



e-Bus Market Feasibility in city of Honiara

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List of Abbreviations

AC	Air conditioned	KW	Kilo Watt
BAU	Business as usual	LEDS	Low emission development strategy
BEB	Battery electric bus	LIB	Lithium Ion Battery
BESS	Battery energy storage system	MFA	Mobility for Africa
BSS	Battery storage system	MW	Mega Watt
BTB	Business to be	NDC	Nationally Determined Contributions
CAFE	Corporate Average Fuel Efficiency	NDS	National Development Strategy
CAPE X	Capital expenditure	NEP	National Energy Policy
CBD	Central business district	NMT	Non-Motorised Transport
CBM	Coal-bed methane	NOI	Net operating income
CBU	Completely built unit	NRE P	National Renewable Energy Plan
CCC	Copenhagen climate centre	OEM	Original Equipment Manufacturer
CCS	Combined Charging System	OLE V	On-Line Electric Vehicle
CKD	Complete knocked-down kit	OPE X	Operational Expenditure
CMED	Central mechanical equipment department	PPP	Public Private Partnership
CNG	Compressed Natural Gas	PT	Public Transport
COE	Centre of Excellence	PTA	Public transport Authority
CPO	Charge Points Operators	PV	Photo Voltaic
CVR	Central Vehicle Registry	RDC	Rural District Councils
DC	Direct current	RE	Renewable Energy
DDF	District Development Fund	RES	Renewable Energy Sources
DISCO M	Distribution company		Road Motor Transportation
EPR	Extended Producers Responsibility	SLA	Service Level Agreements
ESAP	Economic Structural Adjustment Program	SOC	State of Charge
EV	Electric Vehicle	SUV	Sport Utility Vehicle
EVSE	Electric Vehicle Supply Equipment	TCO	Total cost of ownership
GCC	Gross cost contract	TOD	Time-of-day
GCF	Green Climate Fund	TOU	Time-of-use
GHG	Green House Gas	V2G	Vehicle to Grid
HT	High tension	WTT	Well to Tank
ICE	Internal combustion engine	ZERA	Solomon Islands Energy Regulatory Authority
ICT	Information and communication technologies	ZESA	Solomon Islands Electricity Supply Authority

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IPP	Independent power producers
KAIST	Korea Advanced Institute of Science and Technology
KPI	Key Performance indicators

ZETD C	Solomon Islands Electricity Transmission and Distribution Company
ZPC	Solomon Islands Power Company
ZUP CO	Solomon Islands United Passenger Company

1 Introduction

As per IEA Global Energy Review 2021 **Globally**, carbon dioxide emissions via coal energy generation plants are on course to surge by 1.5 billion tones. To address this, Countries around the world have to move rapidly to start cutting emissions addressing climate change. One of the leading sectors contributing to carbon emissions is transport sector. To address emission issues pertaining to transport sector, many country governments have taken initiative to convert conventional (ICE) vehicles to electric vehicles. Electric vehicles are energy efficient over ICEs and get around 85% useful energy conversion (in comparison to ICEs around 15% useful energy). Knowing the importance of climate change Solomon Islands is undertaking similar steps to reduce carbon emissions through different policy measures, initiatives and commitments.

The Solomon Islands is dependent on imported fossil fuels because of its geography, and its usage of fossil fuels is significantly high and 50% of it are used by the transportation sector. This has resulted the transport sector being the leading contributor of carbon emissions (61% of the total emissions) in the country. The government of the Solomon Islands is committed to reducing emissions in the country and has worked on several policies to promote low carbon transportation. Additionally, the government has set targets, to reduce the overall carbon emissions by 45% by 2030. The government is also taking several initiatives in increasing its renewable energy mix such as Tina River Hydro project and the Solomon Power solar PV farms. Despite the advantages of low carbon transportation, there are several barriers to adopt the low carbon transition in Solomon Islands. The main issues arise with the high upfront cost, lacking infrastructure, financial support, etc.

1.1 Objectives of project

To address the above challenges and improve the adoption of low carbon transition in the country, there is a strong need for 1) Transport Policies & Appropriate Policy Revisions 2) Supply – Demand Ecosystem 3) Feasibility and Investment Options and 4) Procurement and Deployments 5) Capacity Building and Awareness.

The overall objective of project focus on 1) assessing available options and barriers for market adoption of electric mobility in Solomon Islands as an approach to low carbon land transport 2) developing policy for supporting sustainable infrastructure with an integrated approach to climate change mitigation and adaptation based on local context 4) **assessing investment size and options by doing pre-feasibility study on select action plans to develop different e-Mobility business cases is very practical.** The holistic approach of building capacity and awareness with relevant government stakeholders on EVs and its adoption bringing in gender perspective is very appreciable.

As per above scope **EV Policy Roadmap for Solomon Islands** is under development and has studied different vehicle segments including, two wheelers, three wheelers, four wheelers,

buses and trucks. The prioritisation analysis undertaken by UNEP CCC and pManifold Consortium in consultation with national and local stakeholders identified **Intracity buses as highest priority for electrification** – given country’s ambition to improve public transport and its electrification.

As **Honiara** city serves as the country's political, economic and cultural centre, and has a population of more than **92 thousand** spread over an area of about **22 sq. km**; it is envisaged to be potential market for e-buses in Solomon Islands with 500 plus privately operated buses are running in the city.

1.2 Scope of Project

With basis to overall project scope, the scope of this assignment is to prepare a "**Market feasibility study for e-Buses deployment in Honiara**". The anticipated outcome from implementation of this phase is a feasibility study for intracity e-Buses including strategic policy measures for implementation, bus routes for electrification with required infrastructure for charging, business models for implementation, and a concept note for funding. This will contribute to developing a modern, sustainable, efficient mode of public transport in city of Honiara.

This study focuses on analysing e-Bus feasibility in city of Honiara before implementing e-Buses. One depot and potential routes are analysed and recommended suitable e-Bus deployment case for adoption of up to 10 e-Buses. It also includes the e-Bus technology comparison and selection, charging infrastructure guidelines, financial requirements, potential impacts and policy measures for adoption of e-Buses.

The first deployment (pilot) leads to set example, build skills, learnings and experiences through introducing any new intervention. Similarly, first e-Bus deployment will help envisaging the applicability, scalability of e-Bus deployment nationwide. It will also help to understand the potential of local ecosystem development for e-Buses as well as other e-vehicle segments.

1.3 Global Learnings on Challenges with e-Buses Deployment

e-Buses are complex from operations perspective than their conventional counter parts like Diesel Buses or CNG Buses. Conventional buses can be refuelled in few minutes and can easily complete their schedule without additional refilling. However, e-Bus often have short range due to lower energy density of batteries. The batteries of e-Buses are heavier, and they impact the bus efficiency expressed in electric units (kWh) consumed per kilometre. To put it in perspective, a Diesel bus can go approximately 4 km for one litre (~0.85 kg) of diesel. However, for 4 km range, an e-Bus with efficiency of 1 kWh/km, needs an on-board battery storage of 40 kg weight. Also, e-Buses can take substantial time to recharge the battery. Time lost during charging can lower daily vehicle utilization of e-Bus.

Financially, e-Buses can deliver economic performance (BNEF, 2020) as compared to that of ICE buses. Lower operational cost due to cheaper fuel combined with lower maintenance, reduces the operational cost of buses. However, e-Buses are costlier. High upfront cost of e-Buses increases capital requirement as well as financing cost. Thus, to deliver net benefits as compared to conventional buses, lower operational cost should offset high acquisition cost. Thus, it becomes important to fully appraise technical concepts involved in e-Bus operation before embarking on planning task.

1.3.1 Technical Concepts: e-Bus, Battery and Chargers

Before starting the feasibility study, it is useful to understand different components of e-Bus ecosystem and their characteristics. Bus, Battery and Charger are Three major components of e-Bus system, which are elaborate below.

1.3.1.1 e-Buses

Electric buses are driven by an electric motor and energy stored on-board. Globally e-Buses are available in different sizes such as 7m-mini, 9m-midi, 12m-standard and 18m to 24m articulated buses¹. An Important attribute of an e-Bus is its efficiency. An electric motor and other allied on-board equipment including Air Conditioners, lighting, etc. consume energy. The efficiency of e-Bus is measured by number of electric units (kWh) consumed per km distance covered. Another important attribute of bus is its weight, which along with weight of battery impact bus efficiency.

1.3.1.2 e-Bus Battery

Battery is an assembly of cathode and anode dipped in acidic solution, which can generate electric current. Numerous forms of assemblies are possible (series and parallel). Battery capacity is measured in kWh. Weight of a battery depends on the size of battery in kWh and the battery technology used. For each kWh increased, weight of battery increases.

Most common battery chemistries used in electric buses are Nickel Base Batteries, Lithium Based Batteries. Among all battery chemistries, Li-ion batteries are most preferred, due to their long life, and high storage capacity per kWh. Following are the concepts related to battery of EV.

- **Battery Power (Watt)** - Multiplying the voltage by the current provides power.
- **Amount of energy stored (kWh)** - Multiplying Battery Power with time for which battery can keep dispensing the power gives Storage Capacity of Battery expressed in watt-hr. 1kWh battery can run an appliance of 1000 watts for one hr.
- **Specific energy/ Energy density (kWh/kg or kWh/m³)** - Is the amount of energy that can be stored per unit weight or per unit volume.

¹ Zero-Emission Technology Inventory, 2021 by [CALSTART](https://globaldrivetozero.org/tools/zero-emission-technology-inventory/). <https://globaldrivetozero.org/tools/zero-emission-technology-inventory/>

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- **Charge Rate (1/hr)** - It is measure of speed with which battery can charge or discharge. It is inverses of time taken in hours to charge or discharge. If a battery takes 5 hours to discharge, its C Rate is 1/5.
- **State of Charge (%)** - State of Charge is charge in % available in battery. Min SOC is often referred as least SOC to be always maintained for long battery life.

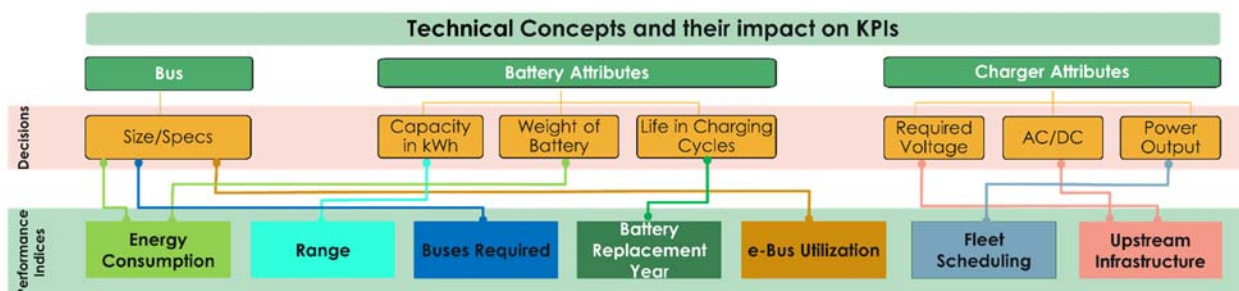
1.3.1.3 e-Bus Charger

Charger is a unit used to refuel/recharge battery and is commonly known as Electric Vehicle Supply Equipment (EVSE). Its power, i.e., ability to deliver energy (kW) in one hour is called charger power, expressed in kW. A 100kW charger (with 1C rate) can fully charge a 100kWh battery in 1hr. Chargers are available in varying powers. A low power charger is generally preferred for long charging time and vice versa.

$$\text{Charging time} = \frac{\text{Battery Capacity (kWh)}}{\text{Charger Power (kW)}}$$

Charger power should be appropriate so as to cause minimal impact on e-Bus availability for operation.

Figure 1.1 Dependence of key performance indicators (KPIs) on Attributes of e-Bus



It is imperative to choose right combination of above-mentioned e-Bus system elements, to minimize the 'Total Cost of Ownership (TCO)' of deployment of the e-Bus fleet. The choice of these elements also affects the overall e-Bus operations and performance. The key performance indicators of bus operations are; energy consumption, range, buses requirement, battery replacement, e-Bus Utilization, fleet scheduling and upstream infrastructure.

Interconnection of the e-Bus elements is shown in Figure 1.1. The right choices, planning and pre-implementation assessments of the given elements, their impacts with respect to the KPIs would help successful deployment of e-Buses.

1.3.2 Key Barriers to e-Bus Adoption

From several pilots, experiments and early adoptions worldwide, it is experienced that; transition to e-buses, has brought up some pain points, practical difficulties and barriers. Industries and governments tend to struggle to maintain, sustain and scale-up e-bus deployments. Such key pain points and barriers identified from various international case studies are organized into the three general categories technological, financial, and institutional and others. Table 1-1 presents barriers² and provides top level guidance for decision making and required planning efforts for e-bus adoption.

Table 1-1 Key Barriers to e-Bus adoption

General Barriers			
	Technological	Financial	Institutional
Vehicle and batteries	<ul style="list-style-type: none"> • Lack of information on the advantages and disadvantages of e-buses • Range and power limitations of e-buses • Design flaws in e-buses • Disjointed or limited e-bus marketplace 	<ul style="list-style-type: none"> • High up-front capital costs of e-buses • Higher TCO of e-Bus than planned • Lack of financing options 	<ul style="list-style-type: none"> • Difficulties for manufacturers in engaging with cities • Lack of a plan to remove current bus stock
Agencies and Operators	<ul style="list-style-type: none"> • Procurement: <ul style="list-style-type: none"> ○ Lack of information on how operators to start ○ Lack of information on e-Bus (size, specs); battery (size, chemistry, specs); etc. • Set-up and commission: <ul style="list-style-type: none"> ○ Lack of understanding on set-up and commission and the requirements to upgrade infrastructure • Operation: <ul style="list-style-type: none"> ○ Unplanned SOC depletion ○ High range deviation than stated specs ○ Trip loss/delays ○ Low e-Bus utilization 	<ul style="list-style-type: none"> • Rigid financial management and business models • Scaling investment past initial pilot programs 	<ul style="list-style-type: none"> • No enabling policies supporting adoption of e-buses • Negative public perception • Coordinating maintenance duties • Weak governmental coordination • Informal transit

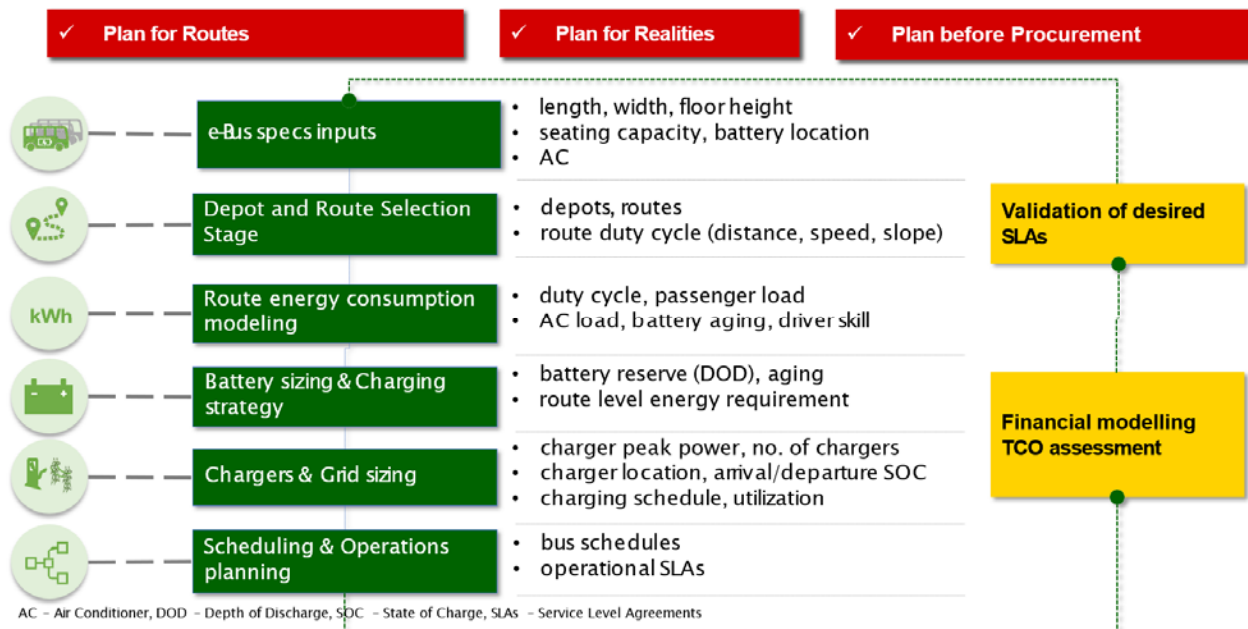
² WRI, 2020 <https://wrirosscities.org/sites/default/files/barriers-to-adopting-electric-buses.pdf>

General Barriers			
	Technological	Financial	Institutional
Grid and Charging Infrastructure	<ul style="list-style-type: none"> • Limitations of the charging ports and stations • Grid instability • Lack of standards and regulations on charging infrastructure 	<ul style="list-style-type: none"> • Large capital expenses for grid infrastructure • Difficult to determine grid infrastructure responsibilities 	<ul style="list-style-type: none"> • Lack of space and land to install infrastructure • Limited planning for long- term implications

1.4 Methodology

Considering the experiences, learnings from global practices on e-Bus deployments; this pre-feasibility study has adopted an inclusive approach for planning first e-Bus deployment in city of Honiara. A six-step approach (refer Figure 1.2) is adopted to undertake the pre-feasibility assessment which is inclusive of desk research, stakeholder engagement and expert consultations.

Figure 1.2 Systematic Planning for e-Buses Technology Selection and Fleet Scheduling



- e-Bus specs and input:** Brief global and regional EVs market overview is undertaken to check availability of e-Bus models in market. A suitable e-Bus size is defined based on consultation with Local Transport Authority in city of Honiara.
- Depot and Route Selection Stage:** Depots/Space for depot has been selected based on their capacity to handle e-Buses considering space requirements of charging infrastructure.

Also, most feasible routes for electrification has been selected from stakeholder consultation based on passenger demand, existing operation.

- c) **Route energy consumption modelling:** Detailed technical analysis is conducted which includes, energy consumption modelling for selected routes under different scenarios like AC on/off; passenger overloading; route conditions; traffic conditions and others has been performed³
- d) **Battery sizing and Charging Strategy:** Estimate required battery sizing (in kWh) for meeting energy need (accounting for SOC and ageing). After which, appropriate charging strategy is selected for bus fleet operations (including different scenario for overnight and opportunity charging). Different battery sizes and charging options are assessed together to identify suitable battery and charging option for e-Bus deployment
- e) **Scheduling & Operations planning:** Overall fleet scheduling has been performed which results into estimating required charging infrastructure for selected e-Bus (fleet) including selection of charging technology, number of chargers, associated grid infrastructure etc.
- f) **Scenario Selection Stage:** All e-Bus scenarios has been evaluated based on TCO and technical attributes of e-Bus System i.e., bus, battery and chargers along with charging strategy has to be finalized.

Further as part of the technical feasibility assessment, (chapter 7, 8 and 9) policy note for e-Bus adoption and scale-up has been recommended. The implementation guidelines and mechanisms for both e-Bus and charging infrastructure has been included. Financial requirements, suggested business models for e-Bus implementation are also included as part of this feasibility assessment.

³ using pManifold's EVFleetPlanner© tool

2 Country Landscape

Solomon Islands is one of the nine archipelagos in the Pacific Island Countries and Territories (PICTs)⁴. It is located in the southwest Pacific, to the east and south of Papua New Guinea and north of Vanuatu with a land area of 28,000 km². Honiara is the national capital of the Solomon Islands and is located on the northern interior slot coast of Guadalcanal. Since the 1970s, the country is seeing population growth of ~3% annually. As of 2019, the population of the Solomon Islands is 7,21,000⁵ with ~25% of the population living in urban areas in 2009.⁶ As of 2021, there are ~35,000 vehicles in the Solomon Islands, of which around 80% are on Guadalcanal (three-quarters in Honiara) and the remainder spread throughout the other provinces. The road network includes 441 bridges and 2,016 culverts. Guadalcanal and Malaita provinces account for 65% of the total network, and only 58% of the country's rural population is estimated to have access to roads.

