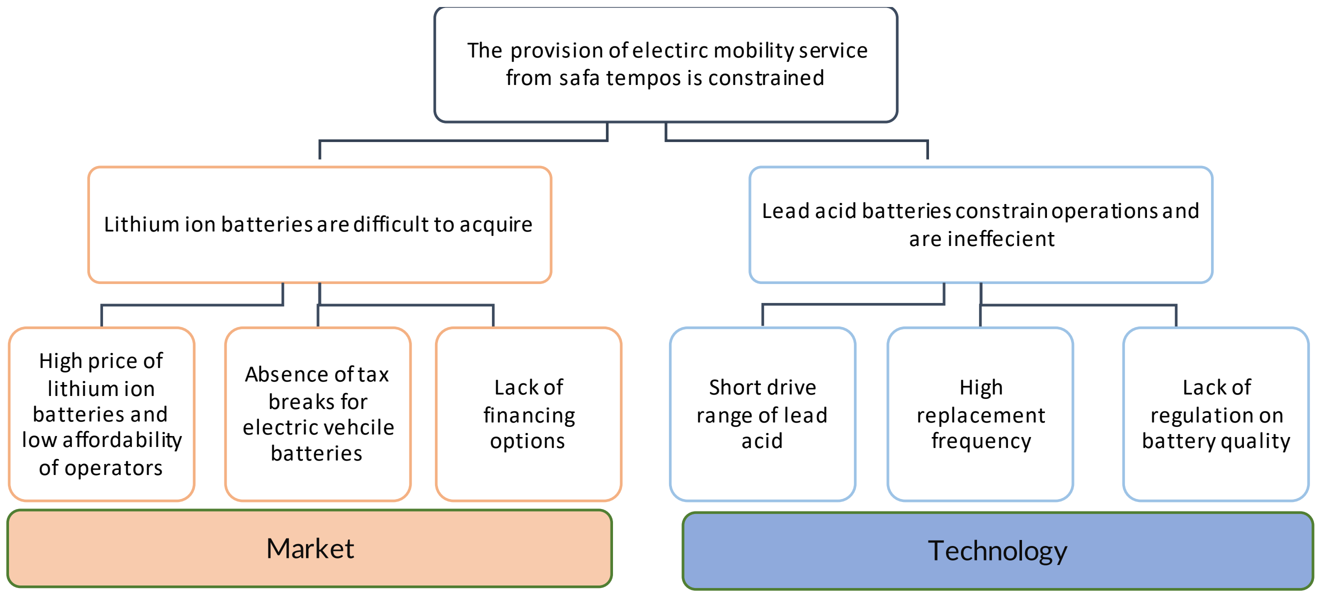
[97] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.

[98] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

[99] Department of Electricity Development. 2018. Operating Projects. Accessed online at: http://www.doed.gov.np/operating_projects_hydro.php

Figure 4.3. Problem Analysis



However, a number of challenges and barriers restrict the uptake of lithium ion batteries by safa tempos and more generally restrict more effective utilization of safa tempos through other battery types. Lead acid batteries themselves, while cheap, present several crucial short-comings, such as low drive ranges, the need for frequent replacement and slow charging times, which collective constrain *safa tempo* utilization.

These are outlined below:

- *Short drive range of lead acid batteries* – *Safa tempo* drivers report that lead acid batteries will allow a drive range of 60 km per charge. Required to change and charge frequently disrupts operations, which is why each operator buys two sets of lead-acid batteries that can be swapped during the day. As such switching to lithium ion batteries, which can provide drive ranges of 120 km, would be operationally beneficial. A typical *safa tempo*, operating on lead acid batteries, will complete 7-8 round-trips per day (at approximately 11 km for an average trip), limited by the drive range of the batteries. In part this is due to a lack of regulation on the quality of lead acid batteries produced in Nepal.
- *Slow charging of lead acid batteries* - In addition, it takes around 7-8 hours to lead-acid batteries, and longer charging time means less time in operation. Lithium ion batteries, on the other hand, can be charged within 5-6 hours, which reduces waiting time for the operators.
- *High replacement frequency of lead acid batteries* - Moreover, lead acid batteries typically require replacement each year. For a *safa tempo*, two sets of lead-acid battery costs NPR 400,000 (USD 3,861)[100] per year. This leads to battery recycling challenges due to high frequency of disposal of batteries. Estimated 64 *safa tempos* are currently not in operation because the operators are unable to afford a replacement lead acid battery.
- *High price of new lithium ion batteries and low affordability of operators* – A range of better-quality batteries are available on the market, with lithium ion batteries being amongst the most popular. However, acquisition cost of a lithium-ion battery suitable for a *safa tempo* is around USD 10,000 (approximately 2.5 times the cost of two sets of lead acid batteries). Such a battery, however, leads to numerous benefits over the life of the battery, including net savings. The battery is expected to last for 4-5 years, meaning a net saving in replacement costs of NPR 1,000,000 (USD 9,652). Similarly, the drive range of lithium ion batteries for *safa tempos* is expected to reach 120 km on a single change, around double the travel distance of a lead acid battery.
- *Lack of financing options for lithium ion batteries* – For *safa tempo* operators who wish to swap from lead acid batteries to lithium ion batteries, there are no financing options available. A few private companies are currently importing lead-acid batteries, and they control prices. In addition, financing institutions such as the NMB Bank and Nepal Investment Bank have

[100] USD 1 = NPR 103.6

provided loans to support the initial acquisition of *safa tempos*, but no financing is available for the purchase of lithium ion (or other) batteries.

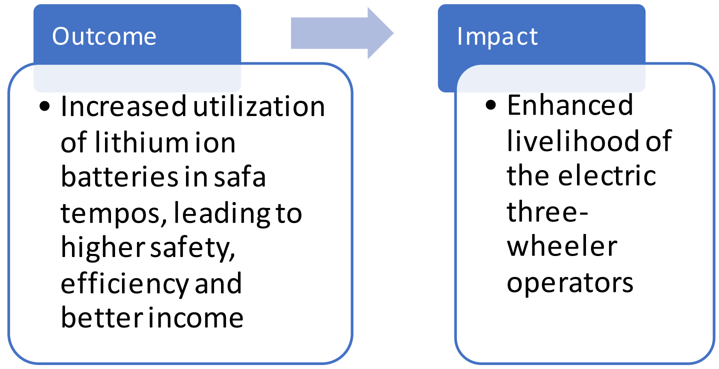
- *Lack of regulation for battery quality and standardization* **-** There is no regulation on the type of batteries being used in *safa tempos*. As a result, many *safa tempo* operators are effectively forced to purchase low-quality lead acid batteries due to a lack of options. Monopolistic practices within lead acid battery distribution means prices are sometimes inflated.

To address these challenges, a key intervention involves the commercialization of a battery swap program for safa tempos, effectively upscaling the early project lead by EVAN/Shree Eco Visionary Pvt. Ltd.

3. Proposed mobility service project

To address these challenges and increase the efficiency of the metropolitan *safa tempo* fleet, as well as enhancing the livelihood of the operators, the proposed project envisages the establishment of pilot lithium ion battery recharge, swap and leasing stations in Kathmandu. Such stations will allow *safa tempo* owners to benefit from higher quality lithium ion batteries, optimized battery life through regular maintenance activities, providing quality and international standard batteries with battery management systems and saving charging time. For this reason, many safa tempo operators and charging station owners are interested in introducing battery swap programs in existing lead-acid charging stations within Kathmandu.

The proposed project, which involves the establishment of a lithium ion battery swap station for safa tempos would effectively build on the work undertaken by EVAN/Shree Eco Visionary Pvt. Ltd. at the Safa Charging Station facility. The proposed project is expected to deliver the following outcome and impact.



To take this proposed project forward, the following presents key components as well as the results of initial analysis using preliminary numbers undertaken by GGGI in collaboration and discussion with partners in the transport sector.

1. *Feasibility Study*
   The feasibility of establishing the station needs to be carefully analysed. While EVAN/Shree Eco Visionary Pvt. Ltd. has undertaken a small initiative, the commercial viability at higher scale has not been tested.
   Fundamentally, quick battery swapping mechanisms support *safa tempos* in making more trips and will not have to worry about charging their batteries in the overnight charging stations that are currently in 30 locations around Kathmandu. The pilot battery swap station will be placed in a high traffic area such as Lagankhel, perhaps within a pre-existing safa tempo charging station.

   After completion of the pilot project, this will be expanded to other areas namely, Lagankhel, Ratnapark, Chabahil and Kalanki providing accessibility to *safa tempos* on all routes within the metropolitan area. The estimated land area required for such a station is 200 m^2. The operator of the proposed battery swap stations will be a private company, and several existing lead acid battery charging station companies have expressed interest during preliminary discussions. A company, Safa Chargin Station Limited, is particularly interested in setting up a battery swap station within their premises. Currently Safa Charging Station has a capacity to charge 50 safa tempos.

2. *Business Model for Commercialization*
Under the project, in the best case scenario, 51 lithium-ion batteries would be acquired from China at a per unit cost of USD 10,000. These would be imported through EVAN/Shree Eco Visionary Pvt. Ltd. The batteries would be leased to 50 *safa tempo* operators, most likely on the Lagankhel to Baneshwor route. The lithium-ion batteries would allow a drive range of 120 km, or some 9 route trips. This would allow the operator to operate the *safa tempo* for a full day, optimizing deployment of the vehicle. This will aid in lowering the operating costs of *safa tempos* from NRs. 11.62/km[101] to NRs. 4.19/km (USD 0.11 to USD 0.04 per km).

   Safa tempo drivers will need to register at the respective swap stations with a proposed annual registration fee of NPR 1000 (USD 9.6). The driver will be required to pay for each battery usage, a simple fee of NPR 500 (USD 4.8) per use. A single battery swap station will be able to service 50 *safa tempos* per day.

   Since existing charging station owners are willing to install battery swap stations within their facility, the investment required for setting up the station was excluded from this estimation. The cost of acquiring the 51 batteries is estimated at NPR 51,500,000 (USD 492,278). With that outlay, and the income streams indicated above from annual fees and daily use fees, the project would have an estimated internal rate of return of 5.28% and a payback period of 8 years. Battery replacement costs have not been considered with the assumption that the life of batteries is 8 years.

3. *Operational Guidelines and Capacity Development*
To support this, technology transfer and capacity building will be key. There are several leading battery swap service providers in India that have tested its battery swap technology. One such is Lithion Power that has installed battery swap stations in five locations within Delhi. The batteries in Lithion Power stations are lithium ion, and currently utilized mainly by two- and three-wheelers. A technology provider, such as Lithion Power, with quality batteries and service model could be approached for technology transfer to Nepal. In addition to transfer of technology, companies like Lithion Power could also be approached for skill development training and related activities to to ensure efficiency and quality are maintained.
Additionally, operating guidelines, and regulatory and compliance guidelines would need to be developed to ensure that the stations are correctly managed, and performance is optimized.
4. *Financing and Agreements*
Initial numbers as outlined above point to an IRR of 5.28%, which with subsidy on battery from government, will be attractive to local investors, including commercial and retail banks. As such, if the implementing organizations could demonstrate the required battery management practices, financing should be obtainable. Agreements with safa tempo operators and fleet owners would need also to be prepared.

Table 4.3 CAPEX, OPEX, Revenue and IRR of the project

Capital expenditure (USD in Millions)	Operational expenditure (USD in Millions)	Revenue	Project IRR (%)
0.49	0.30	974,094	5.28%

[101] EnergyHimalaya. N.d. Electric Vehicle in Kathmandu Nepal. Accessed online at: http://www.energyhimalaya.com/energy-efficiency/transportation.html

4. Intended impact, scalability and replicability

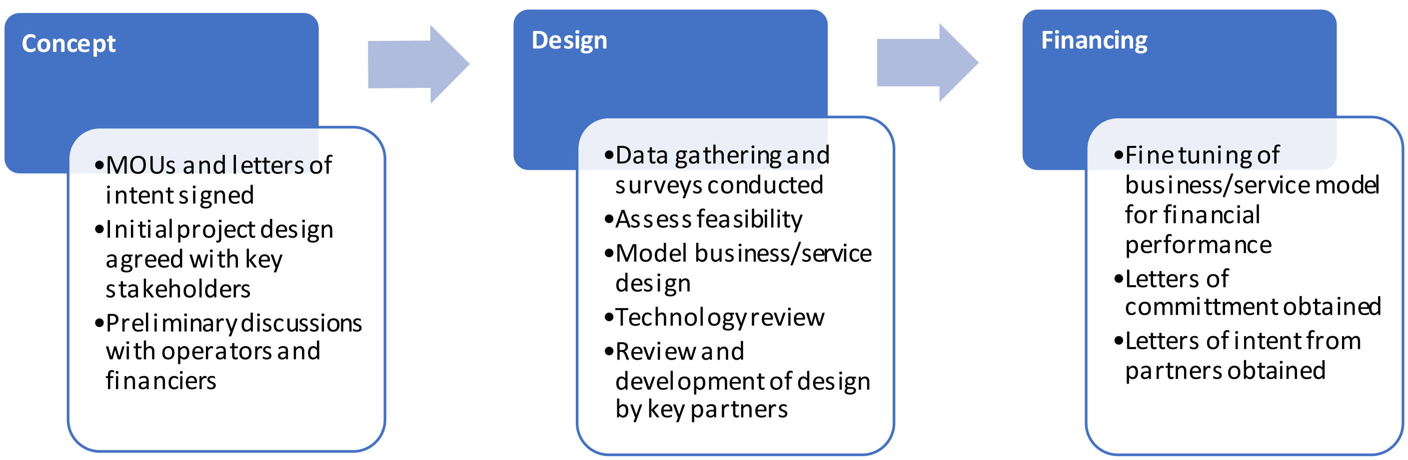
There are several areas for scale up and replication. Firstly, battery swap stations can be expanded beyond the initial 51 batteries proposed. Secondly, there is scope for replication across Kathmandu to service the full 714 lead-acid safa tempos currently in operation in the city. There is also scope to replicate this service for other vehicle types, including two-wheelers (scooters and motorbikes) and cars. Lastly, the service can be expanded to the *terai*,(low-lands of Nepal bordering India), where more than 15,000 electric rickshaws are operating daily across the main cities of the *terai*.
In addition, since such stations have also been known to work as storage units that can assist in managing grid operations,[102] integrating these batteries as storage units in the grid depends on interests from the Nepal Electricity Authority.

5. Main Partners

- Safa Charging Station
- Nepal Electricity Authority
- Electric Vehicle Association of Nepal
- Department of Transport Management
- The Ministry of Physical Infrastructure and Transport

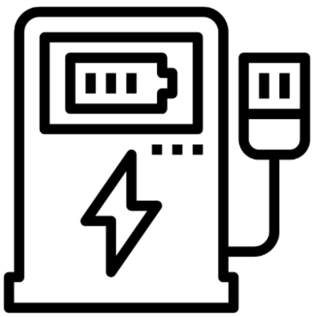
Ministry of Physical Infrastructure and Transport will be the key counterpart for this project.

6. Timeline



[102] Zeng, X. Rao, R. 2016. A Benefit Analysis of Electric Vehicle Battery Swapping and Leasing Modes in China. Emerging Markets Finance and Trade, 52:6, 1414-1426.

4.2.4 Upscaling and Monetizing Public Access Charging Stations



CAPEX	NPR	8 M	USD	77,220
OPEX	NPR	31.3 M	USD	1.7 M
LIFE	YEARS	20		
COST RECOVERY	YEARS	1		
NPV	NPR	18.2 M	USD	175,644
IRR	%	26.05		

Publicly accessible charging stations, at which private electric vehicle consumers can charge their vehicles, are required to enable widespread adoption of private passenger electric vehicles. Currently, there are five publicly accessible stations in Kathmandu, but more are needed. The deployment of a further 10 stations by the public power utility in partnership with a major retail outlet is a way to expand the number of stations available, while still achieving financial sustainability. These additional 10 stations could service an estimated consumer base of 100 drivers daily, generating revenues of USD 2.2 M, as well as generate brand value for the retail outlet through association with a high-tech, emerging and sustainable technology. The monetary return on investment would be an estimated 26.05%, however the real value of the project is not in the immediate financial return. The project would help to strengthen the utilization of power over the long-term in Nepal, given upcoming surplus generation, reduce greenhouse gas and particulate matter pollution, and reduce dependency on imported fossil fuels.

1. Case for public charging stations

Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020. According to a KfW estimate, there are currently around 2500 electric vehicles (particularly three-wheelers and four-wheelers) operating in Nepal, some of which are public transport.[103] The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[104] Fiscal and monetary policy also increasingly favors electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles. Similarly, electric vehicles are exempt from value added tax (VAT). The Nepal Reserve Bank has also increased its loan limit to 80% for electric vehicles, compared to 50% for fossil fuel vehicles, recognizing the higher price tags on electric vehicles.

Electricity generation in Nepal is steadily improving, as the gap between supply and demand is minimized through the operation of new plants, improved supply management and power imports from India. Construction of the 456 MW Upper Tamakoshi hydropower plant is due for completion by the end of 2018, after which total supply will be almost 1500 MW during the wet season[105] - greater than the peak hour demand of 1300 MW. The surplus energy can be utilized to implement clean transport services within the country. In total, the IFC has estimated Nepal's hydropower potential at 83,000 MW, of which 42,000 is commercially exploitable, and only 802 MW has been installed (some 2% of commercially exploitable potential).

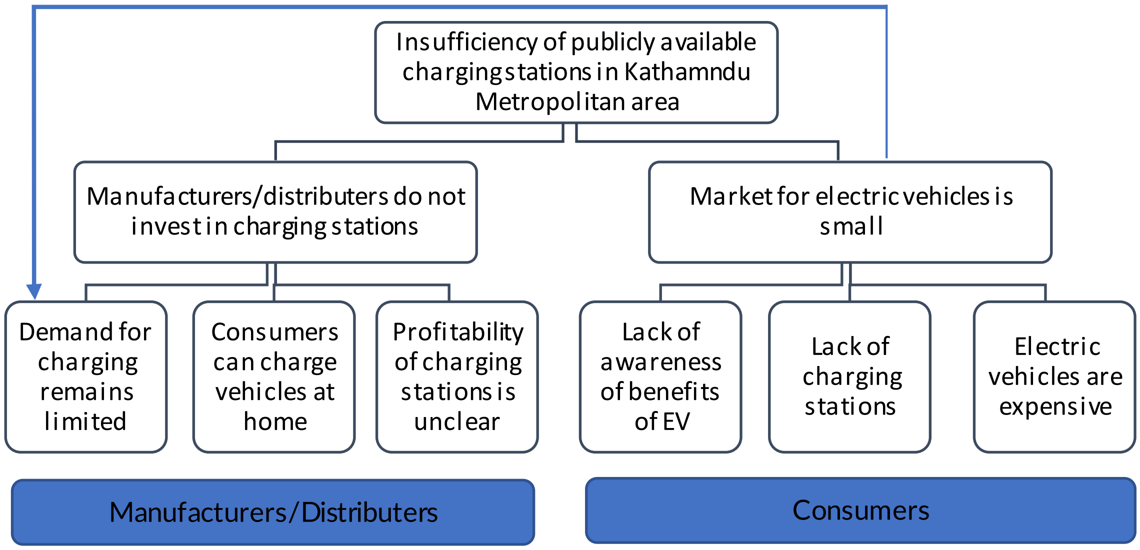
The first private passenger electric vehicle to gain market traction in Nepal was the Mahindra reva, released in 2012[106], by local distributor and Nepal Mahindra representative Agni Energy. An estimated 350 electric vehicles (four wheelers) are purchased in Nepal per year. Most electric vehicle owners charge their vehicles at home. Within the Kathmandu Metropolitan area, there are limited charging stations available. In Dec. 2017, the Nepal Electric Authority in collaboration with BYD, the Chinese battery and electric vehicle producer, established a demonstration charging station in Kathmandu.[107] Following that, in Feb. 2018, four further public electric vehicle charging stations in Kathmandu were installed and are open to the public.[108] Despite this, overall, the number and availability of public access charging stations in Kathmandu and Nepal are insufficient to reassure potential electric vehicle consumers. One of the main anxieties articulated by electric vehicle drivers and potential electric vehicle consumers is this insufficiency of charging stations.

