KINGDOM OF TONGA

BARRIER ANALYSIS AND ENABLING FRAMEWORK FOR CLIMATE CHANGE TECHNOLOGIES

MITIGATION REPORT

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Author: Dr Tevita Tukunga
Former Director of Energy
Current Director of the Board of Utilities

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2 List of Abbreviation

AC – Alternating Current

ADB – Asian Development Bank

BAEF- Barrier and Analysis and Enabling Framework

BAU - Business-As-Usual

BESS – Battery Energy Storage System

CNBC – Consumer News and Business Channel

CTCN – Climate Technology Centre and Network

DC – Direct Current

EE – Energy Efficiency

Eff - Efficiency

EU – European Union

ESCAP – Economic and Social Commission for Asia and the Pacific

EV – Electric Vehicle

GCF - Green Climate Fund

GEF- Global Environment Facility

GHGs – Green House Gases

GGGI – Global Green Growth Institute

GOT – Government of Tonga

ICE – Internal Combustion Engine

IEA – International Energy Agency

IMF – International Monetary Fund

INDC – Intended Nationally Determined Contribution IPCC –Inter-governmental Panels on Climate Change

IPP- Independent Power Producers

IRENA – International Renewable Energy Agency

LED – Light Emitting Diode

MCA – Multi-Criteria Analysis

MEIDECC - Ministry of Meteorology, Energy, Information, Disaster, Environment, Climate Change and Communication

Climate Change Policy

NEXSTEP - National Expert SDG Tool for Energy Planning

NDC - Nationally Determined Contribution

NDC IP - Nationally Determined Contribution Implementation Plan

NREL - National Renewable Energy Laboratory

O&M – Operation and Maintenance

OIREP – Outer Islands Renewable Energy Project

PCREEE – Pacific Centre for Renewable Energy and Energy Efficiency

PICs – Pacific Island Countries

PPA – Power Purchase Agreement

PV – Photovoltaic

RE - Renewable Energy

SHS – Solar Home System

SIDS – Smal Islands Developing States

TAPs -Technology Action Plans

TEC - Tonga Electricity Commission

TERM - Tonga Energy Road Map

TERM – IU Tonga Energy Road Map Implementation Unit

TEEMP – Tonga Energy Efficiency Master Plan

TNA – Technology Needs Assessment

TNC = Third National Communication

TOP – Tongan Paanga, $

TPL – Tonga Power Limited

TREP – Tonga Renewable Energy Project

UNDP – United Nation Development Programme

UNEP - United Nations Environment Programme

UNEP/CCC-United Nations Environment Programme (UNEP) and Copenhagen Climate Centre)

UNFCCC - United Nation Framework Convention Climate Change

V2G – Vehicle to Grid

V2H – Vehicle to Home

3 Foreword

Tonga takes great pride in its decade-long journey from 2010 to 2020, which serves as a global model for the shift towards renewable energy. The Tonga Energy Road Map (TERM), initiated in 2010, set an ambitious goal of achieving a 50% share of renewable energy in electricity generation by 2020. This initiative established a strategic framework aimed at shielding the Tongan economy from the fluctuations ofoil prices, enhancing access to energy services, and laying the groundwork for a sustainable future in renewable energy. The newly developed TERM, known as TERMPLUS, draws on the expertise of experienced professionals to chart a course towards 2035. Our transition is now clearly articulated, as TERMPLUS seeks to raise the bar once again, aiming for 70% renewable electricity by 2025 and ultimately achieving a 100% share ofrenewable energy by 2035.

The insights gained from the implementation of TERM have not been encouraging, as the average proportion of renewable energy (RE) in the network from 2010 to 2020 was reported to have reached at most 24%. Additionally, Tonga Power Limited indicated in June 2024 that the average contribution of RE to the country's total electricity generation was below 17%. This suggests that the share of RE has not approached 50% even as of

June 2024. Key stakeholders have identified three priority energy technologies that require promotion, particularly in the electricity generation sector. Moreover, in the transportation sector, stakeholders have also pinpointed three priority technologies that should be advanced to mitigate carbon emissions resulting from fossil fuel use. It is reasonable to conclude that there are obstacles impeding the adoption of both energy and transportation technologies. Therefore, it is essential to enhance the enabling framework to tackle the identified barriers to the promotion of these priority technologies in the energy and transport sectors. This underscores the necessity of the Barriers Analysis and Enabling Framework (BAEF) Report for the country.

This BAEF report aims to emphasize the various types of barriers that have been identified, analyzed, and ranked by key stakeholders. It includes a ranking of the characteristics of these barriers, such as technical barriers, as well as the types of enabling frameworks that require enhancement for each priority technology.

BAEF proposed substantial modifications in the generation and distribution of energy, asserting that the advancement of energy policies via the effective Energy Act will result in a more complex electrical system in Tonga. Additionally, the BAEF report emphasized the necessity for capacitybuilding initiatives aimed at enhancing the skills of individuals responsible for managing, maintaining, and regulating this increasingly dynamic electricity network.

BAEF has addressed the progress of the transportation sector towards a clean energy ecosystem, leveraging technology, enhanced grid infrastructure, and public policy to optimize the utilization of our nation's renewable resources.

Consequently, as we move into 2025, an Investment Plan will be developed in accordance with the guidance provided by the TERMPLUS and this BAEF report, aiming to realize a Tonga energy sector that is affordable, accessible, inclusive, resilient, sustainable, and secure.

Mr. Sione 'Akauola

CEO for the Ministry of MEIDECC

4 Executive Summary

Under the financial assistance of the Global Environment Facility, which was carried out by UNEPCCC, the Department of Energy of the Ministry of Meteorology, Energy, Information, Disaster, Environment, Climate Change and Communication (MEIDECC) coordinated the many multi-stakeholders' barriers analysis and enabling framework (BAEF) assessment of the six previously prioritized climate technologies. Following a well-guided Technology Needs Assessment, which was the first phase of the TNA project, the prioritized climate technologies for Tonga were determined.

The second stage of the TNA project is the BAEF assessment, which aims to identifying obstacles that impede the adoption and spread of prioritized technologies and creating supportive structures to surmount them in order to promote the transfer, uptake, and dissemination of particular technologies in Tonga. In order to mitigate climate change in Tonga, the Energy and Transportation sectors' TNA process was used to select the prioritized climate technologies that will be applied in the second phase of the process, which is called Barriers Analysis and Enabling Framework. The country's NDC priority activities and energy targets, as outlined in the NDC program, are aligned with the chosen sectors of transportation and energy.

The purpose of the BAEF report is to offer operational and practical advice on how to evaluate the obstacles to identified technologies in the relevant countries and how to address and remove these obstacles using various strategies.

This report will review the barriers to climate technologies that have been identified by the majority of research studies on small island nations based on literature reviews and/or one-on-one stakeholder consultations. Unfortunately, there aren't many literatures that use the consultation process with all relevant stakeholders to identify barriers; this analysis process uses this approach.

The energy sector's technologies of choice include energy-efficient home appliances, on-grid wind farms, and on-grid solar farms. The battery-powered electric vehicle, hybrid vehicle, and on-grid electric vehicle are the technologies that were chosen from the transportation sector. Six technologies in all were included in the mitigation priorities for the transportation and energy sectors, which will be further assessed in the BAEF report. Stakeholder consultation processes are situated within a decision context established by the National Climate Change Policy, NDC Targets, and Tonga Energy Road Map Plus.

The six technologies that were identified have been categorized as indicated in Table 1 below for the purposes of the Barriers Analysis and Enabling Framework (BAEF).

Table 1: Prioritized Technologies for Mitigation of Climate Changes for Tonga showing market categories. Adapted from: Nygaard and Hansen (2015)

Sector	Prioritized Technology	Market Categorization
Energy	on-grid solar farm	Publicly Provided Good
	on-grid wind farm	Publicly Provided Good (Technologies in this

		category are often publicly owned)
	energy efficient home appliances	Consumer Good (Goods targeting the mass market; households, business, and institutions)
Transportation	Battery powered Electric Vehicle	Mixed Public Good
	Hybrid Vehicle	Mixed Public Good
	On-Grid Electric Vehicle	Mixed Public Good

The study has identified numerous obstacles to the development and transfer of the prioritized mitigation technologies mentioned above, including policy, legal and regulatory issues, economic and financial constraints, and a lack of technical expertise that hinders the technologies' deployment, particularly in small island nations.

The report demonstrated that more institutional and human resources are needed to uphold the regulatory process and develop technical skills among the local workforce in order to support these on-grid mitigation projects, based on the names and features of the technologies displayed in the factsheets and given deployment recommendations. The report recognizes the necessity of increasing capacity building so that all of the implementing institutions have enough resources to fulfil their individual mandates.

The report identified the following obstacles to the development and transfer of the prioritized technologies for the chosen mitigation technologies: financial and economic, policy, legal and regulatory, and technical skills to implement the technologies. The report demonstrated that more institutional capacity is needed to support these large-scale mitigation projects by strengthening the regulatory framework and developing technical skills among local workers, given the scope and magnitude of the technologies that are advised for deployment. The report also emphasized the necessity of increasing capacity building so that all of the implementing agencies have enough resources to fulfil their individual mandates.

5 Introduction to BAEF Report

In order to facilitate the continued adoption of the prioritized climate change mitigation technologies in Tonga, the TNA project's overall result will be an element required for the implementation of the NDC through the use of the technologies that have been prioritized. The BAEF report is designed to identify and analyse the main barriers against the adoption and dissemination of prioritized mitigation technologies as well as suggested appropriate enabling frameworks or barriers removal mechanisms. The mitigation technologies were chosen from the energy and transportation sectors, which are also highlighted in the nation's NDC report and Implementation Plan, as priority sectors for mitigating climate change. The market conditions for each of the technologies that have

been prioritized within each sector are analyse in this report, along with the obstacles to market penetration and the supportive environments for the adoption and spread of each technology.

Based on the methodology and classification described in the TNA Guidebook on "Overcoming Barrier for the Transfer and Diffusion of Climate Technologies" (Nygaard and Hansen, 2015), barriers and enabling environment were identified. The Technology Executive Committee (TEC) of the United Nations Framework Convention on Climate Change (UNFCCC) has adopted this standardization process for categorization in order to facilitate work on TNA processes and the ensuing barrier analysis and enabling framework.

The process of identifying the barriers involved meetings with technical working groups related to their respective sectors, exchange of ideas with regional experts, and literature review. In order to steer the conversation around the barrier analysis, the national consultant organized and led stakeholder workshops. It was made possible for stakeholders to express worries, offer suggestions, and dispel any misunderstandings regarding the steps involved in carrying out the barriers analysis. Six prioritized technologies were selected and ranked across the two sectors of mitigation, with an emphasis on the actions and solutions that could get past these obstacles. Table 2 shows the market categorization of the six identified technologies, which were ranked under TNA report as priority technologies from the mitigation sectors of energy, and transportation.

Table 2: Prioritized Technologies for Mitigation of Climate Changes for Tonga showing Market Categorization Adapted from: Nygaard and Hansen (2015)

MITIGATION TECHNOLOGIES IN TONGA		
Sector	Prioritized Technology	Market Categorization
Energy	1. on-grid solar farm	Publicly Provided Good- is either owned by the Government Owned Utility or PPA with private sector
	2. on-grid wind farm	Publicly Provided Good (Technologies in this category are often publicly owned) - is either owned by the Government Owned Utility
	3. energy efficient home appliances	Consumer Good (Goods targeting the mass market; – is owned by households/electricity customers business, and institutions)
Transportation	1. Battery powered Electric Vehicle	Mixed Public Good – Owned by Private or Institutions

	2. Hybrid Vehicle	Mixed Public Good – Owned by Private of Institutions
	3. On-Grid Electric Vehicle	Mixed Public Good – Often Owned by Government or private sector companies

In view of market assessment, the spread of capital goods and consumer goods is often primarily affected indirectly by politically altered market conditions. Efforts to lower barriers to consumer goods are primarily indirect. Examples of such initiatives include awareness-raising and educational campaigns, enhanced standards for product quality, more benevolent import tax and duty laws, assistance for private supply chain companies, and product-specific subsidies (like energy-efficient lightbulbs). For public provided goods, the political decisions made by governments and public entities regarding the implementation of particular projects have a direct impact on the diffusion of publicly provided goods and non-market goods. Government actions to support specific non-market good technologies, such as creation of new institutions, through focused projects and programs.

5.1 Market Categorization and Market Characteristics

This study noted the market characteristics for each market categorization that must be realized and understood in order to help us identify and prioritized the key barriers for the advancement and dissemination of the prioritized technologies for the chosen mitigating sectors. These market characteristics are related to issues such as financial and economic, policy, legal and regulatory, and technical know-how, institutional, market and information and data for the technologies' implementation.

Table 3: Market Characteristics of the Selected Technologies.

MITIGATION TECHNOLOGIES IN TONGA			
Sector	Prioritized Technology	Market Categorization	Market Characteristics
Energy	1. on-grid solar farm	Publicly Provided Good- is either owned by the Government Owned Utility or PPA with private sector	• very few sites • large investment, government/donor funding • public ownership or ownership by large companies • simple market chain: technology procured through national or international tenders. • investments in large-
	2. on-grid wind farm	Publicly Provided Good (Technologies in this category are often publicly owned) - is either owned by the Government	

		Owned Utility	scale technologies tend to be decided at the government level and heavily dependent on existing infrastructure and policies.
	3. energy efficient home appliances	Consumer Good (Goods targeting the mass market; – is owned by households/electricity customers business, and institutions)	• a high number of potential consumers • interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain. • large and complicated supply chains with many actors, including producers, assemblers, importers, wholesalers, retailers and end consumers. • barriers may exist in all steps in the supply chain. • demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts
Transportation	1. Battery powered Electric Vehicle	Mixed Public Good – Owned by Private or Institutions	• The good can be used simultaneously by more than one person, • Part capital good and part public good • Insufficiently profitable to be provided by the private sector and in the absence of government support, these goods and services would be produced in relatively small quantities or perhaps not at all.
	2. Hybrid Vehicle	Mixed Public Good – Owned by Private of Institutions	
	3. On-Grid Electric Vehicle	Mixed Public Good – Often Owned by Government or private sector companies	

			• Public goods include knowledge, official statistics, national security, common languages,[5] law enforcement, public parks, free roads, and many televisions and radio broadcasts. • Public goods problems are often closely related to the "free rider" problem, in which people not paying for the good may continue to access it. Thus, the good may be under-produced, overused or degraded. • Public goods may also become subject to restrictions on access and may then be considered to be club goods; exclusion mechanisms include toll roads, congestion pricing, and pay television. • There is a good deal of debate and literature on how to measure the significance of public goods problems in an economy, and to identify the best remedies.

6 Prioritization of Barriers and Enabling Environment

6.1 Prioritization of Barriers

6.1.1 Selection of Priority Barriers

The following categories of barriers were created using a qualitative Likert-type Scale: 1. Insignificant; 2. Less important; 3. Important; 4. Crucial; and 5. Critical/killer/non-starter.

This was significant because different obstacles affect the deployment and adoption of technologies in different ways. Furthermore, depending on how the market is classified, some barriers might be more important than others or they might be connected.

Table 4 : Prioritized Mitigation Technologies and Types of Identified Barriers

MITIGATION TECHNOLOGIES IN TONGA			
Sector	Prioritized Technology	Market Characteristics	Identified Barriers to Be Addressed
Energy	on-grid solar farm- Publicly Provided Good- is either owned by the Government Owned Utility or PPA with private sector	• very few sites • large investment, government/donor funding • public ownership or ownership by large companies • simple market chain: technology procured through national or international tenders. • investments in large-scale technologies tend to be decided at the government level and heavily dependent on existing infrastructure and policies.	• Financial and Fiscal • Policy, Regulation and Legislation • Institutional • Technical. • Market • Information and Public Awareness
	on-grid wind farm - Publicly Provided Good (Technologies in this category are often publicly owned) - is either owned by the Government Owned Utility		• Financial and Fiscal • Policy, Regulation and Legislation • Institutional • Technical. • Market • Information and Public Awareness
	energy efficient home appliances - Consumer Good (Goods targeting the mass market; – is owned by households/electricity customers business, and institutions)	• a high number of potential consumers • interaction with existing markets and requiring distribution, maintenance and installer networks in the supply chain. • large and complicated supply chains with many actors, including producers,	• Financial and Fiscal • Policy, Regulation and Legislation • Institutional • Technical. • Market • Information and Public Awareness

		assemblers, importers, wholesalers, retailers and end consumers. • barriers may exist in all steps in the supply chain. • demand depends on consumer awareness and preferences and on commercial marketing and promotional efforts	
Transportation	Battery powered Electric Vehicle - Mixed Public Good – Owned by Private or Institutions	• The good can be used simultaneously by more than one person, • Part capital good and part public good • Insufficiently profitable to be provided by the private sector and in the absence of government support, these goods and services would be produced in relatively small quantities or perhaps not at all. • Public goods include knowledge, official statistics, national security, common languages,[5] law enforcement, public parks, free roads, and many televisions and radio broadcasts. • Public goods	• Financial and Fiscal • Policy, Regulation and Legislation • Institutional • Technical. • Market • Information and Public Awareness
	Hybrid Vehicle - Mixed Public Good – Owned by Private of Institutions		• Financial and Fiscal • Policy, Regulation and Legislation • Institutional • Technical. • Market • Information and Public Awareness
	On-Grid Electric Vehicle- Mixed Public Good – Often Owned by Government or private sector companies		• Financial and Fiscal • Policy, Regulation and Legislation • Institutional • Technical. • Market • Information and Public Awareness

		problems are often closely related to the "free rider" problem, in which people not paying for the good may continue to access it. Thus, the good may be under-produced, overused or degraded. • Public goods may also become subject to restrictions on access and may then be considered to be club goods; exclusion mechanisms include toll roads, congestion pricing, and pay television. • There is a good deal of debate and literature on how to measure the significance of public goods problems in an economy, and to identify the best remedies.	

The barriers were ranked for more analysis using a Likert scale from 1 to 5, where 1 was insignificant or non-essential and 5 was the most critical. When appropriate and where data was available, a logical problem analysis using problem trees (see Annexes for details) was employed as a tool in the analysis of critical/starter barriers for various technologies. With the starter problem at the centre, the direct cause beneath it, and the direct effects above, all identified problems were arranged in a hierarchy of cause-and-effect relationships. The barriers were broken down and put out for stakeholder consultation and comment using the problem tree as a filter.

In order to learn from the best practices and success stories of the chosen technologies both domestically and regionally, as well as from comparable circumstances in other Small Island Developing States, a literature review process was employed during the development of the "enabling framework." The TNA guidance documents state that barriers can be broken down into four main categories: market goods, non-market goods, financial goods, and non-financial goods. After breaking down the obstacles, the report suggests ways to get through them. In order to steer Tonga's economy toward decarbonization and greater climate resilience, the measures centre on establishing an environment that is favourable to the transfer and diffusion of technologies that are deemed important.

The report demonstrated that increased institutional capacity is needed to fortify the regulatory framework and develop technical skills among the local workforce in order to support these extensive mitigation projects, given the scope and magnitude of the technologies that are advised for implementation. The report also emphasised the necessity of increasing capacity building across all of the implementing agencies in order to provide them with sufficient resources to fulfil their individual mandates.

The requirements for the diffusion of consumer goods may include, among other things, financial, market conditions, cost-benefit analyses, market surveys, technical training, and other incentives to boost the local economy, according to Nygaard and Hansen (2015). On the other hand, publicly supplied goods are large-scale infrastructure projects that need substantial financial outlays and are typically supported by the government or state. Furthermore, additional non-market goods are separated into three categories: technologies supplied by public institutions; institutional change, meaning an enhanced rural standard of living; and "behavioural change at the individual level (i.e. change of practice)."

The methodology described in the TNA Guidebook, "Overcoming Barrier for the Transfer and Diffusion of Climate Technologies," published in 2015 by Nygaard and Hansen, was used to identify barriers, prioritized them and the mechanisms for removing them. Table 3 displays examples of the barrier market category's classification and scenario-based ranking.