The country heavily relies on intermodal transport to connect the population with essential goods and services. 75% of the population lives in rural areas making it critical for the government to create a reliable, sustainable, and affordable transport system for economic growth. Efficient transportation infrastructure is required for fast access to essential goods and services to create livelihood opportunities.⁷

The Solomon Islands is dependent on imported fossil fuels because of its geography. In 2012, the total petroleum worth SBD 843 million (~14% of the country's GDP) was imported for supporting the country's demand for fuels.⁸ The country's transportation accounts for 50% of the total petroleum fuel consumption and 61% of the GHG emissions in the country making the sector the biggest contributor to pollution in the country.⁹ The emissions caused by the transport sector will grow unless a significant measure is taken by the government.

The Pacific Island Countries and Territories (PICTs) is still in the nascent stages of e-Mobility development. The PICTs have issues with the lower rate of adoption of electric vehicles because of lacking an integrated approach to promote and simultaneously expand renewable energy power generation, e-Mobility and electrical storage.

In the Fourth Pacific Regional Energy and Transport Ministers, 2018, all the PICTs developed a regional electric mobility policy and program. The policy outlined the short-term and long-term vision of PICTs concerning integrated e-Mobility and renewable energy power markets with targets for 2030 and 2050.¹⁰ The policy also focused on the existing barriers in the regulation,

4 Other PICTs consist of Federated States of Micronesia (FSM), Fiji, Commonwealth of the Northern Mariana Islands (CNMI), Palau, Samoa, Vanuatu, and Wallis and Futuna.

5 2009 Population & Housing Census National Report

6 Asian Development bank and the Solomon Island: Fact Sheet, 2020

7 Proposed Technical Assistance Grant Solomon Islands: Transport Sector Project Development Facility: Report and recommendation of the President of the Board of Directors, ADB

8 CTCN Technical Assistance Request Submission Form

9 Intended Nationally Determined Contributions (INDC), 2016

10 PCREEE Elevator Pitch High-level Luncheon Event "Mission Transforming Island Lives! The Network of Regional Sustainable Energy Centres for Small Island Developing States"

knowledge management, qualification/certification, and the promotion of investment, entrepreneurship and innovation.

In acknowledgement with the regional e-Mobility policy and program, **the Ministry of Mines, Energy & Rural Electrification** of Solomon Island planned to up the scale of renewable energy from the Tina River Hydro project and the Solomon Power solar PV farms and hybrid plants. The Ministry also highlighted the importance and preparation to shift towards low carbon transport in future.¹¹

Several government policies with the help of international support from “Asian Development Bank (ADB)” focused on developing infrastructure to support inclusive growth, including transport assets, renewable energy, and water supply and sanitation of Solomon.¹²

Since 2015, the Solomon government had taken some initiatives to improve the infrastructure and reduce the carbon footprint emissions caused by the transport sector. The policy and program initiatives inclined for the betterment of transportation in Solomon are mentioned below:

Policy	Aim and Target
Intended Nationally Determined Contributions (INDC)	Targets to reduce 45% GHG emissions (overall) by 2030 ¹³
National Development Strategy (NDS)	Aims to create an equitable socio-economic growth Targets to at least provide improved transportation to 40% of the rural population by 2035 ¹⁴
The Ministry of Infrastructure Development (MID)	Aims to design safety standards for bridges, wharves, or houses as required in natural disaster-prone regions Ensures that national transportation is well planned, affordable and conducive to both economic growth and social well being Targets to achieve a safe mode of transportation across segments ¹⁵
National Transport Plan (NTP)	Priorities, and plans for improving transport infrastructure and services in line with the NDS ¹⁶
Medium-Term Transport Action Plan (MTTAP)	Prioritizes the investments for the projects identified in the NTP, between the years 2017–2021 MTTAP total investment required during this period is \$280 Mn ¹⁷

11 PCREEE: Solomon Island joins regional program to prepare for electric mobility
<https://www.pcreee.org/article/solomon-islands-joins-regional-programme-prepare-electric-mobility>

12 ADB Member Fact Sheet, 2020

13 Intended Nationally Determined Contributions (INDC), 2016

14 Government of Solomon Islands. 2016. *National Development Strategy, 2016–2035*. Honiara.

15 Ministry of Infrastructure Development of Solomon Islands (MID)

<https://www.developmentaid.org/#!/donors/view/143418/ministry-of-infrastructure-development-of-solomon-islands-mid>

16 Government of Solomon Islands. 2016. *Solomon Islands National Transport Plan, 2017–2036*. Honiara.

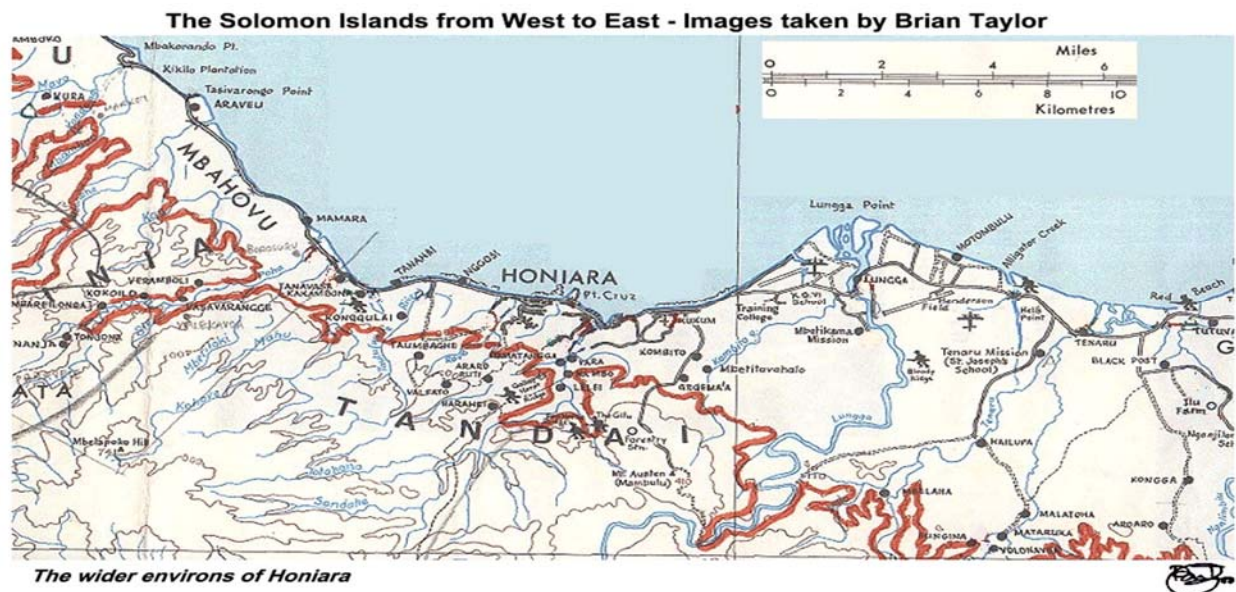
17 Proposed Technical Assistance Grant Solomon Islands: Transport Sector Project Development Facility: Report and recommendation of the President of the Board of Directors, ADB

3 City Profile and Existing Bus Transport in Honiara

3.1 Honiara City profile

Honiara is the capital and the largest city in Solomon Islands and is situated on the northwest coast of Guadalcanal Island. Honiara, city, is located at the mouth of the Mataniko River on the north coast of Guadalcanal. As of 2021, the city is now home to a population of 92,344 people. An international port and several commercial establishments with government offices are in the city. It trades primarily in coconuts, timber, fish, and some gold (from Gold Ridge in the centre of the island). Honiara International Airport is located approximately 10 miles (16 km) east of the town.

Figure 3.1 Honiara City Map



According to the Inland Revenue Department (IRD 2021) there are about 40,126 vehicles which were registered in the country. More than two third of which are in operation in Honiara, while less than a third on Malaita and part of Guadalcanal Provinces. Albeit the un-availability of figures by city, it is estimated that about 90% of these vehicles are in Honiara. It is evident that there is a clear mismatch between increases in the number of vehicles plying the streets of Honiara and provision of road space resulting in severe congestion. The city experiences high levels of congestion which can be protracted for several hours.

3.2 City Transport in Honiara

Solomon Islands' Road network of 1,463 km is extremely small relative to the size of the land area, but it is not so small relative to the size of the population. An estimated 82 percent of the population are within reach of the road network (77 percent of the rural population, and all of Honiara). While the existing network is vital for connectivity, there are some key gaps and weaknesses. Key gaps include the limited connectivity of Honiara with large parts of Guadalcanal (terrain, cost, and land access are significant constraints) and the limited road network of Honiara itself which is now grossly inadequate for existing traffic volumes. Key weaknesses include the present poor physical quality of the road network, as well as the poor ability to effectively operate and maintain it. Only 12 percent of this road network is paved. The remaining roads are mostly of Coronus material, with 56 percent in maintainable condition (about a quarter of which are not usable after heavy rains), and the rest is in poor condition or impassable. Thus, the quality of the network seriously constrains the connectivity it ostensibly provides. Public transport is available in and around Honiara, provided by privately owned minibuses and taxis. In rural areas, public transport takes the form of light trucks carrying goods and passengers. Due to growing private vehicle ownership in and around Honiara as well as lack of roadside management along remote provincial roads, road safety is a growing concern.

3.3 Existing Bus Transportation in Honiara

Public transport system within Honiara city mainly is dominant by private sector operations. **The Honiara City has more than 200 intracity public transport vehicles** which mainly comprises of mini and standard buses. The buses are not registered to operate along any particular route, such as Honiara City Market to AJ City in the east or Honiara City Market to Kakambona to the West. The decision to operate along a particular route depends entirely on the bus driver and whether there are passengers available for that specific that route.

Public transport operation

to operate a public transport in Honiara, for example a bus transport service, after complying with the Ministry of Finance (MoFT) and Ministry of Infrastructure Development (MID) requirements, one just have to pay for a business license with the Honiara City Council (HCC) and get a bus driver and start picking passengers along the road. According to personal interview with a World Bank official, Solomon Islands especially Honiara is very open market, one can quickly establish any business of any nature, including transport service if you have adequate capital for investment. There is no policy which controls the entrance and exist into the transport sector operations in the city.

Origin of buses

Almost 90% percent of buses imported into the country from Japan, Europe, Asia and some Australia. The buses both mini and standard are mainly Toyota Hiaces and Nissan Caravan, and some other models. A majority of these are imported and sold as second products, there is no vehicle assembling in the country.

3.3.1 Existing Bus Ownership and Operating Models in Honiara

There is not “state or local government” ownership of public transport operation in the country. Most of the government ministries and departments including the local government (Honiara City Council) operate some fleet of buses for transport but is only for their employees’ pickups and drop offs for work in the morning and afternoon respectively.

Majority of the bus operators runs as private businesses. They either run single unit or multiple units from 2 to 6 or 7 buses. There is no major bus operator in the transport sector. On every bus, there is a driver and a bus conductor. The responsibility of the bus conductor is to collect cash (bus-fare) from passengers as they enter or exit the bus. The daily collection is prepared and handed over to the bus owner at the end of each day.

3.3.2 Existing bus Operations, PT infrastructure and Routes in Honiara

Most of the bus service providers in Honiara City operates for 14 hours a day; starting its first operation from 6 am in the morning till 9 pm in the night. 7 am to 9 am in the morning and 4 pm to 6 pm in the evening are peak hours of the day; and rest till 9 pm are non-peak hours. Since there is no bus schedule in place, the bus just leaves the main bus stand if it has maximum passengers on board. Majority of these buses have capacity of only 15 or 16 passengers.

The Ministry of Infrastructure Development (MID) through the Honiara City Council (HCC) is responsible for the development, repairs, and improvement of the road and supporting infrastructure for the public transport operation in the city boundary. These infrastructures are very basic and include bus bay and stops only. There is **no depot** and proper shelters at some bus stops. There are informal parking activities that happens at the depot and the other terminal location as shown in Figure 3.2 and Figure 3.3.

e-Bus Market Feasibility in city of Honiara

Figure 3.2 Informal Parking at the Honiara City Market



Figure 3.3 Buses at Honiara City Market



The bus in Honiara city runs along three main routes with flat rate of \$3 Solomon dollars as standard bus fare. The first route is from Honiara City Market to the AJ City mall, the second route is from the Honiara City Market to the Border line and return and the third is from Honiara City Market to Kakambona.

In addition to the major routes above, there are also short routes to other locations into the suburbs of Honiara (as shown in Figure 3.4). For example, from Didao Service station to Borderline and return, from Honiara City council to Vavaya ridge, from Holy Cross to Tuaruhu, and from AJ City mall to Henderson Domestic Airport. The bus fare for these short routes varies from \$2 to \$3 Solomon dollars.

e-Bus Market Feasibility in city of Honiara

Figure 3.4 Bus routes in Solomon Islands



4 e-Bus Depot and Routes Selection

As mentioned in the preceding chapter, Honiara has several routes for urban bus transit. The current practise of running ICE buses on routes differs greatly from running an electric bus on the same route, as the energy requirements for each route vary based on unique route features. An e-Bus is battery-powered, and the battery can react differently depending on the route's terrain, length, journey time, driving style, and overall route energy consumption. This finally translates to charging requirements, i.e., charging time, charging infrastructure requirements alter, giving each route a new scenario for running e-Buses.

Considering e-Bus deployment as a new ecosystem with the sole purpose of serving passenger demand, it is critical to choose the depot and prospective routes for electrification strategically. To support the aforementioned goal, the following chapter provides the background, selection criteria, and selected depots and routes.

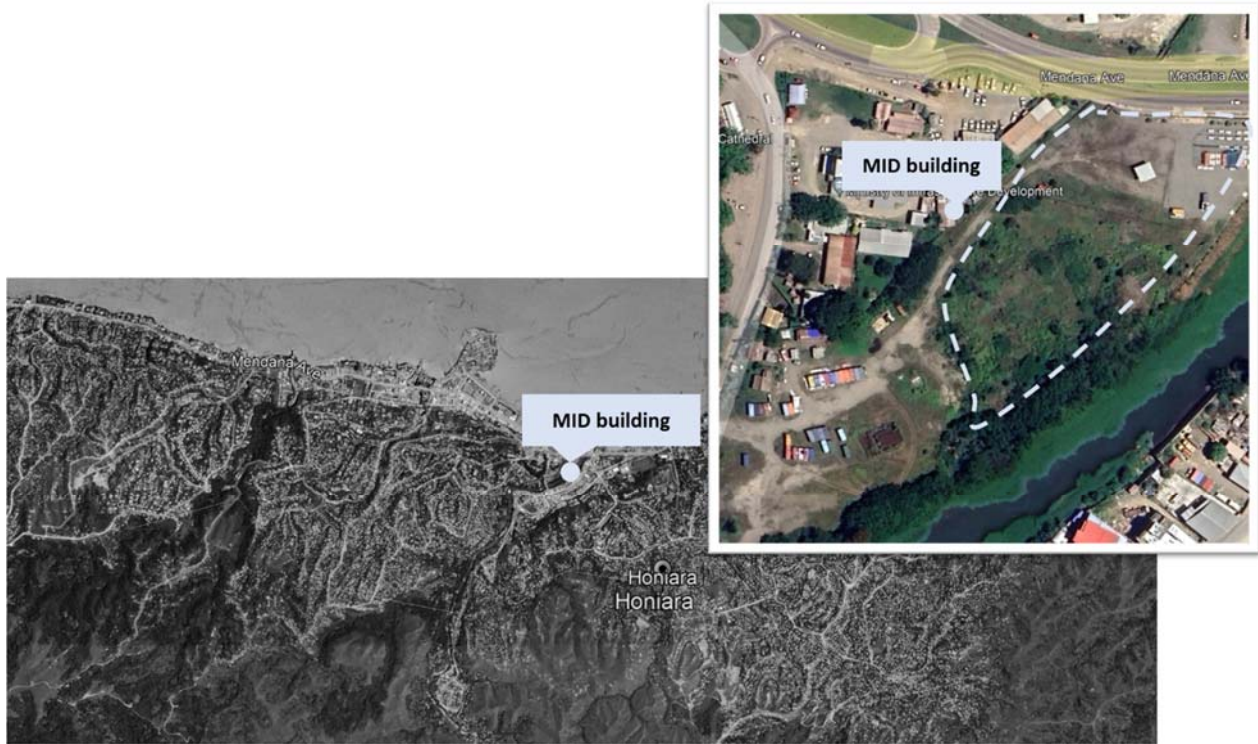
4.1 Depot Selection

Currently, the urban bus transport ownership in Honiara is privately owned and henceforth there are no Depot in the city. However, as per consultations with the city council, one potential place for setting up depot (near the MID building) and 3 potential terminals (Tandai fuel station, Didao fuel Station, AJ City Mall) were being identified. The above potential depot and terminals were identified based on the high demand routes and availability of land space.

The potential depot near the MID building is located 300m from the Honiara city market has a vacant land area of more than 12,000 sq.m. The location has a capacity to park 80 plus buses. This depot location will make an ideal case for first deployment of e-Buses considering it can provide service to i) high demand areas ii) utilize the of the space, infrastructure and optimum use of available facilities in the depot

e-Bus Market Feasibility in city of Honiara

Figure 4.1 Potential Location for setting up e-Bus Depot



4.2 Route Selection

4.2.1 Route selection criteria

To ensure an implementable concept for validation this study focuses on BEB implementation considering on existing routes. The road network serving existing city bus transportation services have mostly paved and of acceptable quality of road surfaces.

The routes are selected in multiple consultations with Honiara City Council and other relevant stakeholders. Key operational, technical and commercial parameters are used for route selection and are described as follows;

e-Bus Market Feasibility in city of Honiara

Table 4-1 Parameters for route selection

Parameter	Description
Passenger demand	<ul style="list-style-type: none"> • Passenger demand is important aspect to understand financial and commercial viability and bankability of the service. Passenger demand¹⁸ is used to design bus service (number of buses, trips, bus size, headways etc.) on given routes. It also useful to analyse patterns of passenger travel behaviour based on gender, occupation, Origin-destination, travel time, accessibility, affordability and others. Based on scope and need for study, the depth of passenger demand survey varies • For this feasibility study, ‘Boarding-alighting’ survey was conducted where the number of passengers boarding, on-board and alighting at each stop were counted. This helped calculating average ridership and to select bus and fleet sizing
Route length and condition	<ul style="list-style-type: none"> • Route length is necessary to understand as it directly impacts the energy/fuel consumption. City of Honiara has radial road network (with radius of ~25 km) where every major (Arterial) road starts and ends at the city centre (CBD). Current bus routes range from 5 km to 25 km in and around periphery of the city of Honiara. • Existing conditions of the bus routes range from average to good. Good condition or routes with paved surfaces helps smooth operations of buses
Distance to depot / charging station	<ul style="list-style-type: none"> • Distance from depot impacts the daily travel distance for a bus More distance increases the dead mileage i.e., distance travelled by bus without passengers (non-billable). More dead mileage leads to more consumption of fuel, time and hence the extra cost. Short/no distance would make an ideal case for setting-up charging infrastructure and eliminating chances of delays, losses, extra energy requirement and saving ‘extra’ cost as well
Distance and capacity of feeders on envisaged charging stations/depots	<ul style="list-style-type: none"> • The distance and capacity of feeders (grid) to respective charging stations is important to assess any power infrastructure issues that would affect the operational and technical aspects of the e-bus operations

¹⁸ Usually, the passenger demand and is derived from Public Transport Authorities (PTAs), from a planned public transport system. In case of Solomon Islands there is no PTAs so the data was collected by surveys.

Parameter	Description
Maximum gradient and elevation profile of route	<ul style="list-style-type: none"> • The grade is elevation profile of a route. The difference between two gradient points impacts energy requirement to ply buses on the route. Gradient upward would require high energy and vice-versa for downward gradient • Choice of e-Bus is an important decision which depends on power requirement for a route. With higher motor power the cost of bus will increase • An average gradient of 5% is considered acceptable (normal conditions) to operate e-Buses
Operational characteristics	<ul style="list-style-type: none"> • Operational characteristics include, time of operation, route specific travel time, schedule, headways, layovers, operations and maintenance of buses • For electric buses, the operational characteristics may require change as full charging of e-Buses requires 1 – 4 hours for fast charging or 3-6 hours for slow charging • Based on route energy, battery size, passenger demand and charging, the e-Bus operations may need modifications and optimisation in required number of fleets, their headways and charging schedules
Number of stops per route	<ul style="list-style-type: none"> • Bus stops allow passenger boarding and alighting and ensure accessibility to the users. While it also increases the travel time • A distance of 500 m – 750 m is considered as ideal distance between two stops from point of view of users, bus service, accessibility. While planning the service, the number of stops should be considered wisely with focus on catering travel demand and optimising energy consumption

4.2.2 Route selection methodology

Figure 4.2 Route selection methodology



All existing public transport routes in city of Honiara were identified. Broader operational, institutional and regulatory and financial data was collected from key stakeholders¹⁹(refer Chapter **Error! Reference source not found.**). HCC has played a major role in providing inputs and validating the understanding about city bus transportation in Honiara.