2. Key consumer needs and market challenges

Achieving the policy goals and targets outlined above and realizing this terrific potential for electric mobility in Nepal is not easy, especially within the consumer segment. Adoption of electric vehicles by private consumers remains subdued, for a number of reasons as outlined below in Figure 4.4.

[103] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.
[104] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.
[105] Department of Electricity Development. 2018. Operating Projects. Accessed online at: http://www.doed.gov.np/operating_projects_hydro.php
[106] Walkeasyktm. 2012. Agni Incorporated lands Reva dealership. Republica. Accessed online at: https://walkeasyktm.wordpress.com/2012/06/10/agni-incorporated-lands-reva-dealership/
[107] The Kathmandu Post. 2017. NEA introduces e-vehicle charging station in Capital. Accessed online at: http://kathmandupost.ekantipur.com/news/2017-12-24/nea-introduces-e-vehicle-charging-station-in-capital.html
[108] Inheadline. 2018. 4 more charging stations added in Kathmandu Valley. Accessed online at: https://www.inheadline.com/news/4-more-charging-stations-added-in-kathmandu-valley

Figure 4.4 Problem Analysis



It should be noted that while residential charging is foundational for an electrified transport system in Nepal (as in other countries), non-residential charging options are necessary for widespread adoption of electric vehicles. Semi-public charging stations (for example at apartment complexes) is an option. For the private sector, part of the challenge here is "chicken-and-egg": manufacturers hesitate to invest in charging facilities, because the consumer market remains small; and consumers hesitate to purchase because of the absence of charging facilities. A number of countries have led the development of investment in charging infrastructure, to facilitate consumer uptake, and several of these examples are explored in Chapter 3 of this report.

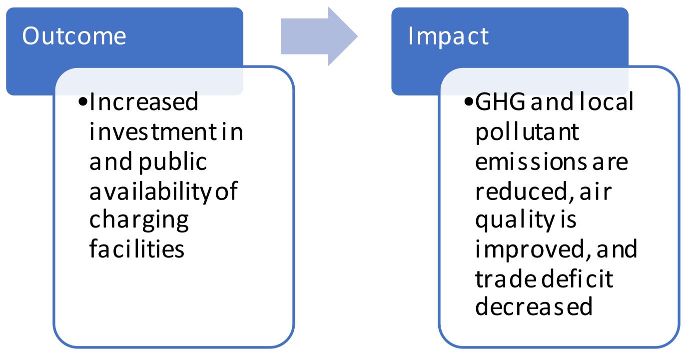
- Manufacturers hesitate to invest – With relatively small demand from the private consumer market for electric vehicles, manufacturers and distributers (or OEMs more generally) of electric vehicles hesitate to invest in the provision of publicly available charging stations. Some OEMs, such as Mahindra, provide charging facilities at their service centers – available to Mahindra vehicle owners.
- Consumer demand remains small – A core challenge is that due to a lack of awareness of electric vehicle benefits, as well as a lack of charging stations, and the overall higher price of electric vehicles, demand of electric vehicles in Nepal remains subdued. Semi-structured interviews with prospective and current electric vehicle owners undertaken by GGGI confirm that drivers are concerned over a lack of charging stations, and that higher availability of charging stations would lead to greater commitment from consumers to switch to electric.
- *Business model and viability are unclear* – The best business or service model for the deployment of publicly available charging stations is unclear and, in the case of Nepal, unproven. While there is growing consensus internationally that the best model is utility-led, Nepal has only just started to explore this. Importantly, the Nepal Electricity Authority has installed 4 charging stations – although much more are needed to facilitate a widespread transition.

3. Proposed mobility service project

Generally, for fully public charging stations, the best option tends to be utility-led charging stations. While different contexts call for different responses, charging stations that are developed and operated by utilities appear to be the emerging standard.

The proposed investment project would seek to address the problem identified above. Primarily, this would involve development of a model for the commercialization of charging stations in Kathmandu and/or Nepal. Nepal's principal utility, the Nepal Electricity Authority, would have a key role to play. The project would facilitate the broader establishment of such facilities and include associated feasibility and operationalization.

The proposed project is expected to deliver the following outcome and impact.



Key components of the proposed project are outlined below.

1. *Assess feasibility and develop a service model*
   There is a need for a clear understanding of the current and future demand for charging stations under different scenarios, and the locations both in Kathmandu and nationally where charging stations would be ideally situated. OPEX for charging stations tends to be high over a 20-year lifespan. Therefore, there's a need to explore ways to boost revenue by focusing on reduced OPEX for financial viability.[109]

   One option is for the utility to make better use of partnerships. For example, partnership between charging station operators and retail outlets can generate clear financial advantages for the retailing partner. Typically, electric vehicle owners tend to spend 30-50 mins longer at a business while charging, and over 40% of drivers are likely to return weekly to a retail location with a charging station[110]. Such a business partner may be willing to provide a contribution to maintenance, or off-set cost (provide land/area). Major retail outlets with adequate parking, such as Bhat Bhateni Supermarkets and Civic Malls, could be viable partners. These brands may benefit from the association with what is seen as an emerging, sophisticated technology, and the convenience provided to typically higher-income customers.

   In addition, advertising mounted on charging stations, or displayed on charging station screens is a source of revenue for the operator. Taking advertising further, another option is 'sponsored charge points' where the advertiser pays for the acquisition and installation of the charging station, in return for permanent branding of the charging station.[111]

   The cost of a BYD AC fast-charging station is USD 7,722[112] and USD 5,405 for a Mahindra charging station[113]. To establish a small set of ten AC fast-charging stations in a major retail outlet will cost NPR 8 Million (USD 77,220). Revenue would be derived from advertising and charging. This initiative, which could be implemented by the utility, would hold the financial performance indicated below (table 4.4). Various models of electricity provision are being explored internationally. Revenue would be derived from advertising and sponsorship. For a summary of the financial analysis, see Annex 2.

   Operationally, the utility may establish a separate subsidiary to manage the charging facilities, depending on the service model and revenue structure required.

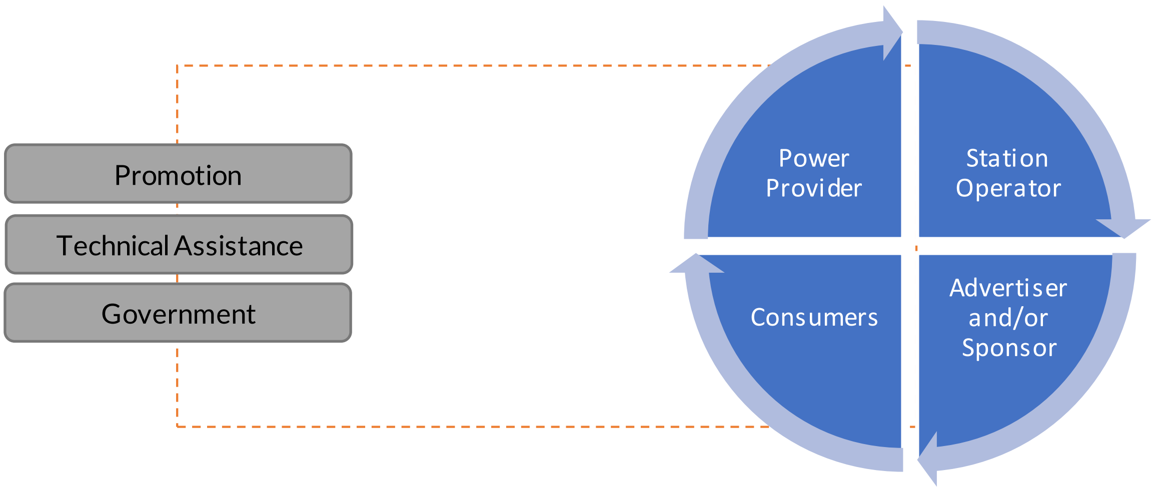
2. *Undertake awareness raising and promotion*
   To support broader uptake of electric vehicles on the market, awareness raising and communications are needed. Electric vehicles need to be promoted, and in this regard, the NEA is well placed to undertake promotion. A dedicated promotional campaign could focus on the benefits to the consumer of going electric, primarily maintenance and operations savings.

[109] Stenberg, Juha. n.d. How can you profit from the EV charging business? Accessed online at: https://blog.ensto.com/blog/how-can-you-profit-from-the-ev-charging-business
[110] Ritter, Todd. n.d. The First EV Charging Station with Digital Advertising. EVstructure. Accessed online at: http://www.evstructure.com/ad-kit.pdf
[111] Nichols, Will. 2015. Volta plugs in advertising to spark up charge point market. BusinessGreen. Accessed online at: https://www.businessgreen.com/bg/feature/2414108/volta-plugs-in-advertising-to-spark-up-charge-point-market
[112] The Kathmandu Post. 2018. Valley armed with 4 more stations. Accessed online at: http://kathmandupost.ekantipur.com/news/2018-01-02/valley-armed-with-4-more-stations.html; cost of station is around NPR 800,000 and cost of transformer is around NPR 800,000.
[113] Mishra, Ashish. 2014. Mahindra developed low-cost charging stations for electric Reva e2o: CEO. Firstpost. Accessed online at: https://www.firstpost.com/business/auto-show/mahindra-developed-low-cost-charging-stations-for-electric-reva-e20-ceo-1957819.html

Table 4.4 CAPEX, OPEX, Revenue and IRR of the project

Capital expenditure (USD in Millions)	Operational expenditure (USD in Millions)	Revenue (USD in Millions)	Project IRR (%)
0.08	1.73	2.2	26.05

Figure 4.5 Schematic structure



4. Scalability and replicability

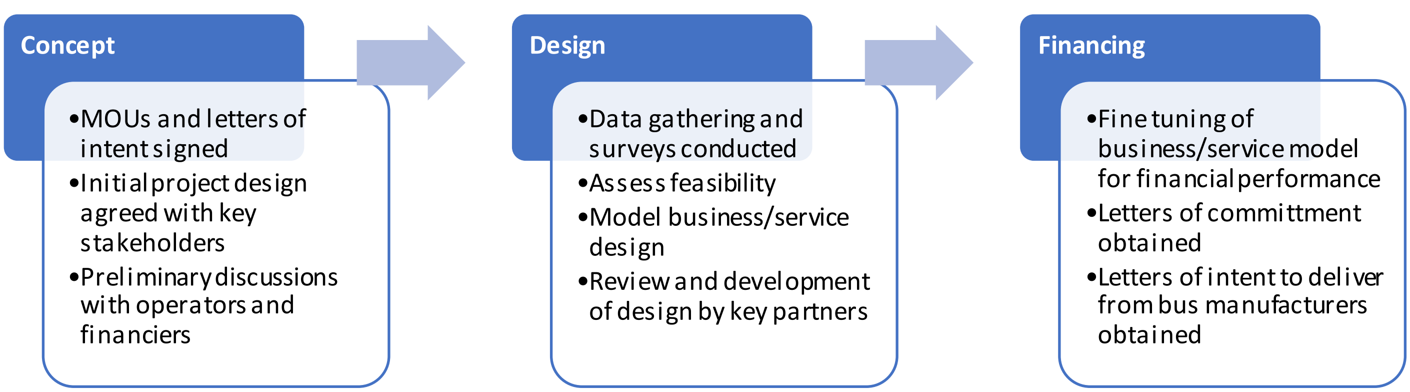
The model can be replicated across other supermarkets and malls in Kathmandu, especially if a chain of supermarkets or malls is interested. Beyond Kathmandu, replication into other metropolitan cities is feasible.

5. Main Partners

- Ministry of Physical Infrastructure and Transport
- Private sector

Nepal Electricity Authority will be the key counterpart for this project

6. Timeline

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4.2.5 Establishing and Valorizing Battery Recycling

CAPEX	NPR	514 M	USD	4.9 M
OPEX	NPR	560 M	USD	5.9 M
LIFE	YEARS	10		
COST RECOVERY	YEARS	4		
NPV	NPR	589 M	USD	5.7 M
IRR	%	20.3		

Over 24,000 tons of batteries are discarded every year in Nepal, either through improper dumping or through export to India. Nepal lacks a domestic battery recycling facility. Given that greater adoption of electric vehicles is a policy goal, a robust domestic used battery management solution is needed. A battery recycling facility can be established for an estimated USD 4.9 M investment, and with correct policy support can achieve return on investment of 20%, leading to cost recovery within 3.7 years. The project would reduce pollution due to improper disposal of used batteries and support economic growth through provision of recycled byproducts back into the domestic market.

1. Case for domestic battery recycling

With an increasing policy focus on electric mobility, Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020.

The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[114] Fiscal and monetary policy also increasingly favors electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles. Similarly, electric vehicles are exempt from value added tax (VAT). The Nepal Reserve Bank has also increased its loan limit to 80% for electric vehicles, compared to 50% for fossil fuel vehicles, recognizing the higher price tags on electric vehicles. Under any scenario, with increased electrification of the transport sector, the waste generated from the electric mobility sector is only set to increase.

According to a KfW estimate, there are currently around 2500 two-wheelers operating in Nepal,[115] and more than 15,000 three wheelers operating throughout the tarai (low-land plains of Nepal), most on lead acid batteries. Beyond vehicle batteries, there are also significant numbers of batteries in use within commercial and residential power back-up supplies, which was 9,286 ton in 2015.[116] Around 40,000 tons of lead-acid batteries are used in the solar home systems. The amount of lead-acid battery waste generated in 2015, mainly from solar applications, transport, industrial applications and back-up power, was around 24,000 tons, according to a recent study by the Alternative Energy Promotion Centre and KfW. Lastly, there are some important, though, minor sources of battery waste – for example two telephone companies namely, Nepal Telecom and NCell also use lead-acid batteries for their operation and generate about 800 tons of used batteries annually, accordingly KFW. The general population of Nepal is not aware about the negative impacts of draining the sulphuric acid from lead-acid batteries on health and the environment. Furthermore, people are not aware of the benefits of recycling used lead-acid batteries within the country, which in addition to decreasing cost of batteries, will increase employment opportunities and aid in developing a robust market.

Indeed, the management of used batteries from all sources has long posed a challenge in Nepal, and constitutes one of the federal government's primary concerns in regards to longer-term electrification of Nepal's transport sector. Currently there are three lead-acid manufacturing[117] companies as well as five companies importing as well as distributing[118] lead-acid batteries in Nepal. Only one of the manufacturers, JBU Energy-Shree Jagadamba Battery Udhyog P. Ltd is in the process of implementing a small capacity battery recycling plant in Rautahat, which is not in operation yet. Otherwise, acid from the used batteries is being dumped in Nepal and rest is being exported to India for recycling and Nepal lacks a commercially viable battery recycling facility.

2. Problem analysis

In order to establish battery recycling centers in Nepal, a range of challenges will need to be addressed. These challenges exist both in terms of facilities and their business model, as well as more broadly for consumers.

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[114] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

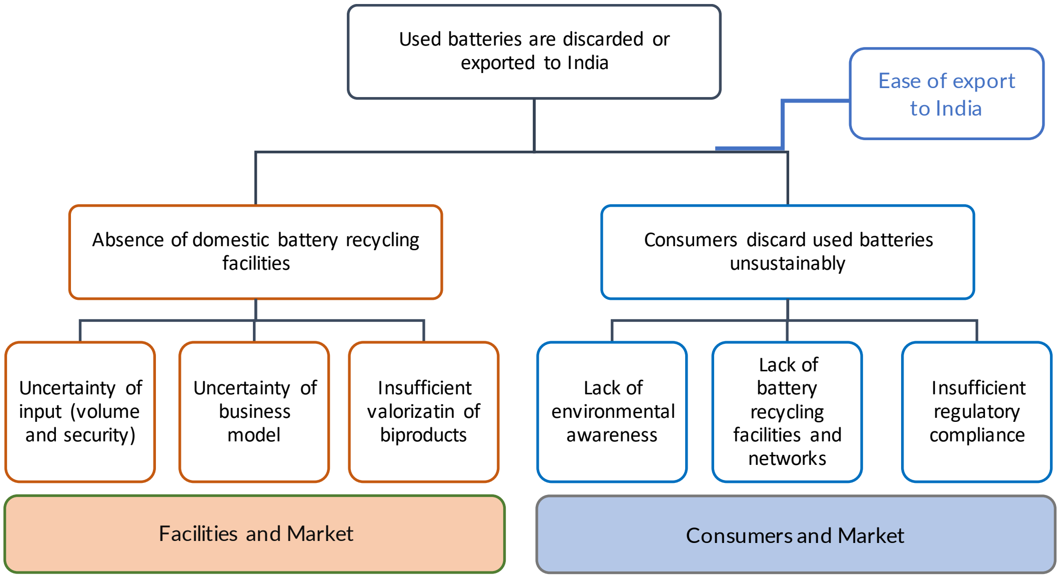
[115] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.

[116] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

[117] Asian Batteries P. Ltd, Kulayan Battery Industries P. Ltd and JBU Energy-Shree Jagadamba Battery Udhyog P. Ltd

[118] Sipradi Energy, Ultra Solar, Top Energy P. Ltd, Birat Infrastructure Development and Rahimafrooz

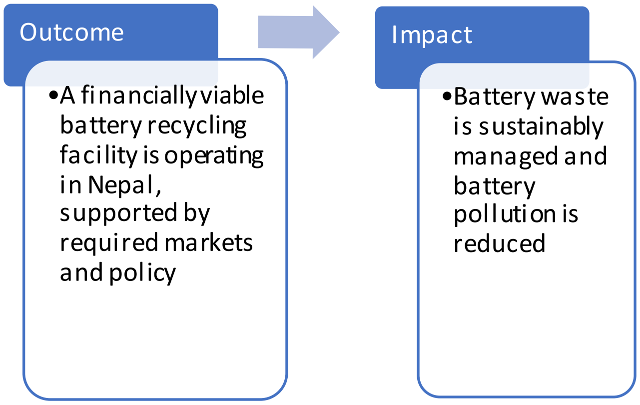
Figure 4.6 Problem Analysis



1. *Uncertainty of supply* - On an average, the Indian battery recycling companies are paying around USD 1,000 per ton of lead for used batteries. In addition, an unregulated network of more than 18,000 collectors and 8 transporters have control over the spent lead-acid battery sector, transporting all used batteries to India. Without security of supply, the private sector will not be able to invest in battery recycling plants in Nepal.
2. *Poor quality of used battery disposal* - Due to lack of regulation of handling these batteries, the scrap collectors drain over 3 million litres of acid from spent lead-acid batteries every year in Nepal, before transporting the remaining lead to India. This causes long-term environmental damage and impairment to human health. Once dumped into the environment, these can seep into the soil to contaminate ground water and threaten aquatic life if dumped in rivers and streams. The acid causes irritation or burning to the skin, affecting eyes as well as respiratory system of humans.
3. *Lack of government leadership for battery recycling* - Another associated issue is the improper disposal of used lead-acid batteries due to which the country has resorted to exporting all battery waste to India, where it is recycled. Indeed, due to lack of proper regulatory mechanisms, the government itself goes through the tendering process to sell used lead-acid batteries that is eventually sold to India. Although it is illegal to export spent batteries, all of the used lead-acid batteries are currently being taken to India to be recycled.
4. *Insufficient regulation* - Lead-acid batteries constitute a significant percentage of this waste. Lack of proper regulation and guidelines for disposal of these lead-acid batteries has posed challenges in terms of implementing battery recycling plants in the country.