Table 5 : Example of Categorization and Ranking of Barriers

Market Category	Name of Barrier	Criteria of Barriers for Dissemination of Prioritized Technologies					Rank
		1. Insignificant	2. Less Important	3. Important	4. Very Important	5. Highest Important	
Consumer Goods	Finance and Econo	x					1

	mic						
Capital Good	Finance and Economic		x				2
Non-Market Good							
Publicly Provided Goods	Finance and Economic			x			3
Other Non-market Good	Finance and Economic					x	5

Table 6: Key Steps for the Barriers Analysis Approved by Stakeholders

Mitigation Technologies 1) Determine every potential obstacle using a review of the literature, interviews, and/or workshop brainstorming 2) Sort the list of obstacles to determine which are most important. 3) Provide a hierarchy of categories or market categories for the chosen essential barriers. 4) Provide enablers to address most essential barriers. 5) Assess the costs and benefits of measures to determine whether they comply with policy objectives. 6) Select a set of complementary measures to include in programme

7 Mitigation Technologies

The technology needs assessment (TNA) for mitigation was utilized to identify two primary priority sectors and technologies based on the country's Nationally Determined Contribution (NDC) and its Implementation Plan (NDC IP) under the Paris Agreement. Additionally, it considered other significant national policies such as the Tonga Energy Road Map, Tonga Climate Change Policy, and other relevant environmental policies that are currently emphasized at both regional and global levels, including sustainable development goals (SDGs). The outcomes of the MCA prioritized technologies are presented in Table 6, showcasing their market categorization and associated barriers.

Table 7 : Prioritized Sectors and Technologies and Market Categories

MITIGATION TECHNOLOGIES IN TONGA			
Sectors	Prioritized Technology	Market Categorization	Related Barriers

Energy	1, on-grid solar farm	Publicly Provided Good- is either owned by the Government Owned Utility or PPA with private sector	Economic and Financial. Market Conditions, Legal and regulatory, Network, Institutional and organisational capacity, Human skills, Institutional and organization capacity, Human skills, social, cultural and behaviour, Information awareness, Technical, Other.
	2. on-grid wind farm	Publicly Provided Good (Technologies in this category are often publicly owned) - is either owned by the Government Owned Utility	Economic and Financial. Market Conditions, Legal and regulatory, Network, Institutional and organisational capacity, Human skills, Institutional and organization capacity, Human skills, social, cultural and behaviour, Information awareness, Technical, Other.
	3. energy efficient home appliances	Consumer Good (Goods targeting the mass market; – is owned by households/electricity customers business, and institutions)	Economic and Financial. Market Conditions, Legal and regulatory, Network, Institutional and organisational capacity, Human skills, Institutional and organization capacity, Human skills, social, cultural and behaviour, Information awareness, Technical, Other.
Transportation	4. Battery powered Electric Vehicle	Mixed Public Good – Owned by Private or Institutions	Economic and Financial. Market Conditions, Legal and regulatory, Network, Institutional and

			organisational capacity, Human skills, Institutional and organization capacity, Human skills, social, cultural and behaviour, Information awareness, Technical, Other.
	5. Hybrid Vehicle	Mixed Public Good – Owned by Private of Institutions	Economic and Financial. Market Conditions, Legal and regulatory, Network, Institutional and organisational capacity, Human skills, Institutional and organization capacity, Human skills, social, cultural and behaviour, Information awareness, Technical, Other.
	6. On-Grid Electric Vehicle	Mixed Public Good – Often Owned by Government or private sector companies	Economic and Financial. Market Conditions, Legal and regulatory, Network, Institutional and organisational capacity, Human skills, Institutional and organization capacity, Human skills, social, cultural and behaviour, Information awareness, Technical, Other.

8 Energy Sector Development in Tonga

8.1 Introduction

Tonga heavily depends on imported oil to fulfil its energy requirements. As per the 2000 Tonga Energy Balance report, 75% of the nation's energy supply is sourced from imported fossil fuels, with 98% of the electricity consumed in Tonga being generated by imported diesel fuel. Despite fluctuations in fuel prices over the years, the current prices remain

significantly high. To combat the overreliance on fossil fuels, reduce greenhouse gas emissions, and enhance national energy security, the Tongan government set a target in 2010 to generate 50% of electricity from renewable sources and reduce electricity losses in the network by 9% by 2020 through the Tonga Road Map 2010-2022. After reassessing the energy targets in 2020, Tonga revised the renewable energy goal in 2021 under TERMPlus. Although the network loss target was achieved, the renewable energy target was deemed unattainable. Consequently, Tonga increased its renewable energy target to 70% by 2030 in 2021. In 2022, the Tonga Power Limited Board of Directors reviewed the same target and advanced the deadline to 2025 to reach the 70% renewable energy goal. The Tonga TNA report endorsed by the United Nations Environment Programme (UN Environment) and the UNEP Copenhagen Climate Centre (UNEP-CCC) in 2024 identified renewable energy and energy efficiency technologies as crucial for climate change mitigation in both the energy and transport sectors. While there is sufficient effort to increase share of renewable energy and push energy efficiency technologies, it is equally important to find important barriers against renewable energy and energy efficiency technologies.

Numerous studies have highlighted the significant barriers hindering the adoption of renewable energy and transportation technologies in small island nations such as Tonga. However, there is a lack of literature that offers a prioritized ranking of these barriers based on input from key stakeholders. This information is crucial for small island countries to effectively address the most pressing barriers as well as the less significant ones.

8.2 Literature Review on Barriers to Renewable Energy Technologies.

8.2.1 Fiscal and Financial Barriers

H., Wade (2004) has highlighted the obstacles to the adoption of renewable energy, particularly solar home systems for lighting in Tonga, with Fiscal and Financial Barriers being the most prominent. Various studies have pointed out different reasons for financial barriers hindering the uptake of renewable energy technologies. These include local tax policies such as duty-free diesel for electricity generation (Wade, 2004), the impact of social equity tariffs (Tukunga, T., 2013), high upfront service costs in a limited market (Tukunga, T., 2013), and the substantial initial investment required for renewable energy (TPL, 2020). Reliance on financial policies from donors has led to heavy dependence on investments from development partners (D'Este, G. et al, 2010; TPL, 2020), resulting in a dominance of donor-funded renewable energy projects and a lack of investor confidence (IRENA, 2013). The high cost of remoteness has also created barriers, such as increased expenses for renewable energy technologies due to rising labor costs on outer islands (Wade, 2004) and uncertainties regarding payments to cover maintenance costs (Tukunga, T., 2013). Additionally, unstable household incomes have led to insufficient revenue collection compared to the initial investment and inadequate incentives for solar home system projects (Tukunga, T., 2013). Fiscal barriers have also emerged due to inflation triggered by oil price shocks and fluctuations (GOT, 2010a; TPL, 2020), an increasing imbalance of payments resulting from excessive petroleum imports

compared to total exports (GOT, 2021b), severe labor shortages, and damage to tourism facilities impeding recovery and exacerbating inflation pressures (IMF, 2023).

8.2.2 Summary of the Literature Review for Fiscal and Financial Barriers

Most of the financial and fiscal barriers identified in the literature review are closely linked to the uptake and implementation of on-grid solar power and on-grid wind power technologies in Tonga. In terms of energy-efficient home appliances, the primary obstacles for the technology revolve around technology costs and inflation concerns. Table 7 illustrates that the various financial and fiscal barriers identified in the literature impact both on-grid solar and on-grid wind power technologies.

Table 8 : Fiscal and Financial Barriers for Renewable Energy and Energy Efficiency Technologies

Types of Financial and Fiscal Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes		
	On-Grid Solar	On-Grid Wind	Energy Efficient Home Appliances
Local Tax Policy-Duty Free Diesel for Power Generation	√	√	
Social Equity Tariffs	√	√	
High Upfront Cost on Small and Remote Market	√	√	√
Reliance and Dependence on donor funding	√	√	
Lack of investment from Private Sector	√	√	
Uncertainties on payment of services to recover full cost	√	√	
Insufficient revenue collection	√	√	
Inflation of prices triggered by oil price shocks	√	√	√
Inflation due to Unbalance of Payment	√	√	√
Inflation due to Labour Shortage and cyclone recovery	√	√	√

8.2.3 Policy, Regulatory and Legislative

Barriers associated with Legislative, Regulatory, and Policy issues often arise from the implementation of privatization policies by public institutions, such as the transition of power utility from government-owned to privatization (Wade, 2004). Some laws are found to be lacking in substance (TPL, 2020), and at times, energy policies are unclear with regards to the regulation of PV (GOT, 2010a). Developing appropriate Power Purchase Agreements (PPA) with IPP owners is often a challenge for TPL (TPL, 2020). The absence of energy efficiency legislation has impeded the attainment of national energy efficiency targets (MEIDECC, 2019). It is imperative to establish energy efficiency policies and legislation to steer efforts towards the targets outlined in the TERM and NDC at the national level (MEIDECC, 2019). Inadequate infrastructure development can be attributed to ineffective public policies, institutions, and legislation (D'Este., G. et al, 2010). The lack of transparency in regulatory and monitoring activities may be due to insufficient expertise and poor coordination with end users (Tukunga., T, 2013).

The diversity of political interests often hinders the effective implementation of business plans and the involvement of local technical experts in political decision-making processes (Pandey, S., et al, 2013). In the case of Tonga, the government has taken steps to regulate electricity tariffs by setting it at 65 seniti, which has significant implications for Tonga Power Limited (TPL, 2020). Additionally, Tonga's political interests have endorsed policies aimed at reducing reliance on fossil fuels (GOT, 2010a), enhancing energy security (GOT, 2021b), and increasing the share of renewable energy in electricity generation to 50% by 2020 (GOT, 2010a) and 70% by 2030 (GOT, 2021b).

8.2.4 Summary of Literature Review for Policy, Regulatory and Legislative Barriers

Based on the results of the literature review mentioned above, it is evident that Tonga lacks the required policies, regulatory tools, and legislations to promote the implementation and acceptance of on-grid wind and on-grid solar technologies. Despite the availability of energy-efficient appliances in the country, Tonga still lacks energy efficiency legislation. Table 8 provides a visual representation of the absence of crucial policies, regulatory tools, and legislation that are necessary to facilitate the adoption of various energy-saving technologies, on-grid wind and on-grid solar technologies.

Table 9 : Policy, Regulatory and Legislative Barriers Directly for Renewable Energy and Energy Eff. Technologies

Types of Policy, Regulatory and Legislative Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes		
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances
Implementation of Privatization Policy by Power Utility	√	√	√
Insufficient Legislative and Regulatory Aspects	√	√	√
Unclear Policy for regulation of services	√	√	
Insufficient Development of PPA with IPP owners	√	√	
Absence of Energy Efficiency Legislation			√
Ineffective Public Policies leading to Infrastructure Development	√	√	√
Lack of Transparency in regulatory and monitoring activities	√	√	√
Diversity of political decisions that hinders effective business plan	√	√	

Insufficient capacity building in energy institutions in Tonga has resulted in institutional barriers. For instance, the outer islands solar committees lacked technical and management capacity, the power utility lacked information on renewable energy and energy efficiency, and there was a lack of training capacity for business management and outer islands technicians (Wade, 2004). Additionally, the energy sector reforms and

decisions made by TERM-IU excluded input from in-country technical experts (Pandey, S., et al, 2013). In 2010, Tonga did not have an entity with the mandate and capacity to oversee the electricity or petroleum sectors (GOT, 2010a), highlighting the need for a clear and effective institutional arrangement for the sector to implement the TERM. Although Tonga has the capacity to improve accessibility to renewable energy in the grid (GOT, 2010a), the TERM itself lacks operational guidelines, milestones, and performance benchmarks (Pandey, S., et al, 2013). The Country Programme for GCF funding on MITIGATION prioritizes renewable energy technology projects (Solar, Wind, and Biomass) (GOT, 2018), but innovative approaches are necessary to overcome implementation challenges such as COVID-19, tropical cyclones, in-kind commitments, and organizational readiness (TPL, 2020). In the context of small island nations, the existing institutions and mechanisms to address climate change are insufficient to match the scale of the threat to the climate security ambitions of Pacific Island Countries (PIC), particularly atoll nations like Tuvalu, Kiribati, and the RMI (Bryar, T. and Westbury T., 2023).

8.2.6 Summary of Literature Review for Institutional Barriers

It has been observed that there is a deficiency in institutional capabilities for implementing on-grid wind and on-grid solar technologies. This deficiency is primarily attributed to the lack of technical, management, information, human, and institutional requirements. In the case of energy-efficient home appliances, the primary obstacles lie in the absence of suitable institutions, as well as inadequate technical and management capacities. Table 9 presents a graphical depiction of the insufficiency in crucial institutional capabilities required to support the implementation of on-grid wind and on-grid solar technologies. However, when it comes to energy-efficient home appliances, the absence of institutional capacities is relatively insignificant.

Table 10 : Institutional Barriers Directly Related with the Renewable Energy and Energy Efficiency Technologies

Types of Institutional Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes		
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances
Insufficient Capacities in Energy Institution	√	√	
Lack of technical and management capacity	√	√	
Lack of information on renewable energy and energy efficiency	√	√	√
Lack of training capacity for business management	√	√	√
No entity with mandate and capacity to oversee electricity and petroleum	√	√	
Need for clear and effective institutional arrangements	√	√	

Lacks guidelines, milestones and performance benchmarks	√	√	√
Insufficient institutions and mechanisms to address threats of climate change	√	√	√

The lack of experience with hybrid and wind systems in the Pacific region, as well as insufficient knowledge regarding renewable power generation in rural and remote communities, are significant technical barriers to the adoption of renewable energy technologies (Wade, 2004; ADB, 2020a). Additionally, the scarcity of spare parts due to a lack of private sector interest in supplying them poses a challenge, with the utility currently responsible for addressing this issue (Tukunga., T,2013). In the capital, distributed generators connected to TPL's network do not have energy storage facilities for nighttime usage, potentially resulting in substantial revenue losses for TPL (TPL, 2020). The high cost and time-consuming nature of renewable installations further hinder progress in this area (Wade, 2004). Moreover, government agencies lack the necessary technical knowledge to effectively address these barriers (GOT, 2016b). Tonga's climate is prone to cyclones that frequently cause extensive damage to TPL's network and generation assets (TPL, 2020). To promote floating solar and productive uses of energy, as well as highlight the innovative joint procurement approach, technical knowledge is crucial, and discussions on these topics are expected to take place during the Pacific Regional Infrastructure meeting in October 2021 (ADB, 2023). Concerns regarding energy efficiency technologies revolve around the efficiency of energy consumption, particularly in the building sector, where factors such as building design, appliance use, and energy consumption behavior play a significant role in Tonga's electricity consumption efficiency (GOT, 2021b; UNCTCN, 2020).

8.2.8 Summary of Literature Review for Technical Barriers

The primary challenges faced in on-grid solar and on-grid wind systems stem from limited experience with new technologies. Additionally, issues such as inadequate technical understanding of power generation, scarcity of spare parts, lengthy installation times for renewable energy projects, and a lack of technical expertise within government institutions contribute to the overall need for more knowledge in deploying on-grid wind and solar power generation. Energy-efficient home appliances face various technical challenges that are influenced by building design, appliance usage, and energy consumption habits. Table 10 emphasizes the significance of possessing suitable technical proficiency in on-grid solar and on-grid wind technologies over other technical prerequisites, in addition to having technical knowledge on energy-efficient appliances.

Table 11 : Technical Barriers Directly Related with the Renewable Energy and Energy Efficiency Technologies

Types of Technical Barriers	Does it directly relate with the diffusion of the following technologies?

	(√) means Yes		
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances
Lack of experiences with Hybrid wind systems in Pacific		√	
Insufficient knowledge regarding RE power generation	√	√	
Scarcity of spare parts due to lack of private sector investment	√	√	
Insufficient battery storage leading to, loss of revenue at night	√	√	
time-consuming nature of renewable installations	√	√	
government agencies lack the necessary technical knowledge	√	√	√
Tonga's climate is prone to cyclones that frequently cause extensive damage to TPL's assets	√	√	√
energy efficiency technologies revolve around the efficiency of energy consumption			√
building design, appliance use, and energy consumption behavior revolving around electricity consumption efficiency			√

Market barriers for renewable energy technologies stem from challenges in accessing rural sites, leading to high risks and low profits for renewable businesses in remote islands (Wade, 2004). The adequacy of the environment management plan (EMP) is crucial in demonstrating the environmental viability of renewable energy projects (TPL, 2015). An in-depth analysis of the Tonga energy market is essential to align the country with upcoming TERM, NDC, and SDG7 objectives (Yamaguchi., K, Undated). Furthermore, discussions on key issues, risks, and barriers in adopting innovative technologies in the energy sector are necessary for progress (ADB, 2023). Identifying challenges and opportunities for clean energy investments in Small Island Developing States (SIDS) is vital for transitioning from fragility to resilience (ADB, 2023). Understanding the factors influencing energy supply and demand in Tonga is crucial (Yamaguchi., K, Undated). Tonga's heavy reliance on petroleum leaves it vulnerable to oil price fluctuations, impacting the cost of essential goods and services of like food, electricity, and transportation (TPL, 2020). Moreover, the black community involvement in decision-making regarding Solar Home Systems (SHS) design contributes to compatibility issues (Tukunga.,T, 2013).

8.2.10 Summary of Literature Review for Market Barriers

Upon examining the aforementioned literature, the market barriers specified in Table 11 have been identified. These barriers pertain to various aspects such as market accessibility, market risks, environmental market viability, market assessment, market investment opportunities and challenges, market supply and demand, market prices, and market decision makings. It is important to note that these barriers directly impact on-grid

solar and on-grid wind power technologies. However, when it comes to energy-efficient home appliances, the only types of market barriers are primarily associated with a lack of understanding regarding the factors that influence market supply and demand, as well as market prices.

Table 12: Market Barriers Directly Related with the Renewable Energy and Energy Efficiency Technologies

Types of Market Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes		
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances
challenges in accessing rural sites	√	√	
high risks/low profits for renewable businesses in remote islands	√	√	
Need to confirm environmental viability of renewable energy project	√	√	
In-depth analysis of energy market to align with NDC, TERM, SDG	√	√	√
Identifying opportunities and Challenges for RE investments	√	√	
Understanding factors that influenced supply and demand in Tonga	√	√	√
Tonga Market prices are highly vulnerable to oil prices fluctuation	√	√	√
Lack of community involvement in RE decision making	√	√	

8.2.11 Information and Public Awareness

Information and Public Awareness Barriers were attributed to the absence of knowledge regarding renewable energy and energy efficiency across all levels (Wade, 2004). For instance, information such as ensuring that the electricity network upgrade will not result in significant, long-term environmental impacts during the construction, operation, and decommissioning of the solar farm project (TPL, 2015). It was observed that there were obstacles in establishing an evidence-based data collection and analysis system in Tonga (Yamaguchi., K, Undated); and the effective use of evidence to guide decision-making can enhance the decision-making process (Yamaguchi., K, Undated). There was a lack of consultation with local outer island communities regarding the replacement of old generators with new ones, as well as the introduction of solar farm energy technologies alongside diesel generation (ADB, 2020a). The Tongan electricity sector leaned towards implementing a fixed tariff for all districts, but there is insufficient data to support a specific tariff level that is both affordable for users and profitable for energy suppliers (Tukunga., T, 2013). Comprehensive coordination of data collection across the entire sector is essential for effective policy development and implementation, along with capacity building initiatives for all energy stakeholders, including local communities (Tukunga., T,

2013). There have been instances of unforeseen social and cultural impacts related to electricity services due to a lack of community involvement in the design and installation of such services. This lack of community engagement may be attributed to disinterest on the part of service providers (Tukunga., T, 2013). Additionally, unexpected events like COVID-19 have significantly impacted the timelines of all projects under TERM (TPL, 2020), affecting the implementation and schedules of renewable energy adoption.