¹⁹ Consultations with Honiara City Council, Local bus operators and experts were conducted during June to July 2022. The other source of information is National transport plan.

Broad mapping (refer chapter **Error! Reference source not found.**) of existing city bus routes was prepared based on consultations with HCC. Through preliminary analysis major public transport corridors and possible electrification corridors were identified and validated from key stakeholders (HCC, MID, Private bus operators)

HCC also provided guidance and recommended most suitable corridor and possible routes thereafter. A list of routes and requested operational, technical, financial parameters was provided for further assessment.

4.2.3 Shortlisted Route profile

Based on common understanding (with HCC) the high demand routes connecting the potential depot location were agreed to be prioritised among all the public transport routes in Honiara. The routes are shortlisted based on parameters described in Chapter 4.2.1; and are namely 1) Honiara City Market to AJ City Mall 2) Honiara City Market to Kakambona as shown in Table 4-2.

Additionally, as depot centric approach was chosen for electrification, the shortlisted routes are in proximity to the depot location. This will help the e-Bus have 1) High passenger demand and ridership 2) no dead mileage

Table 4-2 Route profiling for shortlisted routes for electrification

Parameter	R1	R2
	Honiara City Market to AJ City Mall	Honiara City Market to Kakambona
Round Trip Length (km)	14.8	10.5
No. of existing Buses	85	65
No. of Round Trips/day	25	22
Route Ridership (Pax/day)	29,750	20,020
Daily Operational Distance Travelled (kms/day/bus)	175	150
Dead Mileage (kms/day/bus)	-	-
Total distance (kms/day/bus)	175	150
Number of stops one way	6	5
Operational hours	6:00am to 9:00pm	

5 Technical Assessment for e-Bus feasibility

This chapter presents the route level characteristics and energy demand assessment of selected five (5) routes for e-Bus deployment. After route and depot selection the route level information was collected for analysing energy consumption requirements of each route. The data was collected through on-site surveys.

Two types of surveys were conducted on selected five routes, namely;

- 1) Enroute duty cycle data collection through mobile application
- 2) Boarding alighting survey to capture passenger ridership data

Both the surveys conducted during peak time (Morning). Duty cycle survey has captured travel information of bus on specific route i.e., time, location, speed, distance travelled (after regular intervals of 1-4 second); while boarding alighting survey captured the peak our passenger demand and the number of stops enroute. Other characteristic of the bus service and inputs were captured through the consultations with Honiara City Council and other key stakeholders in Honiara.

5.1 Key considerations for technical assessment

The duty cycle data was captured through and out was received in MS-Excel formats. Through preliminary assessment following characteristics of routes were identified (**Error! Reference source not found.**). Average, minimum, maximum speeds; total time of travel (completion of one trip); total distance travelled; route gradient are the key characteristics (outputs) derived from preliminary assessment; useful for route level energy modelling.

5.1.1 Existing ICE Bus Operations

5.2 Routes energy assessment

Route energy assessment is an outcome of processing duty cycle data collected using ICE bus and applying for an e-Bus through virtual modelling²⁰. This gives the likely energy consumption by e-Bus operations on same routes where ICE buses are currently plying. Each route has different characteristics in terms of terrain, length, traffic condition, road surface conditions hence the energy consumption and performance of buses vary route to route. This is further reflected in Route level profiling and energy consumption assessment.

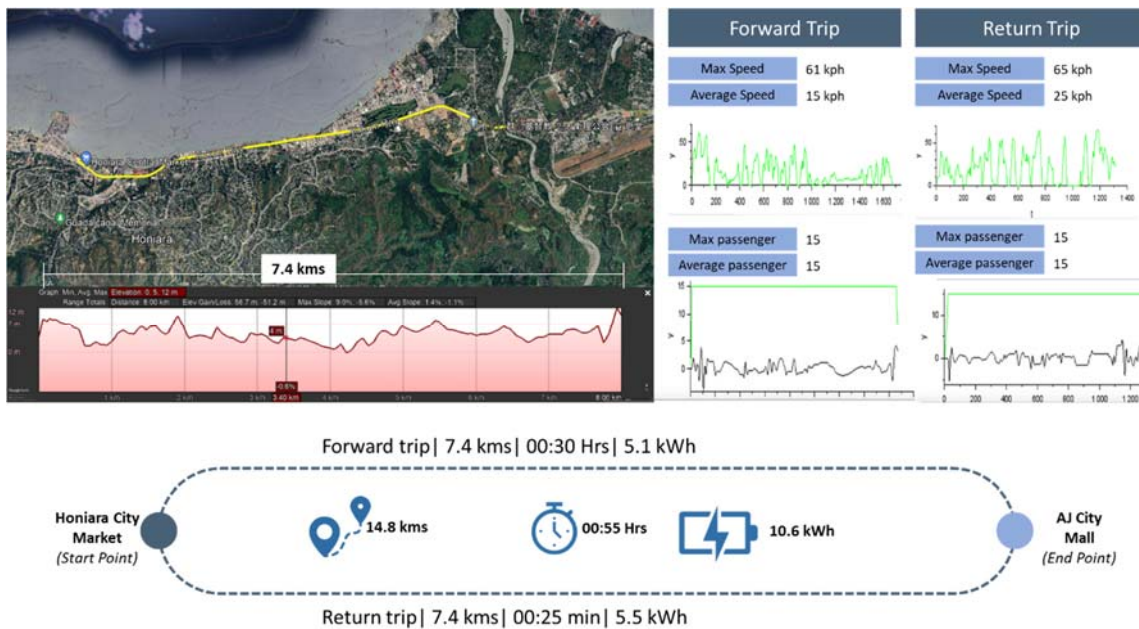
²⁰ In this case the virtual model used for simulation is developed in Sci-lab. Sci-Lab: Sci-Lab is a free and open-source software for engineers & scientists, with a long history (first release in 1994) and a growing community (100 000 downloads every month worldwide). <https://www.scilab.org/about/scilab-open-source-software>

e-Bus Market Feasibility in city of Honiara

5.2.1 Route profile and energy consumption

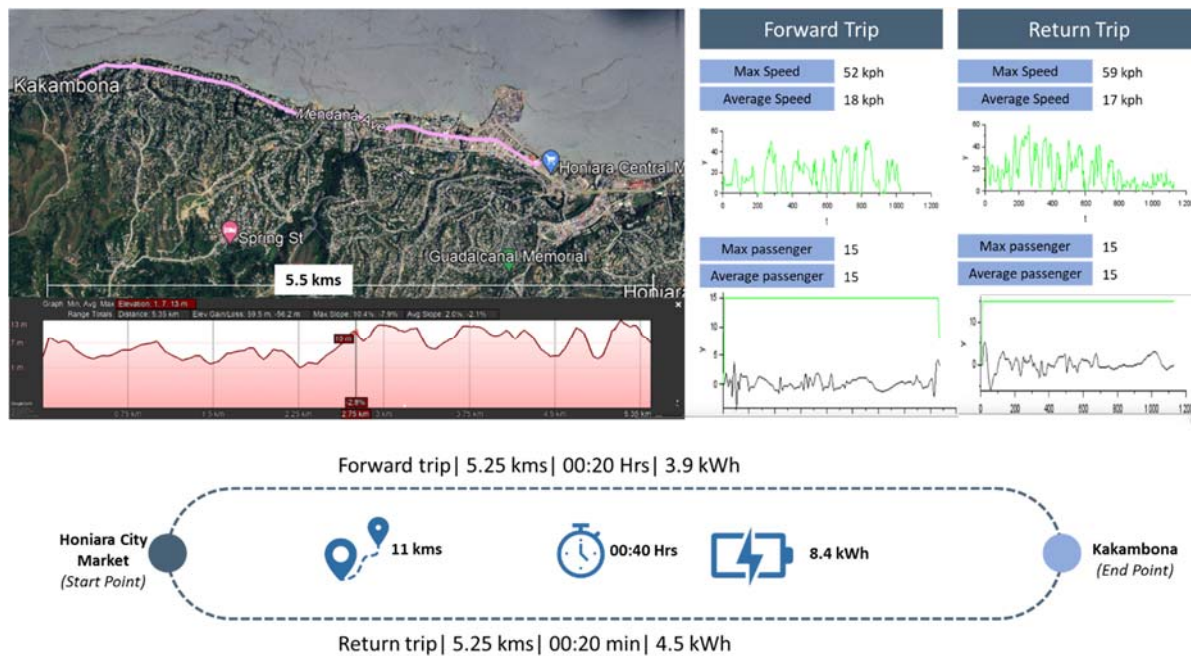
Following illustrations present the forward, return and round-trip profiling for each of the two routes. It includes, 1) Route profile: Length, terrain; 2) Passenger Loading – maximum and average passenger loading against grade; 3) Speed Profile: maximum and average speed (kph) against time (s); 4) Round trip energy consumption (kWh) with split between forward and return trips (also time and distance).

Table 5-1 R1 Honiara City market to AJ City mall Route Profile



e-Bus Market Feasibility in city of Honiara

Table 5-2 R2 Honiara City market to Kakambona Route Profile

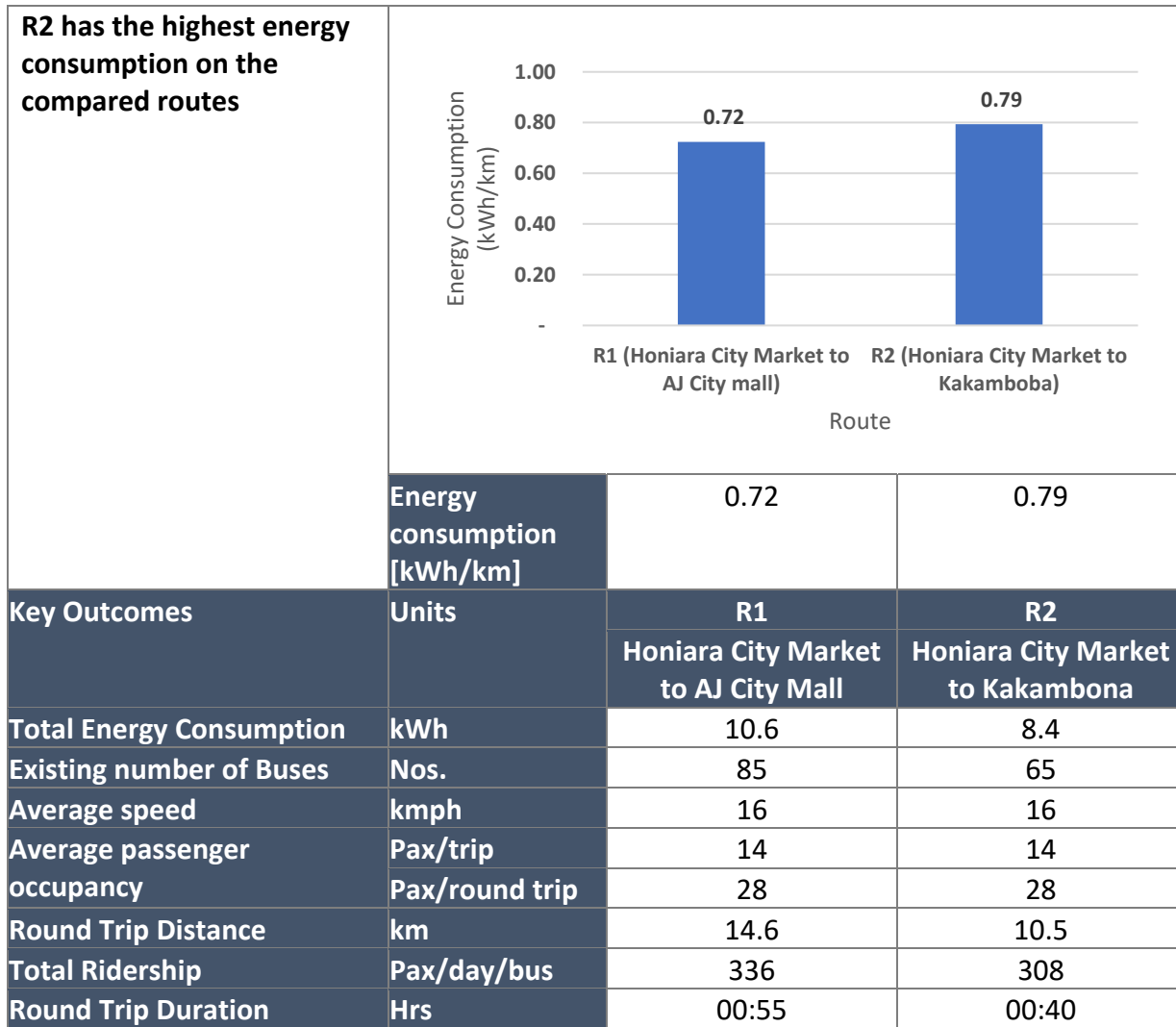


The R1 (Honiara City Market to the AJ City mall) is the longest of both the routes and requires 10.6 kWh energy demand for a round trip. The speed profile of the route also shows that the frequent accelerations and decelerations of vehicles during peak hours results in high energy demand for the route.

The R2 (Honiara City Market to the Kakambona) has shorter distance when compared to R1. The total energy demand for one round trip is 8.4 kWh. The speed profile of the route also shows that the average speed of the route is lower when compared to R1 which results in frequent acceleration/deceleration and stoppages. This results in higher energy demand for the route.

5.2.2 Energy consumption analysis

The R1 is the longer of the two routes and has the highest overall energy demand for a round trip. However, the energy consumption per km for R1 and R2 is 0.72 kWh/km and 0.79 kWh/km respectively. R2's greater per kilometre energy usage is due to the route's low average speed and frequent stops/km (as mentioned in 5.2.1).



The energy consumption per kilometre is used to determine the daily route energy demand for providing e-Bus service. The choice of battery size, selection of charging strategy and charger type is further decided based on energy requirement.

5.3 e-Bus Battery and Charging Strategy selection

Selecting battery size and appropriate charging strategy for e-Bus deployment is the next step after route level energy consumption assessment. The high energy consuming routes mentioned in above chapter (5.2) lead to higher daily energy requirement. Sizing of batteries for e-Buses on high energy consuming route in this case may give and oversized battery as a result while other lower energy consuming routes may not require huge battery to serve required daily operations. Batteries are rechargeable and can serve required daily energy demand through opportunity charging. On one hand high-capacity battery sizes are capable to give more range and battery life to that of lower capacity batteries. While on the other hand High-capacity batteries are expensive, add into the investment requirement, reduce passenger

e-Bus Market Feasibility in city of Honiara

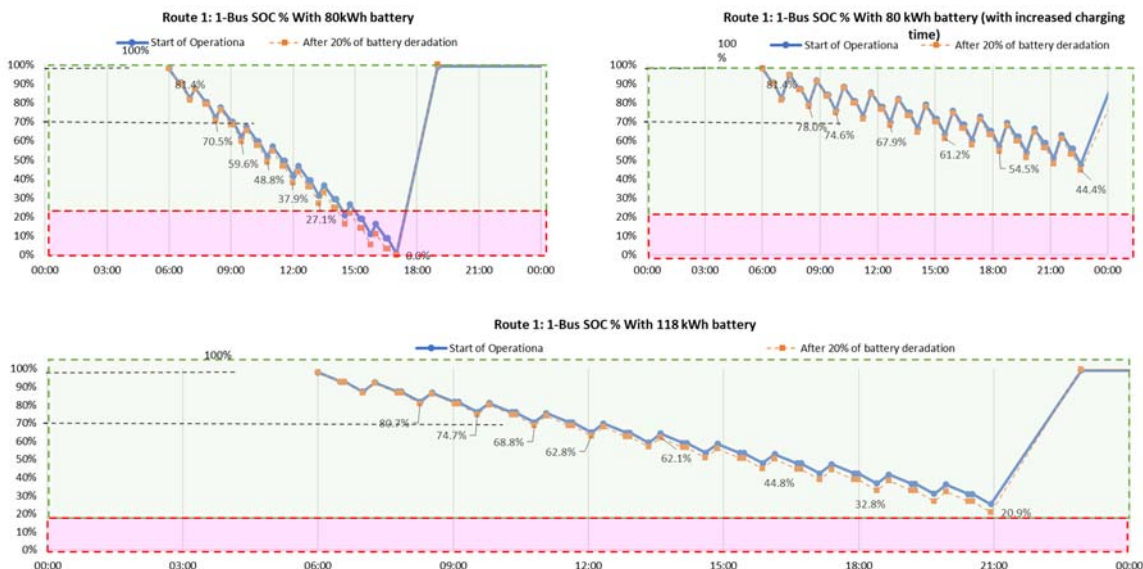
occupancy and increases the weight of the vehicle; ~ 10 kgs per kWh of capacity. In case of electric buses, the weight is one of the factors which impact energy consumption of the battery and involved operational costs. Hence it is essential to size the battery judiciously. This section analyses minimum battery size that is required to fulfil the operational requirements to serve end users.

Considering two different battery sizes and the charging options identifies; Scenarios evaluated for e-Bus feasibility are as follows. Based on the below consideration the SoC for the select scenarios we estimated as shown in Figure 5.1.

Table 5-3 e-Bus feasibility assessment scenarios

Scenarios	Scenario 1		Scenario 2
	Scenario 1 A	Scenario 1 B	Scenario 2 A
Battery size	80 kWh	80 kWh	118 kWh
Charging strategy	Overnight Charging + Opportunity Charging		
Overnight Charging	@ MID Depot		
Serviceable hours	15hrs	16.5 Hrs	15 hrs
No of Trips round trips	9	12	12

Figure 5.1 Battery SoC for various scenarios



e-Bus Market Feasibility in city of Honiara

Figure 5.2 Battery SOC estimation Scenario 1 a

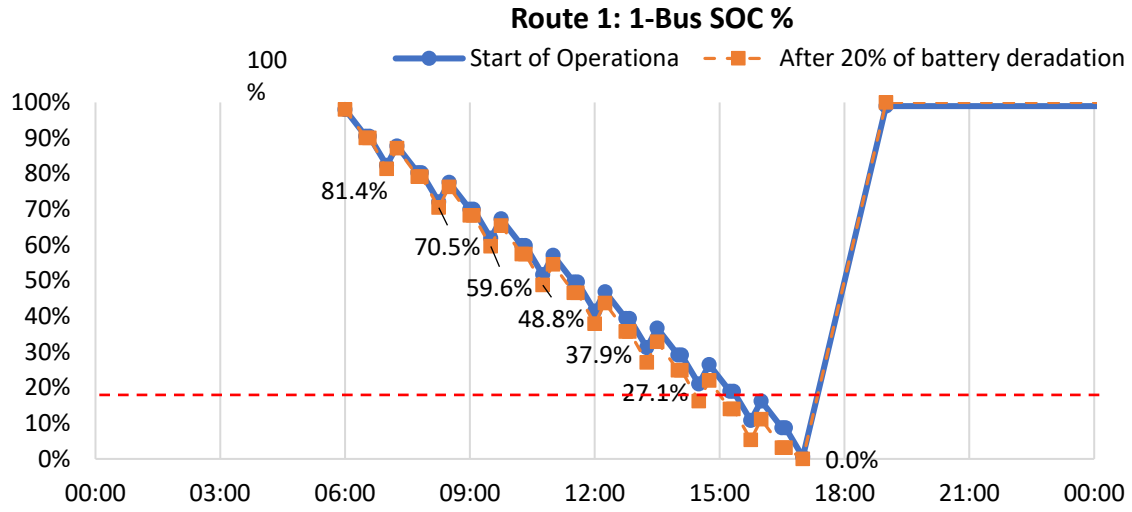
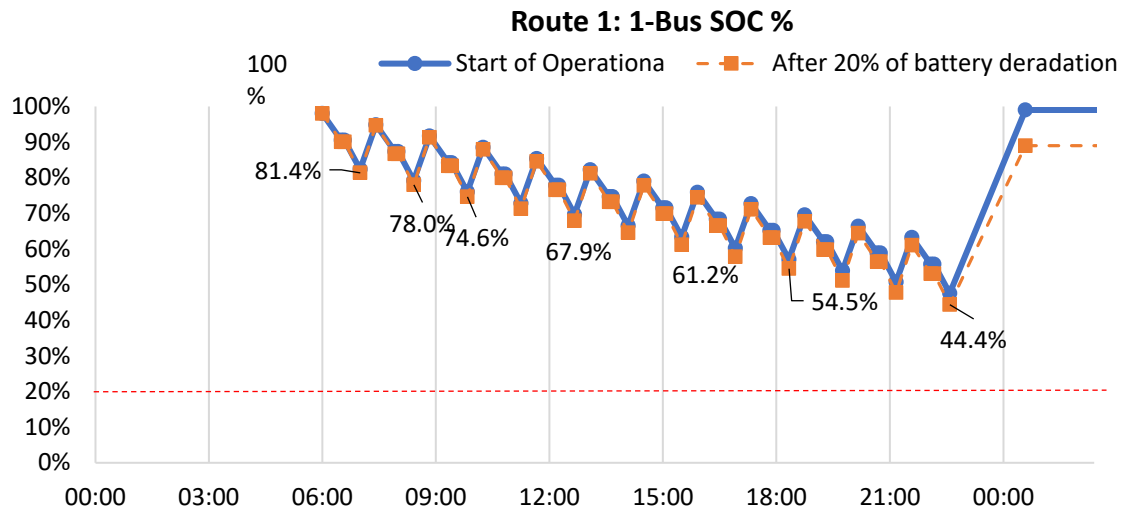