3. Proposed project

In order to successfully establish a domestic financially sustainable battery recycling facility, the proposed project would involve both feasibility for the facility, and interventions in the market, in a bid to correct the distortions currently in place. Implementation and sustainability of a recycling plant is fully dependent on a fully functioning market where collection of batteries is effectively carried out, collected batteries are recycled and the recovered materials are sold. In this way, the proposed project is seeking the following outcome and impact:



To facilitate this outcome, the proposed project would involve the following key outputs:

1. *Assessment of feasibility and overall technical requirements*
   The proposed facility would be able to handle proper recycling of lead-acid batteries.
   Almost all the materials in a used battery can be recycled. For lead recycling, the general process is as follows. After receiving the used batteries and breaking, two rotary furnaces are dedicated to melting the lead grid metallic and smelt the battery paste. Any fume produced during the smelting process is captured to recover any escaped lead. During the refining process, the lead bullion is purified using dedicated kettles. Then a casting machine is used to cast 25 kg lead ingots ready for battery manufacturing plants. Other by-products that can be sold are refined lead alloy ingots, polypropylene pellets and building materials.
   In terms of inputs to the recycling facility, more than 24,000 tons of spent lead-acid batteries are generated every year in Nepal. This is estimated to increase to 35,000 tons by 2020, according to KfW.
   The network of waste battery collectors, transporters, middle agents and depots would need to be assessed to understand the flow of waste battery, and how to ensure that the proposed recycling facility receives adequate input.
   As part of this, a market assessment would be undertaken to further understand the demand for recycled products (namely led ingots), as well as other by-products of the recycling process. This will be critical for the business modelling
2. *Preparation of business model and operations*
   A financially sustainable business model will be assembled. Based on initial review and assessment, the anticipated capital expenditure required for installation of the battery recycling plant is estimated to be USD 4.9 million (as estimated by KfW). The investment cost mainly includes licenses and fees, land costs, construction costs, in addition to equipment and expenses required for initial operation of the plant.
   A funding structure of 50% of the funds through equity and 50% through loan is proposed. Within the 50% loan, a combination of soft loan (interest rate 5%) and commercial loan (interest rate 9%) could be expected given Nepal's current lending environment. The return on investment estimated by the study is 20%, which is largely a factor of export earnings (since recycled lead is assumed to be traded at the London Metal Exchange). Without a developed market in place in Nepal, there is a chance that local demand will not be enough to sustain operations of the recycling plant. Operational guidelines would need to be established as part of this to ensure that the facility operates correctly.

Table 4.5 CAPEX, OPEX, NPV and IRR of the project

Capital expenditure (USD in Millions)	Operational expenditure (USD in Millions)	Net Present Value (USD in Millions)	Project IRR (%)
4.9	5.9	5.7	20

3. *Recommendations for regulatory and market interventions*

The recovered materials will be sold on the international market due to the low cost of materials on the domestic market. An initial assessment indicates that trading on the London Metal Exchange will have potential positive impacts on revenues, also leaving space to increase margins by up to 10% of the price paid for used lead-acid batteries.
From an initial review, potential supply-side market interventions which appear necessary include a) develop an awareness program to educate all stakeholders involved, from battery users to collectors and policy makers, about the impacts of improper battery management practices currently in place and the benefits of recycling lead-acid batteries in house; b) formulate mechanisms to regulate collection of used lead-acid battery through collection centers around Nepal; c) encourage battery manufacturing plants to implement a system of collecting batteries through buyback programs; d) develop monetary tools, such as subsidies and loans, to incentivize the private sector to install battery recycling plants within the country.

Similarly, potential demand-side market interventions which may be necessary include a) promote implementation of local lead-acid battery manufacturing plants, through tax cuts, to cut down imports from neighboring countries and increase demand for materials recovered by the lead-acid recycling plant; b) impose strict monitoring mechanisms at border customs to reduce import of lead-acid batteries and encourage use of locally produced batteries.

Additionally, policy and regulatory support, on the principle of extended producer responsibility (EPR), could be considered. Alternatively, schemes to encourage that consumers sell their used batteries to the recycling facility could be considered, for example through a formal buy-back arrangement that encourages users to sell their used batteries instead of either dumping them in the garbage or selling to collectors. Implementation of this scheme through the existing battery manufacturing companies can secure that the used batteries stay in the country and can be recycled in the battery recycling plant.

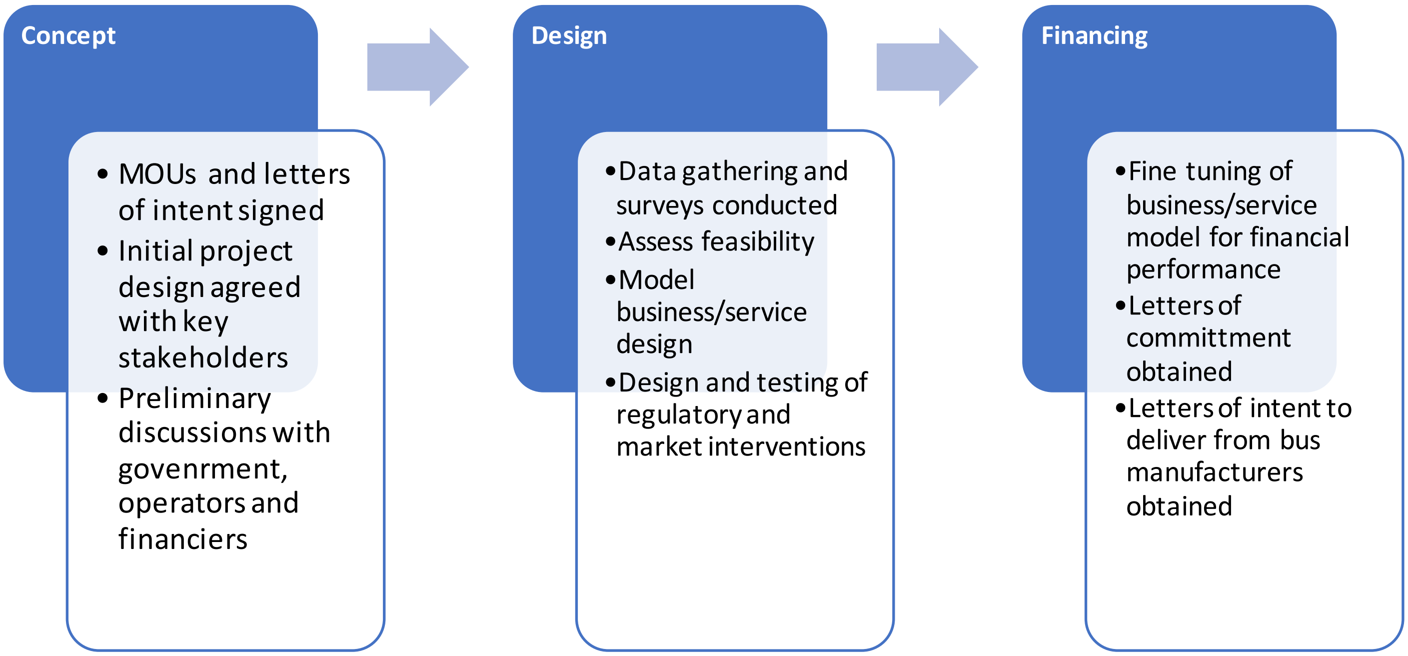
4. Scalability and replicability

This project will have a very high positive impact on the environment and health, with reduced exposure to untreated sulphuric acid. Haphazard disposal of spent batteries can also be limited by introducing organized collection systems, which can be introduced in many different parts of the country.
Since lithium-ion batteries are being introduced in the market, predominantly in the transport sector, this system can be expanded to include recycling lithium-ion batteries as well. Although the specific recycling technology will be different, collection and reselling activities can be aligned with this system.

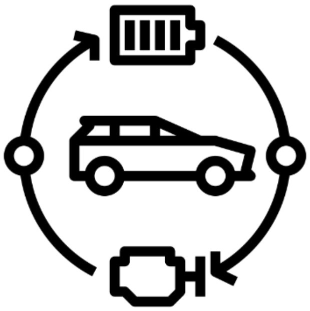
5. Main Partners

- Private sector – Implement battery recycling plant
- Private sector – Implement battery manufacturing and collection center
- Ministry of Forests and Environment - Develop policy and regulatory mechanisms
- Ministry of Finance – Develop monetary mechanisms
- Ministry of Industry, Commerce and Supplies – Regulate battery recycling market
- Department of Customs – Impose strict rules against battery import

6. Timeline


Concept
• MOUs and letters of intent signed
• Initial project design agreed with key stakeholders
• Preliminary discussions with govenrment, operators and financiers
Design
•Data gathering and surveys conducted
•Assess feasibility
•Model business/service design
•Design and testing of regulatory and market interventions
Financing
•Fine tuning of business/service model for financial performance
•Letters of committment obtained
•Letters of intent to deliver from bus manufacturers obtained

4.2.6 Converting Fossil Fuel Taxis to Electric Taxis



CAPEX	NPR	233 M	USD	2.2 M
OPEX	NPR	2.7 B	USD	26.4 M
LIFE	YEARS	10		
COST RECOVERY	YEARS	8		
NPV	NPR	91,488	USD	883
IRR	%	15.01		

An estimated 10,000 taxis provide transport services across Kathmandu. Due to suppressed fares, high inflation and rising operational costs, many drivers and taxi fleet operators see electric taxis as an attractive alternative, due to the significant savings in operations and maintenance that electric vehicles offer. A taxi conversion center in Kathmandu, where conventional taxis can be converted to hybrid electric, would cost an estimated USD 2.2 M to establish. With adequate commitment from drivers and fleet owners, a revenue of USD 19 M for the sale and installation of required technology could be achieved, leading to an internal rate of rate of 15.01 per cent. But first, five taxis will be retrofitted to assess the actual benefits and drawbacks of the technology. The project would deepen the provision of low-carbon mobility across the Kathmandu metropolitan region, improve livelihoods, jobs and the local economy, reduce greenhouse gas and particulate matter pollution, and reduce dependency on imported fossil fuels.

1. Case for conversion of conventional taxis

Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020.

According to a KfW estimate, there are currently more than 2500 electric vehicles operating in Nepal, some of which are public transport.[119] The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[120] Fiscal and monetary policy also increasingly favors electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles.

There are currently around 10,000 taxis plying the streets of Kathmandu, which is 7% of the total four-wheeled vehicle fleet in the city, contributing to total GHG emissions.[121]

Many taxi operators feel increasing operational pressure. The price of crude oil has climbed internationally since its low in 2015, and local petrol prices have increased by 10% during June 2017-June 2018. Many taxi drivers argue that increasing fossil fuel prices, coupled with an increase in the cost of renting taxis from fleet owners (up to NPR 1,500 or USD 14.5 per day), are generating severe economic pressures on drivers and their families. Artificially low official fares complicate this situation. Drivers complain that the fare set by the Department of Transport Management, which is NPR 35 per km, is too low to be profitable. This fare was decreased in 2017 from NPR 36 in 2016 and does not consider the inflation rate within the country. Lastly, effective 15 March 2018, the Government of Nepal imposed a ban on public vehicles, including taxis, which are older than 20 years – an effort to curb tailpipe pollution. This adds to the pressures which many taxi fleet owners and individual operators face.

From initial discussions with Everest Cab Services and Sarathi Cab, both taxi fleet operators in Kathmandu with 400 associated taxis and fleet size of 40 respectively, there is reasonably strong interest from private operators to convert their fleets into either hybrid or battery electric vehicles. Almost any vehicle can be converted to electric. There are two options – the first is to replace the car's combustion engine with an electric motor and batteries, to create an 'all electric' or fully 'battery electric' vehicle. The second option is to replace a larger combustion engine with an electric motor and batteries, and a small combustion engine, to create a hybrid electric vehicle (see Annex 1 for more information on vehicle technologies). Conversion and hybridization technologies are available on the regional and international markets. Indian companies, such as Altigreen Propulsion Labs has introduced a cheap conversion technology, which costs from INR 60,000 – 80,000 (USD 927 – 1,236), depending on the gross weight of the vehicle. This conversion technology is used in all types of vehicles and is an option that is only about 0.1% of the cost of a hybrid vehicle.[122] Altigreen specifies that this technology reduces fuel costs by 25% and tailpipe emissions by 20%.

Given the operational pressures outlined above, the main motivation of taxi fleet operators and owners to invest in hybrid or battery electric vehicles is to obtain the operational savings. A study undertaken by GGGI in 2017 found that operational costs of an electric bus in Kathmandu would be over 60% cheaper than an equivalent diesel bus. With these operational savings, the consumer will be able to recover the cost of converting in under 12 months.[123] Since the acquisition cost of clean transport vehicles, such as electric vehicles, is very high, with limited charging facilities, people in Nepal still hesitate to invest in such vehicles. However, conversion technologies are cheaper options to owning a hybrid or electric vehicle. Converting the taxi fleet in Kathmandu to electric by importing conversion technologies from neighboring countries could be a viable option in reducing the operating and maintenance cost of the taxis, in addition to reducing tail-pipe emissions, as well as promoting electric mobility in Nepal.

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[119] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.

[120] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

[121] Kathmandu Post. 2017. No taxi subsidy for quake survivors. Accessed online at: http://kathmandupost.ekantipur.com/news/2017-06-25/no-taxi-subsidy-for-quake-survivors.html

[122] ETRISE. 2018. Want to save 30% on fuel costs? Altigreen holds the key.

[123] Altigreen. 2018. HyPixi. Accessed online at: <hypixi.in>

Overall, taxi fleet operators express greatest interest in switching to hybrid (rather than full battery electric) for the flexibility. Fleet operators are cognizant of the possibility of power shortages. Hybridization, therefore, allows fleet operators to obtain advantages of both petrol and electric, through reduced tailpipe emissions and increased fuel efficiency. However, in general, there is little awareness and understanding amongst drivers and fleet owners of the benefits of hybridization or electrification of their fleets/vehicles. In addition, there are no conversation centers operating in Nepal.

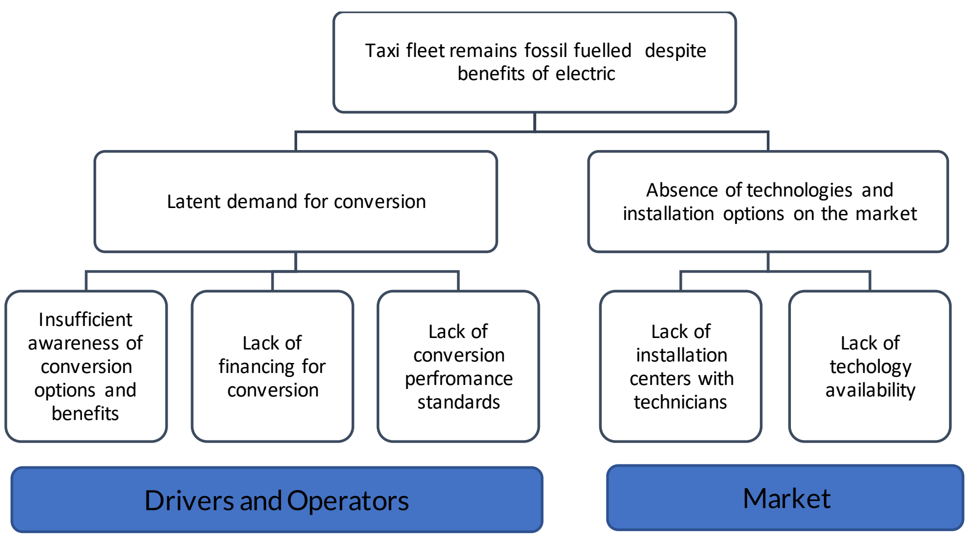
2. Problem analysis

This problem is composed of several challenges and associated barriers as outlined in fig. 4.7.

This fundamental problem is comprised of several components:

- *Low awareness of benefits and options* – Many operators are unaware of the range of benefits which hybridization and electrification can deliver. More generally, they are unaware of the technology options. Partly as a result of this, demand for conversion remains limited.
- *Insufficient financing* - Taxi drivers that fall in this category don't have the resources to buy new taxis. Although there are several banks that provide financing for 60% of the vehicle cost with interest of up to 6% per annum,[124] taxi drivers that fall in the lower-income bracket fail to cover even 40% of the remaining upfront costs. With no government incentives, these taxi drivers cannot even think of purchasing clean and efficient transport modes, such as electric vehicles.
- *Absence of regulation for conversation* – There is no regulation or performance standards in place for the conversion of conventional vehicles to electric. As such, quality, safety and overall performance of converted vehicles are not assured, undermining consumer willingness.

Figure 4.7 Problem Analysis

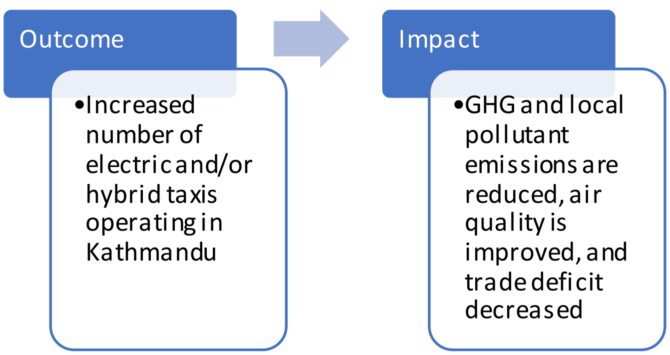


[124] Sanima Bank. 2018. Interest Rates. Accessed online at: https://www.sanimabank.com/article-InterestRates

- *Lack of technology and nowhere to install* – Conversion technologies are not complicated, nor particularly expensive. The costliest component is the battery. Removal of the original combustion engine, and replacement with an electric motor and battery is a relatively straightforward process, as long as there is sufficient space in the vehicle to accommodate the batteries. However, in Nepal, there are no conversion kits readily available on the market, nor are there specific installation locations. Thus, there's a need to demonstrate financial as well as technical viability of the project.