8.2.12 Summary of Literature Review for Information and Public Awareness

Table 13 reveals that both on-grid solar and on-grid wind technologies face various information and public awareness barriers. These barriers include inadequate knowledge, insufficient information regarding electricity network upgrades, a lack of evidence-based data analysis and utilization, minimal stakeholder consultation, insufficient data and analysis, and a lack of comprehensive data coordination. In terms of energy-efficient home appliances, the main obstacles concerning information and public awareness are the absence of evidence-based data analysis and utilization, limited stakeholder consultation, inadequate data and analysis, and a lack of comprehensive data coordination.

Table 13: Information Barriers Directly Related with the Renewable Energy and Energy Efficiency Technologies

Types of Information Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes		
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances
Insufficient knowledge regarding renewable energy and energy efficiency	√	√	
Electricity network upgrade with low environmental impacts	√	√	
Capacity to establish an evidenced based data collection and analysis	√	√	√
Effective use of evidence to guide decision making	√	√	√
Minimum consultation with local stakeholders on RE technologies	√	√	√
Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable	√	√	√
Comprehensive coordination of data collection for policy development	√	√	√

8.3 Scoring Barriers for selected Energy sector technologies

To evaluate and rate the barriers associated with on-grid solar technology, key stakeholders utilized a qualitative Likert-type Scale. This scale consisted of five categories: 1. Insignificant; 2. Less important; 3. Important; 4. Crucial; and 5. Critical/killer/non-starter. The creation of these categories was crucial as different obstacles impact the implementation and acceptance of technologies in varying ways. The key stakeholders were provided with a comprehensive list of barrier descriptions under each category, enabling them to assign scores using the Likert-type Scale. Through group discussions and ongoing communication with the local consultant, the energy group has determined the scoring outcomes for Fiscal and Financial Barriers. Table 13 presented the outcomes of stakeholders scoring for types of Financial and Fiscal barriers for on-grid solar technology. Table 14 also displayed results stakeholders scoring for additional categories of non-financial barriers of on-grid solar technology. Table 15 presented the outcomes of stakeholders scoring for types of Financial and Fiscal barriers for on-grid wind technology. Table 16 also displayed results stakeholders scoring for additional categories of non-financial barriers of on-grid wind technology. Table 17 presented the outcomes of stakeholders scoring for types of Financial and Fiscal barriers for energy efficient home appliances. Table 18 also displayed results stakeholders scoring for additional categories of non-financial barriers of energy efficient home appliances.

Table 14: Financial and Fiscal Barriers and Score for the Diffusion of Utility On-Grid Solar Powered Generation

Technology: Utility On-Grid Solar Powered Generation		
	Description	Score
Financial & Fiscal	• High upfront cost for solar equipment/parts: Panels, Batteries and Storage Capacity. • Local Tax Policy-Duty Free Diesel for Power Generation • Reliance and Dependence on donor funding/Lack of full cost recovery investment from Private Sector • Insufficient and Uncertain demand from the grid • Limited access to capital to finance utility scale solar project. • Inflation of prices triggered by increasing oil prices and other reasons.	5 1 5 3 1 3 4

	• High perceived risk by investors in absence of government guarantee for payments and grid connectivity. • Economic feasibility due to subsidized cost of electricity to the consumer • Inflation due to Labour Shortage and cyclone recovery	5 3

Table 15: Non-Financial Barriers and score for the On-Grid Solar Powered Generation

TECHNOLOGY: Utility On-Grid Solar Powered Generation		Score
Policy, Regulatory, Legislative	• Permits, licensing issues, PPA contract. • Insufficient Legislative and Regulatory Aspects and specific types of • Poor incentives/support mechanisms for the development does not exist to promote widespread adoption. • Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams. • Difficulty establishing Power Purchase Agreements (PPAs) due to Unclear Policy for regulation of PV	3 3 4 5 4
Institutional capacity	• Insufficient Privatization Arrangements by Power Utility • Insufficient Grid connection agreements/arrangements to • Insufficient Development of Solar PPA with IPP contracts	1 2 1
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations • Insufficient knowledge regarding RE power generation. • Scarcity of spare parts due to lack of private sector investment • Insufficient battery storage leading to, loss of revenue at night	5 3 3 3

Market	• Limited feasibility studies to understand key requirements for utility scale deployment and the efficiency gains of the technology in current climate. • Understanding factors that influenced supply and demand in Tonga	3 3
Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable. • Capacity to establish an evidenced based data collection and analysis. • Effective use of evidence to guide decision making. • Lack of community involvement in solar installation decision making • Lack of comprehensive coordination of data collection for policy development	5 3 3 3 5

Table 16: Financial and Fiscal Barriers and Score for the Diffusion of Utility On-Grid Wind Powered Generation

Technology: Utility On-Grid Wind Powered Generation		
Barrier Economic & Financial	Description	Score
Financial & Fiscal	• Insufficient Access for Finance and lack of de-risking guarantees available. • High upfront cost for wind equipment/parts. • Local Tax Policy-Duty Free for Government wind projects • Reliance and Dependence on donor funding/Lack of Access for Finance • Lack of Full cost recovery investment from Private Sector • Limited access to capital to finance utility scale solar project. • Inflation of prices triggered by increasing oil prices and other reasons. • Inflation due to Labour Shortage and cyclone recovery	3 3 1 4 4 1 2 3

Table 17: Non-Financial Barriers and Score for the Diffusion of Utility On-Grid Wind Powered Generation

TECHNOLOGY: Utility On-Grid Wind Powered Generation		Score
Policy, Regulatory, Legislative	• Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote widespread adoption. • Unclear permitting process for wind power and electricity market design • Ineffective Public Policies leading to Infrastructure Development • Lack of Transparency in regulatory and monitoring activities • Difficulty establishing Power Purchase Agreements (PPAs) for wind due to Unclear Policy for regulation of PV	2 3 5 5 1
Institutional capacity	• Insufficient Grid connection agreements/arrangements to • Insufficient Development of Wind PPA with IPP contracts • Unclear and low transparency of wind power project financing and permitting processes of wind power to the grid.	2 1 2
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of wind power installations • Insufficient knowledge regarding wind power generation • Scarcity of spare parts due to lack of private sector investment • Grid Stability and permitting process for wind power	5 2 1 4

Market	• Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing. • Limited feasibility studies to understand key requirements needed for utility scale deployment and the efficiency gains of the technology in current climate.	4 4
Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on wind technologies • Lack of comprehensive coordination of data collection for policy development	2 3 4 4

Table 18: Fiscal and Financial Barriers and Score for the Diffusion of the energy efficient home appliances

Technology: Energy Efficient Home Appliances		
Barrier Economic & Financial	Description	Score
Financial & Fiscal	• Insufficient Access for Finance and lack of de-risking guarantees available. • High upfront cost for small and remote market. • Local Tax Policy-Duty Free for Government wind projects • Reliance and Dependence on donor funding/Lack of Access for Finance • Lack of Full cost recovery investment from Private Sector	5 5 5 1 1

Table 19: Non-Financial Barriers and Score for the Diffusion of the energy efficient home appliances

TECHNOLOGY: Energy Efficient Home Appliances		Score
Policy, Regulatory, Legislative	• Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote widespread adoption. • Absence of Energy Efficiency Legislation • Ineffective Public Policies leading to adoption of energy efficient home appliances. • Lack of regulatory and monitoring activities on energy efficient home appliances	3 3 4 2
Institutional capacity	• Insufficient Capacities in Energy Institution • Lack of technical and management capacity • Lack of training capacity for business management • No entity with mandate and capacity to oversee electricity and petroleum. • Need for clear and effective institutional arrangements • Insufficient institutions and mechanisms to address threats of climate change.	2 2 3 2 1 1
Technical	• Insufficient knowledge regarding energy efficient home appliances • Scarcity of spare parts due to lack of private sector investment • Lack of experiences with energy efficient home appliances • building design, appliance use, and energy consumption behavior revolving around cheap and low energy efficiency appliances	3 1 1 5

Market	• Complexity in technical aspects such as appliances design, and energy consumption. • Limited feasibility studies to understand key requirements need energy efficient home appliances. • Understanding factors that influenced supply and demand in Tonga. • challenges in accessing rural sites. • Need to confirm environmental viability of In-depth analysis of contribution of energy efficiency in the demand side to align with NDC, TERM, SDG • Lack of knowledge on opportunities and Challenges for EE investments	1 2 4 1 1 2
Information & Public Awareness	• Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	1 3 5

8.3.1 Prioritization of Sored/Scaled Barriers for Energy technologies

The energy group or key stakeholders from the energy institutions finalize the score and agree upon it. Based on the understanding of the energy team and the consultant, the priority barriers are selected. The barriers with a score ranging from 3 to 5 are considered as priority barriers. Table 19 provides information on the prioritized barriers and their corresponding scores for on-grid solar technology. Table 20 provides information on the prioritized barriers and their corresponding scores for on-grid wind technology. Table 19 provides information on the prioritized barriers and their corresponding scores for on-grid energy efficient home appliances technology.

Table 20: Prioritized Barriers for Utility On-Grid Solar Powered Generation

TECHNOLOGY: Utility On-Grid Solar Powered Generation		Score
Financial Barriers	• Reliance and Dependence on donor funding/Lack of full cost recovery investment from Private Sector • Economic feasibility due to subsidized cost of electricity to the consumer • High upfront cost for solar equipment/parts: Panels, Batteries and Storage Capacity.	5 5 4 4

	• High perceived risk by investors in absence of government guarantee for payments and grid connectivity. • Insufficient and Uncertain demand from the grid • Inflation of prices triggered by increasing oil prices and other reasons. • Inflation due to Labour Shortage and cyclone recovery	3 3 3
Policy, Regulatory, Legislative	• Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams. • Poor incentives/support mechanisms for the development does not exist to promote widespread adoption. • Difficulty establishing Power Purchase Agreements (PPAs) due to Unclear Policy for regulation of PV. • • Permits, licensing issues, PPA contract. • Insufficient Legislative and Regulatory Aspects and specifics types of	5 4 4 3 3
Institutional capacity	• Insufficient Privatization Arrangements by Power Utility • Insufficient Grid connection agreements/arrangements to • Insufficient Development of Solar PPA with IPP contracts	
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations • Insufficient knowledge regarding RE power generation. • Scarcity of spare parts due to lack of private sector investment • Insufficient battery storage leading to, loss of revenue at night	5 3 3 3
Market	• Limited feasibility studies to understand key requirements for utility scale deployment and the efficiency gains of the technology in current climate. • Understanding factors that influenced supply and demand in Tonga.	3 3

Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable • Lack of comprehensive coordination of data collection for policy development • Capacity to establish an evidenced based data collection and analysis. • Effective use of evidence to guide decision making. • Lack of community involvement in solar installation decision making	5 5 3 3 3

Table 21 : Prioritized Barriers for On-Grid Wind Power Generation

TECHNOLOGY: Utility On-Grid Wind Powered Generation		Score
Financial Barriers	• Reliance and Dependence on donor funding/Lack of Access for Finance • Lack of Full cost recovery investment from Private Sector • Insufficient Access for Finance and lack of de-risking guarantees available. • High upfront cost for wind equipment/parts. • Inflation of prices triggered by increasing oil prices and other reasons	4 4 3 3 3
Policy, Regulatory, Legislative	• Ineffective Public Policies leading to Infrastructure Development • Lack of Transparency in regulatory and monitoring activities • Unclear permitting process for wind power and electricity market design	5 5 3
Institutional capacity	• Insufficient Grid connection agreements/arrangements • Unclear and low transparency of wind power project financing and permitting processes of wind power to the grid.	2 2
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of wind power installations • Grid Stability and permitting process for wind power. • Insufficient knowledge regarding wind power generation	5 4 2

Market	• Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing. • Limited feasibility studies to understand key requirements for utility scale deployment and the efficiency gains of the technology in current climate.	4 4
Information & Public Awareness	• Minimum consultation with local stakeholders on wind technologies • Lack of comprehensive coordination of data collection for policy development • Capacity to establish an evidenced based data collection and analysis	4 4 3

Table 22 : Prioritized Barriers for Energy Efficient Home Appliances

TECHNOLOGY: Energy Efficient Home Appliances		Score
Financial	• Insufficient Access for Finance and lack of de-risking guarantees available. • High upfront cost for small and remote market. • Local Tax Policy-Duty Free for Government wind projects	5 5 5
Policy, Regulatory, Legislative	• Ineffective Public Policies leading to adoption of energy efficient home appliances. • Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote widespread adoption. • Absence of Energy Efficiency Legislation	4 3 3
Institutional capacity	• Lack of training capacity for business management • Insufficient Capacities in Energy Institution • Lack of technical and management capacity • No entity with mandate and capacity to oversee electricity and petroleum	3 2 2 2

Technical	• building design, appliance use, and energy consumption behavior revolving around cheap and low energy efficiency appliances • Insufficient knowledge regarding energy efficient home appliances	5 3
Market	• Understanding factors that influenced supply and demand in Tonga. • Limited feasibility studies to understand key requirements need energy efficient home appliances. • Lack of knowledge on opportunities and Challenges for EE investments	4 2 2
Information & Public Awareness	• Lack of comprehensive coordination of data collection for policy development • Minimum consultation with local stakeholders on energy efficient home appliances	5 3

8.4 Literature Review on Enabling Environment for Energy Technologies

8.4.1 Fiscal and Financial Enabling Environment

Reducing fiscal and financial barriers plays a crucial role in the development and enhancement of fiscal policy. This involves improving taxes, import duties, and government purchasing policies, all of which have an impact on the cost of renewable energy compared to fossil fuels (Wade, 2004). In order to promote the adoption of renewable energy technologies, there is a need to reduce government subsidies and ensure that renewable infrastructure services operate under a commercial model that fully recovers operational costs (D'Este., G. et al, 2010). One approach to achieving this is by increasing access to finance for the private sector, which can fund demand-side renewable energy projects and green initiatives (GOT, 2021c). Additionally, the government can provide loan programs to the private sector for renewable energy investments, such as low-energy buildings (GOT, 2021c). It is crucial for these projects to incorporate a sustainable business model that allows for the recovery of investment costs and prioritizes productive uses of energy (IRENA, 2013). Donor financial support policies can also provide funding to create additional fiscal space for the Government of the Kingdom of Tonga, enabling them to address COVID-19 and TC Harold's response and recovery plans, as well as further enhance the energy sector (EU, 2020). Tariff policies can serve as a source of funding, as Tonga has adopted the inclusion of in-kind contributions to renewable energy projects in electricity tariffs (TPL, 2020). Furthermore, tariff subsidies are another form of financial support, with Tonga implementing standardized electricity tariff rates across its four main islands and providing a lifeline tariff subsidy for the first 100 kWh, applicable to all customers (UNCTCN, 2020). Official capital transfers and disbursements from the Rapid Credit Facility in July 2022 have helped

address the current account deficit and support foreign exchange reserves, despite significant remittances, ongoing grants, and a rebound in tourist arrivals in FY2023 (IMF, 2023).

8.4.2 Enabling Environment of Fiscal and Financial Barriers of the Energy Technologies

After evaluating the prioritized barriers for each technology, the financial and fiscal enabling frameworks highlighted in the literature review are aligned with the barriers listed in Table 22. This table presents the priority levels of different types of financial and fiscal barriers, based on the scores given by the energy group for each technology. Additionally, it shows the enabling framework selected by the group to address these barriers effectively. The energy group has identified government subsidy tariff policy, heavy reliance on donors, and unaffordable tariffs as the primary barriers for the dissemination of on-grid solar technology due to fiscal and financial constraints. Additionally, the high upfront cost for small/remote markets and the absence of a full cost recovery investment model for the private sector are considered secondary barriers. Lastly, the insufficient demand for on-grid solar production from the national grid and the impact of inflation are seen as third priority barriers. It is essential to address these priority barriers to enhance the enabling environment for the advancement of on-grid solar technology, as indicated by the key stakeholders' analysis. It is imperative to involve stakeholders in reviewing the government's electricity tariff subsidy policy and IPP/Utility's PPA tariff contract in order to ensure complete cost recovery of investment for on-grid solar projects. Additionally, the matter of high costs and investment recovery should be addressed in a more suitable manner. Lastly, it is crucial to enhance the grid's capacity through technical and policy improvements to enable maximum solar power production and its seamless integration into the national grid. The energy group has recognized that the main obstacles to the widespread adoption of on-grid wind technology are the heavy dependence on donors, the unaffordable tariffs, and the lack of a comprehensive investment model that ensures full cost recovery for the private sector. These fiscal and financial constraints hinder the dissemination of on-grid wind technology. Furthermore, the high initial expenses in small or remote markets, the perceived risk by investors without government payment guarantees and grid connectivity, and uncertainties regarding the payment of services to cover the full cost are secondary barriers that need to be addressed. Finally, the impact of inflation is considered to be the third most important obstacle. Hence, it is crucial to focus on the necessary factors that enable the effective implementation of on-grid wind technology. These factors include enhancing government policies concerning projects funded by donors and government tax exemption, which ultimately result in the absence of complete cost recovery tariffs. Additionally, the government should reassess its tax and subsidy policies, as well as electricity tariff policies. Lastly, it is essential to review policies and initiatives aimed at mitigating the effects of inflation. The energy group has selected particular obstacles linked to fiscal and financial matters to give importance to energy-efficient household appliances. The necessary facilitators to tackle their prioritized obstacles consist of enhancing taxes, import tariffs, and procurement policies. Furthermore, their goal is to deal with high transaction expenses and strengthen

government assurances to guarantee the recuperation of complete investment expenses for the deployment of energy-efficient household appliances.

Table 23 : Fiscal and Financial Enabling Framework for Priority Barriers of Renewable Energy and Energy Efficiency Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances	
Duty Free Local Tax Policy for Diesel for Power Generation			√ - 5	Improving Taxes import duties, and government purchasing policies
Economic feasibility due to subsidized cost of electricity to the consumer /Social Equity Tariffs	√ - 5			Improve Government Subsidy Policy and adopt commercial model to recover full cost of investment
Reliance and Dependence on donor funding but unaffordable tariff rates and no showing of impacts of fuel saving on tariffs; and insufficient private sector investment project	√ - 5	√ - 4		Encourage full cost recovery tariff and provide justification for unaffordable tariffs with insufficient impacts on fuel saving from renewable energy
High Upfront Cost on Small and Remote Market	√ - 4	√ - 3	√ - 5	Tariff policies can serve as a source of funding, as Tonga has adopted the inclusion of in-kind contributions to renewable energy projects in electricity tariffs
Lack of full cost recovery investment from Private Sector	√ - 4	√ - 4		Increase Finance for private sector for RE and low energy buildings
High perceived risk by investors in absence of government guarantee for payments and grid connectivity Uncertainties on payment of services to		√ - 3	√ - 5	Improve PPA design and contract agreement

recover full cost				
Insufficient and Uncertain Demand from the grid .	√-3			Strengthen the Grid and process digitization of permission process for renewable energy technologies
Inflation due to increases petroleum prices and Labour Shortage and cyclone recovery.	√-3	√-3		Encourage donor supports on Official Capital Transfer and improve unbalance of payment and foreign reserve

8.4.3 Policy, Regulatory and legislative

Tonga has carefully reviewed the implementation of a full cost recovery policy for the adoption of renewable energy technologies. The tariff regime considered by Tonga is deemed sufficient for full cost recovery, ensuring proper operation and maintenance. An analysis conducted by NEXSTEP in Tonga indicates that off-grid PV and mini-grid technology would be more cost-effective, allowing for quicker implementation to achieve 100% universal access to electricity by 2020, as outlined by TERM (ESCAP, 2020). It is crucial for the full cost recovery policy to be in line with regulations, especially when developing renewable infrastructure using green infrastructure standards (GOT, 2021c). The Tonga Power Limited (TPL) has the authority to disconnect customers in cases where electrical hazards are identified or reported by a third party and are considered hazardous (TPL, 2020). To enhance the regulatory process in the electricity sector, a regulatory reform and a donor-supported risk reduction facility are essential to facilitate renewable energy investments (TPL, 2020). An enabling regulatory environment is necessary to attract private sector investments in renewable energy deployment in the region, emphasizing collaboration on common legal tools and regulations, as well as the enforcement of policy and regulatory frameworks as enablers for renewable energy deployment (IRENA, 2013).