Figure 5.3 Battery SOC estimation Scenario 1 b



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Figure 5.4 Battery SOC estimation Scenario 2

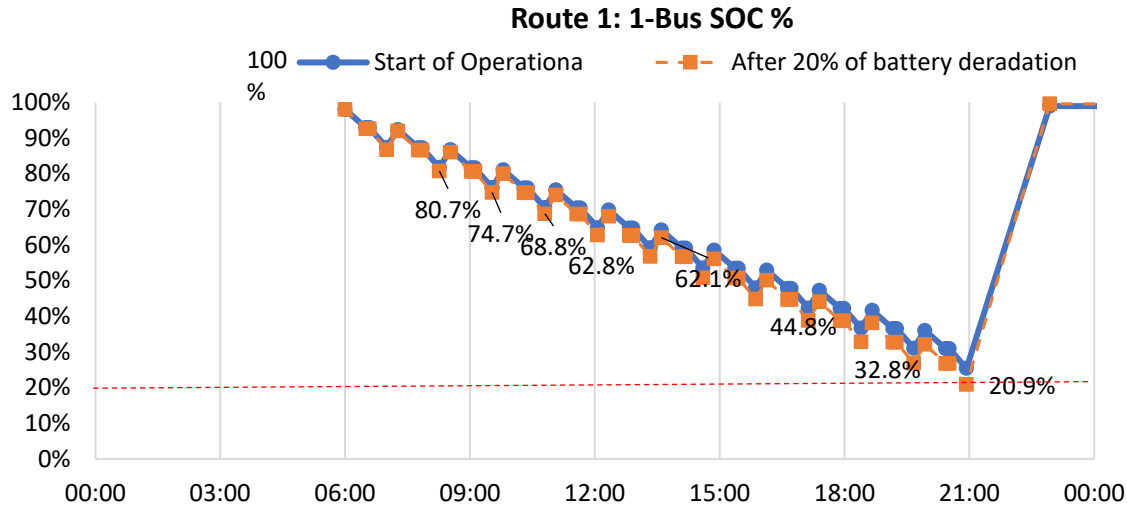


Table 5-4 Route 1: Battery SOC and suitability assessment outputs

	Units	Scenario 1A	Scenario 1B	Scenario 2	Comments
No of Buses	#	6	8	6	<ul style="list-style-type: none"> Scenario 1 B requires 2 additional buses (additional investment)
Charging Time (after each round trip)	min	15	25	15	
Total Time required for opportunity charging	hrs	2.00 (8*15 min)	4.58 (11*25 min)	2.75 (11*15 min)	<ul style="list-style-type: none"> Scenario 1 B consumes more time for opportunity charging
Bus Utilization	%	55%	73%	73%	<ul style="list-style-type: none"> Scenario 1A has low bus utilization
Charger Utilization	%	41%	81%	61%	<ul style="list-style-type: none"> Scenario 1A has low charger utilization
Total Ridership	#	1,512	2,016	2,016	<ul style="list-style-type: none"> Scenario 1A would cater lower ridership
No of round Trips	#	9	12	12	<ul style="list-style-type: none"> Scenario 1A can make less round trips than required
Serviceable hours	Hrs	10.3	15.6	13.8	<ul style="list-style-type: none"> Scenario 1B is consuming more hours than the current service hours (stretching schedule beyond 15 hrs)

e-Bus Market Feasibility in city of Honiara

SoC levels at end of complete schedule (for degraded battery)	%	1%	41%	21%	<ul style="list-style-type: none"> Scenario 1A has drained battery with the given opportunity charging time
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Table 5-5 Battery suitability output comparison

Parameters	Requirements	Scenario 1		Scenario 2
		Scenario 1A	Scenario 1B	Scenario 2
No of trips	12	✗	✓	✓
Passenger demand	336	✗	✓	✓
Serviceable time	15 Hrs	✗	✗	✓
SoC levels	More than 20% at end of complete schedule (for degraded battery)	✗	✓	✓

The following are the observations from Table 5-4:

Scenario 1A: 1-e-Bus is provided with 16 min of opportunity charging time after each round trip is not able to achieve the required no of round trips in the day, because of SoC reaching below 20% by end 9th round trip. Therefore, the scenario is not able to cater the minimum demand required for the route.

Scenario 1B: 1-e-Bus is provided with a total of 25 min opportunity charging time after each round trip to help achieve the required 12 round trip per bus. However, due to high opportunity charging time the serviceable hours of the bus have increased beyond 15 hrs time frame and hence the fleet requires additional bus to cater the travel demand in a day.

Scenario 2: 1-e-Bus is provided with 16 min of opportunity charging time after each round trip, which is adequate to complete 12 round trips within the required 15 hours serviceable time in a day (same as current ICE bus operations).

From the above scenarios it is seen that Scenario 2 (e-Bus with 118 kWh battery) is the minimum battery size required for the route. This scenario will be able to cater the daily energy demand of 127 kWh and 115 kWh for the R1 and R2 respectively.

From the assessment **Error! Reference source not found.**, it is seen that scenario 2 (e-bus with 118 kWh Batter) is sufficing all the requirements to run e-Bus in the route.

Some global examples of different e-Buses and their battery sizes deployed globally are given in the table below Table 5-6.

e-Bus Market Feasibility in city of Honiara

Table 5-6 Global example of e-Buses and their battery sizes

Country	City	e-Bus OEM	e-Bus Size	Seating capacity (Total/Only seating)	Battery Size (kWh)
India ²¹	Delhi	Olectra	7 m	20	120
China ²²	Shenzhen	Ankai	7 m	20	118

e-Bus Charging Strategy selection

Selected battery size needs to be analysed for their suitability with different charging options. In Honiara city, the e-buses are to operate from the depot (near the MID building) which is nearly 200-300 m from the start point of R1 and R2. There is no dead mileage incurred which is likely to consume additional energy. This will largely depend on which charging strategy is used. Hence it is important to plan for different possibilities of charging and evaluate them for selection of best suitable charging strategy for e-Bus deployment. This chapter presents suitable charging option and sizing of required charging infrastructure for e-Bus Deployment.

5.3.1.1 Charger and Charging strategy

Globally there are several applications of e-Bus charging infrastructure adopted, and they vary from case-to case basis. Some Global examples are stated in the table Figure 5.5 & Table 5-7 of this chapter and elaborated with global best practices in Table 8-1 of Chapter 8.1.

Conductive i.e., Plug-in charging is found suitable for the first e-Bus deployment. As first experience; operating e-Buses with Plug-in type charger would help building confidence in operations of e-Buses; understand differences between ICE and e-Bus refuelling and hands-on experience of operating charging infrastructure.

5.3.1.2 Charging Technology

Based on the global experiences, most preferred charging technology is Plug-In charging due to simplicity, market availability, high safety, moderate cost and more successful operations with respect to electric bus charging. The same Plug-in charging is recommended for first deployment of e-Bus charging. This will include the set-up of Electric vehicle supply equipment

21 <https://iea.blob.core.windows.net/assets/db408b53-276c-47d6-8b05-52e53b1208e1/e-bus-case-study-TERI-Kolkata.pdf>

22 China: BYD C8 model is an all-sit bus type with customized seat capacity between 24 and 44. BYD K8 seat number of 87/30-39 means, 30-39 seats, with total passenger capacity (including standing passengers) of 87.

<https://iea.blob.core.windows.net/assets/db408b53-276c-47d6-8b05-52e53b1208e1/e-bus-case-study-Shenzhen.pdf>

e-Bus Market Feasibility in city of Honiara

(EVSE), grid infrastructure, step-down infrastructure located at suitable locations for e-Bus charging.

Figure 5.5 Charging Technology and Types

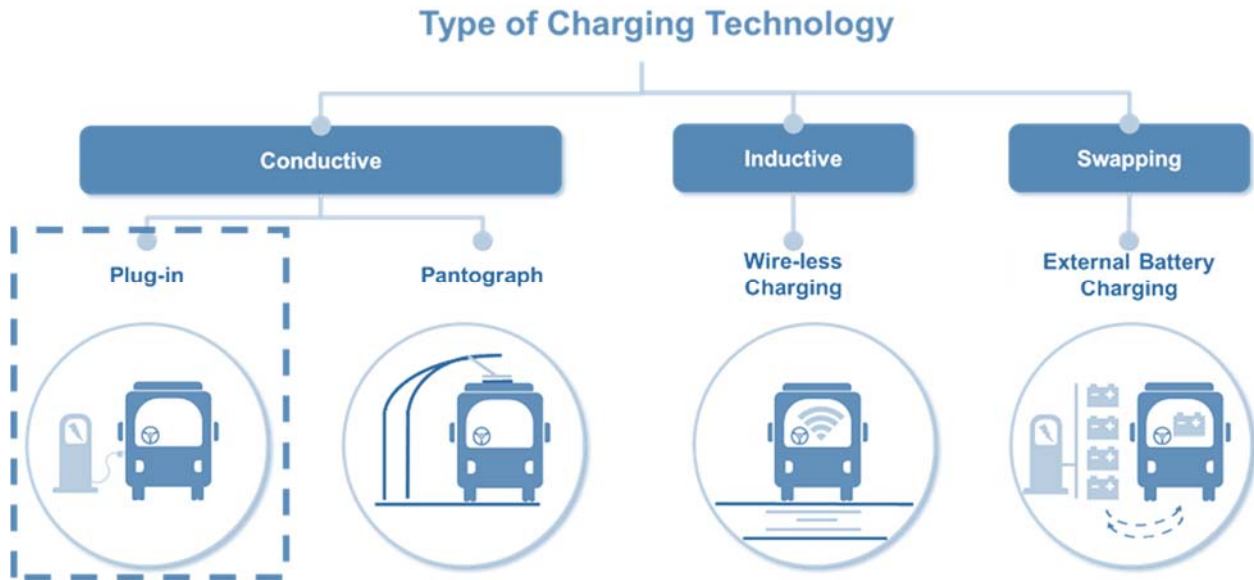


Table 5-7 Charging Technology and Types, pros and Cons

Charging Technology		Pros	Cons
Conductive	Plug-in	<ul style="list-style-type: none"> • Provide multiple charging levels • Provide high efficiency • Coordinated V2G facility • Reduce the grid loss maintain voltage level • prevent grid power overloading • Active power support. 	<ul style="list-style-type: none"> • Complex infrastructure • Restriction to the electricity grid • Fast charging cause voltage instability in the distribution system • Need a standard connector/charging level • Grid power overloading will cause due to uncoordinated charging • V2G operation reduces the lifetime of the battery.
	Pantograph		
Inductive	Wireless charging	<ul style="list-style-type: none"> • EV recharge it safely and conveniently • No need for any standard connector • No need for any standard Socket • Recharge when the vehicle is in motion 	<ul style="list-style-type: none"> • Power transfer is generally weak • The range of 20 to 100 cm for efficient power transmission • The transmitter and the EV should be real-time and communication latency.

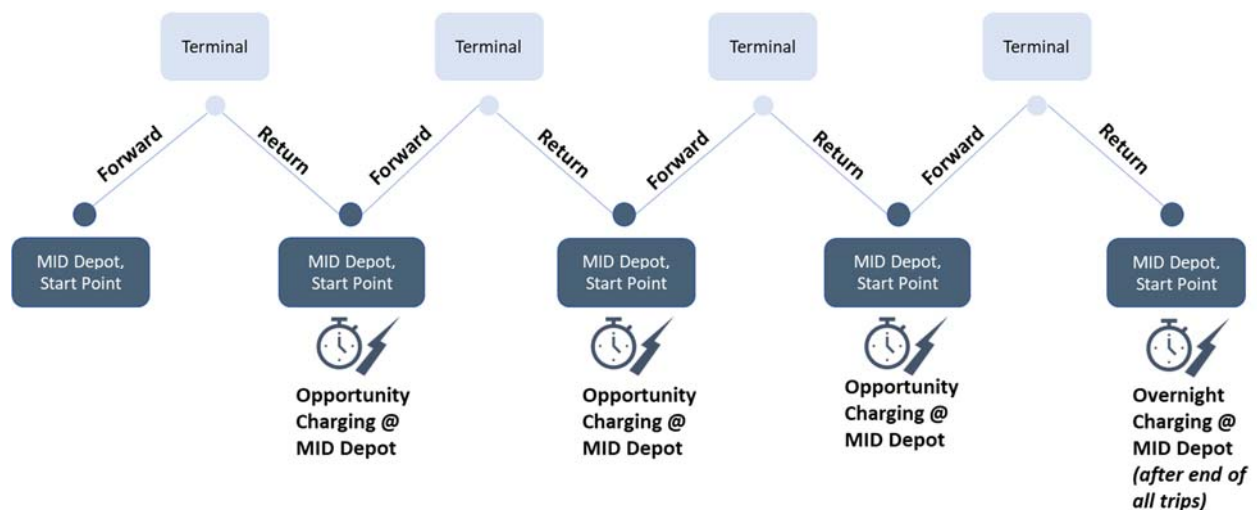
e-Bus Market Feasibility in city of Honiara

Swapping	External Battery Charging	<ul style="list-style-type: none"> • Quick battery replaces (Fully charged) • Extend the battery life by slow charging • Help utilities in balancing the demand and load by using the V2G facilities • Easy to integrate with the locally generated Renewable Energy Sources (RES). 	<ul style="list-style-type: none"> • Costlier than ICE vehicle because of the monthly rent to Battery storage system (BSS) • The huge investment required for both equipment and batteries • Need a large stock of expensive batteries • Many areas needed to accommodate the batteries • Different EVs have different battery standards
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5.3.1.3 Charging strategy: Overnight charging plus Opportunity charging at depot

Overnight depot charging plus opportunity charging is recommended for operation of e-Buses based on the shortlisted battery sizes. The newly proposed depot is near the start point resulting in zero dead mileage for the route. Therefore, the buses can afford to top-up charge at the depot after every round trip which will cater to the need for rest operations. Hence, for overnight plus opportunity charging after each round trip for charging operations are identified (as shown in Figure 5.6) in consultation with the stakeholders.

Figure 5.6 e-Bus Charging options identified for e-Bus deployment



5.3.1.4 e-Bus Feasibility Assessment Scenarios

Considering two different battery sizes and the charging options identifies; Scenarios evaluated for e-Bus feasibility are as follows;

Scenarios	e-Bus Deployment Scenario
Battery size	118 kWh

e-Bus Market Feasibility in city of Honiara

Charging strategy	Overnight + Opportunity Charging
Overnight + Opportunity Charging	@ MID Depot (Place identified. Not developed)

For each of the route's scenarios given in above table are modelled and their outcomes are reported below. Each scenario was first applied to Highest energy consuming route R1 Central Market to AJ city Mall; to understand maximum requirement for e-Buses to ply on the route. The outcomes are captured in following categories and parameters;

- 1) Fleet: Number of Buses
- 2) Battery: Battery size, battery life (battery cycles consumed per day)
- 3) Chargers: Number of chargers (slow and/or fast), type, size and location of chargers, Number of buses shared per charger, charger utilisation
- 4) Operations: Trips (one way and total round trip), passenger demand served, headway, dead mileage, total daily distance travelled), fleet utilisation

e-Bus Deployment Scenario with 118 kWh battery: 1 Bus SOC assessment and optimisation for R1 Overnight + Opportunity charging @ Depot

Figure 5.7 1-Bus SOC % with 118 kWh battery

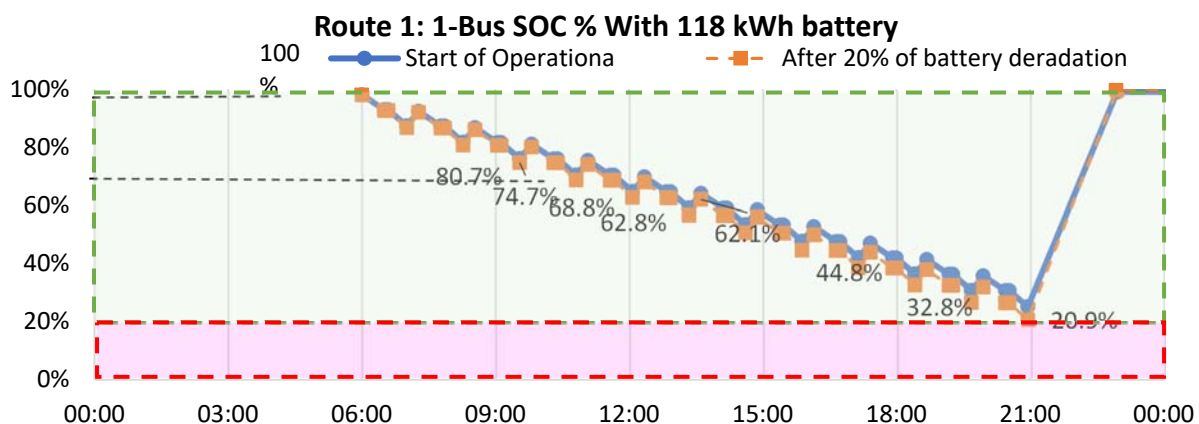


Figure 5.8 R1 operation, e-Bus, Battery charging requirements

Total trips	Headway	Charging		
		Type	Opportunity Charging	Overnight Charging
12	16 min	Number of events	11	1
		Time	16 min	2 Hrs.
		Location	Depot Charging	

Components	Unit	Bus	Charger	Battery
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e-Bus Market Feasibility in city of Honiara

Number of Units	Nos.	6 Buses	2 Fast Chargers (55 kW) @ Depot	105 kWh – Li-ion battery
Utilization	%	79% Utilisation	61 % Utilisation	-
Life	Years	15	10	8.8

The similar route level analysis is carried-out for both R1 and R2 namely Honiara Central City Market to AJ city mall and Honiara Central City Market to Kakambona. The tables bellow summarises the route level requirement of fleet, chargers, battery life and e-Bus operations for different scenarios; for both the routes.

Figure 5.9 Summary of Route level assessment: Fleet, charger sizing and operational requirements

Parameters		BAU- ICE Buses		e-Bus Deployment Scenario with 118 kWh battery	
		R1	R2	R1	R2
Fleet	Nos.	85	6	6	4
Passenger Loading (*design capacity of bus is considered)	Pax/bus/trip	14	14	14	14
	Pax/bus/round trip	28	28	28	28
Operations					
Round trips	Nos.	25	22	12	15
Route Distance	kms	7.5	5.5	7.4	5.25
1 Bus daily operating kms	km/Bus/day	180	165	177	159
Dead Mileage	km/Bus/day	-	-	-	-
Dead mileage ratio	% Of total operational kms	0%	0%	0%	0%
Headway	Hrs	-	-	00:16:00	00:15:00
Total operational hours	Hrs	15 hrs (6:00 am to 9:00 pm)			
Battery Size	kWh	-	-	118	118
Battery Life cycles consumed per day		-	-	1.28	1.3
Number of chargers	#	-	-	2	1
Charger Type	kW	-	-	55	55
Location of chargers		-	-		
Number of Buses shared per charger	Bus/Chargers	-	-	3	4
Charger Utilisation		-	-	61%	92%

6 e-Bus & Charging Business Models

6.1 Actors in the e-Bus Ecosystem

Among the important actors; the electric bus ecosystem is dominated by the following players, Government authorities are charged with the responsibility of providing public transportation services (often referred to as "authority"), Bus Manufacturers (with/without battery), Battery Manufacturers, Electric Utility provider, Private Operators and, Financial Institutions. However, in Solomon Islands no formal public transport system is operated. The current bus operations are privately operated and run with no fixed schedule however the ticket fare is defined by Honiara City Council.