3. Proposed mobility service project

The proposed project would seek to address the challenges outlined above, through both policy and an investment project. Fundamentally, the proposed project would involve the establishment of a vehicle conversation center, specifically tailored to taxis, and seek to secure the buy in and commitment of key fleet operators. The proposed project is expected to deliver the following outcome and impact.



The project would be composed of the following components:

1. *Assessment of technology and installation feasibility*

A close assessment of electrification and hybridization is needed. Various technologies, often bundled into kits, exist on the international market. One example, which the proposed project would assess, is the kit provided by Indian producer Altigreen Propulsion Labs. To convert an existing gasoline four-wheeler to hybrid, dual electric machine, generator, wire harness, power control and control electronics as well as batteries are fitted next to the engine. In a fossil fuel car, 75% of the energy produced by the engine gets wasted, which will be utilized by the hybrid kit increasing fuel efficiency by 25%. The hybrid kit contains four lead-acid batteries[125] making a total of 48 V battery pack, which can be easily fitted into the car or removed, if necessary.[126] Furthermore, the system has been designed in such a way that lead-acid batteries can be replaced by lithium-ion batteries if required.

Technology transfer would be explored, to facilitate importing conversion technology or kits for easy installation. For example, one specific option is Altigreen's Hypixi hybrid kit for conversion of fossil fuel vehicles to partially electrified vehicles. This technology will be acquired through *Support Contract* between the Implementing Partners and Altigreen Propulsion Labs. Through this contract technical support and staff training will be provided. Other components, such as safety would also be assessed to ensure the technical viability of the proposal. It is proposed that a two step approach be adopted to demonstrate the safety and viability of taxi conversion technologies available in the region. In the first phase, a set of five taxis would be converted to assess efficiency and safety of the hybrid system. Once successful implementation of the technology has been assessed, a taxi conversion center would be established in the second phase to provide conversion services to the whole taxi fleet of Kathmandu.

Retrofitting is simple and can be carried out in an area that is similar to an auto-repair workstation. Based on initial calculations around 3 ropani (approx. 1,500 m^2) is estimated to be sufficient. Conversion of 4 taxis can be carried out in this area at the same time. Conversion time will be around 4-5 hours per day leading to conversion of about 1,252 taxis per year (assuming 4 vehicles per day, at six days per week or 313 days per year).

2. *Business modelling for commercialization*

To achieve financial sustainability, the initiative would require business model development. From initial review and discussion, the business model

[125] Although lead-acid batteries have lower energy density than other battery types, a hybrid conversion kit being developed in India by Altigreen Propulsion Labs has built a technology that has reduced the size of the batteries and increased efficiency.

[126] ETAUTO. 2016. This start-up has a low-cost solution to convert diesel cards into hybrid. Accessed online at: https://auto.economictimes.indiatimes.com/news/auto-technology/this-start-up-has-solution-to-convert-diesel-cars-into-hybrid/53446767

would most likely involve the private sector owning and operating the conversion centers.

The project would begin as a pilot initiative, with conversion and regular monitoring of five taxis. Efficacy of the system will be monitored during this period to assess possibility of replication. [127] It is proposed that one fossil fuel taxi conversion center be established in Ratnapark to avail 10,000 taxi drivers within Kathmandu the service of converting their existing fossil fuel taxis to hybrid. This will aid in lowering operating costs of taxis, even during oil price fluctuations.

Two staff members will be required to retrofit and monitor the performance of a single vehicle during and after retrofitting. A total of 15 staff members will be on location all the time to assist with repairs, technical difficulties and servicing. The cost of converting one four-wheeler will be around NPR. 2 Lakh (USD 1931).[128,129] Financial assistance from banks will be sought to ease purchase of the technology. Integration of this technology will support taxi drivers in accruing savings of up to NPR 9,000 (USD 87) per month, which will help taxi operators in acquiring full ownership of the technology in less than two years. The yearly revenue of the conversion center has been estimated at USD 2.41 Million. The initial investment required to lease land and set up a conversion center is estimated at NPR 232.8 Million (USD 2.25 M). Annual maintenance and operating costs is estimated at USD 2.62 Milllion and the project IRR is estimated at 15.01% (see Table 4.6). For a detailed summary of the financial analysis, see Annex 2.

3. Awareness, capacity and policy development

Outreach to taxi drivers and taxi fleet operators would be key, in order to stimulate demand for conversion. In this regard, the project would involve partnerships with key taxi fleet operators who express willingness to commit a certain number of vehicles from their fleet for conversation. This will help to achieve economies of scale on the initial technology imported, plus in terms of facilities established and staff trained etc. Agreements with interested fleet operators would be sought to lock in demand.

To support demand creation, quality and performance standards for conversion of vehicles would also be developed in partnership with the federal government. This will help to assure drivers and fleet owners. More generally, through a working partnership with the technology provider, capacity of technicians and operators would need to be built to ensure sound and effective management of the conversion center, and the converted vehicles.

Table 4.6 CAPEX, OPEX, Revenue and IRR of the project

Capital expenditure (USD in Millions)	Operational expenditure (USD in Millions)	NPV (USD in Millions)	Project IRR (%)
2.2	26.3	33.7	15.01

[127] Although this project focuses on conversion of taxis, the scope of this project can be adjusted to expand services to other types of vehicles, including private four-wheelers.
[128] ETAUTO. 2016. This start-up has a low-cost solution to convert diesel cards into hybrid. Accessed online at: <https://auto.economictimes.indiatimes.com/news/auto-technology/this-start-up-has-solution-to-convert-diesel-cars-into-hybrid/53446767>
[129] USD 1 = NPR 103.6

4. Scalability and replication

If successful, the initial project conversion center could be replicated across Kathmandu to service additional fleets of taxis, as well as three-wheel vehicles.

More generally, replication into other larger metropolitan cities in Nepal is also feasible, in order to provide similar conversion services. Cities such as Pokhara, Bharatpur, Birgunj and Biratnagar all have sizeable fleets of vehicles, including taxis. These are major cities in the Rapti, Narayani and Koshi zones which have a total vehicle fleet of 34611, 625089 and 297028 respectively. As such, replication of a similar conversion facility, once proven in Kathmandu, could be carried out in these cities.

5. Main Partners

- Electric Vehicle Association of Nepal
- Department of Transport Management,
- Ministry of Physical Infrastructure and Transport
- Ministry of Finance
- Electric Vehicle Association of Nepal
- Private sector

Priority taxi fleet operators (private sector) will be the key counterpart for this project

6. Timeline

Concept
Q4 2018

- MOUs and letters of intent signed
- Initial project design agreed with key stakeholders
- Preliminary discussions with operators and financiers

Design
Q1 and Q2 2019

- Data gathering and surveys conducted
- Assess feasibility
- Model business/service design
- Review and development of design by key partners

Financing
Q3 2019

- Fine tuning of business/service model for financial performance
- Letters of committment obtained
- Letters of intent to deliver from taxi operators obtained

4.2.7 Establishing a SME and Consumer Financing Facility for Electric Mobility

The cost of capital is high in Nepal, partly due to high inflation. It is also often difficult to access, especially for ventures in electric mobility and transport, which commercial and retail banks tend to view as high-risk. A central fund to provide debt and equity financing to electric mobility start-ups, provide subsidy to private consumers who buy electric vehicles, and develop electric mobility infrastructure would generate multiple benefits. Series A capitalization of the fund could draw on both domestic and international sources, to constitute a total size of NPR 4.6 billion (USD 45 M). The fund would support long-term development of inclusive, low-carbon mobility across the Kathmandu metropolitan region, support business growth and the local economy, reduce greenhouse gas and particulate matter pollution, and reduce dependency on imported fossil fuels.

1. Current Context

Nepal's policy and fiscal environment supports greater adoption of electric vehicles and a gradual switch to electric mobility. The recently formulated *Environment Friendly Transport Policy* (2015) emphasizes the need for clean technology options in the transport sector. Similarly, Nepal's *Nationally Determined Contribution* (NDC) sets a target of increasing the share of electric vehicles to 20% of the total vehicle fleet by 2020. According to a KfW estimate, there are currently around 2500 electric vehicles operating in Nepal, some of which are public transport.[130] The NDC also prioritizes the electrification of the transport sector more generally, the diversification of energy supply, and improvement in urban air quality.[131]

Fiscal and monetary policy increasingly favours electric vehicles, especially if they are used for public transport. Import tariffs (customs duty) for electric vehicles for public transport have been reduced to just 1%; compared to 40% for electric vehicles for private use and some 240% for fossil fuel vehicles. The Nepal Reserve Bank has also increased its loan limit to 80% for electric vehicles, compared to 50% for fossil fuel vehicles, recognizing the higher price tags on electric vehicles.

Green growth activities, such as a shift towards electric mobility, are crucial in realizing development goals of many developing countries. However, acceleration of green growth in many cases requires access to adequate financing. The United Nations Conference on Trade and Development (UNCTAD) states that financing within a range of USD 5 – 7 trillion, with USD 2.5 trillion in developing countries alone, will be required annually to achieve the Sustainable Development Goals by 2030.[132]

Currently, a move toward clean transport services, mainly electric transport, is being discussed by local governments and the private sector in Nepal. However, private sector is willing to take up electric transport projects only if low interest loans are available. Banks, on the other hand, are not willing to provide concessional loans due to the perceived high risks associated with electric vehicles. Commercial and development banks are obligated to pay lending rate of 6% and 5% respectively to Nepal Rastra Bank, which adds up to the base rate and bank's handling charges, escalating the interest rate to more than 12%.

Although financing for electric mobility is still a challenge, there are funds in Nepal that have been established to facilitate financing for infrastructure development and energy related activities. The Town Development Fund (TDF) is an autonomous financial institution in Nepal, which has been in operation since 1989 and is supporting municipal governments, Water Users' Association and 6 District Health Project by providing grant, soft loan and loan. Up until July 2017, TDF had disbursed NPR 246.8 million (USD 2.4 M)[133] for revenue generating activities and NPR 229.9 million (USD 2.2 M) for social infrastructure activities.[134] TDF has recently partnered with ADB to provide financial support to a private company to acquire 17 diesel buses under the Kathmandu Sustainable Urban Transport Project (KSUTP). Besides this, TDF does not have experience financing transport sector projects. Another fund that is in operation in Nepal since 2013 is the Central Renewable Energy Fund (CREF) for development and promotion of renewable and alternative energy technologies. CREF provides subsidized loans to households, communities, manufacturers, distributers and installers.

2. Problem Analysis

The project addresses the following consumer and enterprise needs:

- Increased access to low cost financing for viable electric mobility projects: Commercial banks currently charge an interest rate of above 12% on public transport loans. The high upfront cost of the vehicles, coupled with high interest loans, discourage private and public operators willing to invest in electric transport. Support from international and local funding sources to provide low cost financing options for viable electric mobility programs is needed.
- Availability of resources for innovative business models: Innovative business models are usually perceived as high risk, due to which investors, including local financial institutions, are not

[130] KfW. 2018. PowerPoint Presentation delivered by KfW 'E-Mobility Scoping Mission' on May 4, 2018.

[131] Ministry of Population and Environment. 2016. Nationally Determined Contributions for Nepal. Submitted to the United Nations Framework Convention on Climate Change.

[132] UNDP. 2017. Impact investment to close the SDG funding gap. Accessed online at: http://www.undp.org/content/undp/en/home/blog/2017/7/13/What-kind-of-blender-do-we-need-to-finance-the-SDGs-.html

[133] Exchange rate of USD 1 = NPR 103.6

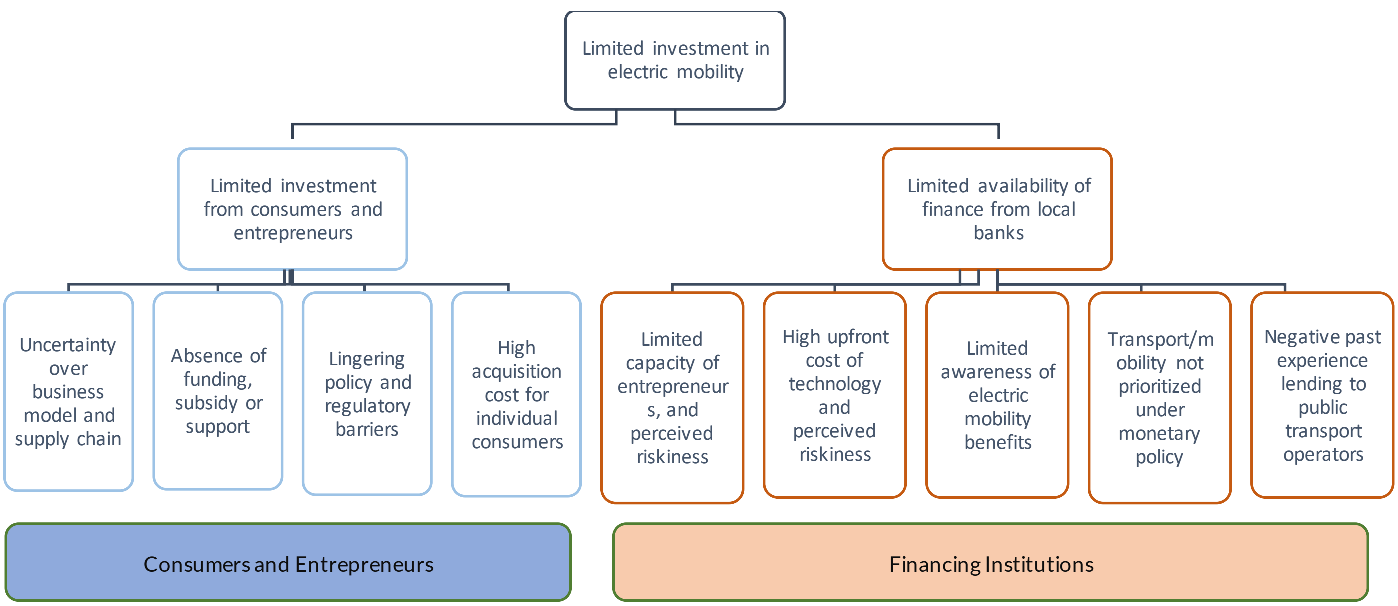
[134] Town Development Fund. 2017. Audit Report 2073/74. Accessed online at: <http://tdf.org.np/wp-content/uploads/2018/05/Audit-Report-73_74.pdf>

willing to invest in such projects. Due diligence for these types of projects will be carried out to determine project feasibility and the type of instrument necessary to facilitate financing.

The key challenges that arise from these issues include:

- *Lack of investment due to inadequate funding opportunities:* Electric vehicles, mainly two- and four-wheelers, have only recently been introduced in Nepal's market. High acquisition cost of these vehicles, in addition to lack of market mechanisms, puts a question mark on their viability. Accessing and deploying capital is expensive in Nepal, due to high rates of inflation over 2016-2018. Interest rates of debt hover above 12%. Servicing debt can be difficult, especially in the low-return transport sector. Public funding and low-interest loans are available in theory, as alternatives to commercial debt, but access and mobilization are complicated. Service providers need support with mobilizing financing for their operations. Local financial institutions such as commercial banks are not aware of the multiple benefits of introducing clean transport services. Furthermore, local financial institutions' (LFIs) previous experiences have rendered investment for private transport operators as being risky. There have been instances in the past whereby ownership of the vehicles has been transferred from one person to another, without the bank's knowledge, leading to high loan default. These are major barriers in the uptake of EVs as private sector entrepreneurs willing to implement Electric Mobility projects cannot convince local financial institutions to provide low interest financing.

Figure 4.8 Problem Analysis

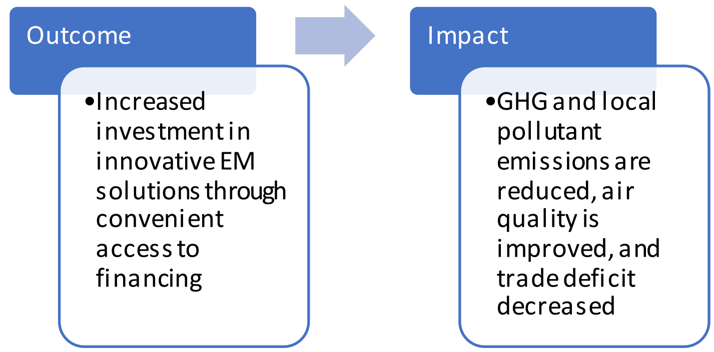


- *Lack of financial incentives and existing regulatory barriers*: Lack of dedicated funding sources and/or financing mechanisms, such as subsidies, makes it even more difficult for consumers to invest in the technologies. In addition to this, although policies are in place to support promotion of clean transport technologies, appropriate directives are yet to be developed. Policies to support infrastructure development for electric mobility, in addition to different regulatory mechanisms supporting preferential tariff for electric vehicles, etc, are yet to be developed. Absence of supporting policies and regulatory mechanisms discourages entrepreneurs from investing in electric mobility options. These are some of the major factors why consumer buy-in of the technology is very low.
- *Transport/mobility not prioritized under monetary policy:* Since only electric three-wheelers have been introduced in the Metropolitan areas within Kathmandu Valley, feasibility of large and mid-sized buses in different routes, as well as different infrastructure related projects are yet to be carried out. Transport companies iterate that an interest rate ranging from 2-5% and loan repayment period of more than 10 years would be ideal in purchasing electric vehicles. However, transport sector lending has not been prioritized in Nepal's monetary policy
- *Limited capacity of entrepreneurs and perceived riskiness:* Local financial institutions are not willing to provide financing to entrepreneurs mainly due to the perceived riskiness of businesses within electric mobility. The electric mobility market is at a very nascent stage in Nepal, due to which the private sector does not have the necessary capacity to design feasible electric mobility projects.

3. Proposed financing facility

The proposed SME finance facility would seek to address the problem identified above. Primarily, this would involve developing a specialized fund to facilitate financing to viable small and medium enterprises working on electric mobility. Such a model may require financing from local as well as international sources. The project would also facilitate the broader establishment of projects and include provisions for capacity building activities.

The proposed project is expected to deliver the following outcome and impact.



In order to facilitate access to financing Electric Mobility related projects, it is essential that a fund dedicated to electric mobility be established. To do this, the following components will be undertaken.

1. *Feasibility study of an SME fund and consumer EV financing scheme*

   The feasibility of establishing a fund to support small and medium enterprises and consumers will be explored, comprised of components a) an SME fund; and b) a consumer support facility.

   For the SME fund, an assessment will be undertaken of the broader uptake of innovative business models for electric vehicles. A combination of concessional loan and grant through GCF, GoN, development partners and local investors will be assessed to fund the small and medium enterprises in the EM sector. Local financial institutions, with potential of managing and distributing international and national funds, will be identified through consultations. The Nepal Investment Bank Ltd is currently in the process of being accredited to the Global Climate Fund and is keen on investing in Electric Mobility projects through GCF. This is a potential financing entity that can carry out the necessary due diligence, prioritize pipeline of projects and provide low interest loans to small and medium enterprises.