In terms of energy efficiency policy, Tonga has introduced the Tonga Energy Efficiency Master Plan in 2021 to address 55% of its total greenhouse gas emissions, with 23% coming from electricity generation (UNCTCN, 2020). Tonga has also considered the draft regulation and policy paper to support the rollout of light emitting diode (LED) streetlamps and interior LED lamps (GOT, 2021c).

8.4.4 Enabling Environment for Policy, Regulatory & Legislative Barriers of Energy Technologies

In the preceding section, Section 5.4.3, several types of enabling frameworks necessary to tackle significant policy, regulatory, and legislative barriers in renewable energy and energy efficiency technologies were outlined. These policy barriers were ranked by the energy group using a Likert-type Scale (1-5), as detailed in Table 23. Additionally, Table 23 includes the suggested enabling frameworks to put forth by the energy group, which will be further discussed in this section. The energy group has stressed the importance of implementing the full cost recovery policy for on-grid solar. They have also highlighted the need for the private sector to actively participate in improving the PPA Contract.

Additionally, they have emphasized the necessity of enhancing the incentive and regulatory policy, as well as streamlining the licensing and permission process for on-grid solar. Finally, they have requested the improvement of the legislative and regulatory structure concerning on-grid solar technology in Tonga. In terms of on-grid wind technology, there is a requirement for an appropriate Government Incentive Policy and more efficient Public Policy, increased transparency in regulatory responsibilities and decisions, and a comprehensive cost recovery investment to ensure the smooth operation and maintenance, as well as a streamlined permission process for integrating renewable energy into the grid. As for energy-efficient home appliances, it is crucial to establish a more effective public policy and incentives, enforce proper legal requirements, and address the Regulatory Needs and tools.

Table 24 : Policy, Regulatory and Legislative Enabling Framework for Priority Renewable Energy and Energy Efficiency Technologies

Type of Barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it indicates that the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	On-Grid Solar	On-Grid Wind	Energy Efficiency Home Appliance	
Implementation of Privatization Policy by Power Utility				Implementation of a full cost recovery policy
Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams.	√-5			Full cost recovery regulations, especially when developing renewable infrastructure using green infrastructure standards
Challenging Development of PPA with IPP owners	√-4			Government and Utility IPP/PPA Contract Policy Development with private sector coordination
Absence of Energy Efficiency Legislation			√-3	Collaboration on common legal tools and regulations
Poor incentives/support mechanisms for the	√-4	√-5	√-4	Suitable Government Incentive Policy A regulatory reform and a

development does not exist to promote widespread adoption/Ineffective Public Policies leading to Infrastructure Development				donor-supported risk reduction facility are essential to facilitate renewable energy investments
Lack of Transparency in regulatory and monitoring activities		√-5		An enabling regulatory environment is necessary to attract private sector investments in renewable energy.
Diversity of political decisions that hinders effective business plan.				Enforcement of policy and regulatory frameworks as enablers for renewable energy
Unclear Policy for regulation of PV/Permits, Licencing issues, PPA Contract	√-3	√-3		Full cost recovery, ensuring proper operation and maintenance and better permission process for allowing renewable into the grid
Insufficient Legislative and Regulatory Aspects	√-3		√-3	Identify Legal requirements and all relevant Regulatory Needs

8.4.5 Institutional Enabling Environment

Reducing the barriers within institutions in the country would necessitate the training of energy officials who are involved in the field and the establishment of an institution dedicated to the production of renewable (Wade, 2004). To illustrate, significant progress was made in enhancing skills related to the integration and reporting of renewable energy by the end of 2019 through the active participation of stakeholders in various workshops and conferences. These included the Energy and Policy Regulation workshop in Fiji, the Asia Clean Energy Forum (ACEF) in Manila, and the Pacific Power Association annual conference in Rarotonga, Cook Islands (ADB, 2023). In 2022, over 1,500 individuals underwent training on innovative approaches to designing and procuring renewable energy projects, as well as utility reforms (ADB, 2023). Additionally, it is crucial to establish a comprehensive procedure for infrastructure planning and management that incorporates a thorough assessment of the full life-cycle costs associated with infrastructure projects (D'Este., G. et al, 2010). Furthermore, there is a need to enhance the management and regulatory environment for the development of both existing and new renewable infrastructure (D'Este., G. et al, 2010). This can be achieved by reviewing and streamlining the overall institutional structure of the economic infrastructure sector to clarify and simplify responsibilities (D'Este., G. et al, 2010). For instance, based on stakeholder interviews and a literature review conducted in Tonga, it is recommended to establish a single regulating body, such as a "Ministry of Energy," to effectively regulate

and enable utilities to operate independently (Pandey, S., et al, 2013). Additionally, it is crucial to adopt a more effective coordinating approach and foster close collaboration with other relevant agencies, such as the TERM and TPL (MEIDECC, 2019).

8.4.6 : Enabling Environment for Institutional Barriers of Energy Technologies

The energy group emphasized the importance of receiving training on innovative methods for designing and acquiring renewable energy and energy efficiency projects. The findings of the discussion conducted by the energy group are presented in Table 24, which highlights that the majority of the institutional enabling framework for on-grid solar and on-grid wind technologies have already been established and is currently operational. However, what is required are training programs for energy efficient home appliances to enhance the business management aspect of the technology.

Table 25 : The Institutional Enabling Framework for Priority Renewable Energy and Energy Efficiency Technologies

Types of Barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ -5 is used, it indicates that the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances	
Insufficient Capacities in Energy Institution				training of energy officials who are involved in the field and the establishment of an institution
Lack of technical and management capacity				Enhancing skills related to the integration and reporting of renewable energy
Lack of information on renewable energy and energy efficiency				a more effective coordinating approach and foster close collaboration with other relevant agencies
Lack of training capacity for business management			√-3	Training on innovative approaches to designing and procuring renewable energy and energy efficiency projects
No entity with mandate and capacity to oversee electricity and petroleum.				Establish a single regulating body, such as a "Ministry of Energy to effectively regulate and enable utilities to operate independently
Need for clear and effective institutional arrangements.				Establish a single regulating body, such as a "Ministry of Energy to effectively regulate and enable

				utilities to operate independently
Lack of guidelines, milestones and performance benchmarks.				Comprehensive procedure for infrastructure planning and management that incorporates a thorough assessment of the full life-cycle costs
Insufficient institutions and mechanisms to address threats of climate change.				Enhance the management and regulatory environment for the development of both existing and new renewable infrastructure.

8.4.7 Technical Enabling Environment

Reducing technical barriers for renewable energy involves enhancing capacity for designing, installing, and maintaining renewable energy systems, as well as developing standards and certifications for renewable energy technologies (Wade, 2004). In terms of operation and maintenance skills, prioritizing maintenance over investing in new infrastructure is crucial (D'Este., G. et al, 2010). Additionally, transferring design and engineering knowledge to remote personnel is essential (TPL, 2020). Encouraging Tonga power utility to manage individual renewable electricity grids in the outer islands is also important (ADB, 2020a). Specialized technical skills are required for operating renewable energy systems due to the variability of solar PV and wind power, especially when integrating them into diesel generator-based power systems (IRENA, 2013). Moreover, skills such as replacing oil-fired power generation with renewable energy, implementing energy efficiency programs, and strengthening transmission and distribution lines are necessary (World Bank, 2012; UNCTCN, 2020). Diversifying the fuel mix with renewables and incorporating battery storage are also key components for upgrading and maintaining a renewable energy network (UNCTCN, 2020; GOT, 2021c). Combining technical and financial skills, Tonga Power Limited introduced the Gross Metering Policy in response to revenue losses caused by the lack of battery storage (TPL, 2020). Assessing grid stability for high levels of renewable energy integration requires modeling and evaluating grids at different penetration levels, supported by a systematic approach to transitioning to renewables (IRENA, 2013).

Reducing technical barriers for energy efficiency involves aligning with various technical standards, such as incorporating energy efficient design into building codes (UNCTCN, 2020), promoting standards that establish energy efficient infrastructure (GOT, 2021c), and implementing standards and regulations for energy efficiency technologies (GOT, 2021c). Justification for energy efficiency is crucial, as NEXSTEP analysis indicates significant energy savings opportunities in the residential, transport, and commercial sectors in Tonga (ESCAP, 2020). This is why the promotion of energy efficient appliances in the Kingdom is essential to reduce electricity consumption (MEIDECC, 2013). It is sometimes necessary to align energy efficiency with renewable energy knowledge and experiences for an integrated approach to both RE and energy efficiency capacity

development assessments. This integrated approach is required to arrive at the optimal solution in terms of feasibility, cost, social acceptance, and phasing (IRENA, 2013). Furthermore, in the transition to RE and diesel hybrid systems with high levels of RE integration, energy efficiency measures can play a key role in the energy supply for island communities and are indeed a viable option for the PICs (IRENA, 2013).

8.4.8 Enabling Environment Technical Barriers of Energy Technologies

According to the literature review provided in sections 5.4.7 above, researchers and authors have proposed several enabling frameworks. These frameworks are listed in Table 25 and are recommended for use when appropriate. The energy group has also examined and, if needed, modified the suggested enabling framework to align with the specific needs of Tonga. The proposed frameworks mentioned below are designed to efficiently tackle the different types of technical barriers, as specified in Table 25, for every technology. For on-grid solar, the priority needs for enabling framework included the need for grid stability and strengthening, ability to design, install and maintain the technology, improving technical knowhow in the remote areas, and finally increasing capacity to diversify the fuel mix with renewable energy and battery storage. For on-grid wind, there are need to improve capacity to strengthen the grid, and capacity to improve the permitting process for wind power in the grid. For energy efficient home appliances, there is a technical need to enhancing capacity for designing, installing, and maintaining energy systems, and essential need to have technical justification for energy efficiency projects.

Table 26 : Technical Enabling Framework for Priority Renewable Energy and Energy Efficiency Technologies

Types of Technical Barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it indicates that the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances	
Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations	√-5	√-5		Improve Grid Stability and encourage land availability process.
Lack of experiences with Hybrid and wind systems in Pacific				Developing standards and certifications for renewable energy technologies

Insufficient knowledge regarding the technologies	√-3		√-3	Enhancing capacity for designing, installing, and maintaining renewable energy systems
Scarcity of spare parts due to lack of private sector investment	√-3			Transferring design and engineering knowledge to remote personnel is essential
Insufficient battery storage leading to, loss of revenue at night.	√-3			Diversifying the fuel mix with renewables and incorporating battery storage Gross Metering Policy in response to revenue losses caused by the lack of battery storage
time-consuming nature of renewable installations				prioritizing maintenance over investing in new infrastructure
government agencies lack the necessary technical knowledge.				manage individual renewable electricity grids and necessary. Specialized technical skills.
Grid stability for high levels of renewable energy integration requires modelling and evaluating grids at different penetration level.		√-4		Consider adopting improved policy for permitting process of renewable energy technologies
energy efficiency technologies revolve around the efficiency of energy consumption.				Implementing energy efficiency programs Integrated approach to both RE and energy efficiency capacity development assessments. With high levels of RE integration, energy efficiency measures can play a key role in the energy supply for island communities
building design, appliance use, and			√-5	Justification for energy efficiency is crucial, as NEXSTEP analysis

energy consumption behavior revolving around electricity consumption efficiency				indicates significant energy savings opportunities in the residential, transport, and commercial sectors

8.4.9 Market Enabling Environment

Diesel generation is being gradually phased out, with solar PV being the main replacement source (ESCAP, 2020). It is essential to have the ability to evaluate and interpret data, utilizing it for energy market and policy analysis to formulate effective policies and scenarios (Yamaguchi., K, Undated). For instance, NEXSTEP has outlined a pathway from 2018 to 2035, aiming to achieve a 70% and 100% renewable power generation share by 2025 and 2030, respectively (ESCAP, 2020). Additionally, new data and information have been compiled based on MEIDECC's analysis for the upcoming TERM in alignment with SDG7 goals and NDCs (Yamaguchi., K, Undated). There is also a need for skill development through local training programs for energy service business management (Wade, 2004), and the delegation of certain functions to the private sector for infrastructure delivery (D'Este., G. et al, 2010). In terms of market potential, wind energy stands out as the renewable energy technology with the highest technical and economic potential for immediate deployment in the region (IRENA, 2013).

8.4.10 Enabling Environment for Market Barriers of the Energy Technologies

According to the literature review provided in sections 5.4.9 above, researchers and authors have proposed several enabling frameworks. These frameworks are listed in Table 26 and are recommended for use when appropriate. The energy group has also examined and, if needed, modified the suggested enabling framework to align with the specific needs of Tonga. The proposed frameworks mentioned below are designed to efficiently tackle the different types of market barriers, as specified in Table 26, for the selected technologies. For on-grid solar, on-grid wind, and energy efficient home appliances the market need for enabling framework included the need for renewable energy targets in order to address the lack of feasibility studies on successful solar projects, and the need to improve capacity to have new data and information on relationship with renewable energy targets, SDGs and NDCs.

Table 27 : Market Enabling Framework for Priority Renewable Energy and Energy Efficiency Technologies

Types of Technical Barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ -5 is used, it indicates that the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	On-Grid Solar	On-Grid Wind	Energy Efficiency Applian	

			ces	
Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations challenges in accessing rural sites.				Delegation of certain functions to the private sector for infrastructure delivery
high risks/low profits for renewable businesses in remote islands				Skill development through local training programs for energy service business management
Need to confirm environmental viability of renewable energy project.				Wind energy stands out as the renewable energy technology with the highest technical and economic potential
In-depth analysis of energy market to align with NDC, TERM, SDG				Have the ability to evaluate and interpret data, utilizing it for energy market and policy analysis to formulate effective policies and scenarios.
Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate and Identifying opportunities and Challenges for RE investments.	√-3	√-4		Aiming to achieve a 70% and 100% renewable power generation share by 2025 and 2030
Understanding factors that influenced supply and demand in	√-3	√-4	√-4	New data and information have been compiled based on MEIDECC's analysis for the upcoming TERM in alignment with

Tonga.				SDG7 goals and NDCs
Tonga Market prices are highly vulnerable to oil prices fluctuation				
Lack of community involvement in RE decision making				

8.4.11 Information and Public Awareness Enabling Environment

Reliable sourcing of data and appropriate analysis of information are crucial factors in making policy decisions. An example of evidence-based decision-making for policy development is the utilization of relevant and up-to-date information (GOT, 2016b). This approach was also applied in creating a database of best practice cases, which facilitated the sharing of knowledge and the implementation of a unified strategy for successful renewable energy deployment in the region (IRENA, 2013). Decision makers in Tonga must be equipped with information regarding suitable renewable energy technologies (Wade, 2004). Additionally, regional public information programs can be developed to provide necessary materials and offer short-term training and guidance on their effective delivery (Wade, 2004). One crucial requirement is the institutionalization of data collection and the establishment of a supporting framework. However, the institutionalization of data collection is still pending, which hinders the regular updating and improvement of the database (Yamaguchi., K, Undated). Policy makers can benefit from utilizing the database, which captures the energy flows from supply to demand and categorizes them by energy type and consumer (Yamaguchi., K, Undated). The availability of indicators such as total final energy consumption and energy intensity, aligned with international standards, can further enhance evidence-based policy making (Yamaguchi., K, Undated). It is important to continue strengthening the institutionalization of inter-ministerial collaboration for data collection and establish the role of MEIDEC in creating the database (Yamaguchi., K, Undated). *Capacity building and stakeholder involvement are also crucial. Renewable energy and energy efficiency should be integrated into the standard education curriculum* (GOT, 2021c). To ensure successful large-scale deployment of renewable energy, careful assessment of the energy, water, and land-use nexus must be conducted, with active involvement of stakeholders in the planning process (IRENA, 2013). Training programs should also be provided (IRENA, 2013). Lastly, it is important to assess the cost of renewable energy solutions for island communities and provide information on the availability of technologies.

8.4.12 Enabling Environment for Information & Public Awareness Barriers of Energy Technologies

According to the literature review provided in sections 5.4.11 above, researchers and authors have proposed several enabling frameworks. These frameworks are listed in Table 27 and are recommended for use when appropriate. The energy group has also examined and, if needed, modified the suggested enabling framework to align with the

specific needs of Tonga. The proposed frameworks mentioned below are designed to efficiently tackle the different types of information and public awareness barriers, as specified in Table 27, for the selected technologies. For on-grid solar, the information and public awareness need for enabling framework included the Institutionalization of data collection and the comprehensive data coordination and collection, capacity to produce indicators for evidenced based policy decision, and sharing of knowledge on solar technology. For on-grid wind, the enabling framework for comprehensive data coordination and collection, capacity to produce indicators to guide evidenced based policy decision, and production of regional public information programs for local communities to understand technologies. For energy efficient home appliances, the required enabling framework included comprehensive data coordination and collection as well as capacity to produce regional public information programs for local communities to understand technologies.

Table 28 : Information and Public Awareness Enabling Framework for Priority Renewable Energy and Energy Efficiency Technologies

Types of Technical Barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ -5 is used, it indicates that the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	On-Grid Solar	On-Grid Wind	Energy Efficiency Appliances	
Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable.	√-5			Institutionalization of data collection and the establishment of a supporting framework Institutionalization of inter-ministerial collaboration for data collection and establish the role of MEIDEC in creating the database. Assess the cost of renewable energy solutions for island communities and provide information on the availability of technologies
Lack of Comprehensive coordination of data collection for policy development	√-5	√-4	√-5	Decision makers in Tonga must be equipped with information regarding suitable renewable energy technologies.
absence of knowledge				Reliable sourcing of data and appropriate analysis of

regarding renewable energy and energy efficiency				information Renewable energy and energy efficiency should be integrated into the standard education curriculum
Electricity network upgrade with low environmental impacts				
Capacity to establish an evidenced based data collection and analysis.	√-3	√-3		Evidence-based decision-making for policy development is the utilization of relevant and up to date information. Availability of indicators such as total final energy consumption and energy intensity, aligned with international standards, can further enhance evidence-based policy making
Effective use of evidence to guide decision making.	√-3			Sharing of knowledge and the implementation of a unified strategy for successful renewable energy deployment
Lack of community involvement in solar installation decision making and Minimum consultation with local stakeholders on RE technologies		√-4	√-3	Regional public information programs can be developed to provide necessary materials and offer short-term training

8.5 Identified Interventions for Overcoming Barriers in the Energy Sector

Table 28 delineates the particular obstacles for on-grid solar power, along with their respective ranking scores indicating the level of importance in addressing them by utilizing the recommended enablers or enabling framework through effective collaboration among the designated responsible entities. Table 29 and Table 30 similarly outline the specific significant barriers, facilitators, and accountable stakeholders for on-grid wind power and energy-efficient household appliances, respectively. The Table 28.29,30 offers several benefits as it allows energy stakeholders to highlight their priority barriers and identify the appropriate enabling environment, as discussed in the preceding sections. Subsequently, sections 5.5.1, 5.5.2, and 5.5.3 place additional emphasis on responsible

institutions and their essential interventions and coordination. This ensures that stakeholders can effectively establish the recommended enabling framework to address the identified barriers for each selected technology, potentially leading to successful outcomes.