High capital costs of e-Buses necessitate adjustments to standard business models rather than focusing exclusively on subsidies aimed at lowering the capital costs to make them comparable to conventional buses. A business model should strive for operational and financial sustainability through technological advancements, effective grid management, and efficiency enhancements.

6.2 Global Practices for e-Bus Business Models

The business models widely used around the world have been summed up in Table 6-1. It summarizes the cities of implementation, the activities involved, the suitability of the model, and its benefits.

e-Bus Market Feasibility in city of Honiara

Table 6-1: Global practices for e-Bus Business Models

Activities/Parameters	Government Driven Model	Collaboration between Government. and Energy Supplier	Government. partnering with private operators (PPP model)	Partnership among Government., Energy Supplier, and private operator
Implemented City	SM1/ RTP, CDMX	Nagpur Model (Ola), India	Pan India	Shenzhen Model, China
e-Bus Investment				
e-Bus Ownership				
e-Bus Operation				
e-Bus Maintenance				
Chargers O&M				
Ticketing				
Characteristics	<ol style="list-style-type: none"> 1. Maximum Government. Control 2. Availability of Government. funds to own and operate the service 3. Existing experience of bus operations 4. Capacity to cater all risks 	<ol style="list-style-type: none"> 1. Availability of sufficient Government. funds to own and operate the service 2. Existing experience of bus operations 3. Energy supplier well capable of battery and charging provisions 	<ol style="list-style-type: none"> 1. Limited Government. funds available 2. Government. has minimal experience in bus operations and maintenance 3. Government. is willing to share responsibility 	<ol style="list-style-type: none"> 1. Less cost intensive 2. Risk is shared among all the involved partners 3. Individual experience is leveraged in each sector
Pros	<ol style="list-style-type: none"> 1. Government. has the complete ability to adjust or restructure routes, schedule, and fares 2. Viability gap funding, if available, is easier to obtain 	<ol style="list-style-type: none"> 1. More specialized services (electricity and energy supply) by the energy provider 2. Small but significant engagement of government. 3. Less initial expenditure 	<ol style="list-style-type: none"> 1. Harness actors' experience 2. Less upfront investment by Government. 3. Minimizes authority's staffing requirements 4. Increase in operational efficiency of the system 	<ol style="list-style-type: none"> 1. Improves task efficiency related to operating and maintaining electric buses and the infrastructure 2. Better inventory management and skill concentration
Cons	<ol style="list-style-type: none"> 1. Due to high capital investment, attracting sufficient private players may be difficult 2. Significant influence on government's budget 3. May result in low overall efficiency due to government's 	<ol style="list-style-type: none"> 1. Energy provider might face low utilization during the initial phases, when volumes are low 	<ol style="list-style-type: none"> 1. non-compliance with the SLA, may result in penalties 	<ol style="list-style-type: none"> 1. Management and coordination of participants may be difficult for the state

e-Bus Market Feasibility in city of Honiara

Activities/Parameters	Government Driven Model	Collaboration between Government. and Energy Supplier	Government. partnering with private operators (PPP model)	Partnership among Government., Energy Supplier, and private operator
	lack of expertise or prior experience with electric mobility and management			
Legend	Government	Private Operator	Energy Supplier	Planning & Maintenance (Energy Supplier) + Operation (Government)

6.3 Potential Business Models for e-Bus operations

In consultation with stakeholders from Honiara City Council, private operators and others, it is identified that current buses are running on a privately operated business model where only fare is regulated by Honiara City. All e-Bus assets, operations and maintenance is sole responsibility of stakeholders. Considering the conventional Public Transport operations practices, technical feasibility and requirements for operating e-Buses following two models for e-Bus deployment are identified.

For each of the four proposed business models, six areas of activity have been identified. Those are: 1) e-Buses investment (stakeholder in charge of providing funds or support for purchase); 2) e-Buses ownership (stakeholder in charge of owning the e-Buses); 3) e-Buses operations (stakeholder in charge of operating the buses on the routes and providing necessary manpower); 4) e-Buses maintenance (stakeholder in charge of maintaining the bus fleets); 5) chargers O & M (stakeholder in charge of operating and maintaining the chargers); and 6) ticketing (stakeholder in charge of collecting ticket fares).

Table 6-2 Potential Business Models for e-Bus deployment.

Potential Business Models	e-Buses Demand Aggregation	e-Buses Investment	e-Buses Ownership	e-Buses Operations	e-Buses Maintenance	Charger's Setup and O&M	Energy Supply	Ticketing
Model-1 (Private Operator Ownership)	SOE + HCC	Donor agency + SIG support + Private Operator(s)	Private Operator(s)	Private Operator(s)	e-Bus Supplier/Private Operator(s)	Solomon Power (SP)/CPO	Solomon Power (SP)/RE-IPP	Private Operator(s)
Model-2 (Leasing from SOE)	SOE + HCC	Donor agency + SIG support + SOE	SOE (leasing to Private Operator(s))	Private Operator(s)	e-Bus Supplier/Private Operator(s)	Solomon Power (SP)/CPO	Solomon Power (SP)/RE-IPP	Private Operator(s) (Escrow to SOE)

6.3.1 Business Model 1: Private Ownership Model

This Business model is suggested with basis to existing capacity of Private Operators, Honiara city council and prevailing settings and practices for bus operations in Honiara city. As upfront cost for e-Bus purchase is high, e-Bus purchase to be supported by Solomon Island Government (SIG) / State Owned Enterprise (SOE), Honiara City Council (HCC), Donor Grants, Loan, and

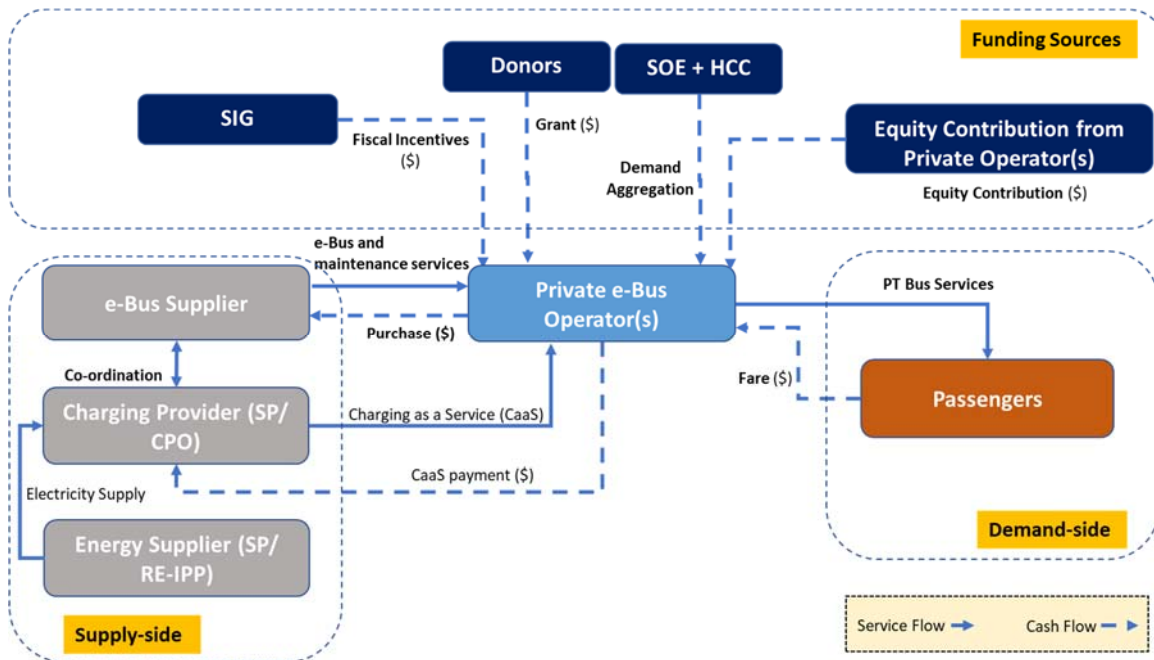
e-Bus Market Feasibility in city of Honiara

partially though self-finance by operator. The amount equivalent to ICE buses purchase to be borne by private operator through either full or partial bank finance at lower interest rates (100% bank finance or; 60% Bank finance plus 40% self-finance). The remaining cost over and above to be financed through National subsidies (granted as per EV Roadmap) and climate finance. Through such mechanism Private Operator would own e-Buses and be responsible for their operations, maintenance and revenue collection fully.

e-Bus charging to be facilitated through ‘Charging as service’ mechanism. E-Bus chargers are high capacity chargers and are expensive to be owned privately. Hence it is useful to set-up charging station (EVSEs, Grid infrastructure, back-up) by Power Distribution company and provide charging as a service with lower charging tariffs to the private e-Bus operators (similar to the domestic power supply).

The e-Bus operations (Schedules), service level agreements (SLA), fares to be decided by Honiara City council. This will help regulating the operations of e-Buses and ensure reliable service to the users. Through this model, Government would be able to save the cost and run e-Buses efficiently.

Figure 6.1 Service and cash flows for Business model 1 – Private Operator Ownership



6.3.2 Business Model 2: Leasing from SOE

This Business model is suggested based on the requirements for e-Bus operations; its newness to the country, current service levels of public transport and city government’s requirement to regulate Public Transport in Honiara. As upfront cost of e-Buses is very high; e-Bus purchase to be done by SOE and through National subsidies and Donor Grants, Loan. The buses would

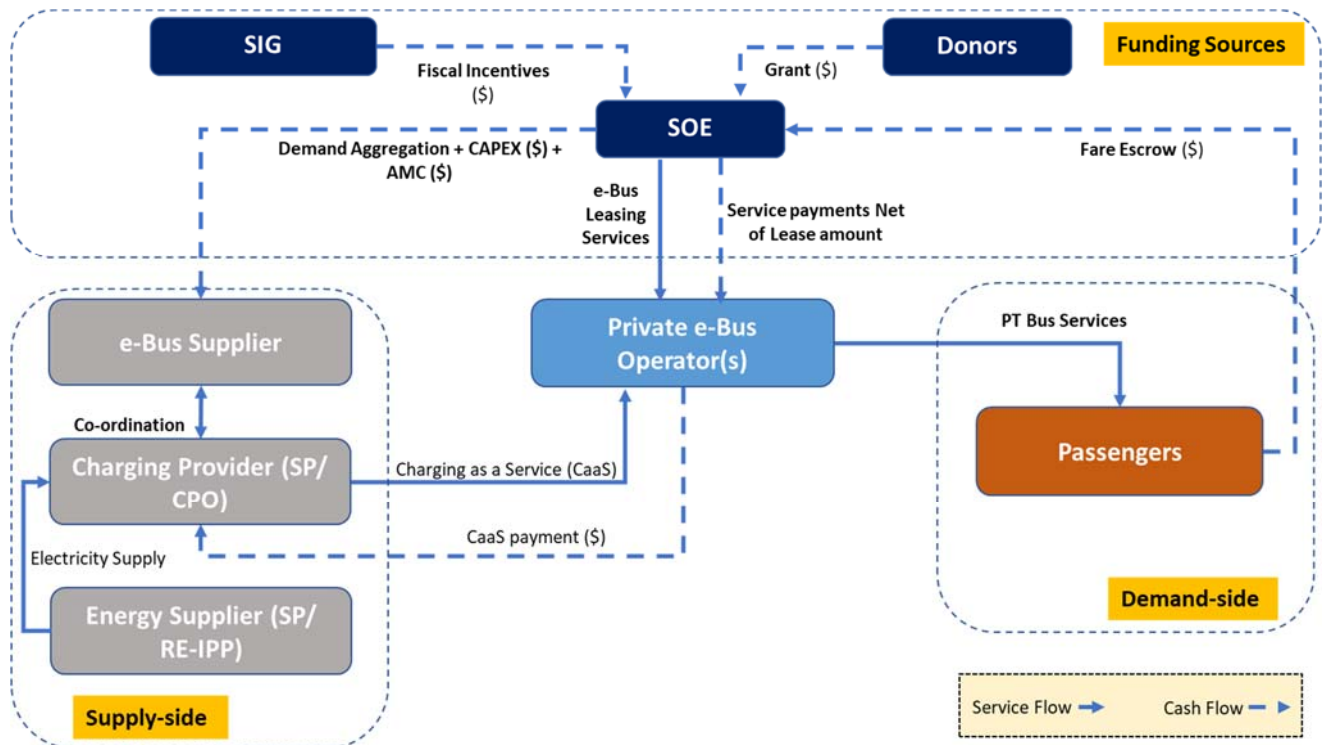
e-Bus Market Feasibility in city of Honiara

become asset to the SOE while their operation and maintenance would be responsibility of the private operator (one or more) under lease contract for e-Bus operations.

e-Bus charging to be facilitated through 'Charging as service' mechanism. e-Bus chargers are high capacity chargers and are expensive to be owned privately. Hence it is useful to set-up charging station (EVSEs, Grid infrastructure, back-up) by Power Distribution company and provide charging as a service with lower charging tariffs to the private e-Bus operators (similar to the domestic power supply).

The e-Bus operations (Schedules), service level agreements (SLA), fares to be decided my Honiara City council. The revenue collection to be the collected by SOE through fare Escrow. This will help reducing burden on private operators to own buses, reducing complexities, regulating the operations of e-Buses and ensure reliable service to the users. This model would increase Government expenses but run e-Buses under government ownership and regulation.

Figure 6.2 Service and cash flows for Business model 2 – Leasing from SOE



7 Enabling Policy measures for e-Bus Adoption

The EV Roadmap for Solomon Islands is being prepared (in-progress) and is in finalization stage. As part of the process, electrification potential and possibility was systematically analysed as part of vehicle segment 'Prioritization'. Intracity Bus segment was prioritized based on the respective findings. This Policy Roadmap has come up with Demand and Supply side policies for all EV segments including e-Buses. This chapter highlights the specific policies for e-Bus segment directly drawn from EV Policy Roadmap for Solomon Islands (in-progress).

7.1 Target

It is targeted to electrify 70% e-Buses sales every year by 2035²³. This targets account for 239 number of mini e-Intracity buses and 270 midi/Standard buses in Solomon Islands by 2035. Nearly 170 Number of captive chargers would be required for the targeted fleet.

The first deployment of 10 mini e-Buses will set an example, for replicating it in other cities for intracity passenger commute. The Government. incentives to be extended only for advanced battery chemistries including Lithium-ion based. Lead acid batteries to be discouraged.

7.2 Demand side Measure

Demand side measures are responsible to boost the e-Bus demand for different use cases by subsidising, incentivising e-Buses and if required by mandating adoption for e-Buses. The demand side measures include Fiscal and Non fiscal measures for e-Buses and policy description in this chapter.

7.2.1 Financial Incentives for e-Bus Purchase

7.2.1.1 Lower Purchase Cost

²³ 70% Sales target = 70% e-Buses in yearly purchase/adoption of buses

Action	Policy Description
Subsidizing e-Buses	<ul style="list-style-type: none"> • Encourage e-Bus fleet owners/operators through right amount of Government. capital subsidy²⁴ on new e-Buses, those meeting quality and safety standards. Battery subsidy can be close to today's battery pack price (230 USD/kWh)²⁵. Maximum subsidy per EV can be defined by average battery size for most common use case. EV subsidy can be gradually phased-out over years as EV reaches ICE price parity. • It is proposed to provide effective subsidy of 30% as percentage of landing price of new e-Buses; from 2022-25; 19% from 2026-30; 12% from 2031 • Pre-owned EVs can be exempted from capital subsidy (but can be given GST deduction and registration benefits). • Special consideration for women with additional 0.5% subsidy on EV purchase • Above proposed capital subsidy is one of the incentivising measures. Apart from this there will be need of greater incentives to achieve cost parity/reduce purchase cost. This could be in the form of GST reduction/exemption over + Custom Duty reduction/exemption (if required) over and above subsidies (Refer Policy measure 'Reduction of taxation on EVs')
Reduction of taxation on e-Buses	<ul style="list-style-type: none"> • Reduce GST and Custom Duty on New and Pre-owned e-Buses, and this can be gradually resumed similar to ICEs post price parity and market development²⁶. <ul style="list-style-type: none"> ○ GST Reduction: For New / pre-owned e-Buses (CBUs – completely built units) let GST be reduced from current 19.05% to 0% from 2022-30; 19.05% from 3031 onwards (Normal) ○ Custom Duty Reduction: For New / pre-owned e-Buses (CKDs – complete knocked down kits) let Custom Duty be reduced from 15 % to 0% from 2022-35 (Exempt) • This to be reviewed in every 5 years.
Exemption of vehicle registration charges on e-Buses	<ul style="list-style-type: none"> • Exempt registration fees on New and Pre-owned EVs from 2022-35 to support initial market development and stimulate adoption. It can be resumed same as ICEVs from 2035 onwards after number of EV's are at par with ICE. The exemption in repeat taxes to be reviewed in year 2025 (after three years) based on level of EV adoption.

²⁴ The capital subsidy to be linked to battery size and vehicle performance and should be capped at two levels 1) Max. subsidy per EV 2) Max. number of EVs to be subsidised. This will allow certainty to government budget planning.

²⁵ Subsidy is subject to change with change in the National Policy Roadmap for Solomon Islands

²⁶ GST concession/exemption is subject to change with change in the National Policy Roadmap for Solomon Islands

e-Bus Market Feasibility in city of Honiara

Action	Policy Description
Exemption of repeat taxes on e-Buses	<ul style="list-style-type: none"> Exempt the repeat taxes including registration renewal and licensing on New and Pre-owned EVs from 2022-35 to support initial market development. It can be resumed same as ICE buses from 2035 onwards. The exemption in repeat taxes to be reviewed in year 2025 (after three years) based on level of EV adoption.
Support for retrofit e-Buses	<ul style="list-style-type: none"> Extend Pre-owned EV benefits also to ICEV retrofitted EVs from year 2022

7.2.1.2 Ease and lower cost of Financing

Action	Policy Description
Provision to encourage Banks to finance e-Bus both for Individual (B2C) and Fleet (B2B) ownership	<ul style="list-style-type: none"> Develop mechanisms to allow easy and attractive financing for e-Bus (individual and fleet) at differential reduced interest rates from banks (National banks, Private banks, NBFCs). This to include individual, public transport fleet and commercial fleet operators Direct banks to include e-Bus financing into their priority sector lending portfolio
Allowance of accelerated depreciation and/or appropriate tax holidays for e-Buses	<ul style="list-style-type: none"> Allow accelerated depreciation and/or tax holidays on investment in new e-Buses

7.2.1.3 Lower Usage Cost

Action	Policy Description
Lower cost to smart e-Bus Charging at Charging Stations	<ul style="list-style-type: none"> Local Electricity Distribution Company (DISCOM) can support through 1) Setting-up e-Bus charging infrastructure , 2) Integrated and attractive financing mechanism for EVSE OEMs 3) Integrating Solar rooftop electricity production with unit-for unit charging fees incentive

7.2.2 Non-Fiscal Incentives

7.2.2.1 Convenience and ease

Action	Policy Description
Ease of process of registration, permits, transfers and ownership of e-Buses	<ul style="list-style-type: none"> Establish single window clearance system for vehicle registration, licensing, permits, transfers (aligned with new and clear vehicle classification system) for both Individual and Fleet ownership of e-Buses
Provision of dedicated parking and charging stations for e-Buses	<ul style="list-style-type: none"> Provide separate and planned charging stations with dedicated space e-Bus parking and charging, servicing, storage, maintenance and monitoring

7.2.3 Building and City Development codes

7.2.3.1 Easy access to EV charging in new buildings and urban spaces

Action	Policy Description
Revision and Redrafting of Building code and City Development code to incorporate e-Bus charging infrastructure	<ul style="list-style-type: none"> Revise 'Building code' and 'City development code' for mandatory installation of e-Bus charging infrastructure. Prepare guidelines on mandate for setting up e-Bus charging infrastructure (stations) with minimum space, layout allocation and respective adjustment in consecutive land-uses, activities and structures.