   Furthermore, disbursement of low-cost loans to individual consumers to purchase EVs will also be assessed. In addition to GCF, there are possibilities of raising funds internally through tax on petroleum products, for example, which can be utilized to establish a revolving fund. In this way, financing sources will be analysed, and financing will be secured for two funding areas as outlined below:

- Electric Mobility Entrepreneurship Facility - Viable business propositions from SME's will be assessed by the local financial institutions to determine the type of financing instrument which can be applicable. USD30 M soft loan from development partners and GCF, along with local investors, will be requested. Two main funding opportunities will be open to the private and public sectors, which are: i) Business Innovation and ii) Business Technology Transfer and Implementation Program. Both funding options will be accessible to for-profit organizations partnering with NGOs and Academic Institutions.
- Electric Vehicle Support Scheme – A total of USD 15 M will be sought from GCF and federal governments for loans on private EVs. This will provide incentives, in-terms of subsidy and soft loans, to individual customers willing to purchase EVs.

In terms of fund structure, a governing body will be established, which will include representatives from the Ministry of Physical Infrastructure and Transport, Nepal Bankers' Association, Department of Transport Management and the Electric Vehicle Association of Nepal. The fund operating body will be a consortium of local financial institutions, that have established lending portfolios in non-traditional sectors and which will be responsible for carrying out due diligence of proposals, making decisions related to fund dispersal and carrying out M&E activities. A consortium would also be useful in attracting interest of a range of funding partners. Institutional oversight will be provided by the development partners and funding agencies to ensure smooth operation of the Nepal Electric Mobility Fund. See Figure 4.9 below.

The municipal government's endorsement of the project will be a critical component in strengthening the project proposal submitted to the Nepal EM Fund. Government endorsements will also inform the decision makers that although the private sector is initiating project implementation, there is buy in from the local government as well. GGGI will liaise with small and medium enterprises to seek for government's approval, where necessary.

Required project documentation, including operation manuals, investment assessment procedures, evaluation criteria, institute regulation, etc will be developed through collaboration with the Federal Government and the Local Financial Institutions.

The structure of the fund is presented in Figure 4.9.

2. *Design and implementation of supporting financing instruments*
   Financing instruments such as National Subsidy Schemes, including concessional loans, with priority to women entrepreneurs, will be designed and implemented. Endorsement of these financing instruments will be sought from the Ministry of Finance. USD 5 M grant will be requested through the GoN for subsidy schemes within the EM sector to promote private sector uptake of the vehicles.

3. *Awareness, capacity and development*
   Outreach to local financial institution and government institutions would be key, in order to stimulate financing for innovative EM business models. In this regard, the project would involve partnerships with key financial institutions who express willingness to commit certain funds for investment in projects related to electric mobility. This will help to achieve economies of scale on the initial technology imported, plus in terms of facilities established and staff trained etc. Agreements with financial institutions would be sought to lock in demand.

Figure 4.9 Basic structure of Nepal Electric Mobility Fund

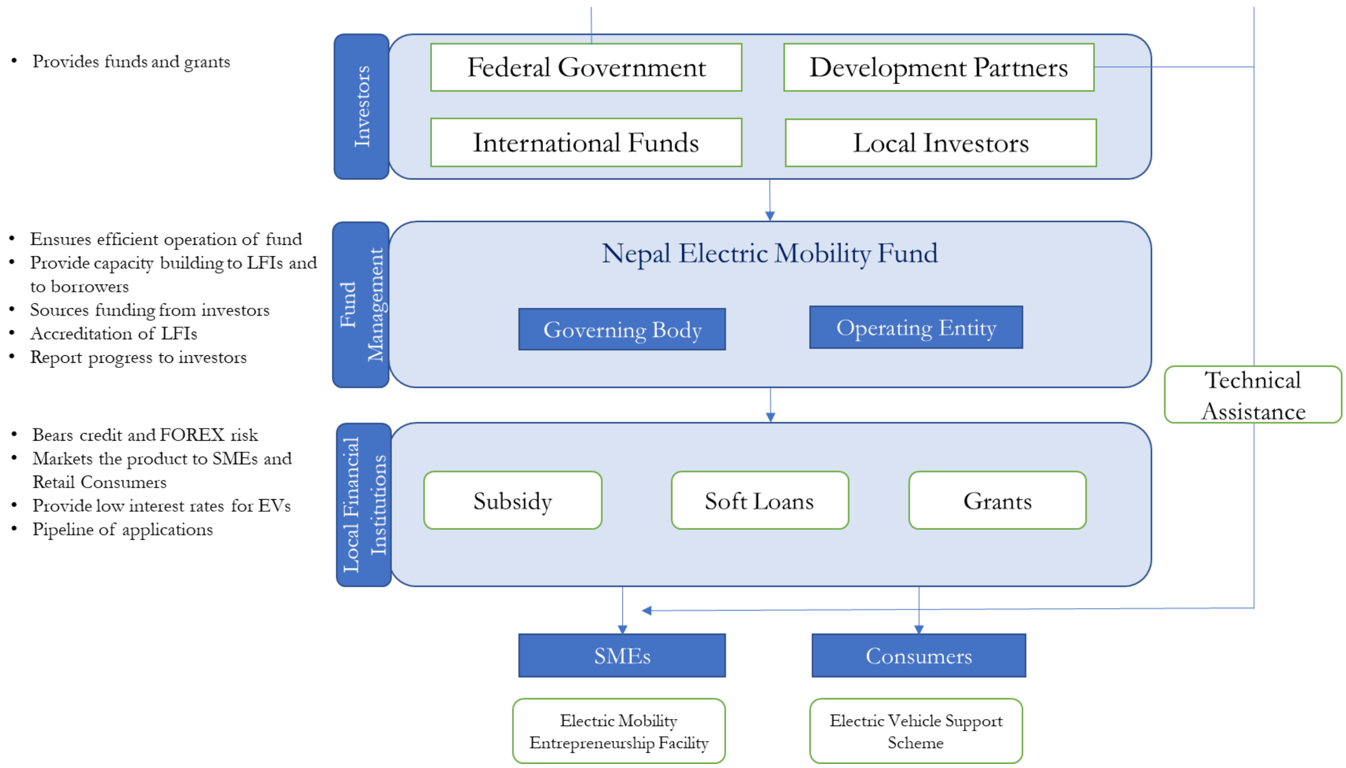


Table 4.7 Nepal Electric Mobility Fund Capitalization Structure

#	Contribution	GCF	GoN	LFI	TOTAL
1	Loan financing	20	10	10	**40.0**
2	Grant	5			**5.0**
	TOTAL	**25.0**	**10.0**	**10.0**	**45.0**

4. Scalability and Replicability

The SME and consumer financing facility will be a channel to invest in the Electric Mobility sector within the country. A seed fund will be established at the initial stages to initiate projects. This fund will cater small and medium enterprises working in the electric mobility sector in Nepal. The fund will have positive effects in not only encouraging enthusiastic private sector participants to initiate projects but will also incentivize other private and public sector players to take up electric mobility projects.

Success of this fund can pave way for investments in the “green growth” sector. If increasing investment appetite is observed, this funding modality can be easily replicated to fund sustainable economic development activities in other sectors.

5. Main Partners

- Consortium of Financial Institutions: Operation of the fund
- Nepal Rastra Bank: Develop regulatory policies
- Ministry of Finance: Develop regulatory policies
- Ministry of Physical Infrastructure and Transport: Play an advisory role

Ministry of Finance will be the key counterpart for this project.

6. Timeline

Concept

- MOUs and letters of intent signed
- Initial fund design agreed with key stakeholders
- Preliminary discussions with financiers

Design

- Data gathering and surveys conducted
- Market assessment conducted
- Assess feasibility
- Model business/service design
- Review and development of design by key partners

Financing

- Fine tuning of business/service model for financial performance
- Letters of committment obtained

5. Conclusion and Recommendations

This report outlines six investment projects for electric mobility, each delivering financial, environmental and social benefits. The report also proposes a dedicated facility to support broader adoption of electric vehicles by private consumers, and investment in electric mobility by small- and medium-sized enterprises. As such, the projects documented in this report support implementation of the Government of Nepal's *National Action Plan for Electric Mobility*, and the *Nationally Determined Contribution*. In particular, the action plan proposed the establishment of a national program focused on investing in markets and infrastructure (Priority Action 2) and the establishment of a national financing vehicle for electric mobility (Priority 3).

More generally, these projects deliver clean public and private transport, foster the electric mobility market, introduce new commercially-viable clean transport technologies, develop sustainable infrastructure and mobilize financing for transport sector programs. These projects contribute the development on an inclusive transport sector. Such a sector promotes equal opportunities in employment, education and services. Seeking these opportunities in transport related investments is an important entry point to the implementation of Nepal's priorities for gender equality, poverty reduction and social inclusion. In addition, through carefully crafted transport sector projects, opportunities for equal employment and capacity development can be optimized.

In this way, the transport sector contributes towards closing the gender gap in Nepal's economy, which has the potential to add millions to the country's economy. Looking forward to the active funding and implementation of selected projects, the following concluding thoughts are offered:

<u>Overall Investment Performance</u>

- **Attractive internal rates of return can be achieved in the sector** – While the high capital requirement of many projects, though not all, presents a challenge, rates of return are generally favorable. In part, this is linked to the lower operational costs of electric vehicles, compared to conventional fossil fueled vehicles. The lowest IRR, 5.2%, was achieved for the fleet of mid-size electric buses. However, excluding this project's IRR, IRRs for all other projects are double-digit, ranging from 10.1-20.3%, with a simple average IRR of 14.9% across the projects.

- **Beyond financial performance, projects offer social and environmental benefits –** All projects promote clean transport and use clean energy. This reduces greenhouse gas emissions, reduces environmental pollution, improves health and air quality in cities, and delivers improved livelihoods to key stakeholders, such as taxi drivers. Projects also benefit commuters and the public more broadly, through the provision of higher quality transport services to access jobs, schools, clinics and other services, and supports economic development.

- **Capacity building and careful project management are required to execute on these investment opportunities –** To successfully deliver projects, the capacity of stakeholders will need to be built. Regulatory, financial, social and operational risks in Nepal will need to be carefully managed, and project execution carefully controlled. For this, an integrated approach would be most appropriate, where be entrepreneurs, investors, beneficiaries and government are all integrated into the project design and delivery process.

Designing an Ecosystem

- **Strategic and coordinated efforts to design an electric mobility ecosystem in Nepal's largest urban area, Kathmandu Valley, is needed –** Kathmandu Valley is comprised of several metropolitan cities and municipalities, and is Nepal's largest urban area by population, service density, and GDP. With such a range of players, a strategy to coordinate efforts across the valley to design and build a valley-wide electric mobility ecosystem is needed. Above all, the three metropolitan cities of Kathmandu, Lalitpur and Bhaktapur may seek a coordinated approach to this to leverage economies of scale, and ensure effective design, delivery and management.

- **The ecosystem needs to complement and enhance national transport plans, through multi-modal complementarity** – Some of the most successful cities deploy several, complementary transport services. This also builds urban resilience by introducing a degree of redundancy to transport systems. In the case of Nepal, an electric mobility ecosystem needs to complement national transport masterplans, support national transport policy and deliver on municipal service obligations. A coordinate strategy for electric mobility systems in Kathmandu Valley, for example, should align and supplement other modes of transport under development or already active.

- **Increased spending to establish charging stations is essential for activating the local market-** Government ownership of infrastructure is critical in increasing adoption of electric vehicle technologies and bridging gaps in infrastructure development for electric mobility, as explored in project concept "Upscaling and Monetizing Public Access Charging Stations". Under this project, a partnership between the utility and a major retail outlet, such as Bhatbhateni, can yield a return of 12.65%, when a preferential tariff of NPR 6.48/unit[135] (USD 0.06) is levied. Such a model can be replicated around Kathmandu and outside to increase access to charging infrastructure.

- **Improving public transport services requires not just infrastructure, but technologies that aid in optimizing use of existing services and components -** Establishing battery swap stations are viable options for existing '*safa tempo*' charging stations, with a return of around 10%. In addition, cost optimization technology has been introduced in the project "Converting Fossil Fuel taxis to Hybrid Electric Taxis". Over the 10-year life, this project aims to convert the existing fleet of 10,000 taxis within Kathmandu to hybrid electric at a return of around 15%. As these projects indicate, while it's also important to propose new solutions, new systems and new technologies, it's also important to look at ways to optimize and improve existing transport systems

Financing an Ecosystem

- **A blend of local private capital, government investment, and international climate financing will yield substantial progress –** To implement proposed projects, blended financing may be pursued. While the smaller projects can be financed through local banks and entrepreneurs, to finance larger projects international climate finance is likely to be needed. To support both private and climate financing, the government can play an important role in reducing the risk of investment projects through subsidy, incentive or guarantee. A strategy of blended finance, whereby both public and private sources invest, is likely to be most effective. The project "Deploying Electric Trolley Bus System in the Kathmandu Valley", is an example - the government would finance and own the infrastructure, and the private sector would finance and own the vehicles.

- **Financing tools employed by government and local financial entities have the potential to enhance project viability -** Some of the projects, such as deployment of a fleet of mid-sized electric buses, do not have high commercial viability in terms of return (5.17%), but are attractive to government agencies and transport cooperatives, which factor social, environmental and economic return and benefit into their decision and investment making process.[136]

[135] NEA's existing preferential tariff rate to "safa tempos"

[136] For more information on monetized social, environmental and economic benefits, please refer to the pre-feasibility study on Deploying Electric Buses in the Kathmandu Valley.

Furthermore, incentives such as subsidies, lease to own models, better debt financing terms, blending grant with debt financing or municipal bond models can be further explored to make projects like these more attractive to the private sector.

- **Establishment of a facility helps to bridge the financing gap for private companies and individual consumers** – Loans and grants administered through local financial institutions can effectively stimulate private, corporate and public entities to invest in electric mobility technologies. In addition, although the Nepal Rastra Bank (central bank) already has provisions of high loan-to-value ratio for electric vehicles purchased by individual consumers. Building new financing tools for various entities will be critical for wider adoption of electric vehicles and growth and innovation in the market.

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Annex 1. Summary of Electric Vehicle Technology

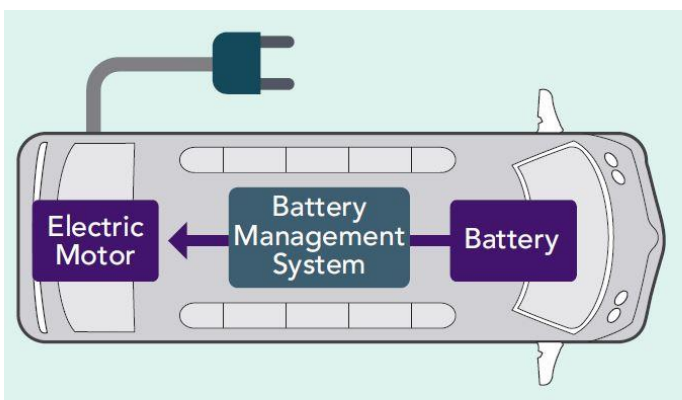
Introduction

Conventional road transport vehicles are powered by burning fossil fuels, namely gasoline or diesel, in internal combustion engines (ICE) whereas pure electric vehicles (EVs) are powered by electricity and propelled by traction motors.

The first patent for an electric motor was granted to Thomas Davenport in 1837. Since then electric motors have evolved significantly and are in use for propulsion in locomotives, surface and underwater vessels, inter-planetary vehicles, unmanned aerial vehicles and road transport electric vehicles. EVs can get electric energy from on-board sources (e.g. battery, fuel cell, ultra-capacitor etc.), from electricity generator connected to ICE, and from off-vehicle energy sources such as overhead lines or underground wireless energy transfer systems. Vehicles with two energy sources, primarily ICE and battery, are called hybrid electric vehicles (HEV).

What is a Battery Electric Vehicle?

Battery electric vehicles (BEV), also known as fully electric vehicles, have an electric propulsion system, which consists of a battery and an electric motor connected to the driveshaft. Electricity from a source such as a chemical battery, ultra-capacitor or fuel cell, is used to energize the electric motor in an electric vehicle.



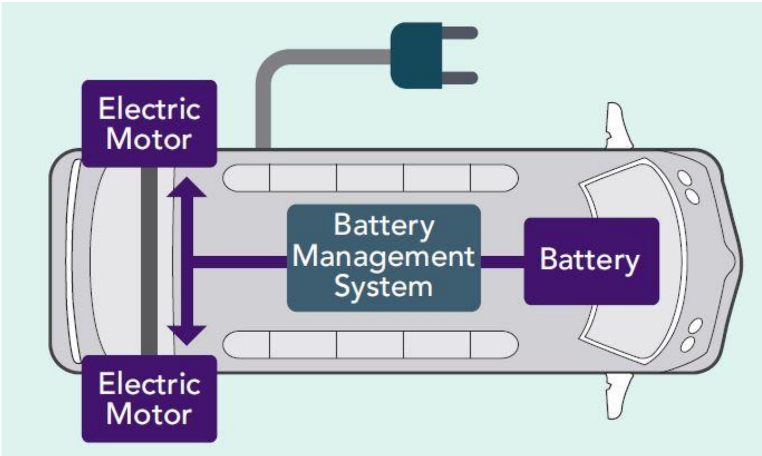
Source: GGGI, 2015[137]

Figure A-1. Electric Vehicle with Basic Elements in Front/Rear Configuration

[137] Global Green Growth Institute. 2015. Deployment of Electric Buses in Himachal Pradesh

The traction motor is connected to a gear-train that transfers motor power to drive wheels. The motor is controlled electronically through a battery management system to generate the required torque and power for vehicle motion, maintain stable electric current, and optimize battery operation for battery life and safety.

There are two popular configurations for connecting motor power to wheels, namely a) connecting the motor to a differential and transferring power to both wheels from a single motor, as shown in Figure A-1 having in-wheel motors to drive the vehicle, as shown in Figure A-2.



Source: GGGI, 2015[138]

Figure A-2 Electric Vehicle with Basic Elements for an In-Wheel Mounted Motor Configuration

There are competing technologies in electric vehicles for traction, energy storage and overall technology implementation. Currently, most commercially available electric vehicles use onboard chemical batteries as the source of electricity for operation.

Major Components of BEV

Battery electric vehicles use chemical battery as a source for electricity. Major components of a BEV that differ from a conventional internal combustion engine (ICE) are:

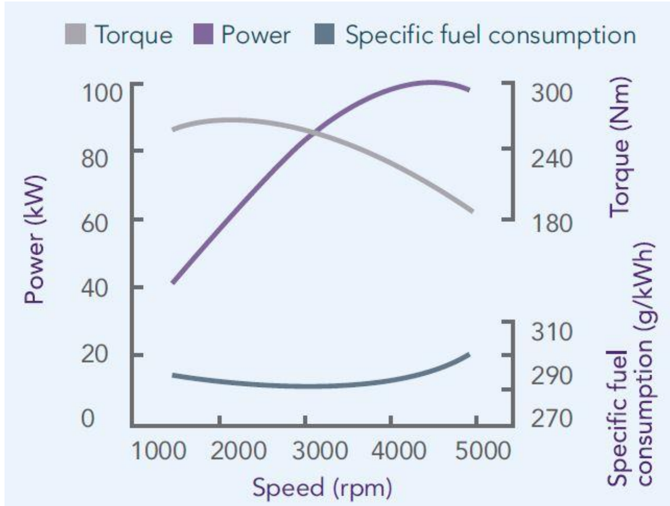
- Traction source – electric motor
- Energy source - battery
- Battery charging station
- Battery management system for safe and optimal use of batteries

Each of these three components will be explored in turn below.