8.5.1 Responsible Institutions Enabling Framework of On-Grid PV Generation

As emphasized in Table 28, it is imperative for the stakeholders engaged in the formulation of electricity tariffs, such as the Ministry Responsible for Energy, Power Utility, and Tonga Electricity Commission, to offer a transparent rationale for the monthly electricity tariffs in order to address the challenges associated with finance and fiscal matters. Additionally, they should emphasize the positive effects of utilizing on-grid solar power in terms of reducing the consumption of diesel fuels and its contribution to the overall electricity tariffs. The process of formulating electricity tariffs should be transparent and well-explained, particularly in relation to the Independent Power Producer (IPP) and Power Purchase Agreement (PPA) contracts. Furthermore, the government should strive to enhance and disclose any potential financial incentives policies that can benefit private sector investments in on-grid solar IPP projects. During the annual government subsidy Policy Review, it is imperative for the Ministry of Finance, Custom Department, Ministry of Trade and Economic, Ministry Responsible for Energy, Power Utility, and Tonga Electricity Commission to establish precise objectives and criteria for the subsidy policy concerning fossil fuels in comparison to government subsidies for electricity tariffs. The Ministry of Energy, Customs Department, Ministry of Finance, Ministry of Trade, Power Utility, Tonga Electricity Commission, and IPP Companies are well-placed to explore various solutions to tackle the high cost of solar equipment and enhance capacity to establish a full cost recovery investment. It is imperative for the Power Utility, Tonga Electricity Commission, IPP Contractors, and donors to devise strategies to facilitate optimal demand and integration of on-grid solar production into the electricity grid. Additionally, the government needs to devise measures to mitigate the impact of inflation on the cost of goods. To address policy, regulatory, and legislative obstacles, the Ministry of Energy, Tonga Electricity Commission, Power Utility, and IPP Contractors should work towards enhancing the regulation and permitting processes for on-grid solar projects, as well as improving the policy and legislative framework for IPP/PPA contracts. In terms of technical enhancements, the Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, and IPP Companies should focus on enhancing Grid assessment and exploring options for grid improvement. Moreover, these institutions need to address the lack of technical expertise by implementing on-site technical training and long-term training programs. The successful diversification of the fuel mix for power generation and the establishment of the appropriate metering policy for IPP/PPA fall under the jurisdiction

of the power utility and Tonga Electricity Commission. To enhance the market, the Ministry of Energy, power utility, and regulatory authority must comprehend the factors influencing electricity supply and demand to mitigate the market price vulnerability to fluctuations in oil prices. The responsible institutions for comprehensive data coordination and collection should utilize data to inform evidence-based policy analysis and decisions, as well as involve local communities in public awareness campaigns for on-grid solar technologies.

Table 29 : Description of Enabling Framework to overcome Prioritized Barriers for On-Grid Solar Power Generation

TECHNOLOGY: Utility On-Grid Solar Powered Generation		Score	Enabler	Responsible Institutions /Roles
Financial / Fiscal Barriers	Reliance and Dependence on donor funding but unaffordable tariff rates and no showing of impacts of fuel saving on tariffs; and insufficient private sector investment project	5	Increase financial incentives to attract IPP/PPA investment contract. Improve Justification to electricity tariffs	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to justify and agree on best monthly tariffs
	Economic feasibility due to subsidized cost of electricity to the consumer /Social Equity Tariffs	5	Improve Government Subsidy Policy and adopt commercial model to recover full cost of investment	Ministry of Finance, Custom Department, Ministry of Trade and Economic, Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to discuss and identify best options for Subsidized Tariffs
	High upfront cost for solar equipment/parts: Panels, Batteries and Storage Capacity.	4	Organized regional procurement of solar equipment for small island countries and responsible regional transport of procured solar equipment	Ministry of Energy and Custom Department and Ministry of Finance to involve in the procurement

			materials to respective small island countries. Implement Tariff policies, which can serve as a source of funding for long term on-grid solar power projects, as Tonga has adopted the inclusion of in-kind contributions to renewable energy projects in the formulation of electricity tariffs. Remove Barriers for participation of the Private Sector Companies in the On-Grid Solar Power generation to increase competition. Increase Loan Finance for private sector companies involving in on-grid solar power generation.	process and arrangement. Government and Local Government Shipping Agencies and Private Sector Companies to arrange the shipping of goods from the regional storage country
	Lack of full cost recovery investment from Private Sector	4	Assess the exiting tariffs for PPA contract and analyse the viability of the tariff in the local context. Identify financial policy incentives and financing opportunities and Loan scheme Finance for private sector for solar technologies	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to assess existing tariff policy, existing financial policy incentives and explore financial opportunities for private sector companies
	Insufficient and Uncertain Demand from the grid	3	Strengthen the Grid permitting processes for PPA solar contract and consider the possibility to allow the digitization of	Ministry Responsible for Energy, Power Utility, Tonga Electricity

			permission process for solar power PPA technologies to the grid	Commission and IPP Companies to discuss and identify opportunities for increasing permission of power from to the grid.
	Inflation due to increases petroleum prices and Labour Shortage and cyclone recovery	3	Encourage donor supports on Official Capital Transfer and financial support to reduce inflation and improve trade deficit and unbalance of payment through increasing exports and increasing foreign reserve	Ministry Responsible for Energy/donors, Power Utility, Tonga Electricity Commission and IPP Companies to discuss and identify possible solutions to address inflation
Policy, Regulatory, Legislative	Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams.	5	Full cost recovery tariff, ensuring the recovery of the proper operation and maintenance cost of operation.	Tonga Electricity Commission and Utility and IPP as well as Government/donors to discuss and identify other direct and indirect financial support needed that are not covered in the tariff, which may need supports.
	Poor incentives/support mechanisms for the development to promote widespread adoption.	4	Enforcement/Award policy incentives through regulatory assessment and identify successful PPA performances as enablers for promotion of solar PPA contracts/projects.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to assess and identify successful PPA projects
	Difficulty establishing Power Purchase Agreements (PPAs) due to	4	Full cost recovery PPA Contract and Solar Investment project, ensuring proper operation and maintenance	Ministry Responsible for Energy, Power Utility, Tonga Electricity

	Unclear Policy for regulation of PV			Commission IPP Companies to identify the regulatory aspects of solar power generation
	Permits, licensing issues, PPA contract	3	Clearly articulate objectives and present a rationale for course of action for increasing issue of licensing for PPA Contracts Collaboration on common legal tools and regulations for solar PPA Full cost recovery regulations, especially when developing renewable infrastructure using green infrastructure standards	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies
	Insufficient Legislative and Regulatory Aspects and specifics types of Legislation	3	Outline driver and benefits of solar RE development to the public, describing current situation of excess generation capacity. A regulatory reform and a donor-supported risk reduction facility are essential to facilitate renewable energy investments.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to identify all legislative, regulatory and policy gaps for solar power on-grid generation.
Institutional capacity	Insufficient Privatization Arrangements by Power Utility		Effectively map the EXISTING institutional framework for solar-GRID and broad plans to ensure the framework stays in place accompanied with a comprehensive solar RE resource assessment.	This group agrees that all institutional improvement will be completed by addressing other identified barriers
	Insufficient Grid connection		A more effective coordinating approach and	This group agrees that all institutional

	agreements/arrangements		foster close collaboration with other relevant agencies	improvement will be completed by addressing other identified barriers
	Insufficient Development of Solar PPA with IPP contracts		A more effective coordinating approach and foster close collaboration with other relevant agencies. Training of energy officials who are involved in the field and the establishment of an institution. Training on innovative approaches to designing and procuring renewable energy projects	This group agrees that all institutional improvement will be completed by addressing other identified barriers
Technical	Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations	5	Grid stability for high levels of renewable energy integration requires modelling and evaluating grids at different penetration levels. Prioritizing maintenance before investing in new infrastructure.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to improve Grid assessment and identify options for grid improvement
	Insufficient knowledge regarding RE solar power generation.	3	Enhancing capacity for designing, installing, and maintaining renewable energy systems through short term on-site training and long-term school curriculum	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and local/international training institutions in designing training program and contents for solar power designing, installation, maintenance, and

				analysis of technical aspects of solar power.
	Scarcity of spare parts due to lack of private sector investment	3	Transferring design and engineering knowledge to the local expertise is essential.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and regional institutions local/international shipping companies participate in the arrangement for sufficient availability of affordable spare parts
	Insufficient battery storage leading to loss of revenue at night	3	Diversifying the fuel mix with renewables and incorporating battery storage Gross Metering Policy in response to revenue losses caused by the lack of battery storage	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and local/international training institutions to discuss and arrange for affordable installation of Battery Energy Storage System (BESS)
Market	Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate	3	Provide opportunity for professional assessment of the economic feasibility of the technology and also provide policy mechanism to allow for reasonable payback period and a reasonable rate of return on investments.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and local/international professionals/expertise to assess the

				economic viability of the on-grid solar
	Understanding factors that influenced supply and demand in Tonga.	3	New data and information to be compiled based on electricity demand in Tonga, and further data analysis to understand electricity demand. Tonga Market prices are highly vulnerable to oil prices fluctuation	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and local/international professionals/experts in the field to assess and identify factors that affect supply and demand of on-grid solar
Information & Public Awareness	Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable	5	Institutionalization of data collection and the establishment of a supporting framework	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies, Regional Energy Institutions, Statistics Department and local/international training institutions to assess the fixed tariff option and identify all possible options for tariffs
	Lack of comprehensive coordination of data collection for policy development	5	Institutionalization of data collection and sharing of data	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy

				Institutions and Statistics Department as well as local/international training institutions to discuss and establish arrangements for comprehensive data coordination, data collection, and data analysis.
	Capacity to establish an evidenced based data collection and policy analysis and decision making.	3	Institutionalization of collaboration for data collection and establish the role of MEIDEC in creating the database. Availability of indicators such as total final energy consumption and energy intensity, aligned with international standards, can further enhance evidence-based policy making.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions and Statistics Department as well as local/international training institutions to arrange for evidenced based data collection and use
	Effective use of evidence to guide decision making	3	Sharing of knowledge and the implementation of a unified strategy for successful renewable energy deployment Decision makers in Tonga must be equipped with information regarding suitable renewable energy technologies.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions and Statistics Department as well

				as local/international training institutions to arrange the adoption of evidence-based policy decision making
	Lack of community involvement in solar installation decision making	3	Regional public information programs can be developed to provide necessary materials and offer short-term training.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions and Statistics Department as well as local communities to communicate and coordinate community based solar power generations

8.5.2 Responsible Institutions for Enabling Framework of On-Grid Wind Generation

As emphasized in Table 29, it is imperative for the stakeholders engaged in the financing on-grid wind power project, such as the Ministry Responsible for Energy, Power Utility, and Tonga Electricity Commission, donors and private investors to identify possible funding to address the challenges associated with finance and fiscal matters. Furthermore, the same institutions can adopt full cost recovery policy and identify possible government's de-risking guarantees policy for investors. The Ministry of Energy, Customs Department, Ministry of Finance, Ministry of Trade, Power Utility, Tonga Electricity Commission, and IPP Companies are well-placed to explore various solutions to tackle the high cost of wind equipment and enhance capacity to establish a full cost recovery investment. It is imperative for the Power Utility, Tonga Electricity Commission, IPP Contractors, and donors to devise strategies to facilitate optimal demand and integration of on-grid wind production into the electricity grid. Additionally, the government

needs to devise measures to mitigate the impact of inflation on the cost of goods. To address policy, regulatory, and legislative obstacles, the Ministry of Energy, Tonga Electricity Commission, Power Utility, and IPP Contractors should work towards addressing of insufficient tariffs and poor government incentives and support mechanisms. The energy institutions need to develop policies to enhance the policy and legislative framework for IPP/PPA contracts and streamline the permitting processes for on-grid solar projects. While there have been no institutional improvements proposed by energy stakeholders, it is crucial for key energy institutions and stakeholders to focus on improving and stabilizing the grid to address challenges in site selection for IPP wind projects. The Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, and IPP Companies should prioritize addressing the lack of technical expertise by implementing on-site technical training and long-term training programs. Diversifying the fuel mix for power generation and establishing appropriate metering policies for IPP/PPA contracts fall under the jurisdiction of the power utility and Tonga Electricity Commission, which would help reduce revenue losses from battery storage. To enhance the market, the Ministry of Energy, power utility, and regulatory authority must understand the factors influencing electricity supply and demand to mitigate market price vulnerability to fluctuations in oil prices. The market should allow for professional assessment of the economic feasibility of technology and provide policy mechanisms for a reasonable payback period and rate of return on investments. The institutions responsible for comprehensive data coordination and collection should use data to inform evidence-based policy analysis and decisions, as well as engage local communities in public awareness campaigns for on-grid wind technologies.

Table 30 : Description of Enabling Framework to overcome Prioritized Barriers for On-Grid Wind Power Generation

TECHNOLOGY: Utility On-Grid Wind Powered Generation		Score	Enabler	Responsible Institutions /Roles
Financial Barriers	Reliance and Dependence on donor funding/Lack of Access for Finance	4	Explore opportunities for the establishment of the Innovation Fund and Loaning Schemes	Ministry Responsible for Energy/donors/Ministry of Finance, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions

	Lack of Full cost recovery investment from Private Sector	4	Improve Government Subsidy Policy and adopt commercial model to recover full cost of investment.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to assess existing tariff policy, existing financial policy incentives and explore financial opportunities for private sector companies
	Insufficient Access for Finance and lack of de-risking government guarantees available.	3	Increase Finance for private sector for RE Improve Government Subsidy Policy and adopt commercial model to recover full cost of investment.	Government/Donors/ Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to explore government financial policy to take risks of investment in wind power.
	upfront cost for wind equipment/parts.	3	Tariff policies can serve as a source of funding, as Tonga has adopted the inclusion of in-kind contributions to renewable energy projects in electricity tariffs	Ministry of Energy and Custom Department and Ministry of Finance to involve in the procurement process and arrangement. Government and Local Government Shipping Agencies and Private Sector Companies to arrange the shipping of goods from the regional storage country
	Inflation of prices triggered by increasing	3	Donors financial support for fiscal space	Ministry Responsible for Energy/donors, Power Utility, Tonga

	oil prices and other reasons.			Electricity Commission and IPP Companies to discuss and identify possible solutions to address inflation
Policy, Regulatory, Legislative	Ineffective Public Policies leading to Infrastructure Development	5	Improve public policy development to ensure the timely installation and investment in supporting infrastructure development	Government/Ministry of Finance/Ministry of Infrastructure, Ministry of Energy and IPP Companies to improve public policy development of infrastructure to assist wind power project sites in the rural areas
	Lack of Transparency in regulatory and monitoring activities	5	An enabling regulatory environment is necessary to attract private sector investments in renewable energy.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to discuss and identify key areas and issues to be covered by regulatory roles
	Unclear permitting process for wind power and electricity market design	3	Acceleration of deployment through increased predictability and faster permitting process.	Government/Donors/ Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to identify opportunities for increasing permission of power from wind into the grid.
Institutional capacity	Insufficient Grid connection agreements/arrangements	2	Enhance the management and regulatory environment for the development of both existing and new	Government/Donors/ Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to

			renewable infrastructure	improve grid stability and wind power permitting processes in the electricity network market
	Unclear and low transparency of wind power project financing and permitting processes of wind power to the grid	2	Establish a single regulating body, such as a "Ministry of Energy to effectively regulate and enable utilities to operate independently.	Government/Donors/ Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to establish wind power innovation fund and loan scheme for the PPA contract
Technical	Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of wind power installations	5	Grid stability for high levels of renewable energy integration requires modelling and evaluating grids at different penetration levels. Developing standards and certifications for renewable energy technologies	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to improve Grid assessment and identify options for grid improvement
	Grid Stability and permitting process for wind power.	4	Digitalization of permitting processes and technical assistance to Grid Upgrade and Stability	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to secure suitable and sufficient policy for grid management and stability
	Insufficient knowledge regarding wind power generation	2	Enhancing capacity for designing, installing, and maintaining renewable energy systems and develop short term and long-	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and Training Institutions

			term courses for wind power generation	
Market	Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing.	4	Training and improve ability to evaluate and interpret data, utilizing it for energy market and policy analysis to formulate effective policies and scenarios.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and local/international professionals/expertise to assess the technical and economic viability of the on-grid wind power and electricity grid
	Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate.	4	Understanding factors that influenced supply and demand in Tonga. New data and information have been compiled based on MEIDECC's analysis for the upcoming TERM in alignment with SDG7 goals and NDCs	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and local/international professionals/experts in the field to assess and identify factors that affect supply relevant knowledge for economic feasibility of wind power
Information & Public Awareness	Minimum consultation with local stakeholders on wind technologies	4	Regional public information programs can be developed to provide necessary materials and offer short-term training.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions and Statistics Department as well as local communities to communicate and coordinate community based

				solar power generations
	Lack of comprehensive coordination of data collection for policy development	4	Decision makers in Tonga must be equipped with information regarding suitable renewable energy technologies. Institutionalization of data collection and sharing of data	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions and Statistics Department as well as local/international training institutions to discuss and establish arrangements for comprehensive data coordination, data collection, and data analysis.
	Capacity to establish an evidenced based data collection and analysis	3	Institutionalization of collaboration for data collection and establish the role of MEIDEC in creating the database. Availability of indicators such as total final energy consumption and energy intensity, aligned with international standards, can further enhance evidence-based policy making. Evidence-based decision-making for policy development is the utilization of relevant and up to date information	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies and other energy related institutions, regional energy Institutions and Statistics Department as well as local/international training institutions to arrange for evidenced based data collection and use

8.5.3 Responsible Institutions for Enabling Framework for Energy Efficient Home Appliances

As highlighted in Table 30, it is crucial for the stakeholders involved in financing energy-efficient home appliances, such as the Ministry Responsible for Energy, Power Utility, and Tonga Electricity Commission, donors, financial institutions, and private investors, to identify potential funding sources to tackle the challenges associated with finance and fiscal matters. Additionally, key stakeholders must find ways to address the high upfront costs and local tax policies that currently favor renewable energy technologies over energy-efficient technologies. Government institutions and financial organizations need to identify ineffective public policies and insufficient legislative and regulatory tools that require improvement to promote the deployment of energy-efficient home appliances. The energy institutions must also address the lack of technical knowledge and business management capacities in the technology sector. In terms of technical aspects, the energy stakeholders should be capable of deploying both short-term and long-term knowledge for the technology. Regarding market aspects, the energy institutions must identify strategies to enhance skill development and capacity for data analysis, which will aid in formulating effective policies. Furthermore, the energy institutions must address the inadequate capacity to utilize data and properly coordinate data collection and analysis to support policy decisions in terms of information and public awareness aspects. Lastly, it is essential to engage in consultations with stakeholders on matters related to the technology.

Table 31 : Description of Enabling Framework for Prioritized Barriers for Energy Efficient Home Appliances

TECHNOLOGY: Energy Efficient Home Appliances		Score		
Financial and Fiscal	Insufficient Access for Finance and lack of de-risking guarantees available.	5	Increase Finance for private sector for EE. Improve Government Subsidy Policy and adopt commercial model to recover full cost of investment	Government/Donors/ Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to explore government financial policy to take risks of investment in wind power.