7.2.4 Dis-incentivizing ICE buses

7.2.4.1 Discouragement on use of ICE buses

Action	Policy Description
Increase of GST and Custom Duty on ICEVs	<ul style="list-style-type: none"> Increase GST on ICEVs from current 19.05% to 21.05% for 2022-2025; 22.05% for 2026-2030; 23.05% for 2031-2035 Increase in Custom Duty on ICEVs; from current 15% to 17% for 2022-2025; 19% for 2026-2030; 21% for 2031-2035²⁷
Increase of taxes on petrol and diesel	<ul style="list-style-type: none"> Increase taxes on fossil fuels to discourage ICE buses Following proposed increment in fuel taxes²⁸: <ul style="list-style-type: none"> Custom duty increase by 1% every year till 2030

²⁷ GST and Custom Duty increase/changes for ICEVs is subject to change with change in the National Policy Roadmap for Solomon Islands

²⁸ Fuel tax increase/change is subject to change with change in the National Policy Roadmap for Solomon Islands

Action	Policy Description
Mandatory periodic pollution test mechanism	<ul style="list-style-type: none"> • Develop robust pollution measurement and control system with annual/periodic mandatory Pollution Test and Certificate (linked to vehicle age and emissions) • Develop pollution control standards and guidelines and Implementation framework ensuring robust quality check mechanism; with clear distinctions in National and Local level actionable and responsibilities • Define penalties and pollution cess for ICE buses (to be paid yearly/quarterly)

7.2.5 Consumer Awareness

7.2.5.1 E-Bus Mass awareness Program

Action	Policy Description
Awareness campaigns, drives and Training programs for Public Transport users	<ul style="list-style-type: none"> • Design and conduct repeat public awareness programs on e-Bus benefits and available support from Government and local ecosystem, targeting fleet owners and public transport users. • Leverage existing automotive dealer network to provision e-Bus experience centre and promote e-Buses. First deployment of e-Bus could incorporate this measure to increase reach and popularity of e-Buses for different e-Bus fleet applications.

7.3 Supply side Measure

Supply side measures are responsible to boost the e-Bus Manufacturing, supply of vehicle, charger and other required sub-systems and create strong local supply chain for e-Buses. The supply side measures include Fiscal, non-Fiscal and regulatory measures described in the chapter below.

7.3.1 Emission Standards

7.3.1.1 Stricter Vehicle emission standards

Action	Policy Description
Stricter e-Bus emission standards and enforcement for ICE buses (new vehicle/pre-owned, imported/local-built, new-entry/running-on-road, end-of-life)	<ul style="list-style-type: none"> • Adopt and strongly enforce stricter vehicle emission standards for all ICE buses in the country, including: <ul style="list-style-type: none"> ○ Import/Local buses (New): comply with new Euro VI standards ○ Import/Local buses (pre-owned): comply with min. Euro IV standards • Import/Local buses (running-on-road): <ul style="list-style-type: none"> ○ 1) If age > 10 years: annual pollution certification mandatory to comply with their built respective Euro II/ Euro III/ Euro IV standards ○ 2) If age > 15 years: Scrappage incentive or higher annual pollution cess

7.3.1.2 Stricter Fuel standards

Action	Policy Description
Stricter fuel standards for petrol, diesel and gas	<ul style="list-style-type: none"> • Adopt and strongly enforce stricter fossil fuel standards (for petrol, diesel, gas) complying with defined vehicle emission standards (Ex: Euro VI fuel standards for Euro VI vehicle standards)

7.3.2 EVs and Charging Infra Standards and Guidelines

7.3.2.1 EVs Vehicle Classification

Action	Policy Description
Vehicle classification system revision to differentiate e-Buses	<ul style="list-style-type: none"> • Revise existing vehicle classification system (separate for passenger and freight transport and distinguishing commercial versus private use) to rightly fit different types of ICE and e-Buses (and any other future vehicle technology) • Classification of e-Buses to be based on battery energy capacity (kWh) and traction motor size (kW) as opposed to engine capacity (cc) for ICE buses

7.3.2.2 EVs Quality and Safety standards

Action	Policy Description
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<p>Formulation of e-Bus Quality and Safety standards for safe import and local production</p>	<ul style="list-style-type: none"> • Formulate standards and guidelines for both New and Pre-owned e-Buses to be eligible for Government. incentives. International standards from UNECE, ICE and others can be appropriately adopted to govern high quality imports (through pre-shipment inspection certification) and local production • Adopt relevant global safety standards for different types of e-Buses (new, pre-owned and retrofits), advanced battery technologies, charging technologies, e-Bus and chargers’ inter-connection and their inter-operability, chargers and grid inter-connection and communication, security against theft and end consumer communications including vehicle to Load/Home/Grid standards
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7.3.2.3 National standards for EV charging

Action	Policy Description
<p>Clear definition of national standards for e-Buses charging</p>	<ul style="list-style-type: none"> • Adopt and strongly enforce clear e-Bus charging standards for both AC and DC chargers across vehicle segments and location (Captive and public charging) • Captive charging and public charging: DC charging given high mix of Europe and Japan imports (30/50/100 kW). The numbers, types, mix and tariffs of chargers can be left open for market forces to decide • Battery Swapping and charging: Allow innovations and deployments

7.3.3 Financial Incentives for e-Bus sub systems and Raw materials

7.3.3.1 Lower EV production cost

Action	Policy Description
<p>Exemption of import duties on e-Bus sub-systems and raw materials</p>	<ul style="list-style-type: none"> • Reduce import duties on EVs raw materials (like cells), sub-systems (EV batteries, on-board and off-board chargers, motors etc.) and to be reviewed every 5 years (continue till local ecosystem is developed)

7.3.4 Financial Incentives for Public and Fleet Charging Infrastructure

7.3.4.1 Lower Capital cost to setup public charging stations

Action	Policy Description
Capital subsidy for all types of public charging stations (AC/DC, fixed/swap battery)	<ul style="list-style-type: none"> Encourage private, public and utility companies set-up e-Bus captive/public charging stations and services and extend capital subsidy. Following proposed subsidy on public chargers (intra-city and inter-city): <ul style="list-style-type: none"> Slow chargers: 50% till 2022-2025; 30% till 2026-2030; 20% from 2031-35 Fast chargers: 75% till 2022-2025; 30% till 2026-2030; 20% from 2031-35 Battery Swapping stations (rural and urban): battery and charger subsidy to be combined and extended to battery swapping stations (if applicable) Renewable integration: with e-Bus charging should be additionally incentivised through available renewable fiscal incentives (and also exempting wheeling charges) Alternative to capital subsidy: Another option instead of giving capital subsidy for e-Bus chargers can be to exempt them from custom duty and/or GST
Low-cost land allotment on long lease for public charging	<ul style="list-style-type: none"> Allocate Government. land on low cost long lease for establishment of captive charging infrastructure. Support ease of land identification and leasing procedures for the same.
Incentives to DISCOMS to own and setup e-Bus charging stations	<ul style="list-style-type: none"> Power distribution companies to be allowed to capitalise cost of setting and running captive and public charging stations for e-Buses

7.3.4.2 Lower Operations cost to run public charging stations

Action	Policy Description
Reduction of electricity cost through separate e-Bus tariff for public charging	<ul style="list-style-type: none"> Build separate e-Bus focused lower cost electricity tariff system for public charging stations as well as commercial EV fleet stations. The tariff system to reflect time-of-day (TOD) or time-of-use (TOU) to differentially charge peak and off-peak charging times There can be exemption on demand charges (variable component of electricity tariff) for e-Business in first 5 years for e-Bus charging stations

7.3.5 EV Mandates for Government. agencies

7.3.5.1 EV Mandates for Government. agencies

Action	Policy Description
Mandate for Government. agencies and offices to adopt e-Buses	<ul style="list-style-type: none"> • Mandate different Government departments and agencies to go for e-Bus procurement and/or leasing for their employees commute. This can be gradual increased to 100% in next 3-5 years. This can drive first demand for e-Buses and also make it higher visible. • This can be started with pool vehicles and Public Service Commission buses which are used to commute government officers and the staff

7.3.5.2 Government. entity driven EVs aggregation and bulk procurement

Action	Policy Description
Aggregation of e-Bus demand and stimulating local supply	<ul style="list-style-type: none"> • Authorize appropriate Government agency to aggregate e-Bus demands (from Government departments, fleet operators, corporate, others) and do bulk procurement of e-Buses with increasing local supplies at additional price discounts

7.3.6 Grid Management

7.3.6.1 Charging Integration for Grid stability

Action	Policy Description
Guidelines/ standards for Grid and Chargers interconnectivity and communications for overall grid stability, safety, and e-Bus transaction	<ul style="list-style-type: none"> • Develop guidelines for grid and chargers interconnectivity for both captive and public chargers and charging stations. This to include easier new connection or existing sanctioned load revision for setting up e-Bus charging

7.3.6.2 Time-of-Use (TOU) Tariff system

Action	Policy Description
TOU tariff system for Grid load management	<ul style="list-style-type: none"> • Introduce TOU tariff system for EVs connection to allow differential tariffs for EV charging based on peak and non-peak power. This to be initiated with public transport e-Buses charging stations • Incentivising EV tariff at lower prices ranging from 0.06 to 0.2 USD/kWh (Refer to Chapter 9.1.2)

7.3.6.3 Improving Grid access in urban and rural

Action	Policy Description
Expansion of grid and off-grid infrastructure and power quality	<ul style="list-style-type: none"> • Encourage expansion of grid and ensure grid infrastructure accessibility for reliable e-Bus charging in urban and rural with right mix of grid, off-grid and smart-renewable integration. Target 100% connections and 24x7 power for all. <ul style="list-style-type: none"> ○ Drive Government. and private investments in National Grid expansion ○ Encourage DRE/solar mini grids (by Government. and Private players) to integrate e-Buses (including plug-in charging and swap batteries) for urban and rural use cases Revise different electricity tariffs for healthy and faster power sector development

7.3.7 Disposal, reuse and recycle

7.3.7.1 Vehicles scrappage guidelines

Action	Policy Description
Definition of National guidelines for vehicle scrappage (focus e-Bus)	<ul style="list-style-type: none"> • Define guidelines for Vehicle Scrappage. • Scrap after 20 years of life, if do not pass fitness and emission tests. Provide additional incentive on e-Bus purchase when ICE bus scrapped • Adopt Extended Producers Responsibility (EPR) by mandating OEMs to set-up collection centres and recycling facilities

7.3.7.2 Retrofit of ICEVs into EVs

Action	Policy Description
Allowance of ICE bus retrofit to e-Bus	<ul style="list-style-type: none"> • Allow retrofit of ICE buses to e-Buses following safety standards

7.3.7.3 Battery re-use and recycle guidelines

Action	Policy Description
Outline environmental guidelines for battery re-use and recycle	<ul style="list-style-type: none"> • Develop guidelines covering collection, storage, transportation, re-use and recycle of used/waste batteries from EVs. <ul style="list-style-type: none"> ○ Collect 100 percent Lithium-Ion Batteries (LIBs) from EVs through Extended Producer’s Responsibility (EPR) ○ Clearly define battery-value for reuse in the market and create a secondary market

7.3.7.4 Vehicles scrappage and Battery recycling facilities

Action	Policy Description
Capex subsidy for setting up vehicle scrappage and battery re-use/recycle facilities	<ul style="list-style-type: none"> • Provide capital subsidy and other support (land, electricity, others) for setting up vehicle scrappage and battery re-use/recycling facilities

7.3.8 R&D, Pilots, Capacity Building

7.3.8.1 National R&D Centres on EVs

Action	Policy Description
Establishment of Industry-Academia e-Bus Centre of Excellence (COE)	<ul style="list-style-type: none"> • Extend R&D grants and facilitate top National Academic Institutes to build Centre of Excellence (COE) driving research and development on various aspects of EVs and broader e-Buses and low carbon transportation and energy • Integrate close industry participation for commercial R&D, patents, start-ups incubation and scalable deployments. Allow additional fiscal incentives to industry for R&D investments in e-Buses

7.3.8.2 EV Pilots and Deployment

Action	Policy Description
Support for e-Bus pilots and Experimentation	<ul style="list-style-type: none"> • Establish one Government. linked e-Bus Accelerator which can actively coordinate academia and industry research with focus on running pilots, developing different use cases viability and their scale-up • It will also facilitate fund raising from various Development agencies and coordinate between different Government. departments

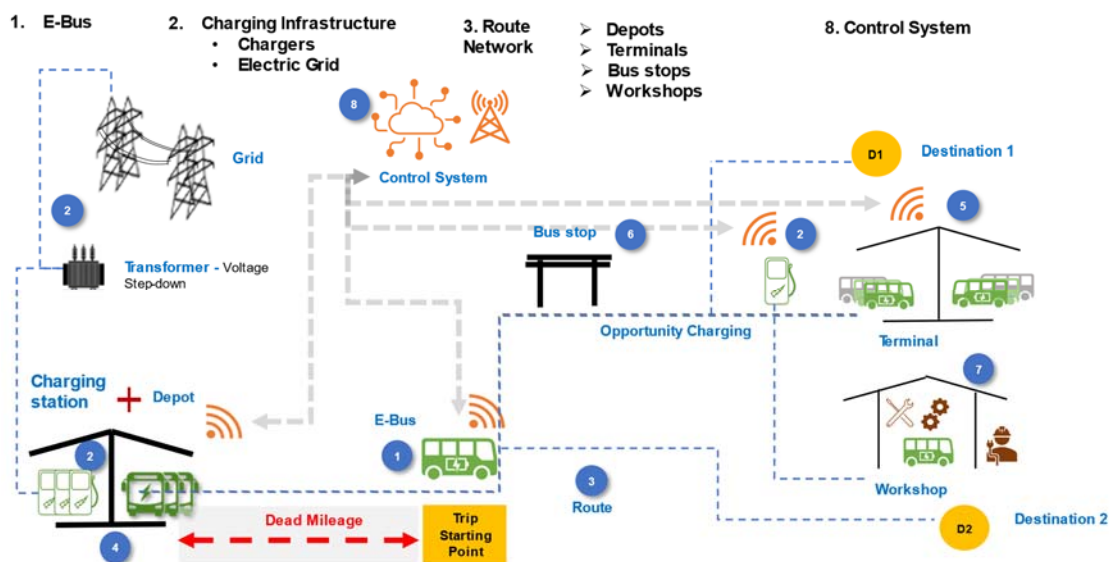
7.3.8.3 EVs Training and Capacity Building

Action	Policy Description
<p>Setup e-Buses Training and Capacity Building ecosystem</p>	<ul style="list-style-type: none"> • Encourage Technical Universities/ Institutes to develop degree and vocational courses in e-Buses and the System planning. • Raise National EV Skills Council to focus on e-Bus skills development and certification across different roles in e-Bus value chain, in close association with Industry and Academia. • Facilitate e-Buses Training infrastructure through grant money and grow Regional Training Centres
<p>Strengthen e-Bus repairs and services across the nation</p>	<ul style="list-style-type: none"> • Develop guidelines for OEMs and Dealers to partner with local institutions and build strong training and certification skill programs to build local expertise with e-Buses assemble, innovate, repairs & services, retrofitting, driving, etc.

8 City Charging Infrastructure Guideline

For smooth e-Bus operations, it essential to establish robust, safe and Charging Infrastructure. An important factor in planning e-Bus charging infrastructure is the size and volume of infrastructure required. e-Buses have batteries with different capacities. To mention few of them such as 60, 80, 120, 180, 240, 320, 400 kwh and more; and have high power requirement for charging. For such high-capacity batteries and volume of e-Bus fleet in a public transport system; charging can be only facilitated through separate set-up. This includes step down infrastructure to pull power from grid, Chargers (i.e., EVSEs), power back-up, safety and monitoring systems. The components of e-Bus charging infrastructure together are cost intensive and hence need a plan to use them judiciously.

Figure 8.1 Sample illustration for Charging infrastructure and e-Bus set-up for operations



The chargers and grid infrastructure requires certain space and arrangement to enable ease of e-Bus plug-in, plug-out and manoeuvring. Introducing a new system needs planned execution and deployment. For a new deployment there will be need to identify, acquire land and set-up new system. While in case of cities with prevailing Public transport infrastructure (with depots, terminals workshops etc;) selected places would need to be appropriately modified and made compliant to operate e-Buses. Including access to grid, setting up grid infrastructure, EVSEs, monitoring systems, shades, workshop set-up for e-Buses and so on. The type of chargers, charging strategy, charger rating also need to be pre-defined and infrastructure to be deployed in a planned manner for desired e-Bus specifications to serve selected routes efficiently.

Guidelines given below will help making right choices (technical, operational and financial) for e-Bus Charging Infrastructure deployment.

8.1 Charging infrastructure for e-Buses: Global best practices

Table 8-1 Detailed summary of e-Bus charging systems and infrastructure best practices²⁹³⁰



Parameters		Justification of the Ideal Value	DC Plug-In	DC Pantograph	Inductive charging	Battery swapping
Description			This entails DC charging by a plug-in connection.	This category includes DC charging via pantograph with on-board bottom up or off-board top-down configuration	This category includes all charging technologies which achieve wireless transfer of electricity, either by static or dynamic induction.	This entails cases; where depleted vehicle batteries are swapped with fully charged batteries.
Technical	Input voltage from grid(V)	Voltage required for the vehicle charging is prescribed as the same as of grid voltage, so that no additional infrastructure is necessary for charging station installation.	415 or above	415 or above	415 or above	415 or above

²⁹ [A Guide for Planning Charging Infrastructure for Intra-city Public Bus Fleet](#)

³⁰ [Handbook of EV Charging Infrastructure Implementation](#)

e-Bus Market Feasibility in city of Honiara

Parameters		Justification of the Ideal Value	DC Plug-In	DC Pantograph	Inductive charging	Battery swapping
Economic	Output range of chargers available in market (kW)	Minimum output range is most preferred.	50 - 150	150 - 650	50 - 250	Data not publicly available
	Output power considered for analysis (kW)	Minimum output power is most preferred.	70	300	200	No typical value assumed
	Charging/Swapping time	Charging technology which charges faster is more suited to maintaining service headways.	1.7 - 2 hours	~ 25 minutes	Not reported	2.5 - 10 minutes
	Electricity connection required (HT/LT)		HT	HT	HT	HT
	Ancillary infrastructure required	Minimum requirement of Ancillary infrastructure is most preferred.	Distribution Transformer , HT / LT switchgear, liquid cooled cables, protection relay and SCADA	Distribution Transformer, HT/LT switchgear, liquid cooled cables, protectionrelays and SCADA	Distribution Transformer, HT / LT switchgear, road embedded cables, protection relay and SCADA	Distribution Transformer, HT/LT switchgear, cables, protection relays and SCADA
	Auxiliary energy consumption	Minimum energy consumption is most preferred.	Low	Medium	High	High
	Area requirement per EVSE (sq. m)	Minimum area requirement is most preferred.	2	2	2	No typical value assumed
Capital cost of charging technology (USD)	Minimum price of the EVSE is suitable for bus charging.	20,000 – 28,000	40,000 – 150,000	2,90,000 or above	420,000 or above	

e-Bus Market Feasibility in city of Honiara

Parameters		Justification of the Ideal Value	DC Plug-In	DC Pantograph	Inductive charging	Battery swapping
	Cost of ancillary infrastructure (USD)	Cost of ancillary infrastructure depends on the type of EVSE. The one which entails least ancillary cost would be desirable.	3,000 – 5,000	7,000 – 16,000	5,000 – 9,500	3,000 – 5,000
	Cost of electricity for charging	Charging system which attracts the lowest electricity tariff would be most desirable. Amount of electricity consumption at system-level is considered to be fixed.	As per HT connection norms	As per HT connection norms	As per HT connection norms	As per HT connection norms
	Maintenance cost (%)	Based on industry practices. Minimum cost is desirable.	10% of installation cost for periodic maintenance; 2% of installation cost for regular maintenance			
Other parameters for selection of	Ease of drawing electricity from the distribution network	Moderately difficult distribution is most preferred.	Moderately difficult; possible to draw electricity through a DT connected to a HT line	Difficult; must be drawn only from an 11/33 kV substation which is not as accessible as a HTline	Moderately difficult; possible to draw electricity through a DT connected to a HT line	Moderately difficult; possible to draw electricity through a DT connected to a HTline
	Established precedence for charging buses		Yes	Yes	Limited	Limited

Best Practice examples

- **DC Plug-In: Shenzhen, China**
 - China has successfully electrified its e-Bus fleet of over 16,000 buses. e-Bus operators collaborated with charging infrastructure providers
 - to establish charging facilities at depots and the bus routes maintaining a 1:3 charger to-bus ratio. The typical charging time reported in case of overnight charging at the depot is around 2 hours. However, there are also charging stations
 - installed enroute, which are reported to charge the buses in approximately 40 minutes.