2.3.1 Traction Source

The ideal vehicle propulsion source provides constant power to the driveline throughout its operating range. Vehicles starting from rest require a high starting torque to overcome the inertia of rest. The vehicle overcomes resistance due to gradient, rolling and wind to achieve a steady drive speed.

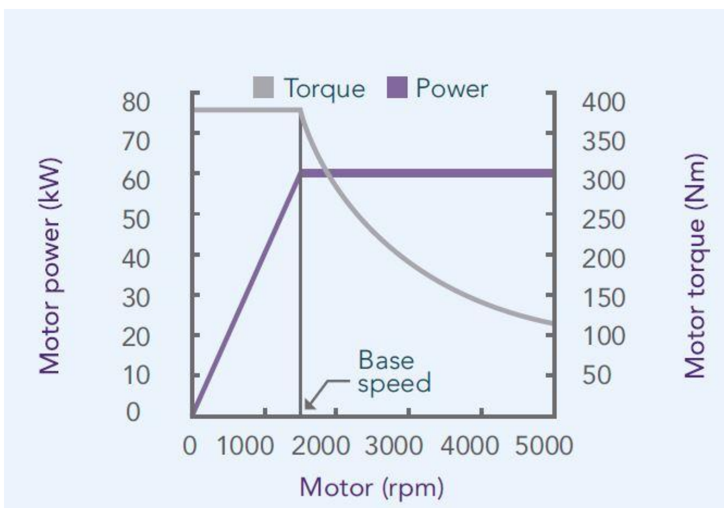
[138] Global Green Growth Institute. 2015. Deployment of Electric Buses in Himachal Pradesh



Source: Mehrdad et al.[139]

Figure A-3 Typical Characteristics of an ICE

In Figure A-3, variation of power output, torque output, and specific fuel consumption with respect to engine speed is plotted for an ICE. As can be inferred from this figure, the power output from an ICE increases with increasing engine speed, reaches a maximum and then drops very quickly. The torque from an ICE increases with engine speed, reaches a maximum value and then decreases with increasing engine speed.



Source: Mehrdad et al.

Figure A-4 Typical Characteristics of an Electric Motor

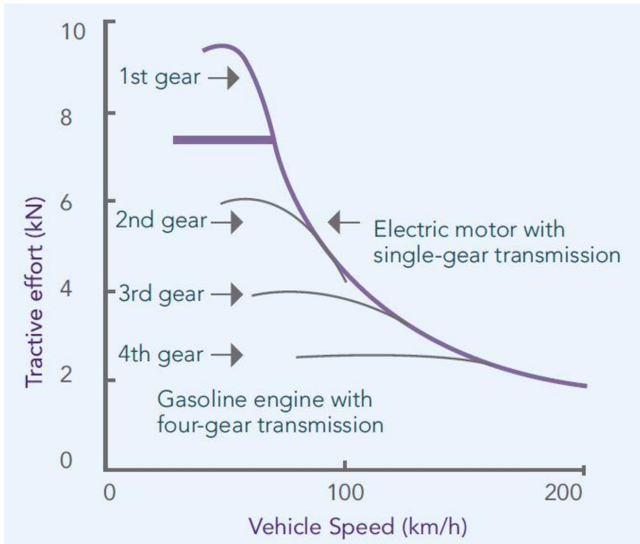
In Figure A-.4, variation of power output and torque output with respect to engine speed is plotted for an electric motor. As can be inferred from this figure, the power output from an electric motor increases with increasing motor speed, reaches a maximum and remains constant after that. The speed at which it attains peak power is called the 'base speed' of the motor. An electric motor starts with the maximum torque which stays at that level for most of its operating range.

Power Band: The power band of an engine or electric motor refers to the range of operating speeds under which the engine or motor is able to operate efficiently. It is defined by the engine speed range from peak torque to peak power. ICEs

[139] Mehrdad Ehsani et al., Modern electric, hybrid and fuel cell vehicles, fundamentals, theory and design.

have a large range of operating speeds but the power band is a much smaller range of engine speed. Conversely, electric motors produce constant torque for most of their operating speed.

An ICE has a lower operating efficiency in low gear than in high gear. Thus, on hilly terrain, ICE buses driving in low gear give poor fuel economy.



Source: Mehrdad et al.[140]

Figure A-5 Tractive Effort from Manual 4-Gear Transmission ICE and 1-Gear Transmission Electric Motor

The torque speed characteristics of an ICE do not match the desired ideal characteristics of a propulsion system. As a result, a gear box is added. As plotted in Figure 3.3, a mechanical transmission with different gear ratios is employed to achieve desired tractive effort over the full range of vehicle speeds. For an electric motor, a single gear transmission allows for desired tractive effort over the full range of vehicle speeds.

A vehicle overcomes different types of external resistance to achieve motion. Such resistances include gradient, rolling, wind, and grade resistance, which is a function of the weight of the vehicle and the gradient of the road. For a given vehicle, grade resistance increases with an increase in gradient. The maximum gradient a vehicle can traverse at a speed is referred to as the vehicle's gradeability. Also, the maximum gradient a vehicle can traverse starting from a stop condition is referred to as the vehicles stop-start gradeability. Rolling resistance is an experimentally determined value and is a property of the vehicle wheels and road condition. Wind resistance is dependent on vehicle velocity and vehicle body profile.

For a hilly area, vehicle wheels and road conditions remain similar and wind resistance is low at slow speeds. Grade resistance becomes the dominant resistance to motion of the vehicle. ICE and EV handle gradient differently – an electric motor can achieve the required tractive effort with a single gear reduction. Conversely, an ICE operates in low gear and at high engine speed to achieve the same level of tractive effort. An ICE operating at a lower gear ratio gives poor fuel efficiency whereas an EV can overcome similar gradients without much loss of efficiency.

Given the above review, a suitably sized electric motor in an electric vehicle can:

- Provide high torque at low speeds
- Effectively handle gradients and provide better fuel economy that ICE
- Match the performance of ICE vehicles on tractive effort parameters

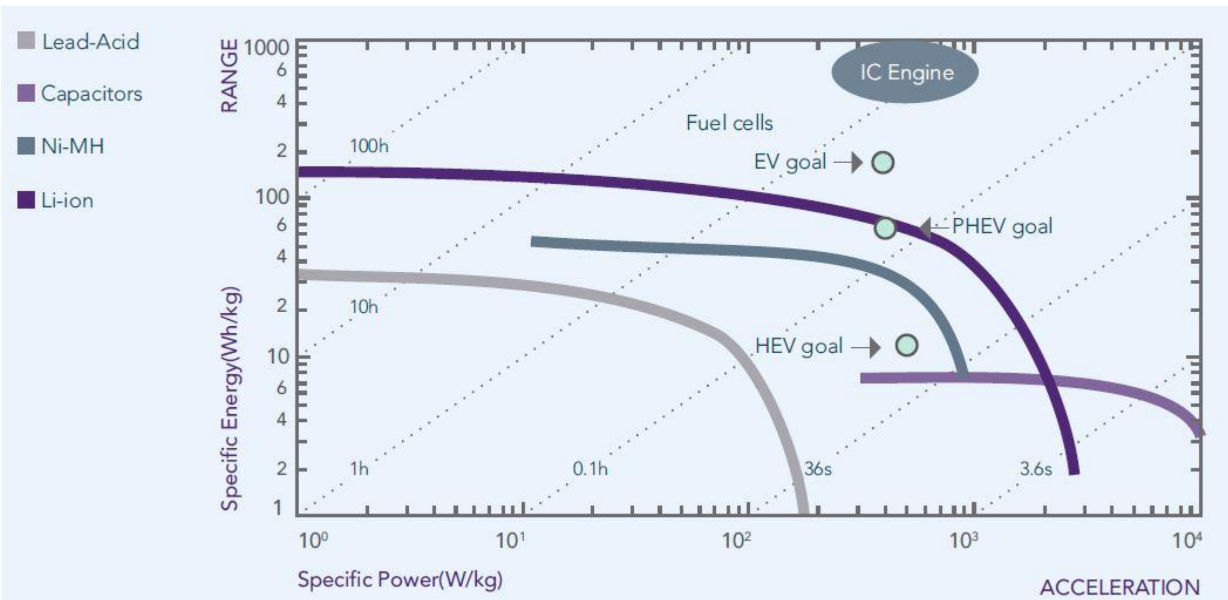
[140] Mehrdad Ehsani et al., Modern electric, hybrid and fuel cell vehicles, fundamentals, theory and design.

2.3.2 Battery Technology

The source of energy in a battery EV is onboard battery packs which store energy as electrochemical potential. These battery packs are charged through dedicated electric charging stations. Different battery technologies have evolved over time as shown in Figure 3.4. Currently, lithium ion batteries are most suitable for EV applications due to the capacity of these batteries to provide high specific energy and high specific power.

Classes of rechargeable battery that have been used for EV applications are as follows:

- Nickel-based aqueous batteries – viable but unsuitable
- Lithium ion batteries – most viable option
- Lead acid batteries – unsuitable for electric bus operations



Source: European Rare Earth Recycling Network, 2014[141]

Figure A-6. Specific Energy and Specific Power for Different Battery Types

Nickel-based aqueous battery

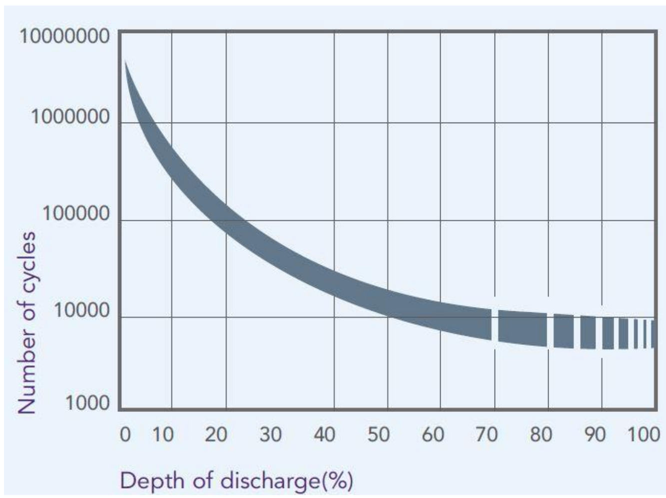
These batteries are mainly nickel cadmium (Ni-Cd), nickel zinc (Ni-Zn) and nickel metal hydride (Ni-MH). The cathode in all these variants is nickel hydroxide, with potassium hydroxide as the electrolyte. The anode is different in each of the above systems, being either cadmium, zinc or a complex metal alloy (a mix of rare earths, nickel, zirconium and aluminum etc.) respectively. Although Ni-Cd were an upgrade from lead acid batteries, the Ni-Cd is being phased out world over due to the toxicity of cadmium. Of these variants, the Ni-MH battery performs better than the Ni-Cd battery in terms of higher specific energy, longer life, higher discharge rate, and greater environment friendliness. However, the Ni-MH battery shows poor performance when operating below freezing, has a low shelf life and has a high self-discharge rate when not in service. On the other hand, the Ni-Zn battery displays good performance in terms of cell voltage, charge storage capacity and high rate discharge capability but suffers from growth of dendrites on the zinc anode during cycling causing internal short circuits and material (storage capacity) loss over time.

Lithium ion battery

[141] European Rare Earth (Magnet) Recycling Network. 2014. Rare earths in energy storage and conversion (2014). http://erean.eu/wordpress/2014/10/

The lithium ion battery displays high cell voltage, reliable high discharge rate, and good cycle-life. It has a cathode, which is a compound of lithium and transition metal oxides (or phosphates), an anode, which is mostly carbon-based, and electrolyte made up of organic solvents with lithium salts. Cell voltage is dependent upon the cathode chemistry, which can be increased using cathode materials with higher voltage.

There are newer high voltage candidate cathode materials but due to electrolyte stability issues beyond 4.8 V, the favorable chemistry of these cathodes remains under-exploited. Discovery of high-voltage-compatible electrolyte materials is crucial. However, new safer cathode chemistries have to be optimized as high inherent oxygen partial pressure in the popular oxide based cathodes can result in explosions. This issue was highlighted in recent battery related fire incidents in Chevy Volt electric car and Dreamliner aircraft. At present, phosphate-based cathode chemistries (e.g. lithium iron phosphate cathode) are preferred over oxide-based alternatives due to higher safety features despite having lower operating voltage.



Source: Saft, 2014[142]

Figure A-7. Life of Li-ion Battery Measured Against Depth of Discharge.

The high cost of cathodes is due to the presence of lithium. In many battery technologies, the anode is the less expensive component. The electrolyte is a mixture of organic solvents like ethylene carbonate or dimethyl carbonate, and contain dissolved salts of lithium (e.g., $LiPF_6$). The major challenges of the lithium ion battery are lower safety and high cost.

Depth of discharge is a measure of the utilization of a battery against the maximum charge it can hold. As seen in Figure 2.7, an increase in the depth of discharge exponentially reduces the number of charge cycles a battery can serve. Even at 90 % depth of discharge a lithium ion battery can last for more than 3000 charge cycles, which is equivalent to nine years of active life (assuming vehicle operating for 333 days in a year on daily charge).

Lead acid batteries

There are two types of Lead acid batteries: sealed lead-acid (SLA) and flooded lead-acid (FLA) batteries. The FLA batteries have been the most commonly used EV batteries as it has a long life (up to four years) and provides the least cost amp-hour among all the available batteries. Unlike the FLA, in the SLA, the electrolyte is held either in mats of glass fibers or in gel form. However, these are more resistant to damage from physical shocks than the FLAs. SLAs are maintenance free but once its electrolytes leak out, there is no way to fix it.

142 Saft. (2014). Litium Battery Life; Solar photovoltaic (PV) - Energy Storage Syatems (Ess). Saft. http://www.saftbatteries.com/system/files_force/li_ion_battery_life__ TechnicalSheet_en_0514_Protected.pdf

The FLAs survive in high temperature, whereas with the SLA batteries, high temperatures cause a loss in electrolyte that decreases efficiency of the batteries. However, one major drawback of the FLA batteries is that it produces hydrogen gas, which can be flammable in high concentrations. Thus, it should be kept in a protective box with a duct that can release the hydrogen gas to the atmosphere (Home Power Inc., 2017).

Lead acid batteries are not suitable for electric bus operation due to following technology limitations:

- Low energy density
- Low charge cycles
- Environmental damage due to lead content

However, for smaller electric vehicles with low loads over small distances, lead acid batteries can be viable. In Kathmandu, sealed lead acid batteries are being used for three-wheeled EV, such as safa tempos and small electric rikshaws. Lead acid batteries also tend to be low cost.

2.3.3 Battery Charging Facilities

Infrastructure for battery charging is essential for a sustainable EV fleet. In order to charge, the batteries of plug-in EVs require a physical connection with electric vehicle supply equipment at the charging station.

There are two principal methods of charging batteries:

- ***Conductive charging*** - Conductive charging requires a physical connection between the EV and EVSE at the charging station. This technology has been historically the most popular option for accessing grid electricity for various charging applications. The automotive standard voltage plugs and sockets interface between the distribution lines and the on-board sockets. All battery systems currently use the conductive charging technology.
- ***Inductive or contactless charging*** - Major approaches to transfer energy to on-board batteries has been through direct electrical contact but innovators have experimented with wireless charging to remove the hassle of connecting high potential electric points. This is a relatively new technology that has emerged in recent years. Inductive charging uses an electromagnetic field to enable the exchange of energy between the EV and the charging station. In this method, no physical contact is needed between the energy source and the vehicle. Inductive charging works by using an induction coil placed within a charging station to create an electromagnetic field. A second induction coil, placed on the EV, takes power from the electromagnetic field and converts it into an electrical current that is used to charge the on-board battery. The advantages of such wireless charging systems include safety (no exposed conducting surfaces, hence no electric shock), no cable needs, high reliability, low maintenance (automatic, minimum intervention required), reduced risk of theft and long product life due to less wear and tear.

The time taken to charge a battery is an important issue for the larger adoption of EVs and is a crucial factor in making decisions regarding charging methods as well as EV route selection. Charging time depends on the charging methodology and also on the battery type, storage capacity and size. Opting for a reduced charging time increases costs due to several associated factors like usage of more expensive battery variants that are made up of materials having higher charge storing capacity, and more efficient and sophisticated charging techniques. As a result, the method of charging should be decided by considering the application needs after doing a thorough techno-economic analysis. The advantages and disadvantages of different charging types are presented in Table A-1 below.

Table A-1 Types of charging facilities

Type of Charging	Charging* Time	Advantages	Disadvantages	Market Segment
Onboard AC to DC charger - Slow (220 V, 13 A)	24 h	Easy to implement	Slow	Private cars, two-wheeler
AC to DC via special extra converter and DC charging of onboard batteries - Fast (220 V, 32 A)	12 h	Moderate, flexibility of a single phase or three phases	More investment	Public cars, public buses

Rapid (50 kW+)	90 min	Fast	Restricted to three phases, high cost, loading issue, low efficiency	Public buses, public cars
Battery swapping	2–5 min	Very fast	Cost of battery, space requirement at EVCPs, robotics	Public buses

Source: GGGI, 2015[143]
*Estimated

2.3.4 Battery Management System

A battery functions optimally within certain operating windows of temperature, voltage, structural changes (during charge - discharge) and other parameters. In order to ensure optimal functionality, EV use a battery management systems (BMS).

A BMS contains sensors and controllers. Sensors measure operating parameters like temperature, current and voltage in the circuit to help manage the cells within the optimum windows – for lithium ion batteries, for example, optimal charging temperature is between 0 C to 45 C and optimal discharging temperature is between -20 C to 55 C). This in turn assists in managing the depth of discharge, prevents cell voltage from falling below the tolerance limit, and prevents over charging of cells which can lead to a fire or explosion. A BMS monitors the temperature at various locations within the cells and also outside each cell and module to prevent any decomposition of the electrode and electrolyte. In addition, a BMS includes an embedded software network which estimates and manages battery state of charge, provides an onboard diagnosis, and manages battery safety control, battery operating parameters, battery equalization (i.e. consistency between all cells within a module), information storage and thermal management.

Comparison of Diesel, Hybrid Electric and Full Electric Buses

Diesel, hybrid electric and electric buses all perform differently, and an understanding of these comparative differences is useful. Such a comparison is summarized in Table A-2 below, and includes a range of factors.

Overall, the greatest hurdle to increased uptake of EV is their higher price tag when compared to ICE vehicles. This is mainly attributed to battery costs, the complex design of powertrain systems and nascent technology. Since an HE bus is powered by an ICE, as well as a battery with an electric motor, the HE models cost the most among the three bus segments under discussion.

The number of moving parts in a full electric bus is less than in a diesel bus. On the other hand, HE buses have more moving parts, making their design the most complicated amongst the three vehicle types. Therefore, diesel and HE buses have higher maintenance requirements as compared with those of BE buses. The types of maintenance in diesel buses include frequent oil changes, filter replacements, periodic tune ups, exhaust system repairs, water pump, fuel pump and alternator replacements, etc. The maintenance requirement for HE buses can be similar, or higher, than those of diesel buses.