	High upfront cost for solar equipment/parts: Panels, Batteries and Storage Capacity.	5	Organized regional procurement of solar equipment for small island countries and responsible regional transport of procured solar equipment materials to respective small island countries. Implement Tariff policies, which can serve as a source of funding for long term on-grid solar power projects, as Tonga has adopted the inclusion of in-kind contributions to renewable energy projects in the formulation of electricity tariffs. Remove Barriers for participation of the Private Sector Companies in the On-Grid Solar Power generation to increase competition. Increase Loan Finance for private sector companies involving in on-grid solar power generation.	Ministry of Energy and Custom Department and Ministry of Finance to involve in the procurement process and arrangement. Government and Local Government Shipping Agencies and Private Sector Companies to arrange the shipping of goods from the regional storage country
	Local Tax Policy-Duty Free for Government wind projects	5	Improving Taxes import duties, and government purchasing policies	Ministry Responsible for Energy, Power Utility, Tonga Electricity

				Commission and IPP Companies to assess and identify successful PPA projects
Policy, Regulatory, Legislative	Ineffective Public Policies leading to adoption of energy efficient home appliances	4	Improve public policy development to ensure the timely installation and investment in supporting infrastructure development A regulatory reform and a donor-supported risk reduction facility are essential to facilitate renewable energy investments	Government/Ministry of Finance/Ministry of Infrastructure, Ministry of Energy and IPP Companies to improve public policy development of infrastructure to assist wind power project sites in the rural areas
	Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for energy efficient; development does not exist to promote wide spread adoption	3	A regulatory reform and a donor-supported risk reduction facility are essential to facilitate renewable energy investments.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and IPP Companies to identify all legislative, regulatory and policy gaps for solar power on-grid generation.
	Absence of Energy Efficiency Legislation	3	An enabling regulatory environment is necessary to attract private sector investments in renewable energy	Ministry of Energy and Government to draft and establish the Energy Efficiency Legislation
	Lack of regulatory and monitoring activities on energy efficient home appliances	2	Enforcement of policy and regulatory frameworks as enablers for renewable energy	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies to

				discuss and identify suitable regulatory frameworks for EE
Institutional capacity	Lack of training capacity for business management	3	Training on innovative approaches to designing and procuring renewable energy projects.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to include short term and long term training scheme for EE technologies
	Insufficient Capacities in Energy Institution	2	Establish a single regulating body, such as a "Ministry of Energy to effectively regulate and enable utilities to operate independently.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify the on-site training needs and program for the technologies
	Lack of technical and management capacity	2	Enhancing skills related to the integration and reporting of energy efficient home appliances	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to identify the relevant technical skills needed and include/arrange suitable overseas training attachments to foreign institutions

				on EE technical knowledge
Technical	building design, appliance use, and energy consumption behavior revolving around cheap and low energy efficiency appliances	5	Include energy auditing and energy efficiency requirements in the country's building code. Implementing energy efficiency programs Integrated approach to the energy efficiency capacity development assessments. With high levels of RE integration, energy efficiency measures can play a key role in the energy supply for island communities	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and the Ministry of Infrastructure to include energy auditing in the building code
	Insufficient knowledge regarding energy efficient home appliances	3	Enhancing capacity for designing, installing, and maintaining energy efficient home appliances	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and the Ministry of Infrastructure to include energy auditing in the building code and increase adoption of EE programs
Market	Understanding factors that influenced supply	4	Skill development through local training programs	Ministry Responsible for Energy, Power Utility, Tonga

	and demand in Tonga.		for energy service business management New data and information have been compiled based on MEIDECC's analysis for the upcoming TERM in alignment with SDG7 goals and NDCs.	Electricity Commission and Private Electricity Appliances Companies and training institutions to identify the relevant technical skills needed and include/arrange suitable overseas training attachments to foreign institutions on EE technical knowledge
	Limited feasibility studies to understand key requirements for energy efficient home appliances.	2	Have the ability to evaluate and interpret data, utilizing it for energy market and policy analysis to formulate effective policies and scenarios.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to identify opportunities EE appliances
	Lack of knowledge on opportunities and Challenges for EE investments	2	Skill development through local training programs for energy service business management Skill development through local training programs for energy service business management Delegation of certain functions to the private sector for infrastructure delivery	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to identify business opportunities for EE appliances

Information & Public Awareness	Lack of comprehensive coordination of data collection for policy development	5	Decision makers in Tonga must be equipped with information regarding suitable energy efficient technologies.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions and other key stakeholders to explore the opportunities for comprehensive data coordination and data analysis and the further use of Evidence-based decision-making for policy development is the utilization of relevant and up to date information
	Minimum consultation with local stakeholders on energy efficient home appliances	3	Regional public information programs can be developed to provide necessary materials and offer short-term training	EE key stakeholders to plan and participate in the energy efficiency planning and management workshop on energy efficiency appliances

9 Transportation Sector Development in Tonga

9.1 Introduction

Insufficient literature exists after examining numerous significant works on the transportation industry, which offers a prioritized hierarchy of obstacles while considering the input and validation of local stakeholders. This information is crucial for small island nations to efficiently and effectively establish a suitable framework that tackles the most crucial barriers, along with the less significant ones. The subsequent parts of this report provide a comprehensive analysis of pertinent literature, emphasizing the key obstacles that can be classified into the subsequent groups such as:

1. Financial and Fiscal

2. Policy, Regulatory and Legislative
3. Institutional
4. Technical
5. Market
6. Information and Public Awareness

9.2 Literature Review on Identifying Barriers to Transportation Technologies

9.2.1 Financial and Fiscal Barriers

There are financial and fiscal barriers associated with the heavy reliance on petroleum products in the transportation sector. To address this issue and improve fuel economy, a suitable policy option has been identified (UNCTCN, 2020). One of the main obstacles to the widespread adoption of electric vehicles (EVs) is the high upfront costs, as highlighted by various studies (GGGI, 2022). The average cost of EVs remains higher than that of internal combustion engine (ICE) vehicles, which deters many consumers due to the expensive manufacturing process (GGGI, 2022). The significant acquisition costs have been identified as major market restraints (Ha., T, and Manongdo., P., 2021). In our assessment of EV viability in different Pacific Island Countries under various use cases (low, medium, and high), we compared upfront costs, fuel/charging costs, maintenance costs, and environmental costs of electric and ICE vehicles. The findings indicate that no new policy interventions are currently in place beyond the existing status quo (ECA and TTA, 2022). Presently, EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits (ECA and TTA, 2022). However, we anticipate that EVs could become more viable if Pacific Island Countries increase solar generation and promote daytime charging (ECA and TTA, 2022).

9.2.2 Stakeholders Validated Fiscal and Financial Barriers for Transport Technologies.

There are significant initial cost barriers for battery-powered electric vehicles, hybrid vehicles, and on-grid electric vehicles. The issue of acquisition costs has impacted both battery-powered EVs and on-grid electric vehicles, while the costs associated with charging, maintenance, and environmental factors have affected battery-powered EVs. The absence of new financial policy interventions has influenced all three prioritized vehicles, and EVs are generally not considered economically viable in most Pacific Island countries due to the high upfront costs. It is essential to implement policies to ensure that on-grid EVs are safe, accessible, affordable, and have minimal impacts on the electricity grid. Table 31 demonstrates the various financial and fiscal barriers that have been confirmed and validated by the transport stakeholders' group, as identified in the literature review, which have impacted the prioritized transport technologies. The barriers that have been identified will be contrasted with the validated enabling framework in subsequent sections of the report.

Table 32 : Fiscal and Financial Barriers for Priority Transportation Technologies

Types of Financial and Fiscal Barriers	Is it directly related with the diffusion of the following technologies? (√) means Yes or No if unmarked		
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle
high upfront costs due to the expensive manufacturing process	√	√	√
acquisition costs have been identified as major market restraints	√		√
upfront costs, fuel/charging costs, maintenance costs, and environmental costs	√		
no new financial policy interventions are currently in place	√	√	√
EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	√		
Policies that ensure that on-grid EVs and charging are safe, accessible, affordable and have minimal or positive impacts on the electricity grid			√

9.2.3 Policy, Regulatory and Legislation

There are various barriers in terms of policy, regulations, and legislation that hinder the reduction of vehicle kilometres traveled by riders (UNCTCN, 2020). These barriers, along with the current uncertainties in policies, have been identified as significant constraints in the market (Ha., T, and Manongdo., P., 2021). In general, there seems to be a lack of planning, policy work, and policy actions for electric vehicles (EVs) across the PICTs, except for the efforts in Fiji supported by GGGI. This creates an opportunity to develop EV policy recommendations from scratch (PCREEE, 2020). However, there is a potential conflict between the adoption of EVs and certain NDC targets in a few PICTs (PCREEE, 2020). To address this, we propose that Tonga prioritize the implementation of V2H capabilities in some Mode 3 private charging stations in the short term. This can be achieved through regulatory approval from Tonga Power Limited, similar to what was done by South Australia Power Networks, or through financial support. V2H technology can enhance resilience for homes and businesses without requiring extensive changes to the grid or compensation structures associated with V2G (Caley, J., et al, 2023). In the long run, Tonga can develop a V2G strategy for its public Mode 3 charging stations, especially as it aims to achieve 100% renewable energy for electricity by 2035. The value of V2G will increase as the percentage of renewables in the energy mix rises. This strategy may involve devising a method to compensate vehicle owners for supplying grid power and ancillary services from EV batteries, while also considering potential battery degradation (Caley, J., et al, 2023).

Mode 4 charging stations might be less relevant for V2G because the vehicles themselves are not connected to the station for long periods of time (Caley, J., et al ,2023). The GHG emissions from Tonga's land transportation sector are projected to increase 35% by 2050 in a BAU scenario, as increasing GDP leads to more private car travel (Caley, J., et al ,2023). Past efforts have been made to chart future emissions reductions, resulting in goals proposed in TEEMP and TERMPLUS (Caley, J., et al ,2023). Successful EVs initiative in Barbados includes Policies such as Reduced import taxes on EVs (from 45% to 10%), pilot maintenance course development for technicians, and Independent companies operate EV charging infrastructure (viewed as an access service and not electricity delivery, so not in the exclusive domain of the electric utility) (Prateek., J and Carishma., G-W ,2022). This policy framework translates those goals into specific policies that have been effective in relevant jurisdictions and that were developed through stakeholder working group meetings in Tonga in June 2023(Caley, J., et al ,2023). These policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market (Caley, J., et al ,2023). The EV market is promoted through policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid (Caley, J., et al ,2023). The policies are scalable and can be set to achieve the specific subgoals in TEEMP and TERMPLUS. The policies generally build upon each other and are therefore laid out in chronological phases (Caley, J., et al ,2023).

The implementation of these policies has the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions in the sector by 60% compared to the business-as-usual scenario (Caley, J., et al, 2023). Moreover, this policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems (Caley, J., et al, 2023). Collaboration with organizations such as PCREEE, the Local2030 Islands Network, NREL, or others could provide additional support for the application of this policy analysis framework and the implementation of policies with other island partners (Caley, J., et al, 2023). The majority of vehicles in Tonga consist of cars, light trucks, vans, and SUVs (UNCTCN, 2020).

Tonga is exploring ways to enhance energy efficiency, with the TERMPlus plan highlighting the importance of improving transportation (GOT, 2021b). In 2016, the average vehicle kilometres traveled per person was estimated to be 2289, with a projected increase to 5103 by 2050 (UNCTCN, 2020). There are significant barriers to the adoption of e-mobility in the Pacific Island Countries that must be addressed. In addition to the reliance on diesel-fired generation, barriers to e-mobility uptake include a lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies (ECA and TTA, 2022). The policies of TEEMP and TERMPLUS complement each other and are presented in sequential phases (Caley, J., et al, 2023).

9.2.4 Stakeholder Validated Policy, Regulatory and Legislative Barriers for Transport Technologies.

The challenges posed by uncertainties in public policies, as well as the lack of policy actions and planning, serve as barriers for Battery powered EVs, Hybrid vehicles, and On-grid electric vehicles. Some have recognized the conflict between adopting EVs and achieving NDC targets. All three types of technologies are affected by current government import taxes and duties. Battery powered EVs lack policies aimed at reducing GHG emissions by enhancing the EV market. Additionally, both battery powered EVs and on-grid EVs face inadequate policies to ensure safe, accessible, affordable charging that minimally impacts the national electricity grid. Hybrid vehicles lack policies that could potentially improve the land transportation system to be safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions. Furthermore, battery powered EVs lack a sufficient policy framework tailored to the specific transportation system of Pacific Island countries, along with limited charging infrastructure, financing options, subsidies, and regulations. Table 32 illustrates the different types of policy, regulatory, and legislative barriers that have been identified and validated by the transport stakeholders' group, as outlined in the literature review, which have affected the prioritized transport technologies. These barriers will be compared with the validated enabling framework in subsequent sections of the report.

Table 33 : Policy, Regulatory and Legislative Barriers for Priority Transportation Technologies

Types of Policy, Regulatory and Legislative Barriers	Is it directly related with the diffusion of the following technologies? (√) means Yes or No if unmarked?		
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle
current uncertainties in policies, have been identified as significant constraints in the market	√	√	√
lack of planning, policy work, and policy actions for electric vehicles	√	√	√
potential conflict between the adoption of EVs and certain NDC targets	√		
Policies such as Reduced import taxes on EVs	√	√	√
maintenance course development for technicians, and independent companies			
policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market	√		
policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	√		√
policies have the potential to enhance Tonga's land		√	

transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions			
policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems	√		
lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies	√		

Institutional barriers related to knowledge production (GOT, 2021c) can hinder the adoption of electric vehicles (EVs) due to the reliance on charging infrastructure availability. The scarcity of charging points can deter consumers from considering purchasing an EV (GGGI, 2022). Additionally, lengthy charging times can further impact the reliability of charging, leading to concerns among potential buyers regarding waiting times and the limited availability of fast charging stations for public use (GGGI, 2022). Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations (GOT, 2021c) may also impede the integration of renewable energy-based transport options, such as electric cars and sustainable biofuels, which could offer direct benefits to island power-generation systems. Therefore, incorporating renewable energy-based transport systems into the long-term planning of the Pacific Island Countries and Territories (PICTs) should be a crucial consideration (IRENA, 2013).

9.2.7 Stakeholders Validated Institutional Barriers for Transport Technologies.

Public policy uncertainties, lack of policy actions, and inadequate planning pose challenges for Battery powered EVs, Hybrid vehicles, and on-grid electric vehicles. Some have noted the conflict between adopting EVs and meeting NDC targets. Insufficient institutional capacity and knowledge impact battery powered and hybrid vehicles, with both relying heavily on charging infrastructure availability. Battery powered EVs face issues with charging point scarcity in certain areas and lengthy charging times. The limited availability of fast charging stations for public use is a common challenge for battery powered EVs and on-grid EVs due to institutional capacity constraints. The lack of capacity to enforce policies, regulations, and legislation has hindered the deployment of battery powered EVs and hybrid vehicles. Additionally, there is a lack of institutional capacity to integrate renewable energy into the transport system for battery powered EVs and on-grid EVs. The insufficient institutional capacity of hybrid vehicles may discourage consumers from purchasing them. Table 33 displays the diverse institutional barriers identified and validated by the transport stakeholders' group, as outlined in the literature

review, which have impacted the prioritized transport technologies. These barriers will be compared with the validated enabling framework in subsequent sections of the report.

Table 34 : Institutional Barriers for Priority Transportation Technologies

Types of Institutional Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes or No if unmarked		
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle
Insufficient Institutional Capacity and knowledge production	√	√	
reliance on charging infrastructure availability	√		√
scarcity of charging points can deter consumers from considering purchasing an EV	√		
lengthy charging times can further impact the reliability of charging	√		
limited availability of fast charging stations for public use	√		√
Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations	√	√	
incorporating renewable energy-based transport systems into the long-term planning	√		√
Lack of Institutional capacity on hybrid vehicle can deter consumers from purchasing hybrid vehicle		√	

Technical barriers resulting from inadequate maintenance of transportation infrastructure contribute to high emissions (GOT, 2021c). It is crucial to ensure the safety of electric vehicles (EVs) and charging infrastructure in Tonga for the well-being of humans, infrastructure, and the environment (Caley, J., et al, 2023). The challenges associated with EV adoption extend beyond concerns about EV models and battery safety. The introduction of new technology and limited expertise in service centres pose difficulties for both potential EV buyers and current EV users. Many individuals who own EVs have expressed frustration over the lack of expert assistance when encountering technical issues (GGGI, 2022). To address these concerns, it is advisable to establish legislation that regulates car ownership on a per household or per company basis. Additionally, the use of cars with large engines and low efficiency should be prohibited (MEIDECC, 2013). Encouraging the adoption of Hybrid Electric Vehicles (HEVs) can also be promoted (MEIDECC, 2013). Ground transportation accounts for approximately 32% of emissions (UNCTCN, 2020), and addressing this issue should be done in a phased manner as outlined by Caley, J., et al (2023).

9.2.9 Stakeholders Validated Technical Barriers for Transport Technologies.

The Transport stakeholders' group has verified and approved that battery-powered and hybrid vehicles are impacted by insufficient maintenance, with battery-powered EVs being particularly affected by safety concerns, charging infrastructure limitations, and issues related to EV models. All three types of vehicles are impacted by new technology and a lack of specialized knowledge. Battery-powered EVs, along with hybrid vehicles, are affected by inadequate expertise and technical challenges. Battery-powered EVs encounter issues related to large engines and low efficiency, while hybrid vehicles suffer from a lack of knowledge in maintenance development. Lastly, there is a notable absence of regulations and standards for on-grid EVs. Table 34 displays the diverse technical barriers identified and validated by the transport stakeholders' group, as outlined in the literature review, which have impacted the prioritized transport technologies. These barriers will be compared with the validated enabling framework in subsequent sections of the report.

Table 35 : Technical Barriers for Priority Transportation Technologies

Types of Technical Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes or No if unmarked		
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle
inadequate maintenance of transportation infrastructure contributes to high emissions	√	√	
safety of electric vehicles (EVs) and charging infrastructure	√		
concerns about EV models and battery safety	√		
new technology and limited expertise in service centres	√	√	√
lack of expert assistance when encountering technical issues	√	√	
the use of cars with large engines and low efficiency	√		
Encouraging the adoption of Hybrid Electric Vehicles			
Maintenance course development for technicians, and independent private companies		√	
Absence of vehicle regulations and standard, and the absence of endorsed regional or national e-mobility strategies			√

Market barriers arise due to the necessity of decentralizing services (GOT, 2021c). The reduction of emissions in the Transport Sector is also a significant concern (GOT, 2018).

One of the main perceived nonfinancial limitations of adopting electric vehicles (EVs) is the driving range, which frequently raises concerns (GGGI, 2022). Additionally, the lack of a comprehensive review of motivators and barriers in decision-making processes is a notable issue (GGGI, 2022). The limited availability of EV models and designs further hinders adoption, as there are only a few models in the market and a limited number of original equipment manufacturer (OEM) companies investing in electromobility. This restricts consumer freedom for diversification compared to internal combustion engine (ICE) vehicles (GGGI, 2022). As the sales of all-electric vehicles grow slower than anticipated, major automakers are responding by offering hybrid vehicles to meet customer demands (CNCB News, 2023). Automakers are reconsidering the viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties (CNCB News, 2023). In the United States, hybrids accounted for 8.3% of car sales, with approximately 1.2 million vehicles sold through November of the current year, representing a 2.8 percentage point increase compared to total sales last year (CNCB News, 2023). The underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints (Ha., T, and Manongdo., P., 2021).

9.2.11 Stakeholders Validated Market Barriers for Transport Technologies.

For battery powered EVs, the market has experienced the necessity to decentralized services such as charging services and there are market concerns on driving range. All three types of vehicles have experienced lack of comprehensive review of motivators and decision making processes. Furthermore, all three technologies have faced limited availability of models in the market and underdeveloped EV industry as market constraints. Finally, the viability of hybrid vehicles to comply with engine fuel economy and emissions standard. Table 35 displays the diverse market barriers identified and validated by the transport stakeholders' group, as outlined in the literature review, which have impacted the prioritized transport technologies. These barriers will be compared with the validated enabling framework in subsequent sections of the report.

Table 36 : Market Barriers for Priority Transportation Technologies

Types of Market Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes or No if unmarked		
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle
necessity of decentralizing services	√		
driving range, which frequently raises concerns	√		

the lack of a comprehensive review of motivators and barriers in decision-making processes	√	√	√
The limited availability of models and designs further hinders adoption,	√	√	√
viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties		√	
underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	√	√	√

9.2.12 Information and Public Awareness

Barriers to information and public awareness arise due to the novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics. Consequently, there exists a dearth of knowledge and familiarity concerning the safety and performance of EVs (GGGI, 2022). Consumers persist in expressing concerns about EVs, citing anxieties about potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries (GGGI, 2022).

9.2.13 Stakeholders Validated Information & Awareness Barriers for Transport Technologies

For battery powered EVs and On-Grid electric vehicles, the technologies are new and limited adoptions in various countries. For all three technologies, there is insufficient knowledge and familiarity concerning the safety and performances of the technology. For battery powered EVs, there is concerns on potential explosions and risks associated with batteries. For hybrid vehicles there are essential needs to have evidenced based data collection and analysis of hybrid vehicles. For hybrid vehicle and on-grid EVs, the technologies faced minimum consultation with local stakeholders, lack of comprehensive coordination of data collection for policy development and decision making. Table 36 displays the diverse information and public awareness barriers identified and validated by the transport stakeholders' group, as outlined in the literature review, which have impacted the prioritized transport technologies. These barriers will be compared with the validated enabling framework in subsequent sections of the report.