- **DC Pantograph: City of Geneva**
 - City of Geneva employs DC pantograph-based technology for charging trolley e-buses (ABB, 2019). The e-buses are charged at three different output power levels: 600 kW, 400kW and 45 kW. The 600 kW 'flash' charging stations which provide a quick power boost in a short span of 15-20 seconds are reportedly the fastest in the world. The 400 kW and 45 kW charging stations charge the battery for 5 and 30 minutes respectively

- **Inductive charging (Wireless): Gumi, South Korea**
 - South Korea started e-bus operation in 2014, where the fleet is charged via induction (Ahn, 2017).
 - The Korea Advanced Institute of Science and Technology (KAIST) developed the proprietary magnetic resonance technology used for charging e-bus batteries.
 - Every On-Line Electric Vehicle (OLEV) e-bus is equipped with a special receiver which can collect electric power wirelessly from the underground power supply while in motion or at the stationary condition.
 - It is reported to operate at an efficiency of 85%

- **Battery swapping: Jeju Island South Korea**
 - Jeju Island South Korea is a unique market for e-buses where charging by conductive, inductive and battery swapping technologies have been employed. E-buses with battery swapping technology operate on Jeju Island (Park, 2016).
 - The e-buses used in this project has 51 kWh battery bank which is mounted on the roof of the bus. The battery swapping stations located at the bus-stops have battery charging facilities and robotic systems for swapping.
 - At the swapping station, there are two automatic robotic systems to remove the depleted battery from the bus and attach a fully charged battery.
 - The swappable batteries used in this project weigh approximately 760 kg and has a special shock absorption design feature (Begins, 2019).

8.2 Criteria for the strategic development of Charging Infrastructure

8.2.1 Charging Demand Assessment

Sr. No.	Components	Description
1	Charger Sizing	Charger sizing needs to be done after knowing the e-Bus operations requirements (energy, battery, bus and charging scheduling). It is required to select the charging technology and estimate required number of charging units (EVSEs/Pantographs/swapping system etc.). This will further be basis to estimate the power load to be proposed.
	Power load estimation	<p>Estimating demand for required peak power is necessary to consider as it is the foremost deciding factor for planning and providing charging infrastructure.</p> <p>The required peak load to be calculated including considerations for power losses at generation, transmission and distribution. Estimated peak power to be used to sanction the load to operate e-Bus charging station.</p>

For first deployment of e-Buses charger sizing is done based on recommended e-Bus operations. The charger required for Depot Charging (Overnight + opportunity Charging) - 3 Chargers with 55 kW rating

Based on existing peak power assessment; e-Bus deployment would add up to the existing power requirements for city of Honiara. It is estimated that the load for charging station at depot (overnight + opportunity charging) will add 0.2 MW (260 kW) peak power more in existing peak demand for city of Honiara.

This can be facilitated through special agreements between Solomon Power and the HCC to provide un-interrupted a reliable power supply. It would be an added benefit if the energy is generated from renewable sources such as solar and hydro power.

8.2.2 Spatial Planning

Sr. No.	Factor	Description
1.	Charging Location and integration with Urban land-use planning	<ul style="list-style-type: none"> • e-Bus charging infrastructure need to integrate with urban land-use and its related activities. considerations are as follows <ol style="list-style-type: none"> i. placement of e-Bus charging locations at either ends of routes or at one end as per requirement and planning. ii. Making opportunity charging options available for e-uses. iii. Using public charging station accessible and usable for buses and others. • Appropriate city and building codes revision for e-Bus charging infrastructure will be important for i) public charging stations ii) dedicated/ captive fleet charging iii) battery swapping iv) others (commercial malls, homes, kerb side parking, public parking, etc.)
3.	Area selection	<ul style="list-style-type: none"> • Metro cities, capital cities/ regions are experiencing scarcity of land and that impacts the land acquisition cost as well. This may affect land acquisition for EV Charging infrastructure • Support from National, Regional, local government departments, power utilities, existing fuel (oil) stations; for (including power utilities, petrol fuel stations, etc.) extending long-term low-cost leases for their available suitable land pockets will allow competitive EV charging infrastructure development.
4.	Area Requirement	<ul style="list-style-type: none"> • Suitable sizing of the land to be undertaken accounting for i) charger (EVSE) setup ii) EVs parking and charging iii) EVs queuing iv) EVs manoeuvring/ circulation for entering and exiting the charging bays and v) administrative office.
5.	Accessibility to grid	<ul style="list-style-type: none"> • Typically, the costs for providing grid connection from high voltage line to EV chargers is quite high (depends on distance, kms) and is to be borne by charging station operator, which has potential to limit financial viability (specially in early EV market development time when EVs demand will remain low for initial years). • Suitable size of land to be undertaken accounting for the spatial proximity of land and access to grid. Proximity of Grid connection will enable easy access and minimize the grid connection cost to bring electricity to charging station.

Charging Location and integration with Urban land-use planning: Location of e-Bus charging is decided based on start and end points of routes. The charging strategy adopted for e-Bus deployment is Overnight + Opportunity charging. The routes are to be operated from Depot proposed near the MID building; where charging station for overnight + opportunity charging is needed.

Currently the proposed location is privately owned, hence it is recommended for the HCC to facilitate the land through the appropriate Acquisition for Solomon Island. Based on technical feasibility, the charging station is proposed to be provided in this depot selected.

Area selection:

Selected areas of the Depot have enough space to accommodate more than 80+ buses. However, HCC must invest in the land and construct the depot infrastructure for the buses in the location

Area Requirement: An EVSE with 30kW-160 Kw capacity requires space of ~1 sq.m. and a 7 m e-Bus would require space of ~40 sq.m. Based on the fleet size and charging requirement. Additionally, a total charger space requirement of 25 Sqm is required for Depot Charging

Accessibility to grid: As per consultations with Solomon Power distribution agencies can ensure required load, access to grid and reliability of power. The Depot is in proximity to the grid connection it is doable for local power distribution company to provide un-interrupted grid access.

8.2.3 Grid Infrastructure requirements

Sr. No.	Factor	Description
1.	Accessibility to required load and supporting infrastructure	<ul style="list-style-type: none"> e-Bus charging stations because of combined high connected load (coming from multiple chargers) will require high grid voltage access (13.2kV/220V) point and appropriate distribution transformer It should be ensured that grid has the sufficient capacity to accommodate the heavy load as required to charger the buses or should make provisions for access to sufficient power required as estimated/sanctioned
2.	Electricity tariff	<ul style="list-style-type: none"> Electricity cost (both fixed demand and variable energy charges) is significant operating cost for charging stations Appropriate EV specific separate tariff category or concession to existing applicable tariff (both demand and energy charges) can support early market development
3.	Grid interconnection and safety	<ul style="list-style-type: none"> At e-Bus charging stations, use of fast chargers (typically DC) lead to high power load on grid. This may cause power factor, load factor, harmonics, voltage deviations, etc. on the power grid, and hence should follow country’s grid code and regulations for overall grid safety

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4.	Integration with renewable energy (generation and storage)	<ul style="list-style-type: none">• e-Bus will have positive impact on operation, environment and economy if they can use renewable sources for charging. The source of renewable generation can be at charging site and/or wheeled from distant plant• This renewable energy integration with local battery energy storage system (BESS) at charging stations can allow cleaner EVs transition, healthier air, improved peak load management and lower cost of electricity
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As described in chapter 8.2 e-Bus pilot will require 0.2 MW Peak power on the charging stations. To facilitate the power demand; a grid voltage of 220 V and 1000 A is required at the depot.

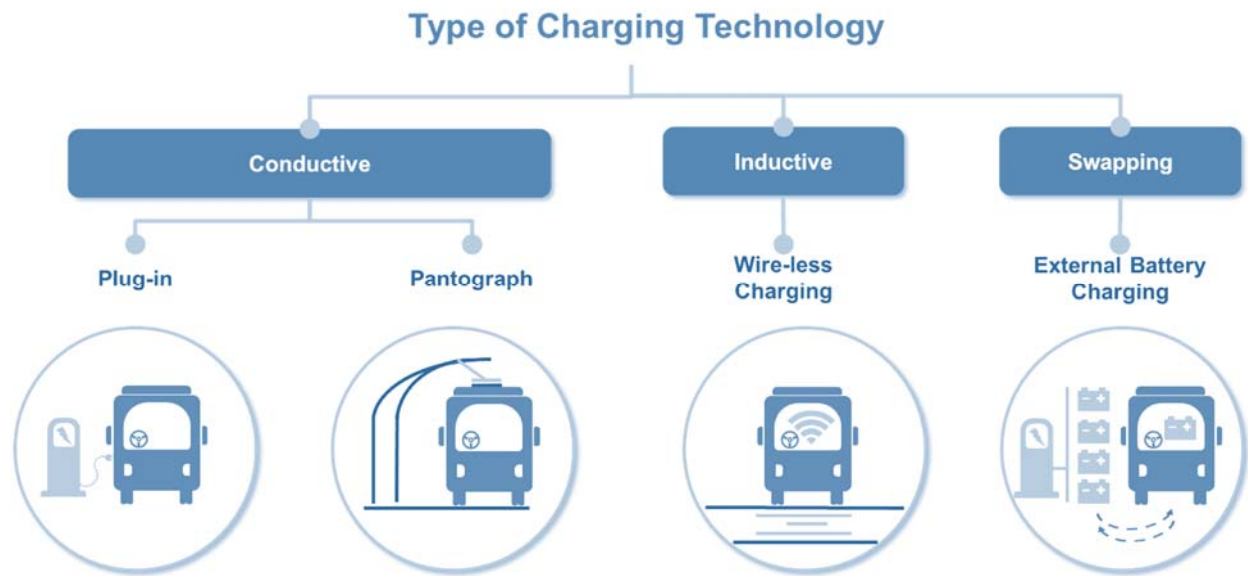
The required grid voltage and current to be facilitated by Solomon Power appropriately with detailed demand assessment before deployment. Power distributors need to ensure uninterrupted and reliable power supply to the charging stations. The flexibility of augmenting the capacity in future has to be taken in account in case of future expansion of e-Bus deployment.

Current tariffs of electricity are based on the unit consumed is 0.77 USD/kWh³¹. The tariffs to be revised and Time of Use tariff system can be introduced (chapter 7.3.6) to allow differential tariffs for EV charging based on peak and non-peak power. It is also necessary to plan for optimizing grid load requirement. Grid code regulations can be followed by Solomon power while planning grid infrastructure for e-Bus charging station to ensure interconnectivity and grid safety.

Integrating renewable energy would help eliminating Well to Tank emissions (WTT) and it can be facilitated through enabling special contracts for clean energy provision; between e-Bus operator and Solomon Power. Innovation and experiments with business models for e-Buses to be encouraged for integration of renewable energy.

³¹ <https://solomons.gov.sb/wp-content/uploads/2022/01/Gaz-No.-328-Sup-No.-274-Wednesday-22nd-December-2021-.pdf>

8.2.4 Charging Technology Selection



Sr. No.	Factor	Description
1.	Charging Technology used in electricity transfer	<ul style="list-style-type: none"> Different charger technologies i) conductive charging (fixed chargers/ down pantograph/ up pantograph) ii) inductive or wireless charging iii) battery swapping existing and need to be rightly mapped to different type of e-Buses (as per technology, battery capacity, battery ratings, service need and others)
2.	Charging Types and Power output of the charger	<ul style="list-style-type: none"> e-Buses will require AC and/or DC chargers of different power rating capabilities (Level 1, Level 2, and Level 3) for charging. This will be based on battery size and type, model of charging, number of planned charging events and required charging time
3.	Charging strategy	<ul style="list-style-type: none"> e-Buses by their operational characteristics (Daily distance, time and speed profile, terrain, weather) will have varying energy requirements. This can be supported by different battery–charger systems like; <ol style="list-style-type: none"> Big battery and overnight charging Small battery with mix of overnight charging and en-route opportunity charging Battery Swapping: based on appropriate e-Bus operations planning for battery swapping; and others This charging strategy needs to be designed considering specific e-Bus application and cost-performance trade-offs

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4.	Communication and protection protocols	<ul style="list-style-type: none"> • EV chargers will increasingly use advanced communication protocols with; <ol style="list-style-type: none"> i. Power distribution grid for better load management and ii. Charge Points Operators (CPOs) for billing, payment and smart management & maintenance services. • E-Bus fleet for their high impact on power grid and continuity of public services will need increasing use of advanced/smart monitoring and control systems at charging stations
5.	Interoperability	<ul style="list-style-type: none"> • Interoperability in different e-Bus models and makes (across different OEM models) can allow access charging stations operated by different providers through a single application or platform • Interoperability can also help in improving charging station utilization by share of e-Bus fleet chargers between; <ol style="list-style-type: none"> i. Other Public Transport vehicle segments (e.g., bus depot chargers shared with taxis, UV express and others) ii. Other non-PT vehicle segments (e.g., share of intra urban public charging station with private vehicles; share of inter-provincial bus charging stations with heavy commercial/freight vehicles like trucks)
7.	Charging standards	<ul style="list-style-type: none"> • There are existing different charging standards including Combined Charging System (CCS), CHArge de MOve (CHAdeMO) and GB/T which OEMs and countries are adopting (either allowing all or limiting to one-to-two standards for public chargers). • These standards govern mainly i) design of connectors (both charging outlet and vehicle inlet) ii) communication between charger and vehicle, and influence interoperability • Charging standards for e-Buses need to be developed in co-ordination with National standards for electric vehicle charging

Plug-in charging (conductive) technology is suggested considering the first-time e-Bus deployment in city of Honiara. E-Buses with 118 kWh battery capacity are suggested for the first deployment which will require DC charging (55 kW) charging at Depot for Overnight and Opportunity charging. The EVSEs has to be aligned/adjusted with the communication protocols of grid and battery and CPOs. The chosen e-Buses to ensure interoperability with the charging infrastructure helping optimizing charger utilization. The suggested chargers are DC Fast chargers where cars and other light duty vehicles cannot charge. e-Bus deployment will bring experience on e-Bus charging and their experience over the years; till then, for first deployment, it is suggested to provide dedicated charging for e-Buses at present with no integration for other than e-Bus use (taxi, SUV and any other vehicle segments).

OEMs available locally, regionally and globally could be approached for required EVSEs their technologies. Inviting quotations along with technical specification of the EVSE products would help choosing required chargers at competitive prices.

8.2.5 Operation planning

Sr. No.	Factor	Description
1.	Route Coverage	<ul style="list-style-type: none"> Buses typically operate on defined routes and local regions by their franchisee terms and conditions. Charging model selection should ensure appropriate coverage of Public Transport routes and their local demand dynamics for suitable utilization (today and in future)
2.	Charging Optimisation	<ul style="list-style-type: none"> The charging model should optimize and provide flexibility and capacity to cover dead mileage for e-Buses over and above daily billed travel distance from their typical daily operations

The charging infrastructure sizing is undertaken based on integrated analysis of route energy, battery sizing, and scheduling of both fleet and chargers. The analysis includes the consideration of overnight and opportunity charging at the depot. The e-Bus will top-up charge at the depot after ever round trip. Since the depot is at proximity to the start point of the trip there is no dead mileage occurrence during the event of operations. Planning the opportunity charging only at the depot and not at the terminals will help minimize the charger cost and also improving the serviceability of the e-Bus.

8.2.6 Charging infrastructure safety

Sr. No.	Factor	Description
1.	Disaster resiliency	<ul style="list-style-type: none"> The land topography should be checked for any natural and man-made disasters like floods, earthquake, etc. that could disrupt safe EV charging.
2.	External Safety considerations	<ul style="list-style-type: none"> The weather conditions and safety of surroundings (living things) from any short circuits and direct contact with electricity should be taken into considerations.

The city of Honiara encompasses a hilly terrain with a max elevation of 29 m in the city. The west part of the city is at 13 m elevation which gradually reduces to 4 m at the centre of the city and again raises to 10m as it moves east of the city. The routes chosen for e-Bus deployment currently are not vulnerable for natural disasters. As the weather is moderate in Solomon Islands e-Bus are likely to suite and perform well in city of Honiara. Actual operation of e-Buses and their performance further will vary once operations start. First deployment will help gathering the experience and apply it for the future deployment of e-Buses.

8.2.7 Business model selection

Sr. No.	Factor	Description
1.	Cost of charger and charging infrastructure	<ul style="list-style-type: none"> • Cost of chargers and required supporting associated infrastructure has high implication on cost overall project cost. This becomes further challenged with lower charger utilization in early market development years if the e-Bus fleet is small • The number of chargers need to be judiciously calculated including contingency considerations before purchasing chargers and charging infrastructure • Government fiscal incentives on EV chargers and required associated infrastructure can allow better business viability for charging infra providers and operators.
2.	Charging infrastructure investment and ownership model	<ul style="list-style-type: none"> • Potential business models for providing charging infrastructure; to be explored leveraging current practices such as; <ol style="list-style-type: none"> i. Sub-Contracting Through e-Bus OEMs where they may invest and/or operate charging stations ii. Sub-Contracting for e-Bus charging i.e., Charging as a service where a. <ul style="list-style-type: none"> ▪ EVSE OEMs would invest and/or Operate charging stations or ▪ Energy Distribution companies (public and or private) would invest and/or Operate charging stations iii. Full ownership of infrastructure and sub-contracting Operations and Maintenance to OEMs; and others
3.	Business synergies with EV charging	<ul style="list-style-type: none"> • Different businesses (e.g., fuel station operators, power utilities, commercial malls, public parking spaces, EV OEMs, etc.) not directly into e-Bus operations may benefit from supporting EV charging (investing and/or leasing land) and leveraging their primary business
4.	Pricing Model	<ul style="list-style-type: none"> • Depending on the charging infrastructure ownership model and e-Bus types; there can be different pricing models for charging stations like i) pay by electricity use ii) pay by charging session iii) pay by battery swap iv) pay by charging time v) bundled subscriptions and others

Currently there are no public transport authority operating the buses. All the buses are privately franchised and operated.

9 e-Bus Investment, Funding, and Deployment Plan

This section assesses the technical scenarios in chapter 5.3.1.4 on cost parameters. All costs related purchase of e-Bus, charging infrastructure and their operations are considered to assess lifecycle cost implications of e-Bus deployment.

9.1 TCO analysis

Total cost of ownership is studied to understand the comparative lifecycle cost of e-Buses to that of current ICE buses running on roads. The TCO helps comparing two desecrate technologies based on common parameters (both operational and financial).

9.1.1 Key parameters for TCO assessment

The routes identified through the technical feasibility are further assessed on parameters that impact different costs of owning the buses. Total Cost of Ownership is performed to assess the financial feasibility of e-Buses in comparison with currently operational ICE buses. TCO helps comparing two different technologies based on their operational parameters and their results in cost (USD) kilometre.

Following tables (**Error! Reference source not found. & Error! Reference source not found.**) represent key operational and cost parameters that impact the cost of operating ICE and e-Buses and explained below.

Parameter	Unit	ICE Bus	e-Bus
Operational Days per year	No of Days/ Year	300	300
Avg. km Run per day ³²		~ 180	~175
Dead Mileage per day (minimum) ³³	km	-	-
Vehicle characteristics		Toyota Coaster³⁴	Greenpower EV Star + (plus) 7m AC bus³⁵
Fuel tank capacity/ Battery capacity	Litres or kWh	70	118
Motor Power	kW		150
Battery technology		N.A.	LI-Ion battery

³² The daily kilometres travelled by bus will change per route

³³ The dead mileage adds up to the daily travelled distance by a bus

³⁴ [Batfa Japan Inc; Japanese New bus; 2022](#)

³⁵ [GreenPower; EV Star+; 2022](#)

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Range (stated by OEM)	Km/Full tank	-	250
Vehicle efficiency	Km/Litre Km/kWh	7.7 km/l	0.5 to 1 km/kWh* ³⁶ can go up to 2 km/kWh
Refuelling/Charging Time	Hrs	5-10 Minutes	Fast Charging: 1 to 2 Hrs
Bus Life	Years	15	10
Charging infrastructure characteristics			
Charger rating	kW		DC Fast: 55 kW
Number of Vehicles shared per charger	Nos.		Refer chapter 5.3.1.4
Charger efficiency	%		92%
Grid Losses	%		10%
Charger Life	Years		10

The operational days per year for e-Buses are considered equal to the ICE buses. On and average the daily operational distance (billable, with passengers) is ranging from 165 km to 180 km per day (chapter 5.3.1.4; and **Error! Reference source not found.**). As the depot location is in proximity to the start point of operations, there is no dead mileage incurred for R1 and R2. This is calculated for each route across all scenarios and has summarised in chapter 5.3.1.4.