Battery electric buses have controllers and chargers, which manage the power and stored energy levels in the battery. These are electronic devices without any moving parts, and, hence, they require little or no maintenance. The lithium -ion batteries that are used in electric buses require minimal maintenance. Battery replacement is one type of maintenance, which may need to be undertaken every several years. However, continual technological advancement aims to make batteries co-terminus with the service life of a bus.

143 Global Green Growth Institute, 2015. Electric Buses in India: Technology, Policy and Benefits

Battery charging, which is similar to refuelling, is not considered maintenance work, even though it contributes to significant downtime in bus operations. In developed electricity markets, due to a Time of Usage (ToU) tariff policy, off-peak charging allows the application of lowest utility rates, leading to significant operating cost advantages. In this way, the total cost of operating a BE bus is less than an ICE bus due to lower maintenance, cheap power and high fuel efficiency. However, BE buses are more expensive to acquire initially, a result of a higher price tag on the bus itself, and the need to install charging facilities.

Diesel hybrid buses, typically demonstrate 7-44% better fuel economy than diesel buses at slow and medium speeds. However, the fuel economy for the hybrid bus is reported to be the same, or lower, than the diesel bus at high speeds. The majority of city transport buses (90%) operate at slow or medium speeds.

The external features of the battery electric bus design are similar to those of an ICE bus. The main difference is that BE buses do not have tail pipe emissions. However, the internal design of the components is moderately different among ICE buses, HE buses and battery electric buses. According to California's Advanced Transportation Consortium, up to 70% of the components of an electric bus can be different from those of an ICE bus. Diesel and hybrid electric buses have a distinct feature; both have a fuel tank, which is absent in BE buses. Diesel buses have only one energy source, ICE, which uses diesel fuel. A HE bus contains both an ICE and a battery pack with an electric motor.

Table A-2. General Comparison of Three Segments of Buses

Parameters	BE Bus	HE Bus	Diesel Bus
Power source	Electricity	Electricity and diesel	Diesel
Power generator	Battery	ICE and battery	ICE
Costs (NPR)	>1.5-3.5 crores[144]	>4.8 crores[145]	0.32–1.41 crores[146]
Fuel efficiency	1.12 kWh/km[147]	2.75–4 km/L[148]	2.2–3.3 km/L[149]
Fuel tariff	4.69 NPR/kWh[150]	77.5 NPR/L[151]	77.5 NPR/L
Fuel cost [152]	NPR 3.12/km	NPR 19–28/km	NPR 23–35/km
Emissions	Zero (local)	Low (less CO_2, SO_x, NO_x and NMHC)	High (baseline)
Noise	Minimum (at slow speeds)	Low (at slow speeds)	High (baseline)

144 Global Green Growth Institute. 2014. "Green Growth Strategy for Karnataka." Case Studies. http://gggi.org/wp-content/uploads/2014/12/Karnataka-GG-Case-Studies_FINAL_Web-Version.pdf.

145 Noel, Lance, and Regina McCormack. 2014. "A Cost Benefit Analysis of a V2G-Capable Electric School Bus Compared to a Traditional Diesel School Bus." Applied Energy. http://www.udel.edu/V2G/resources/V2G-Cost-Benefit-Analysis-Noel-McCormack-Applied-Energy-As-Accepted.pdf.

146 Adapted from a range of global studies exploring fuel efficiency of battery electric buses. Also see Global Green Growth Institute. 2014. "Green Growth Strategy for Karnataka." Case Studies. http://gggi.org/wp-content/uploads/2014/12/Karnataka-GG-Case-Studies_FINAL_Web-Version.pdf.; Truckaurbus.com. 2015. "Tata Starbus 32 AC (BS4), ₹ 20,19,000." August 23. http://www.truckaurbus.com/new-cv/tata/starbus/tata-starbus-32-ac-bs4-8377-20-19-000-l1232.html.

147 Global Green Growth Institute. 2014. "Green Growth Strategy for Karnataka." Case Studies. http://gggi.org/wp-content/uploads/2014/12/Karnataka-GG-Case-Studies_FINAL_Web-Version.pdf.

148 M.J. Bradley & Associates LLC. n.d. "Comparison of Modern CNG, Diesel and Diesel Hybrid-Electric Transit Buses: Efficiency & Environmental Performance." http://mjbradley.com/sites/default/files/CNG%20Diesel%20Hybrid%20Comparison%20FINAL%2005nov13.pdf.

149 Global Green Growth Institute. 2014. "Green Growth Strategy for Karnataka." Case Studies. http://gggi.org/wp-content/uploads/2014/12/Karnataka-GG-Case-Studies_FINAL_Web-Version.pdf.

150 Nepal Electricity Authority. 2016. Annual Report.

151 Nepal Oil Corporation. 2017. Oil prices.

152 Fuel cost per km is calculated using fuel efficiency and fuel tariff.

Secondary benefits	High	Moderate	Low
Maintenance	Lowest	High	High
Components	EV propulsion system, transmission, battery charging system, power accessories, body	ICE propulsion system, EV propulsion system, transmission, battery charging, power accessories, body	ICE propulsion system, transmission, power accessories, body

Source: GGGI, 2015[153]

[153] Global Green Growth Institute, 2015. Electric Buses in India: Technology, Policy and Benefits

Annex 2. Summary of financial analyses of all project ideas

I. Deploying a Midsize Electric Bus Fleet in Kathmandu Valley

Assumptions

Project Term	16 years
Location	Kathmandu, Nepal
Type of Bus	K7
Number of Buses	50 units
Investment Size	USD 10.99 million

The buses are expected to be operated in the city of Kathmandu in Nepal. The bus model shall be BYD K7 based on the result of the pre-feasibility studies conducted by GGGI early this year. The project term is assumed to be 16 years due to assumption that the battery will be replaced in year 9 and will have another 8 years of life. The cost of each electric bus is estimated to be NPR 23 Million per unit, the analysis assumed that the quoted price will reflect one-year declining battery cost which resulted to NPR 19,455,700 per unit and estimated to be USD 9.39M for 50 units of buses. There will be 50 charging station which will cost a total of USD 0.943 million and a one-time business registration fee of USD 0.657 million. Overall, the total investment cost is USD10.99 million.

Operational Assumptions

The buses are expected to run 350 days in a year with 5 trips a day. Each trip is expected to have 27 kilometers route. According to Sajha Yatayat they expect 12,000 passengers per bus per year. The average bus fare is NPR25 per passenger based on current prices. The bus fare only raised its price by 3% in a span of 5 years and hasn't changed since then. The financial analysis assumed that the annual revenue for the whole bus fleet of 50 units shall be USD 1,737,452 with 3% increase every 5 years.

Route length	27 kilometers
Annual operation days	350 days
Average daily trips per bus	5 trips
Average monthly passengers per bus	12,000 passengers
Current average bus fare	USD 0.24 (NPR 25)
Annual revenue	USD 1,737,452 (NPR 180,000,000)
Annual O&M	USD 296,771
Annual salary	USD 197,635
Battery replacement cost	USD 597,508 per unit

The annual O&M is estimated to be USD296,771 based on the pre-feasibility report which is 37.27% of ICE bus O&M cost. This O&M cost includes the electricity consumption of the electric bus. No escalation was used since the cost estimated in the ICE bus includes the whole life cost that should include oil price fluctuations. Another large portion of the cost is the employee salaries. The analysis assumed that each bus will have two employees with 5 repair men. The minimum wage in Kathmandu is currently at NPR 13,450, the monthly salary assumed is NPR 15,000 with 1 month additional for the mandatory Dashain Bonus. The annual salary escalation is assumed to be 6%.

The battery life of the electric buses is expected to last up to 12 years. However, battery warranty only covers up to 8 years which means that there is a risk of replacement within the 2 years, therefore the analysis assumed that the battery replacement takes place on the 9th year and will give another 8-year life to the bus operations. The battery cost is expected to decrease by 23% annually reaching price parity on the 7th year.

Financing and Economic Assumptions

Leverage	85%
Term	7 years
Interest Rate	12%
Tax rate	20%
Depreciation	10 years
Hurdle rate	1%

The assumption of the financial analysis is based on existing market lending terms for car. Currently the banks allow 85% leverage with 7 years term to consumer lending. The interest rate is assumed to be 12% referenced on bank websites of 9% base rate with 3% spread. There is a possibility of getting a lower rate because Sajha Yatayat is a state-owned company which can have a preferential rate from banks however, the financial result does not seem to be very promising initially, so the assumption is to use existing rate to be conservative.

The tax rate used is 20% and depreciation of is 10 years. Public services usually provide very low returns due to its political and social impact. In this case, the model assumed a hurdle rate of 1%.

Financial Results and Analysis

Project level

Project NPV	3,812,217
PIRR	5.17%
Equity NPV	857,830
EIRR	2.36%

The financial result yielded a positive NPV for both project and equity sides. The project IRR was 5.17%, a little higher than the equity IRR of 2.36%. lower equity IRR means that the financing mix is not optimal and the cost of money on the debt side is very expensive. This means that the solution is lowering the debt financing either by getting lower interest rate and prolonging the tenure of the loan.

The cashflow profile shows that the revenue was stable, and the O&M is gradually increasing with a spike on the 8th year due to battery replacement. Even if the NPV is positive, it can be seen that Sajha Yatayat will experience negative cashflows due to debt repayment which consist of both interest and principal. This means that Sajha Yatayat will be operating at a loss for 7 years before it can recover and will need to infuse additional capitalization every year up with a total amount of USD 3 million not including interest if these are funded by promissory notes. At this point, it is assumed that the losses will be carried out by the Government without cost. In this case there should be an operational financing solution that should be provided to help Sajha Yatayat to continue its operations and does not incur default from lenders that will greatly affect its credit rating and its potential to expand its operations in the future.

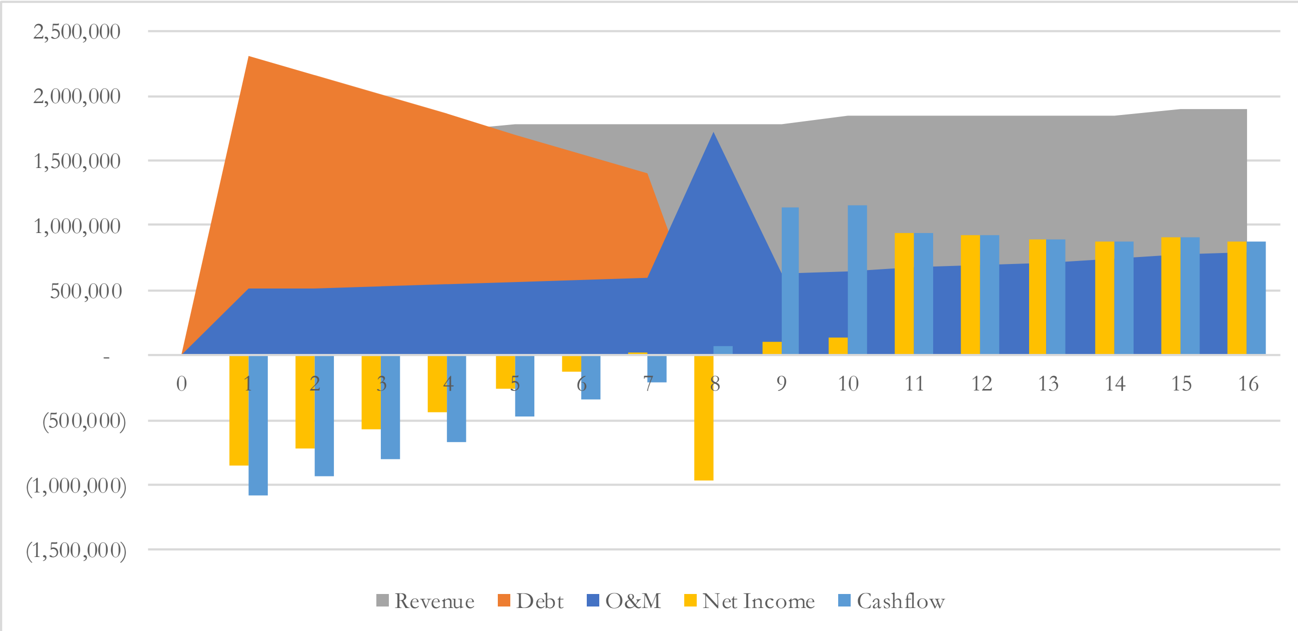


Figure B-1. Financial Profile

Comparative level

Total Economic Cost	16,629.29
Total Social Cost	18,757,893
Total Environmental Cost	5,342,283
Total Cost	40,729,461

As difficult it may seem and less attractive in terms of financial returns, investing into the electric mobility will give more benefits than the cost. The reduction of emissions in the city of Kathmandu will result into a total savings of USD 40.7 million: economic cost of USD 16.6 Million, social cost of USD 18.7 Million and USD 5.3 Million.

NPV	3,634,085
IRR	4%
NPV with non cash	41,099,777
IRR with non cash	23%

Due to this non-cash and indirect impact of the project, it shows that using electric bus will be more beneficial by 23% as compared to an ICE bus. Even without the other indirect costs, electric bus is still better by 4%.

Proposed solutions

Project NPV	4,527,758
PIRR	19.33%
Equity NPV	3,349,008
EIRR	11.66%

The first solution than can be proposed is the lease to own model option that is usually provided by the manufacturers of bus. As initially identified, the initial investment is very high which may be a big problem for Sajha Yatayat or any company that intends to buy electric buses. The 15% equity of the electric bus is already the full cost of an ICE bus.

The chart above shows that if leasing can be done, the operations can cover the annual cost of the installment. The initial payment of 10% can be loaned from the bank which will be equivalent to purchasing an ICE bus. There will also no negative cashflows except on year 8 which is the replacement year for the batteries. When leasing model is applied, the Project IRR increases significantly to 19.33% and 11.66% for Equity IRR.

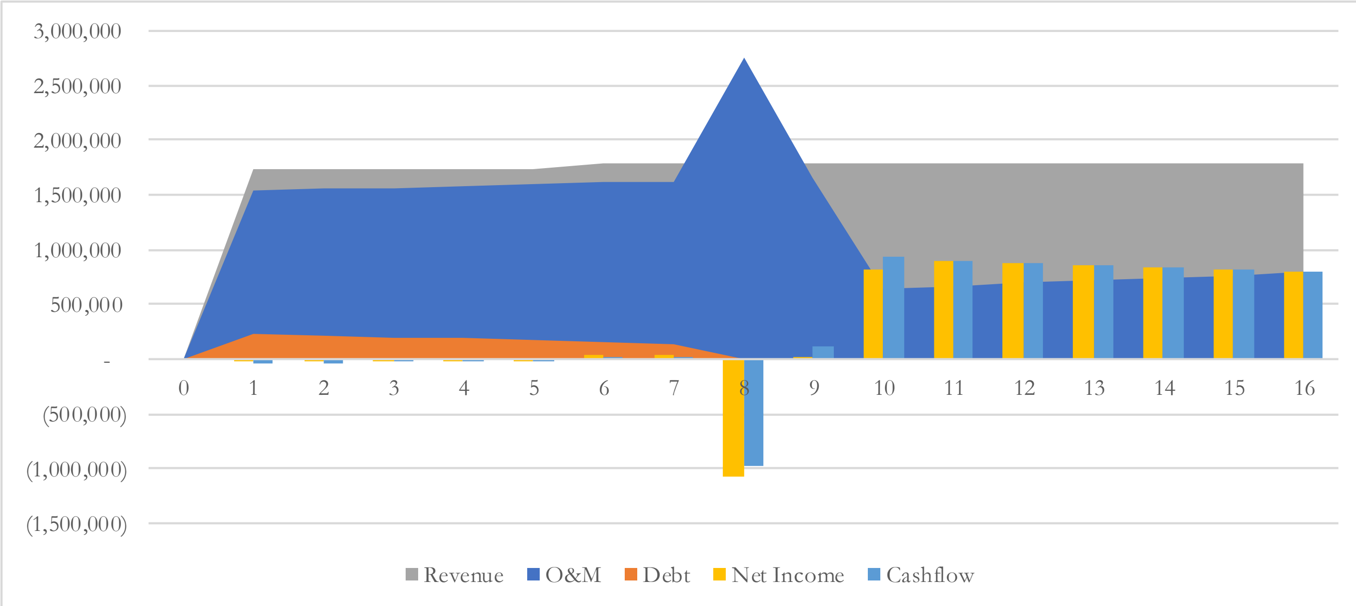


Figure B-2. Cashflow Profile

Conclusion

In summary, investing in electric buses might be unattractive with the current market and financially but its impact on saving throughout its life is very beneficial on the economy, society and environment. The indirect impact makes it significantly better in terms of return. Without the non-cashflow items it is still cheaper compared to an ICE bus throughout it asset life. In this case, to make it more attractive to private sector financially, we are gearing towards providing financing solutions which may include but is not limited to lease to own business model, better debt financing terms, blending grant with debt financing or municipal bond depending on the country viability and availability of resources.

II. Deploying an Electric Trolleybus System in the Kathmandu Valley

Assumptions

Project Term	20 years
Location	Kathmandu, Nepal
Number of Buses	64 units
Investment Size	USD 26.48 million

The trolley busses are expected to be operated in the city of Kathmandu in Nepal. The project term is expected to be 20 years because the supply of the electricity will be coming directly from the wiring system and therefore will make the busses' life longer. The deign expected a hybrid system to also have battery for sloping areas but these battery usages is not as intensive as the normal electric vehicle. Each vehicle is assumed to be NPR 15 million or USD 144,788 and there is a one-time business registration that is estimated to be NPR 67.2 million (USD 648,649). The total investment cost is USD9.92 million.

Operational Assumptions

The trolley busses are expected to be in operations 350 days in a year. All 64 units will be running a 55.8 kilometers route length 8 trips a day. According to the Winrock International and Cemat Consultants, 1999 report, the expected number of passengers every month are 2.3 million for the whole fleet. The fare used is the same as the one in the electric buses and the price escalation shall be the same to increase 3% every 5 years. The first-year revenue resulted to USD 6.67 million.

The electricity usage per km is assumed to be 2.20 kwh according to 2015 Engineering for Rural Development Report. The average peak electricity tariff in Nepal is NPR 11 per kwh according to the GGGI pre-feasibility study. The maintenance of the infrastructure is assumed to be 1% cross the project lifetime. The fleet is expected to have 158 staff with monthly salary of NPR 15,000 which resulted to an annual salary cost of USD 297,394 with 3 years escalation per year. The overall O&M cost is about USD 2.6 million for the first year. The battery replacement assumption was based on the electric buses data; however it may have a longer battery life due to less utilization of the battery. The leasing fee shall be paid to the government for the infrastructure is assumed to be USD 1,937,297 initially and will have 3% increase every 5 years.

Route length	55.8 kilometers
Annual operation days	350 days
Average daily trips per bus	8 trips
Average monthly passengers	2,304,000 passengers
Current average bus fare	USD 0.24 (NPR 25)
Electricity usage per km	2.20 kwh
Electricity tariff	NPR 11 per kwh
Annual O&M for infrastructure	1% of Infrastructure CAPEX
Average annual salary per staff	USD1,882 (NPR 195,000)
Annual Revenue	USD 6,671,815 (NPR 691,200,000)
Annual O&M	USD 2,338,727
Annual Lease	USD 1,937,297
Annual salary	USD 297,394
Battery replacement cost	USD 97,007 per unit

Financing and Economic Assumptions

Leverage	80%
Term	10 years
Interest Rate	12%
Tax rate	20%
Depreciation	10 years
Hurdle rate	10%

The debt financing assumed to be 10 years tenure due to the operational characteristic of the facility. The leverage is set at 80% and the interest rate is still assumed to be 12%. The hurdle rate assumption is 10% due to its large size and public service function.