Table 37 : Information and Public Awareness Barriers for Priority Transportation Technologies

Types of Information and Public Awareness Barriers	Does it directly relate with the diffusion of the following technologies? (√) means Yes or No if unmarked		
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle
novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain	√		√

demographics			
Insufficient (dearth of) knowledge and familiarity concerning the safety and performance of technologies	√	√	√
potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries	√		
Capacity to establish an evidenced based data collection and analysis of hybrid vehicles		√	
Minimum consultation with local stakeholders on hybrid vehicles		√	√
Lack of comprehensive coordination of data collection for policy development and decision		√	√

9.3 Scoring Barriers for selected Transport sector technologies

To evaluate and rate the barriers associated with battery powered EVs, key stakeholders utilized a qualitative Likert-type Scale. This scale consisted of five categories: 1. Insignificant; 2. Less important; 3. Important; 4. Crucial; and 5. Critical/killer/non-starter. The creation of these categories was crucial as different obstacles impact the implementation and acceptance of technologies in varying ways. The key stakeholders were provided with a comprehensive list of barrier descriptions under each category, enabling them to assign scores using the Likert-type Scale. Through group discussions and ongoing communication with the local consultant, the Transportation stakeholders' group has determined the scoring outcomes for types of identified Barriers. Table 37 presented the outcomes of stakeholders scoring for types of Financial and Fiscal barriers for battery powered EVs technology. Table 38 also displayed results of stakeholders scoring for additional categories of non-financial barriers of battery powered EVs technology. Table 39 presented the outcomes of stakeholders scoring for types of Financial and Fiscal barriers for hybrid vehicle technology. Table 40 also displayed results of stakeholders scoring for additional categories of non-financial barriers of hybrid vehicle technology. Table 41 presented the outcomes of stakeholders scoring for types of Financial and Fiscal barriers for on-grid EVs technology. Table 42 also displayed results stakeholders scoring for additional categories of non-financial barriers of on-grid EVs technology.

Table 38 : Financial Barriers and Score for the Diffusion of the Battery powered Electric Vehicle.

Technology: Battery Powered Electric Vehicle		
Barrier Economic & Financial	Description	Score

Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • acquisition costs have been identified as major market restraints. • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new policy interventions are currently in place. • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits.	5 5 5 5 5

Table 39 : Non-Financial Score for the Diffusion of the Battery powered Electric Vehicle

TECHNOLOGY: Battery Powered Electric Vehicle		Score
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on EVs • policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. • policies have the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and	5 5 5 5 5 5 5 5 5

	standards, and the absence of endorsed regional or national e-mobility strategies	
Institutional capacity	• knowledge production • reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning	5 5 5 5 5 5
Technical	• maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • concerns about EV models and battery safety • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • the use of cars with large engines and low efficiency	5 5 5 5 5 3
Market	• Necessity of decentralizing services • Driving range, which frequently raises concerns. • The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of EV models and designs further hinders adoption, • Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	5 5 5 5

Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of EVs. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries	5 5 5

Table 40 : Financial Barriers and Score for the Diffusion of the Hybrid Vehicle

TECHNOLOGY: Hybrid Vehicle		Score
Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • acquisition costs have been identified as major market restraints. • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new financial; policy interventions are currently in place. • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	5 5

Table 41: Non-Financial Barriers and Score for the Diffusion of the Hybrid Vehicle

Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on EVs • policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. • policies have the potential to enhance Tonga's land transportation system by making it safer, less	5 5 5 5

	congested, more equitable, and more resilient, while also reducing greenhouse gas emissions • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies	5
Institutional capacity	• Institutional capacity and knowledge production • reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning • Lack of institutional capacity on hybrid vehicles	4 5
Technical	• maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • concerns about EV models and battery safety • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • the use of cars with large engines and low efficiency • Encouraging the adoption of Hybrid Electric Vehicles	5 5 5 5

Market	• Necessity of decentralizing services • Driving range, which frequently raises concerns. • The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of EV models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	5 5 5 4
Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of EVs. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	5 5 4 4

Table 42 : Financial Barriers and Score for the Diffusion of the On-Grid Electric Vehicle

Technology: On-Grid Electric Vehicle		
Barrier Economic & Financial	Description	Score

Financial & Fiscal	• high upfront costs • acquisition costs have been identified as major market restraints. • no new policy interventions are currently in place. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • policies that ensure that On-Grid EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	3 4 5 5

Table 43 : Non-Financial Barriers and Score for the Diffusion of the On-Grid Electric Vehicle

TECHNOLOGY: On-Grid Electric Vehicle		Score
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on technology • Policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an On-Grid EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	5 5 5 4
Institutional capacity	• knowledge production • reliance on charging infrastructure availability • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning incorporating renewable energy-based transport systems into the long-term planning	4 5 5 3

Technical	• absence of Vehicle regulations and standards, and the absence of endorsed regional or national e-mobility strategies. • maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • new technology and limited expertise in service centres • Encouraging the adoption of Hybrid Electric Vehicles	4 4 4
Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of On-grid models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped industry is also cited as significant market restraints	5 5 1 5
Information & Public Awareness	• Novelty of On-Grid electric vehicle (EV) technology and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of on-grid electric vehicles. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	5 5 5 5 5

9.3.1 Prioritization of Sored/Scaled Barriers for Energy technologies

The transport group or key stakeholders from the transportation institutions finalize the score and agree upon it. Based on the understanding of the transport team and the consultant, the priority barriers are selected. The barriers with a score ranging from 3 to 5 are considered as priority barriers. Table 43 provides information on the prioritized barriers and their corresponding scores for battery powered EVs technology. Table 44 provides information on the prioritized barriers and their corresponding scores for hybrid

vehicle technology. Table 45 provides information on the prioritized barriers and their corresponding scores for on-grid EVs technology.

Table 44 : Prioritized Barriers for Battery Powered Electric Vehicle

TECHNOLOGY: Battery Powered Electric Vehicle		Score
Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • acquisition costs have been identified as major market restraints. • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new financial; policy interventions are currently in place. • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	5 5 5 5 5
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on EVs • policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies	5 5 5 5 5 5 5 5 5

Institutional capacity	• Institutional Capacity knowledge production • reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning	5 5 5 5 5 5
Technical	• inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • concerns about EV models and battery safety • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • the use of cars with large engines and low efficiency	5 5 5 5 5 3
Market	• Necessity of decentralizing services • Driving range, which frequently raises concerns. • The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of EV models and designs further hinders adoption, • Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	5 5 5 5

Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of EVs. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries	5 5 5

Table 45 : Prioritized Barriers for Hybrid Vehicle

TECHNOLOGY: Hybrid Vehicle		Score
Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • acquisition costs have been identified as major market restraints. • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new financial; policy interventions are currently in place. • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	5 5
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on EVs • policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. • policies have the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions	5 5 5 5

	• policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies	5
Institutional capacity	• Institutional capacity and knowledge production • reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning Lack of institutional capacity on hybrid vehicles	4 5
Technical	• maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • concerns about EV models and battery safety • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • the use of cars with large engines and low efficiency • Encouraging the adoption of Hybrid Electric Vehicles	5 5 5 5
Market	• Necessity of decentralizing services • Driving range, which frequently raises concerns. • The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of EV models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	 5 5 5 4

Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of EVs. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	5 5 4 4

Table 46 : Prioritized Barriers for On-Grid Electric Vehicle

TECHNOLOGY On-Grid Electric Vehicle DESCRIPTION OF BARRIERS		Score
Financial and Fiscal Barriers	• policies that ensure that On-Grid EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. • acquisition costs have been identified as major market restraints. • high upfront costs • no new policy interventions are currently in place	5 5 4 3
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • Policies such as Reduced import taxes on technology • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	5 5 5 4
Institutional capacity	• Institutional Capacity and knowledge production • reliance on charging infrastructure availability • limited availability of fast charging stations for public use	4 5 5 3

	• incorporating renewable energy-based transport systems into the long-term planning incorporating renewable energy-based transport systems into the long-term planning	
Technical	• absence of Vehicle regulations and standards, and the absence of endorsed regional or national e-mobility strategies. • inadequate maintenance of transportation infrastructure contributes to high emissions • new technology and limited expertise in service centres	4 4 4
Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of On-grid models and designs further hinders adoption, • Underdeveloped industry is also cited as significant market restraints	5 5 5
Information & Public Awareness	• Novelty of On-Grid electric vehicle (EV) technology and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of on-grid electric vehicles. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	5 5 5 5 5

9.4 Literature Review on Enabling Environment for Transportation Technologies

9.4.1 Fiscal and Financial Enabling Environment

Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles. Boost the utilization of financial hedging for a greater portion of Tonga's fuel supply, leveraging insights gained from TPL's 2011 experience (World Bank, 2012). The Tongan government has the option to formalize the policy package for charging station locations in an official strategic document, which could serve as a framework for guiding decisions on this matter. Additionally, the government could enforce this strategy by offering incentives or subsidies for charging stations in specific areas (Caley, J., et al, 2023). The

exemption of vehicle registration or import fees is suggested as a targeted policy for particular groups that would derive the most benefit from a reduction in vehicle prices, such as individuals with high annual VKT and low income (Caley, J., et al, 2023). This approach also serves as an additional tool for reducing the upfront costs of owning an EV, which can be combined with other policies as necessary and appropriate based on the number of vehicles registered annually (Caley, J., et al, 2023). Avis Car Rental, a prominent international car rental company operating in Tonga, may be interested in collaborating with the government to invest in charging infrastructure. The charging station's utilization rate holds significant importance in its business model and should be a primary focus for owners and operators. In Tonga, planners, developers, and other stakeholders can utilize and adapt NREL's Electric Vehicle Infrastructure – Financial Analysis Scenario Tool (EVI-FAST) to aid in their decision-making process (Caley, J., et al ,2023). Offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles (EVs) and internal combustion engine (ICE) vehicles remains a major barrier to EV adoption due to advanced EV production technology (GGGI, 2022). To address equity concerns, Tonga Power Limited could implement a net metering policy that either pays customers at a reduced retail rate or sets a cap on payments, particularly for customers without distributed energy resources like solar PV and electric vehicles (Caley, J., et al ,2023). Initially, priority can be given to reduced or free EV charging at public charging stations, including battery swap stations if applicable, to encourage early EV adoption and investment in public charging infrastructure with potentially low utilization. As the upfront cost of EVs decreases, the government can consider phasing out the reduced EV charging tariffs (Caley, J., et al ,2023)

Most countries offer financial incentives to promote the adoption of electric vehicles (EVs). These incentives primarily come in the form of tax reductions or exemptions. When it comes to import taxes, countries apply various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade. These measures aim to make EV imports more affordable and attractive (GGGI, 2022).

Similarly, consumption tax incentives also play a role in reducing the upfront cost of EVs. Each country has its own policies regarding consumption fees and taxes, but common incentives include deductions or exemptions for value-added tax (VAT), stamp duty, and excise taxes. These measures directly impact the overall cost of EVs (GGGI, 2022).

Another type of incentive focuses on registration taxes and fees. While the previous incentives affect the upfront cost, registration incentives are linked to the total cost of ownership (TCO) of EVs. These incentives are granted during the official registration of the vehicle and help reduce the financial burden for EV owners (GGGI, 2022).

In addition to these one-time incentives, there are also recurring incentives that target the entire ownership period of EVs. These measures aim to encourage EV ownership and include policies such as import tariffs or registration fees for desired goods. By setting appropriate tax levels, countries can promote the import of goods that contribute to the economic improvement of fuel consumption in the transport sector (PCREEE, 2020).

Furthermore, there are other measures that can be implemented to support the transition to cleaner transportation. These include restrictions on heavy-duty vehicle idle time, promoting the blending of biodiesel up to 10%, and the deployment of electric vehicles (UNCTCN, 2020). These actions collectively contribute to reducing emissions and promoting sustainable transportation options.

9.4.2 Summary of the Enabling Environment for the ranking types of Fiscal and Financial Barriers of the prioritized Transportation Technologies.

The Transportation Stakeholders group has received the identified enabling framework from the literature review to discuss, validate, and select a suitable enabling framework to potentially address the previously prioritized types of financial and fiscal barriers. Table 47 comprises the proposed facilitating frameworks presented by the transportation group, which will be elaborated on in this section. In order to tackle the high upfront costs, financial risk management strategies are essential for all three technologies, along with government incentives and tax reductions or exemptions. To address the acquisition cost issue for battery powered EVs and On-grid EVs, proper government incentives can help reduce the overall cost. Additionally, for battery powered EVs, government incentives and subsidies for charging stations can address the concerns related to fuel/charging cost and maintenance cost. Since there is a lack of new policy interventions to promote the deployment of all three technologies, the transportation group suggests considering the application of various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade to make EV imports more affordable and appealing. To tackle the economic viability issue associated with battery powered EVs, the group proposes reducing or providing free EV charging at public charging stations, including battery swap stations if applicable, to encourage early EV adoption and investment in public charging infrastructure. For on-grid EVs, it is crucial for the government to invest in improving public infrastructure and promote EV adoption and investment in public charging infrastructure to ensure the safety, accessibility, and affordability of on-grid EVs.

Table 47 : Fiscal and Financial Enabling Framework for Priority Transportation Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle	
high upfront costs due to the expensive manufacturing process	√-5	√-5	√-5	Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles

				incentives primarily come in the form of tax reductions or exemptions
acquisition costs have been identified as major market restraints.	√-5		√-4	Offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles
upfront costs, fuel/charging costs, maintenance costs, and environmental costs	√-5			offering incentives or subsidies for charging stations in specific areas The exemption of vehicle registration or import fees is suggested as a targeted policy for particular groups that would derive the most benefit from a reduction in vehicle prices
no new financial policy interventions are currently in place.	√-5	√-5	√-5	formalize the policy package for charging station locations in an official strategic document. countries apply various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade to make EV imports more affordable and attractive
EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	√-5			reduced or free EV charging at public charging stations, including battery swap stations if applicable, to encourage early EV adoption and investment in public charging infrastructure
Policies that ensure that on-grid EVs and charging are safe, accessible, affordable and have minimal or positive impacts on the electricity grid			√-5	government to invest on improving public infrastructure and encourage EV adoption and investment in public charging infrastructure

9.4.3 Policy, Regulatory and Legislation Enabling Environment

Reducing policy, regulatory, and legislative barriers can be achieved by transitioning to Low Emissions Vehicles (GOT, 2021c). In order to ensure proper treatment of End-of-Life (EOL) batteries in Tonga and other Pacific Island countries, it is important to develop coordinated policies (Caley, J., et al, 2023). The adoption of Electric Vehicles (EVs) is expected to significantly reduce emissions and align with the high-level goal of emissions reduction in each Pacific Island Country and Territory (PICT) (PCREEE, 2020). To achieve this, measures such as standardizing a battery passport, establishing centralized recycling facilities, and collaborating with international shipping partners can be implemented (Caley, J., et al, 2023). Setting targets and mandates for EV uptake, as well as developing a national policy on fuel safety stocks, are also crucial steps (PCREEE, 2020; World Bank, 2012). Additionally, promoting non-motorized and cycling transport options, along with encouraging public adoption of 50% EVs, can contribute to sustainable transportation (GOT, 2021c). Prioritizing the implementation of an EV insurance policy that meets the needs of fleets is essential for reliable vehicle operation (Caley, J., et al, 2023). In order to accelerate industry growth and charging infrastructure development, a decisive policy push is necessary in the Philippines (Ha., T, and Manongdo., P., 2021). Governments should also incentivize the adoption of economically viable EV types that offer societal and environmental benefits, such as providing tax breaks that reflect the environmental impact (ECA and TTA, 2022). Lastly, implementing the 26 policy recommendations identified to overcome barriers to e-mobility uptake in Pacific Island Countries is crucial (ECA and TTA, 2022).

9.4.4 Enabling Environment for Policy, Regulatory & Legislative Barriers of Transportation Technologies

The Transportation stakeholders' group has utilized the identified enabling framework from the literature review to deliberate, verify, and choose a suitable enabling framework to potentially tackle the previously prioritized types of policy, regulatory, and legislative barriers. The proposed facilitating frameworks presented by the transportation group are outlined in Table 48, which will be further detailed in this section. The transportation group has recommended the development of coordinated policies involving all key stakeholders, along with the establishment of targets, mandates, and national policies to address the lack of policies and policy actions for EVs and hybrid vehicles. It is imperative to promote non-motorized transport options and transportation EV targets to meet the NDC targets. Offering policy incentives such as tax breaks for the adoption of EVs and hybrid vehicles due to environmental benefits is completely justified. In the case of battery-powered EVs, transitioning to low emission vehicles to reduce GHGs emissions is crucial. It may be necessary to consider and select suitable EV policies that can be adopted for the region to standardize the battery-powered EVs policies. Additionally, considering standardizing a battery passport, establishing centralized recycling facilities, and collaborating with international shipping partners to address the lack of EV regulation and standards is recommended. For on-grid EVs, implementing an EV insurance policy is necessary to address safety, accessibility, and affordability of charging infrastructure. To accelerate

industry growth and charging infrastructure development for hybrid vehicles, it is advisable to ensure a safer, less congested transportation system.

Table 48 : Policy, Regulatory and Legislative Enabling Framework for Priority Transportation Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle	
current uncertainties in policies, have been identified as significant constraints in the market.	√-5	√-5	√-5	Develop coordinated policies
lack of planning, policy work, and policy actions for electric vehicles	√-5	√-5	√-5	Setting targets and mandates for EV uptake, as well as developing a national policy on implemented vehicles
potential conflict between the adoption of EVs and certain NDC	√-5			promoting non-motorized and cycling transport options, along with encouraging public adoption of 50% EVs, can contribute to sustainable transportation targets.
Policies such as Reduced import taxes on EVs	√-5	√-5	√-5	incentivize the adoption of economically viable EV types that offer societal and environmental benefits, such as providing tax breaks
policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market.	√-5			Transitioning to Low Emissions Vehicles
policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive			√-5	implementation of an EV insurance policy

impacts on the electricity grid.				
policies have the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions		√-5		In order to accelerate industry growth and charging infrastructure development, a decisive policy push is necessary
policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems.	√-5			implementing the 26 policy recommendations for Pacific Island Countries (select the most priority policies to start with)
lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies.	√-5			standardizing a battery passport, establishing centralized recycling facilities, and collaborating with international shipping partners

9.4.5 Institutional Enabling Environment

The introduction of Electric Vehicles (EVs) in the municipal government fleet can help reduce institutional barriers, as stated in the report by GOT (2021c). For foreign financiers and industry players interested in entering the market, there are various opportunities available. These include providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV technology solutions and technology transfer, as well as supplying battery systems and other EV components, as mentioned by (Ha., T, and Manongdo., P. (2021).

In the context of small island developing states with isolated grids and monopoly electricity utilities, the adoption of electric vehicles and vehicle-to-grid services can be particularly advantageous. Current literature primarily focuses on the economic aspects of vehicle-to-grid services for large, interconnected grids, but due to the complexity of these grids and their energy markets, a comprehensive analysis of all variables is often

challenging. Therefore, it may be more beneficial to model these simpler systems, especially in the early stages of vehicle-to-grid development (Ha., T, and Manongdo., P., 2021).

To ensure national energy security and reliability of supply, it is essential to upgrade downstream petroleum safety, licensing, and regulation, as highlighted by the World Bank (2012). Additionally, education programs focused on developing maintenance capabilities for EVs in Tonga should be coordinated (Caley, J., et al, 2023). Forming a regional EV hub with representatives from both local and regional programs can facilitate collaboration and support for appropriate EV actions and programs (PCREEE, 2020).