Vehicle efficiency and range gives the amount of fuel that would be consumed per route both for ICE buses and electricity consumed per day for e-Buses. The fuel/charging requirement determines the capacity and number of chargers required and effectively impact on the cost incurred to purchase and operate the chargers.

Parameter	Unit	ICE Bus	e-Bus 118 kWh
Capex			
Vehicle Purchase cost (Including all taxes ³⁷)	USD/Vehicle	102,705	111,552
Battery Cost (Including all taxes ³⁸)	USD/kWh	-	230
	USD/Battery	-	37,786
Total Vehicle cost	USD/Vehicle	102,705	149,338
Charger cost ³⁹	USD/kW		160
Operation Cost			
Fuel/Electricity cost	USD/Litre or USD/kWh	1.25	0.77
Maintenance	USD/km	0.006	0.006

³⁶ The efficiency is OEM claimed and subject to change as per route energy requirement.

³⁷ effective tax = 15% customs and excise +19% Goods Sales Tax + Registration charges = USD 43

³⁸ Taxes on battery are considered same as effective tax on vehicle. Though the battery cost is calculated separately for purposed differentiating the effect of subsidy in further calculation; battery is integral part of the vehicle hence same taxes are applied on the battery

³⁹ The charger cost is considered global benchmarks and average rate of e-Bus chargers worldwide. The charger cost may differ for different technology.

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Staff, administration & other expenses per km	USD/km	0.03	0.03
Finance cost in USD (real terms)	%		
Insurance cost as % of Vehicle value	%	1%	1%
Salvage Value	%		
• Vehicle	%	10%	10%
• Battery	%		20%
• Charger	%		3%

In the cost parameters, two types of cost are considered 1) Capital cost and 2) Operational cost. Capital cost include the vehicle purchase cost including all taxes, additionally battery and charging infrastructure cost for e-Buses. The operational cost includes the fuel, Maintenance, staff, insurance and any other recurring costs in vehicle operations.

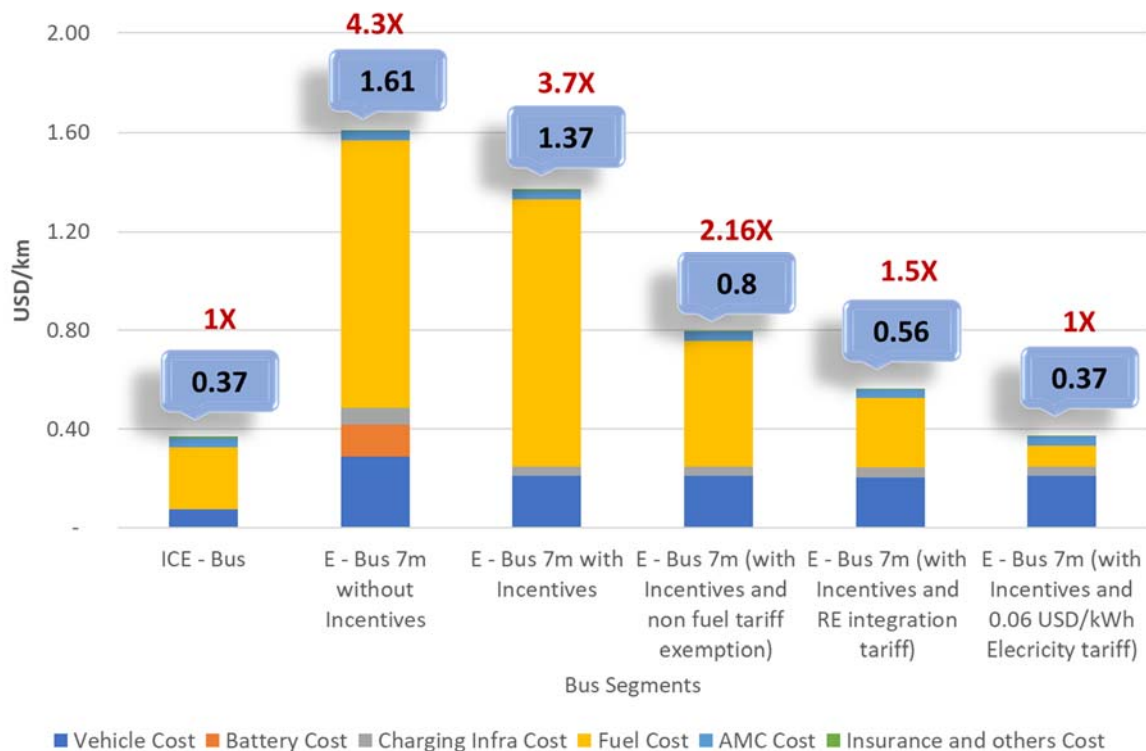
In purchase costs related to e-Buses; costs of battery, chargers and required grid infrastructure makes a sizable chunk of investment. The cost of e-Bus is 2.8 to 3.2 times higher than that of ICE bus cost. While the fuel cost of e-Buses i.e., electricity cost (opex) makes e-Buses cheaper than that of ICE buses. For TCO assessment the capital costs are annualised over a period of fifteen (15) years assuming it as the useful life of e-Buses. Operational costs are calculated per year. Addition of annualised capital cost and annual operational cost make Total cost of ownership per year. This is further calculated as TCO per day and TCO per kilometre. TCO per day reports the daily e-Bus deployment expenses and TCO per kilometre gives the economy of deploying e-Buses. Lesser the TCO per km means less expenditure to operate e-Buses.

9.1.2 TCO assessment for e-Buses

Based on the considerations stated above Total cost of ownership is calculated for existing ICE bus fleet (BAU) and e-Bus fleet required for the feasible bus model.

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Table 9-1 Total Cost of Ownership (TCO) for the Recommended e-Bus Option



The TCO of the 7m e-Buses (with 118 kWh) without incentives is 4.3 times higher than ICE buses. The high TCO is the resultant of the high capital Cost (6.3 times more than ICE Bus) and operational Cost (3.83 times more than ICE Bus). In addition, the incentives provided by the EV roadmap helps to bring down the capital cost of the e-Bus (3.36 times of the ICE Bus), however, the operational cost still remains the same (3.83 times more than ICE Bus).

To bring down the TCO of the e-Bus it is necessary to reduce the operational cost of the buses, therefore exemptions in terms of non-fuel tariff exemptions, integrating RE integration is being recommended. Exemption the non-fuel tariff will bring the fuel cost down to 0.36 USD/kWh whole introducing the RE into the grid will bring the fuel cost to 0.2 USD/kWh. The TCO of e-Bus (after incentives) with exemption of the non-fuel tariff and introducing the RE fares is 2.16 times and 1.5 times higher when compared to ICE bus respectively. However, for TCO of e-Bus to achieve parity with the ICE bus an electricity tariff of **0.06 USD/kWh is recommended**.

9.2 e-Bus Deployment and Investment requirements for shortlisted scenarios

9.2.1 e-Bus Deployment requirements for shortlisted scenarios

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Based on recommendations in chapter **Error! Reference source not found.**, the e-Bus deployment size is given in Table 9-2. The required e-Bus specs; daily operational requirement for e-Buses including daily trips, distance; charging requirements including number of chargers require; charger sizing (kW), peak power requirement (load) for recommended charging stations, daily energy demand are calculated and summarised below.

Table 9-2 Recommended e-Bus scenario 1 and Scenario 2

Item		Units	Specifications	
Number of e-Buses (Fleet size)		#	10 e-Buses	
			Total 10 Buses	
Daily total trips on route by Fleet		#	27	
Vehicle Specifications	Peak Motor power	kW	150	
	Battery pack	kWh	118 kWh	
Charging Infrastructure	No. of Chargers	#	@ MID depot	- 1 (55 kW DC Fast Chargers)
	Peak power/day	kW/day	@ MID depot	260 (~0.2 MW)
	Total Energy Demand per day	kWh/day	2,069 (~2.1 MWh)	
	Charger Specs	kW (AC/DC)	Plug-in DC Fast chargers 55 kW	

9.2.2 Investment requirement for shortlisted e-Bus scenarios

Fore recommended e-Bus scenario (**Error! Reference source not found.**), following is the investment requirement in . It includes Investment requirements for e-us fleet, Chargers, Grid infrastructure, battery replacement and other yearly operational requirements for a size of 50 e-Buses.

Parameter		Unit	Scenario 2	Remarks/Assumptions
			7 m -AC Standard - 118 kWh battery	
Vehicle	Vehicle type	m	7	
	AC		Yes	
	Floor height		High Floor	
Fleet	Fleet Size	#	10	Input variable
Capital Cost (Vehicle + Battery)	One vehicle cost (without battery) including taxes	USD/vehicle	111,522	Refer <i>TCO-Buses</i> Sheet
	Battery Size	kWh	118	Based on electric vehicle specifications for desired vehicle type
	Battery cost	USD/kWh	230	Industry assumptions- Subject to change

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	Effective tax rate on Battery	%	37%	Refer <i>TCO-Buses</i> Sheet
	Battery Cost (without subsidy)	USD/vehicle	37,157	Calculated
	One vehicle cost with battery, including taxes	USD/vehicle	148,679	Calculated
	Subsidy from Government	USD	NA	The investment size is considered without subsidy; however, the subsidy is proposed in EV Roadmap is 230 USD/kWh
	One vehicle cost with battery and including subsidy	USD	148,679	Calculated
	Total Fleet cost with battery (and including subsidy)	USD	1,486,790	Calculated
Charging Capitalization Cost	Fast Charger			As per charging requirements and Battery size
	No. of chargers required	#	3	Operations summary sheet
	Fast Charger Size	kW	55	As per charging requirements and Battery size
	Charger Cost	USD/charger	19,200	
	Grid Infra cost	USD/charger	4,400	
	Installation and commissioning charges	USD/charger	3,540	Assumption- 15% of overall charging cost
	Total cost per charger		13,758	
	Overall cost of charger and infrastructure	USD/charger	4,169	Calculated
	Overall charging capitalization cost	USD	41,690	Calculated
Land Capitalization Cost	Land Required per charging station cum service station cum workshop (assuming idling area)	Ha	No Existing Depot	additional cost required -
	Land Cost per Hectare (including Land Acquisition)	USD/Ha		
	Total Land Cost	USD	1,819,500	
Total CAPEX		USD	3,428,480	
		Million USD	3.4	

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Operational Cost	Annual Vehicle kms (Operational)	kms/year/vehicle	50,400	Refer operations summary sheet
	Total Annual kms (Operational)	kms/year	504,000	Refer operations summary sheet
	Electricity consumption	kWh/year	707,370	
	Annual Electricity Cost/Fuel Cost	USD/year	546,010	
	Maintenance cost	USD/km	0.003	
	Annual Maintenance Cost	USD/year	1,546	
	Annual insurance and other charges	USD/year	2,153	
Total OPEX		USD/year	549,709	
		Million USD/year	0.55	

9.3 Environmental impact Analysis

The environmental impact assessment is done for selected scenario 2 to compare an ICE bus with an e-Bus, as shown in Table 9-3. ICE buses are responsible to produce 1.3 kg CO₂ per kilometre, while e-Buses produce zero tailpipe emissions. The tailpipe emissions are also known as tank to wheel emissions which directly affect the human health and e-Buses have potential to curtail up to 100%. There is other emission measured; known as well to tank emissions i.e., emissions produced due to extraction of oil/fuel from its source to its transportation to the fuel station. In case of e-Buses the well to tank emissions are five times more as the source of electricity generation is from coal. With more renewable mix these emissions can be tailored which will help reducing well to tank emissions and make e-Buses even cleaner mode of transport.

The table below presents the emission factors to calculate the implied emissions per vehicle-km. It is found that the Grid factor significantly influence the GHG impact of e-Bus. For the year 2022, the Business-as-usual scenario (BAU) with a grid dominated by fossil fuel sources with 5% renewable mix; e-Bus causes 28% less GHG emissions from e-Bus. Therefore, only operating e-Buses will not meet the greener target unless source of electricity is coming from cleaner grid (with more share of renewables). Solomon Islands overall is working in scenario of optimizing and bringing more renewables to mitigate both tailpipe and lifecycle emissions so as to meet GHG mitigation target mentioned in national roadmap.

Business-to-be scenario (BTB) where renewable mix is envisaged to be 95% by 2035⁴⁰. This will help further to reduce Well to Tank emissions from e-Bus deployment. Although this is one way to reduce emissions; the project need not wait till 2035 for the grid to become clean. Other mechanisms like solar power integration in e-Bus charging are helpful to make energy production cleaner.

Table 9-3 Implied Emission per Vehicle-km of e-Bus and ICE Bus

Engine Type	Average Distance Travelled	Operational Days	Fuel Efficiency	Emission factor (EF)	GHG Emission	VKT	Implied Emission/Veh-km
	V-km/day						

⁴⁰ Solomon Islands National Energy Policy, 2014.

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	A	B	kWh/ 100 kms	D	E = (AxB) x (C/100) x D	F = (AxB)	G = E/F
			C				
Diesel	177	300	20	2.48	26,338	53,100	0.50
BAU: Electric with 5% renewable mix	177	300	79	0.74	31,042	53,100	0.58
BTB: Electric with 100% renewable mix	177	300	79	0	0	53,100	0.00

Table 9-4 Emissions, fuel and Economic savings from e-Bus deployment

Benefits over lifetime (15 years)	Unit	1 e-Bus (BAU)		10 e-Buses (BAU)	
		BAU	BTB	BAU	BTB
GHG Reduction	Tons CO2	314.79	395.06	3,148	3,951
Economic Savings from GHG reduction	USD	31,479	39,506	3,14,790	3,95,064
Fuel saving	Litres		1,59,300		15,93,000
Economic savings from fuel saving	USD		1,99,125		19,91,250

The proposed e-Bus deployment has potential to reduce ~1.99 Mn USD from fuel savings and ~0.39 Mn USD from GHG emission reduction; over 15 years e-Bus operations.

9.4 Recommended e-Bus deployment size

Routes	1) Honiara City Market to AJ City Mall 2) Honiara City Market to Kakambona
Depot	Newly proposed MID Depot
Terminal	1) AJ City mall 2) Kakambona
e-Bus and Battery Size	7 m AC, standard; 118 kWh battery
Fleet Size	10
Charging strategy and Sizing	<ul style="list-style-type: none"> • Charging Strategy: Overnight charging + Opportunity Charging • Charger Sizing: <ul style="list-style-type: none"> ○ 3 chargers: 55 kW, Plug in- 1-gun, Fast DC MID Depot
Bus operations	15 hours schedule Headways <ul style="list-style-type: none"> • 16 minutes Honiara City Market to AJ City Mall • 15 minutes Honiara City Market to Kakambona
Total Investment Size	1.52 Mn USD (without subsidy and not accounting the land procurement and depot setup cost)

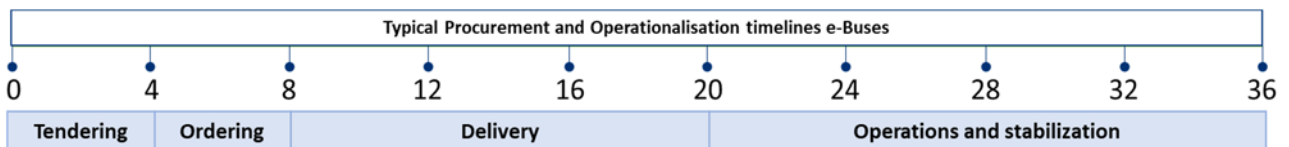
9.5 Deployment Plan

In this chapter, the phases of the e-Buses’ deployment are defined, and an estimated amount of time has been considered to complete the process. To realize the project phases, three phases in the project group are defined in terms of planning, procurement, and manufacturing. The short-term deployment phase continues till the third year from the initial deployment of the e-Bus pilot, wherein the first 10 e-Buses are deployed in the city of Honiara. The complete built unit is to be imported⁴¹. The second-year plans refer to the medium-term deployment phase where an additional 20 e-Buses are to be deployed in Honiara and other cities. In this phase as well, the complete built unit is to be imported. Beyond the fourth year, the long-term deployment vision is to scale up the deployment of 75 e-Buses across Solomon Islands with higher fleet sizes. Table 9-5 reflects the deployment strategy as explained above.

Table 9-5 e-Buses Deployment Phases

Phases	Year-1	Year-2	Year 4-5
Planning & Procurement	10 e-Buses Pilot	Second batch of 20 e-Buses	Third batch of 45 e-Buses
Plying		10 e-Buses	10+20+45=75 e-Buses
Monitoring & Capacity Building		First pilot learning and capacity building	Capacity and fleet expansion and related capacity building

Table 9-6 e-Buses Deployment Phases



⁴¹ Solomon imports vehicles from Japan, Europe, Asia and some Australia

10 Conclusion

The proposed project is earmarked to be implemented on two routes in city of Honiara namely Honiara City Market to AJ City mall and Honiara City Market to Kakambona. Other routes within the city could also be operationalized to increase electric bus ridership and make e-Buses visible. Under the proposed Project, the daily trips catering nearly ~4000 passengers daily Honiara; will be served by 10 e-Bus with 15-seater capacity (7m buses). This will generate multiple benefits over the implementation period on the selected corridors where the electric buses will be in service. Exposure to tailpipe emissions, air pollutants to many street vendors, passengers, walkers, cyclists and others will be reduced. It will also help reduce the health risk associated with local air pollution.

e-Bused have potential to improve service quality in terms of comfort, convenience and reliable means of public transport. Many local artisans, start-ups, training on maintenance, transport service operators and parts replacement of the e-Bus would be potential beneficiaries of this project. This project has potential to set best regional example of e-Bus deployment and carving clean mobility path. This will not only be the motivation for public transport users to use clean fuel buses but may other people to shift from private transport to the public transport in and around city of Honiara.

Although the intent of this Project is to introduce e-Bus It could set an example also for private individuals and other vehicle segment fleet operators for adopting EVs by replacing ICEVs. The network of charging stations in the city, connectivity from CBD to Suburbs would increase EV visibility and encourage other potential vehicle owners to procure electric powered vehicles instead of fossil fuel-based ones. If integrated with solar power, the project will add value to country's clean energy and make e-Bus deployment much cleaner by cutting down the grid emissions (Well to Tank).

Being the first of its kind to be introduced in Honiara, electrification of e-Bus would drive Solomon Islands' green development initiatives. This project would be pioneer for e-Bus and broader e-Mobility pilots and further scale-ups in Solomon Islands. This will allow gradual decarbonisation of urban transport systems across the country. The Project would be a suitable model for implementing Solomon Islands' National e-Mobility Policy Roadmap and the realization of the transport emission reduction objectives under Solomon Islands' NDCs.

In technology transfer impacts, the project will be an ambitious effort for realization of electric mobility not only in Solomon Islands but across the sub-region. It would help introducing and establishing strong local e-Bus and EV market, supply chain and regional industry connect for Solomon Islands. By far, the electric bus project would further demonstrate Solomon Islands' commitment to modernizing urban transport by entirely shifting from fossil-fuel-based systems to green electric mobility. The Project will transform the modal mix of urban transport into

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more organized and competitive bus services. It is envisaged that by 2035, the total number of electric buses in Solomon Islands are envisaged to scale-up more than 500.

11 Annexure

11.1 Disruptions in e-Bus Operations

Table 11-1 Typical disruptions in the e-Bus operations

Disruptions	Mitigation Measure
During the rainy season, there may be flash floods or water logging	Provision of storm water drainage in the depots and upliftment of the drainage system with a proper gradient of 1:150 (concrete roads) along the routes.
Battery Ageing	Charging at slow rates of 0.18 to 0.5C for a long duration, so that per day, 1-1.5 charging cycles are consumed. It would ensure a longer duration of battery life. If fast charging is required, the charging time should be kept to a minimum and the SoC should be kept between 20 and 90 percent at all times.
Changes in passenger loading	Operations with variable frequency for off-peak and peak hours
Power Outage	Micro grids, generator availability, or alternative power sources such as solar power in depots and terminals. The use of solar power would also reduce the dependency on non-renewable electricity generation.
Bus/Charger breakdown/ Extremely high passenger demand for certain days (for instance, festival/some major program)	Spare buses/chargers can be used.
Route blockage due to unavoidable situations such as accidents	Buses can be re-routed for the specific time period while retaining the passengers. ITS infrastructure can be utilized to get information about accidents instantly.
Non-availability of depot staff for parking and charging / non-availability of drivers	Capacity building programmes should be held for all the depot staff. future technology of automated charging can be developed as an option. Additional drivers, with proper knowledge, can be kept on standby or can be taken on contract for such periods.
Regular maintenance	It can happen either at the depot or during the layover between trips.