The depreciation is 10 years and the tax rate is 20%.

Financial Results

Project NPV	21,340,689
PIRR	19.19%
Equity NPV	18,317,063
EIRR	33.00%

The Trolley Bus fleet shows a positive return on both project and equity level. The margin significantly increases as soon as the loan get paid in 10 years. The increase of O&M on the 8 year is contributed by the replacement of battery which can be fully covered by the operations.

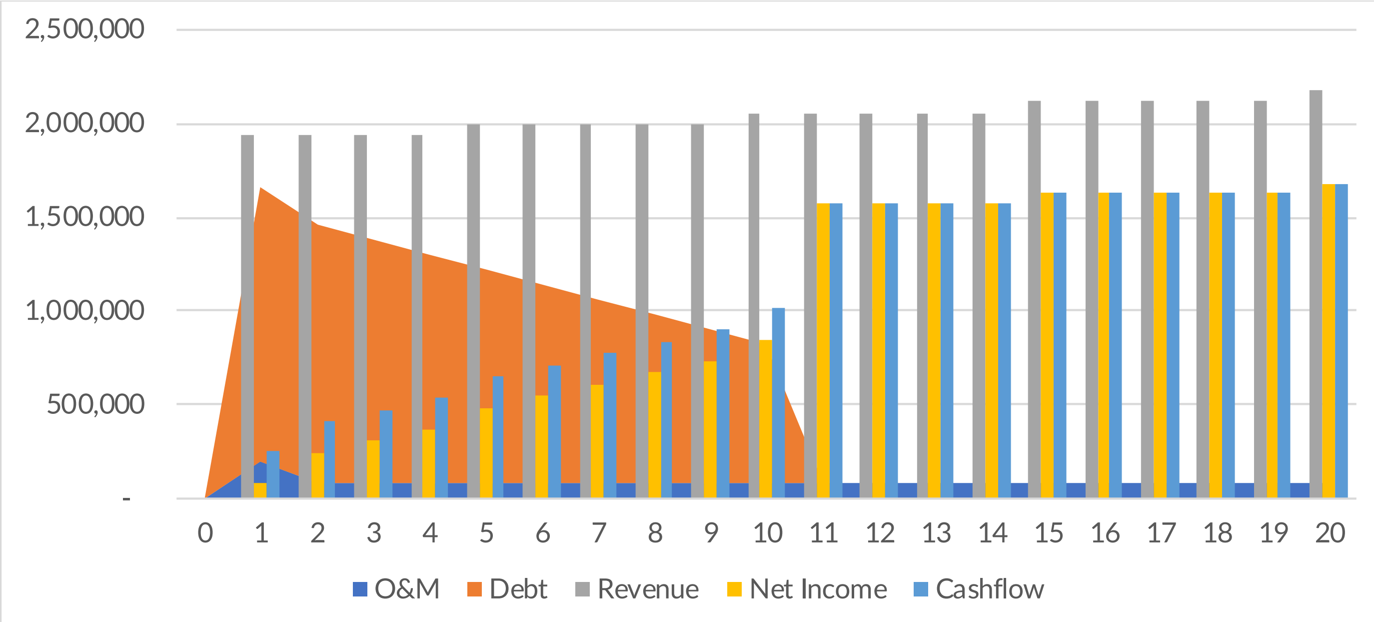


Figure B-3. Cashflow Profile

Conclusion

The investment opportunity for the trolley bus is very attractive for the private sector. The large capitalization will also be another challenge to check in there's a local capital capacity to invest in this infrastructure.

III. Upscaling and Monetizing Public Access Charging Stations

Assumptions

Project Term	20 years
Location	Kathmandu, Nepal
Number of charging stations	10 units
Investment Size	USD 0.077 million

The assumption is that the charging station has a life of 20 years. The project is expected to install 10 units of charging station to a parking area of a supermarket. Each unit costs NPR 800,000 or USD 7,722 with a total investment size of USD 0.77 million. The charging stations will be owned and operated by Nepal Electric Authority (NEA). Nepal's electric utility, this model is a replication of existing charging stations for safa tempos using preferential rates to encourage owners to charge on those facilities rather than charging in their own houses.

Operational Assumptions

The annual operations day is expected to be 365 as the charging stations will always be available the whole time and there is no need for a staff to manage it. The operational cost is assumed to be 10% of the investment cost. The charging stations is assumed to have free lease in exchange for supermarket's marketing strategy to get customers in their vicinity. The cost of the electricity of NPR 5.57/kwh is based on the new run of river plant that will come online by 2019 and will supply excess capacity to the grid. The current PPA of that plant is NPR 3.63/kwh for 5 months in dry season and NPR 6.96/kwh for 7 months during wet season. The first-year effective average rate of electricity is NPR 5.57 which results to an annual total cost including 10% O&M of the facility to be USD 179,231.

The revenue mechanism for this business will be for both advertisement and sponsorship which is USD 965 per year for each type of revenue stream. In addition to that, the stations will ear revenue with the electricity tariff being paid by charging vehicles. The tariff of NPR6.48/kwh is calculated by using the existing preferential rate of NEA for Safa Tempos which is NPR5.40/kwh for 5 months (dry season) and NPR 7.25/kwh for 7 months (wet season). With whole year operations and assuming 100% utilization, the total revenue per year including the advertisement revenue is expected to be USD 218,721.

The PPA also states 3% annual increase in cost which is taken into calculation. The electricity tariff of NEA historically increased by 18% in 2016 after 4 years of fixing the rate. To be conservative the electricity price is assumed to increase 3% every 3 years.

Annual operation days	365 days
Capacity of charger	40 kwh
Efficiency	91%
Electricity Tariff per kwh	NPR 6.48
Electricity cost per kwh	NPR 5.57
O&M cost	10% of investment cost
Sponsorship fee per year	USD 965 (NPR 100,000)
Advertisement fee per year	USD 965 (NPR 100,000)
Annual revenue	USD 218,721
Annual O&M	USD 179,231

Financing and Economic Assumptions

Tax rate	20%
Depreciation	10 years
Hurdle rate	5%

It was assumed that the facility will not be financed by debt or will be 100% equity financed. The depreciation is also considered to be 10 years and 20% tax rate. The hurdle rate is set to be 5% because the ownership of the charging station will be NEA which is a state-owned company and usually have low return expectations.

Financial Results

Project NPV	175,644
PIRR	26.05%

Since there is no leverage assumed, only project level analysis was conducted. The return shows higher than expected return with 26.05%. The project shows good advantage for the utility to set up the charging station specially when the new hydro plant becomes online to increase utilization and manage the off-peak hours.

Conclusion

Financially the project seems viable with returns having higher than expected. Locating the charging stations at certain nodal points can technically manage the losses and grid based on load management. The model made it even better with additional revenue coming from the advertisement and no fee on the lease. The project will be very attractive to the utility to integrate specially after 2019, there will be a huge excess energy capacity in Nepal.

IV. Upscaling Electric Vehicle Battery Leasing for Three-Wheelers in the Kathmandu Valley

Assumptions

Project Term	8 years
Location	Kathmandu, Nepal
Number of Safa Tempos	50 units
Investment Size	USD 0.487 million

The battery swap stations is expected to purchase initially 50 units which will service 50 safa tempos assuming one battery change a day. These safa tempos are currently servicing the Kathmandu Area in Nepal. The project term is assumed to be 8 years based on 8 year battery warranty life provided by the supplier. The battery cost per unit is assumed to be USD 6,327 (NPR 1 million) which makes the total investment size to be USD 0.478 million.

Operational Assumptions

The battery swap stations will cater to 50 battery changes per day with 350 operating days assumptions. Each swap is priced at USD 4.83 and on top of that, the safa tempo owners are required to pay a registration fee of USD9.65 per vehicle which leads to an annual revenue of USD 91,216. The O&M cost is assumed to be 2% of the total investment price based on industry practice which assumed to include all cost including administrative costs. The batteries will be charged at night when off-peak electricity price is at USD 0.05 per KWh. The two costs are combined to have a total of USD 37,388 annual expenses. The revenue and O&M are assumed to escalate 8% annually based on 5 year inflation rate average in Nepal.

Capacity per battery	30 KWh
Annual operation days	350 days
Electricity price (offpeak)	USD 0.05 (NPR 5.40) perKWh
O&M cost	2% of investment cost
Price per swap	USD 4.83 (NPR 500)
Annual registration per vehicle	USD 9.65 (NPR 1,000)
Annual revenue	USD 91,216
Annual O&M	USD 37,388

Financing and Economic Assumptions

Leverage	70%
Term	7 years
Interest Rate	12%
Tax rate	20%
Depreciation	8 years
Hurdle rate	12%

The assumption of the financial analysis is based on existing market lending terms for term loans in Guyana. This business cannot be defined as auto loan, therefore an SME type of debt can be assumed at this point. The interest rate is still assumed to be at 12% based on existing bank market rates and the tenure is 7 years.

The tax rate used is 20% and depreciation of is 10 years. This project is assumed to be taken over by existing swapping stations using old technology batteries. The expected upgrade will just show the return they will expect as they invest into new technology. In this case the equity cost of money or hurdle rate that will be used is 10%.

Financial Results

The financial results show that the investment on Battery Swap Station will yield 5.58% on project level and -0.72% on an equity level. The negative NPV on the equity IRR means that the cost of money for the debt is too expensive. The negative EIRR suggests that the cost of debt is very expensive, and the capital structuring is not optimal. The possible ways to get a better NPV is to reduce the CAPEX and also having better terms on the debt financing.

Project NPV	(83,151)
PIRR	5.58%
Equity NPV	(98,689)
EIRR	-0.72%

The Cashflow profile of the Battery Swap Stations shows that the first 4 years will incur negative cashflow due to debt repayments. This means that the private company may need to infuse additional capital on the first three years of operations before it can start earning from the batteries. This scenario does not look very attractive to private sector and will cause them to turn their back on the investment.

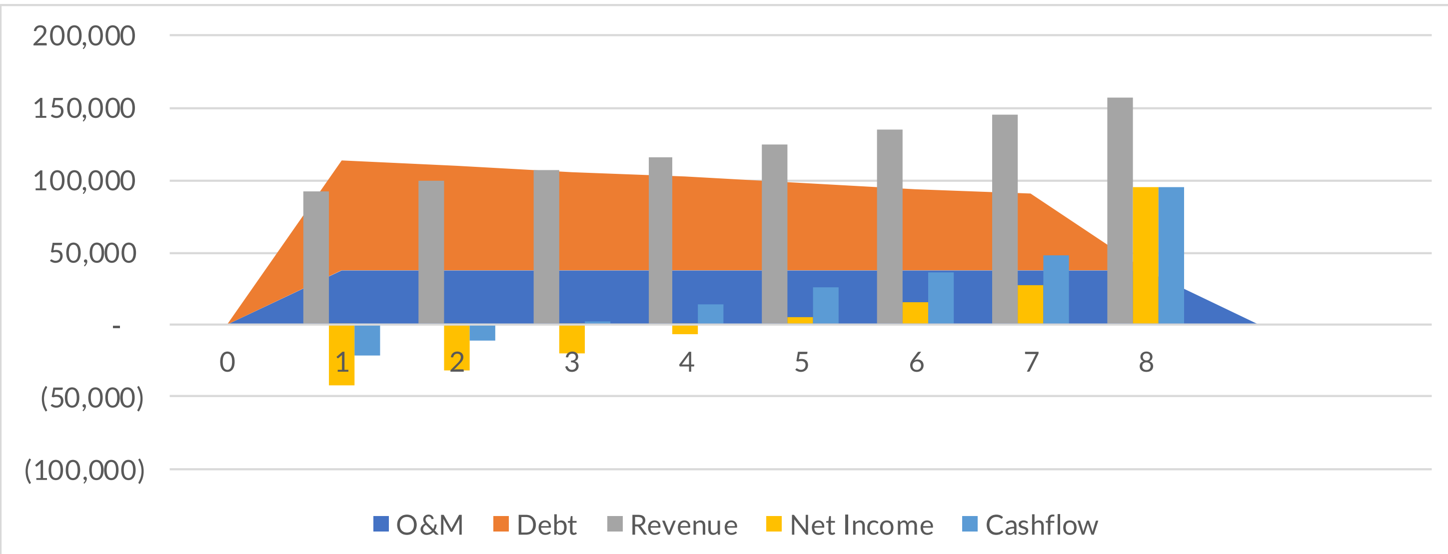


Figure B-4. Cashflow Profile

Conclusion

Battery swap station project will be attractive to existing station owners that wishes to upgrade their technology. The returns of the facility upgrade is acceptable at 10% level for an existing business, however the three year negative cashflow may result in a disappointment on the investor side. Therefore, a better debt financing terms are proposed to encourage SMEs to invest on cleaner and more efficient battery technology.

V. Converting Fossil Fuel Taxis to Electric Taxis

Assumptions

Project Term	10 years
Location	Kathmandu, Nepal
Investment Size	USD 2.3 million

The Taxi conversion station is expected to be in Kathmandu to accommodate taxis converting into full electric or hybrid system. The total investment size is USD 2.3 million which consist of investment on infrastructure, business licensing fee and technology cost for one year of converted units.

Operational Assumptions

The taxi conversion is expected to have a capacity to convert 1252 units per year or 4 vehicles per day. This is based on the assumption that the company will have 15 staff and a land size of 2035 sqm. The revenue is expected to generate NPR 200,000 per conversion with a total annual revenue potential of USD 2.4 million.

The company is expected to have 15 staff with a salary of NPR15,000 per month. The biggest chunk of the operations expenses is the technology cost per unit that is assumed to be NPR 150,000. The station will lease instead of buying a property which will be an annual cost of USD 200,000. The transportation of the materials from India to Nepal is expected to be NPR27,930 per unit. The total O&M cost for the first year is USD 2.6 million.

The revenue on the conversion is assumed to increase by 6% annually to cover for inflation while the O&M cost also assumed to increase the same rate. Normally the technology cost should decrease over time but in this case, we will just assume it to be constant, the transportation cost escalates the same rate as the revenue to cover inflation and to be conservative.

Expected number of vehicles per year	1,252 units
Conversion revenue per unit	USD 1930 (NPR 200,000)
Annual operation days	313 days
Average annual salary per staff	USD 1882 (NPR 195,000)
Technology cost per unit	USD 1448 (NPR 150,000)
Transportation cost per unit	USD 270 (NPR 27,930)
Annual lease	USD 1930 (NPR 200,000)
Annual revenue *(first year)*	**USD 2.4 million**
Annual O&M *(first year)*	**USD 2.6 million**

Financing and Economic Assumptions

Leverage	70%
Term	5 years
Interest Rate	12%
Tax rate	20%
Depreciation	5 years
Hurdle rate	15%

The assumption of the financial analysis is based on existing market lending terms for term loans in Guyana. This business cannot be defined as auto loan, therefore an SME type of debt can be assumed at this point. The interest rate is still assumed to be at 12% based on existing bank market rates and the tenure is 5 years due to its business operations and usually the capex is used as an inventory instead of PPE.

The tax rate used is 20% and depreciation of is 5 years. This project is assumed to be a new project and therefore new investment might require higher equity IRR and usually higher than the lending rate. For this analysis we are using 15%.

Financial Results

Project NPV	883
PIRR	15.01%
Equity NPV	3,351,673
EIRR	16.11%

The financial run shows a positive result for both equity and project level. Which means that the private sector might be interested to venture into this type of business. However, the project size of USD 3 million with 4 years negative cashflow might be hard for a local company to takeover. On top of that, the margin is a little small for a local company to be fully interested. In this case the local capacity must be checked and a joint venture with a high capital international company is a good way to make this project happen. Geographically and financially the best candidate may come from either India or China. Partnering with a big international company will also bring capacity building aspect, technology sharing, more funding sources and better financing terms.

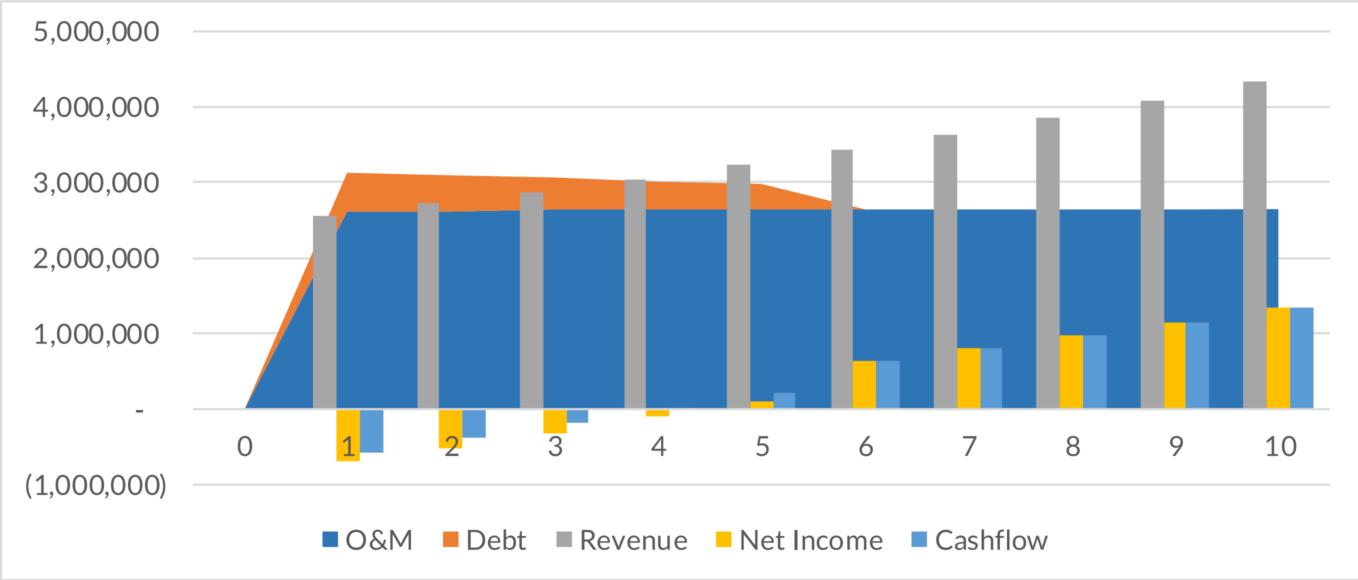


Figure B-5. Cashflow Profile

Conclusion

In summary, the financial potential of the project seems to be attractive for private sector in both local and international companies. The project shows good potential however, the high capital requirement and 4-year negative cashflow will be challenging for a full local ownership. The low margin characteristic of the project will have benefits if the partnering international company will also be the technology provider and will therefore increase the margin and the negative cashflow will be avoided.

In addition to the joint venture aspect, a lower interest rate will also be helpful to support the project or a better payment terms with the suppliers.