9.4.6 Enabling Environment for Institutional Barriers of Transportation Technologies

The Transportation stakeholders' group has utilized the identified enabling framework from the literature review to discuss, validate, and select a suitable enabling framework to potentially address the previously prioritized types of institutional barriers. The proposed facilitating frameworks presented by the transportation group are outlined in Table 49, which will be further elaborated in this section. It is recommended to introduce the deployment of technologies as a government fleet for all three vehicle technologies in order to mitigate institutional barriers. In the case of battery-powered EVs and on-grid EVs, it is essential to have funding available for charging infrastructure and EV components to ensure the availability of charging infrastructure. Additionally, for battery-powered EVs, sufficient funding would alleviate the scarcity of charging stations and reduce lengthy charging times, thereby enhancing the reliability of charging stations. Simplifying the modelling of on-grid EVs would eliminate the need for charging stations and facilitate the adoption of renewable energy-based on-grid EV transportation systems. The coordination of education programs focused on developing maintenance capabilities for EVs in Tonga should be undertaken by transportation stakeholders to address the policy, regulatory, and legislative requirements for the proper deployment of battery-powered EVs and hybrid vehicles. The establishment of education programs focused on the maintenance and operation of hybrid vehicles would enhance the institutional capacity of the country.

Table 49 : Institutional Enabling Framework for Priority Transportation Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle	
Insufficient institutional capacity	√-5	√-4	√-4	introduction of Electric Vehicles (EVs) in the municipal

and knowledge production				government fleet can help reduce institutional barriers
reliance on charging infrastructure availability	√-5		√-5	providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV technology solutions and technology transfer, as well as supplying battery systems and other EV components
scarcity of charging points can deter consumers from considering purchasing an EV.	√-5			providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV technology solutions and technology transfer, as well as supplying battery systems and other EV components
lengthy charging times can further impact the reliability of charging.	√-5			the adoption of electric vehicles and vehicle-to-grid services can be particularly advantageous
limited availability of fast charging stations for public use	√-5		√-5	model these simpler systems, especially in the early stages of vehicle-to-grid development
Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations.	√-5	√-5		education programs focused on developing maintenance capabilities for EVs in Tonga should be coordinated
incorporating renewable energy-based transport systems into the long-term planning	√-5		√-3	Forming a regional EV hub with representatives from both local and regional programs can facilitate collaboration and support for appropriate EV actions and programs.
Lack of institutional Capacity on hybrid vehicle		√-5		education programs focused on developing maintenance and operation of hybrid vehicle

9.4.7 Technical Enabling Environment

Reducing technical barriers by implementing vehicle standards and providing incentives for more efficient vehicles through tax breaks, fees, and import tariffs (GOT, 2021c). Enhancing the efficiency of petroleum supply chains in Tonga to reduce costs related to fuel transportation, storage, and handling (World Bank, 2012). Strengthening road maintenance in Tanu Hala (GOT, 2021c) and decentralizing services from urban to rural areas to alleviate traffic congestion (GOT, 2021c). Ensuring sustainable maintenance of all vehicles (GOT, 2021c). The government of Tonga should formally adopt the AC Type 2 standard for public Mode 3 stations and DC CCS Type 2 standard for Mode 4 stations promptly, as recommended by PCREEE's draft proposed charging guidelines (Caley, J., et al, 2023). Additionally, low-voltage DC chargers for electric bikes and push scooters should be included in this policy along with Mode 1 and Mode 2 chargers (Caley, J., et al, 2023). Tonga could benefit from using the EV Charging and Grid Integration Tool developed by the IEA to assess the grid impacts of EVs and implement strategies to mitigate these impacts (Caley, J., et al, 2023). Developing standards and guidelines for various industries is crucial (PCREEE, 2020). To fully embrace the advantages of e-mobility, Pacific Island Countries should invest in solar generation and promote daytime EV charging through incentives like time-of-use tariffs and workplace charging infrastructure (ECA and TTA, 2022) to enhance vehicle efficiency and expand transportation options (UNCTCN,2020).

9.4.8 Enabling Environment for Technical Barriers of Transportation Technologies

The stakeholders in the transportation sector have employed the established enabling framework identified in the literature review to deliberate, validate, and choose a suitable enabling framework to potentially tackle the previously prioritized technical barriers. The proposed facilitating frameworks put forth by the transportation group are detailed in Table 50, which will be further explained in this section. In the case of hybrid vehicles, the group has stressed the importance of ensuring sustainable maintenance of hybrid vehicles to enhance the technical capabilities of local technicians and private companies. It is also advised to adopt a simpler model of on-grid vehicle infrastructure to address the lack of regulations and standards in Tonga. All three technologies advocate for sustainable maintenance of infrastructures and the adoption of renewable-based charging infrastructures in workplaces to ensure proper upkeep. To alleviate traffic congestion, it is recommended to decentralize charging services for Battery powered EVs from urban to rural areas. The implementation of vehicle standards and the provision of incentives for more efficient vehicles through tax breaks, fees, and import tariffs would raise concerns about the safety of batteries. The government of Tonga should officially adopt specific EV models such as the AC Type 2 standard for public Mode 3 stations and DC CCS Type 2 standard for Mode 4 stations to avoid a shortage of expertise in new technology. Tonga could also benefit from utilizing the EV Charging and Grid Integration Tool developed by the IEA to evaluate the grid impacts of EVs and implement strategies to mitigate these impacts in order to address the lack of expertise in assisting battery-powered EVs and hybrid vehicles in the country. Enhancing the efficiency of battery-powered EVs would reduce technical issues associated with large engine low efficiency.

Table 50 : Technical Enabling Framework for Priority Transportation Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle	
Maintenance course development for technicians, and independent private companies		√-5		Ensuring sustainable maintenance of hybrid vehicles
Absence of vehicle regulations and standards and absence of endorsed regional or national e-mobility strategies			√-4	Adopt simpler regional model of on-grid EVs, of which vehicle standard and regulations are developed
inadequate maintenance of transportation infrastructure contributes to high emissions	√-5	√-5	√-4	Ensuring sustainable maintenance of all transportation infrastructures invest in solar generation and promote daytime EV charging through incentives like time-of-use tariffs and workplace charging infrastructure
safety of electric vehicles (EVs) and charging infrastructure	√-5			decentralizing services from urban to rural areas to alleviate traffic congestion
concerns about EV models and battery safety	√-5			implementing vehicle standards and providing incentives for more efficient vehicles through tax breaks, fees, and import tariffs
new technology and limited expertise in service centres	√-5	√-5	√-4	The government of Tonga should formally adopt the AC Type 2 standard for public Mode 3 stations and DC CCS Type 2 standard for Mode 4 stations
lack of expert assistance when	√-5	√-5		Tonga could benefit from using the EV Charging and Grid

encountering technical issues				Integration Tool developed by the IEA to assess the grid impacts of EVs and implement strategies to mitigate these impacts
the use of cars with large engines and low efficiency	√-5			Enhancing the efficiency of engine operations
Encouraging the adoption of Hybrid Electric Vehicles				Developing standards and guidelines for various industries is crucial

9.4.9 Market Enabling Environment

Enhancing Market Access by Implementing Emergency Fuel Rationing. Formulate a comprehensive strategy for managing a potential liquid fuels shortage in Tonga, which includes establishing fuel rationing protocols (World Bank, 2012). Instead of attempting to inspect all EV imports for compatible chargers, it is recommended that Tonga focuses on inspecting a specific percentage of imports based on the available resources of the Ministry of Revenue and Customs (Caley, J., et al, 2023). With the aim of boosting the fuel efficiency of Tonga's transportation sector, responsible for 75% of petroleum imports compared to the 25% utilized in the power sector (World Bank, 2012), these initial sites could serve as a model for the development of charging stations in various locations across the nation. Potential locations in Tonga could encompass Fua‘amotu International Airport, Vuna Wharf, the Western Bus Terminal, Vaiola Hospital, the Royal Tombs area, a potential future P&R lot (Section 3.5), and major churches (Caley, J., et al, 2023). By commencing with EV chargers at government facilities, Tonga's ministries can familiarize themselves with the infrastructure and capitalize on their investment by concurrently transitioning their fleets to electric vehicles (this would also facilitate EV education initiatives like ride-and-drive events on a regular basis) (Caley, J., et al, 2023). The concept of an "electricity delivery service" for EV charging would likely entail that the ownership and operation of EV chargers would be under the jurisdiction of the national electric utility, Tonga Power Limited (Caley, J., et al, 2023), mirroring the situation in many of Barbados' Caribbean Island counterparts. Conversely, an "access service" interpretation would permit other entities to own and operate EV chargers, procuring electricity from Tonga Power Limited at wholesale rates and retailing it to consumers (Caley, J., et al, 2023). This approach could be most efficiently executed as an incentive for private enterprises engaged in providing electrified transportation services or managing fleets.

9.4.10 Enabling Environment for Market Barriers of Transportation Technologies

The stakeholders within the transportation sector have utilized the established framework outlined in the literature review to discuss, validate, and select a suitable framework to address the previously identified market barriers. The transportation group has presented

detailed facilitating frameworks in Table 51, which will be further elaborated upon in this section. In the case of battery-powered electric vehicles (EVs), we can identify potential and feasible locations for charging services to decentralize their availability. By accessing regulatory services, we can monitor the driving ranges of battery-powered EVs. To gain a better understanding of the infrastructure, it would be beneficial to initially deploy all three types of vehicles within the government-owned fleet. The ownership of electricity delivery services by the power utility would help overcome the limited availability of technology models and designs. Additionally, providing incentives to private businesses would encourage their involvement in the deployment of hybrid vehicles and ensure compliance with emissions standards. In order to address the underdeveloped EV industry and limited charging infrastructure in Tonga, it may be necessary to initially import a small percentage of vehicles to the country. These factors have been identified as significant market restraints.

Table 51 : Market Enabling Framework for Priority Transportation Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle	
necessity of decentralizing services	√-5			Potential locations in Tonga could encompass Fua‘amotu International Airport, Vuna Wharf, the Western Bus Terminal, Vaiola Hospital, the Royal Tombs area, a potential future P&R lot (Section 3.5), and major churches
driving range, which frequently raises concerns	√-5			Access regulatory service"
the lack of a comprehensive review of motivators and barriers in decision-making processes	√-5	√-5	√-5	By commencing with EV chargers at government facilities, Tonga's ministries can familiarize themselves with the infrastructure and capitalize on their investment by concurrently transitioning their fleets to electric vehicles (this would also facilitate EV education initiatives

The limited availability of models and designs further hinders adoption,	√-5	√-5	√-5	The concept of an "electricity delivery service" for EV charging would likely entail that the ownership and operation of EV chargers would be under the jurisdiction of the national electric utility, Tonga Power Limited
viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties	√-5	√-5		as an incentive for private enterprises engaged
underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	√-5	√-5	√-5	specific percentage of imports based on the available resources of the Ministry of Revenue to assess EVs import

9.4.11 Information and Public Awareness Enabling Environment

Enhancing transport data collection and waste management to reduce information and public awareness barriers (GOT, 2021c). Implementing fuel standards suitable for Tonga's conditions and engine fleet, alongside initiatives to enhance energy efficiency (World Bank, 2012). Raising consumer awareness through a public information campaign to promote electromobility, and increasing developer awareness by establishing construction requirements for EV charging stations (Caley, J., et al ,2023); Tonga could launch a public awareness campaign to ensure EV owners are informed about compatible charging standards and potential hazards of using incompatible Mode 1 or Mode 2 chargers (Caley, J., et al ,2023). The public information campaign can also educate EV operators on how to charge their vehicles at public stations and at home, as the charging procedures with tethered and untethered cables vary slightly (Caley, J., et al ,2023). Initiating education events with a general awareness campaign and progressing to ride-and-drive events once EVs are available in government fleets or voluntarily provided by private owners (Caley, J., et al ,2023). Promoting awareness and adoption of EVs and associated measures, while monitoring international advancements and staying updated on relevant global technologies (PCREEE,2020). Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector (IRENA,2013).

9.4.12 Enabling Environment for Information and Public Awareness Barriers of Transportation Technologies

The stakeholders in the transportation industry have utilized the established framework from the literature review to discuss, validate, and choose an appropriate framework to tackle the information and public awareness barriers identified earlier. The transportation team has presented detailed enabling frameworks in Table 52, which will be further explained in this section. For battery-powered EVs and on-grid EVs, there is a recommendation to improve transport data collection and raise public awareness about EV vehicles. To increase consumer awareness for all three technologies, public awareness programs can be implemented. For hybrid vehicles and on-grid EVs, it is crucial to have comprehensive data coordination and collection to support evidence-based decision-making. Community consultation is important for hybrid vehicles to enhance public awareness. Encouraging a sector-wide approach to data collection and analysis is essential for hybrid and on-grid EVs to address the lack of comprehensive evidence-based decision-making. For battery-powered EVs, it is vital to conduct public information campaigns to educate EV operators on proper charging procedures at public stations and at home to prevent potential explosions in extreme circumstances or risks associated with the unique components of EV batteries.

Table 52 : Information and Public Awareness Barriers an Enabling Framework for Prioritized Transportation Technologies

Types of barriers	Stakeholders Ranking of Barriers (1-5) Scale (For instance, when √ - 5 is used, it means, the barrier is given priority at a level of 5)			Types of Enabling Frameworks
	Battery powered Electric Vehicle	Hybrid Vehicle	On-grid electric vehicle	
novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics	√-5		√-5	Enhancing transport data collection and waste management Promoting awareness and adoption of EVs and associated measures, while monitoring international advancements and staying updated on relevant global technologies
Insufficient knowledge and familiarity concerning the safety and performance of EVs.	√-5	√-5	√-5	Raising consumer awareness through a public information campaign to promote electromobility, and

				increasing developer awareness by establishing construction requirements for EV charging stations. Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector
Capacity to establish an evidenced based data collection and analysis of hybrid vehicles		√-5	√-5	Comprehensive data coordination and collection
Minimum consultation with local stakeholders on hybrid vehicles		√-4		Encourage community consultation
Lack of comprehensive coordination of data collection for policy development and decision making		√-4	√-5	Involving a whole sector approach data collection and analysis and formulation of key indicators
potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries.	√-5			The public information campaign can also educate EV operators on how to charge their vehicles at public stations and at home, as the charging procedures with tethered and untethered cables vary slightly

9.5 : Identified Interventions for Overcoming Barriers in the Transportation Sector

Table 53 presents a comprehensive overview of the specific challenges faced by battery-powered electric vehicles, along with their corresponding ranking scores that indicate their level of importance in terms of addressing them. These challenges can be effectively tackled by utilizing the recommended enablers or enabling framework mentioned in the same table, through collaborative efforts among the designated responsible entities. Similarly, Table 54 and Table 55 outline the significant barriers, facilitators, and accountable stakeholders for hybrid vehicles and on-grid electric vehicles, respectively. The utilization of these tables, namely Table 53, 54, and 55, offers numerous benefits as it allows energy stakeholders to prioritize their barriers and identify the appropriate enabling environment, as discussed in the preceding sections. Furthermore, sections 6.5.1, 6.5.2, and 6.5.3 place additional emphasis on the crucial role of responsible institutions and their interventions and coordination. This ensures that stakeholders can

effectively establish the recommended enabling framework to address the identified barriers for each transportation technology, ultimately leading to successful outcomes.

9.5.1 Responsible Institutions for Enabling Framework for Battery Powered Electric Vehicle

It is crucial for key stakeholders involved in determining the initial cost of electric vehicles (EVs) in Tonga, such as the Ministry of Energy, Customs Department, Ministry of Finance, Ministry of Economic and Trade, to actively participate in discussions, processes, and planning aimed at reducing the high upfront costs of EVs. Providing a transparent justification for local vehicle costs is essential to address financial and fiscal challenges. Moreover, improving financial risk management by offering financial incentives and exploring options like tax reductions or exemptions can help overcome fiscal and financial barriers. Collaboration among relevant entities including the Ministry of Energy, Ministry of Transport, Ministry of Finance, private vehicle dealers, Power Utility, Tonga Electricity Commission, commercial banks, and financial institutions is necessary to identify practical solutions for the economic feasibility of EVs in Tonga. Discussions should focus on cost-related issues, charging infrastructure, maintenance needs, and spare parts availability. Considering initiatives like free EV charging at public stations and potential battery swap stations can promote early adoption of EVs and encourage investments in public charging facilities. Lastly, the Ministry of Energy, Ministry of Transport, Ministry of Finance, banks, and financial institutions should work together to formulate an appropriate financial policy package for e-vehicles in Tonga.

The Ministry of Energy, Ministry of Transport, Ministry of Finance, private vehicle dealers, Power Utility, Tonga Electricity Commission, commercial banks, and financial institutions are coming together to establish a comprehensive policy framework for the operation, management, and maintenance of battery-charged electric vehicles in Tonga. This framework aims to address the current lack of suitable policies and uncertainties surrounding existing EV policy. The stakeholders involved must ensure that this policy framework is well-coordinated, setting clear targets and mandates for EV uptake as a national policy. By promoting non-motorized and cycling transport options, as well as encouraging public adoption of EVs, such as aiming for 50% EVs, Tonga can work towards sustainable transportation goals. It is crucial to address the lack of policy actions, clear targets, and planning for EVs, as well as resolve any conflicts between EV adoption targets and NDC targets. Import taxes, carbon emissions reduction policies, and EV insurance policies must also be considered to ensure the safety, accessibility, affordability, and minimal risk or positive impact on the electricity grid of EVs and charging stations. The adoption of the 26 policy recommendations for Pacific Island Countries should be considered, and the most important policies should be selected to begin with. Additionally, the recycling and transferring of EV materials for recycling purposes should be taken into account. The government and donors are providing financial support for charging infrastructure and other EV-related initiatives. They are also offering innovative EV technology solutions and technology transfer to ensure the availability of charging stations and reduce charging time. To implement the institutional enabling framework, it is crucial to introduce EVs in the government fleet to address the lack of institutional capacity and insufficient knowledge. The stakeholders must ensure the availability of

charging infrastructure and the capacity to reduce the lengthy time of recharging. Incorporating renewable energy into the electricity system is also important. To improve the technical enabling framework, the stakeholders must develop maintenance capabilities for EVs through educational programs and on-site training courses. They should also consider the safety of EVs and charging infrastructure, as well as suitable EV models to be used. Addressing the limited technical expertise is also necessary. For the market enabling framework, it is necessary to decentralize EV services to rural areas and transition the government fleet to EVs to increase education and knowledge. The stakeholders must consider suitable EV models and identify possible sites for charging while addressing the limitation of charging infrastructure. For the information and public awareness enabling framework, it is important for stakeholders to address the insufficient knowledge and ensure the safety performance of EVs. A public information campaign and proper education of EV operators on the procedure for charging EVs at home or other places should be conducted.

Table 53 : Enabling Environment for Prioritized Barriers for Battery Powered Electric Vehicle

TECHNOLOGY: Battery Powered Electric Vehicle		Score	Enablers	Responsible Stakeholders/Roles
Financial & Fiscal	high upfront costs due to the expensive manufacturing process	5	Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles incentives primarily come in the form of tax reductions or exemptions. countries apply various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade to make EV imports more affordable and attractive.	Ministry of Energy and Custom Department and Ministry of Finance. Ministry of Economic and Trade to involve in the meetings and processes and arrangement for possible ways to reduce high upfront cost of EVs in Tonga

			The exemption of vehicle registration or import fees is suggested as a targeted policy for particular groups that would derive the most benefit from a reduction in vehicle prices.	
	acquisition costs have been identified as major market restraints.	5	Offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles	Ministry of Energy and Custom Department and Ministry of Finance. Ministry of Economic and Trade to involve in the meetings and establishment of processes and arrangement for possible ways to reduce high upfront cost of EVs in Tonga
	upfront costs, fuel/charging costs, maintenance costs, and environmental costs	5	offering incentives or subsidies for charging stations in specific areas	Ministry of Energy and Custom Department and Ministry of Finance, Ministry of Transport to involve in the procurement process and further regional arrangement for bulk procurement to reduce prices .
	no new financial policy interventions are currently in place	5	formalize the policy package for charging station locations in an official strategic document	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, Banks and Financial institutions to discuss and develop financial policy package for e-vehicles
	EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefit	5	reduced or free EV charging at public charging stations, including battery swap stations if applicable, to encourage early EV adoption and investment in public	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and Financial institutions to discuss and identify viable solutions to cost, charging

			charging infrastructure	stations, maintenance requirements and spare parts issues
Policy, Regulatory, Legislative	current uncertainties in policies, have been identified as significant constraints in the market	5	Develop coordinated policies	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to discuss/establish suitable policies for operations, management and maintenance of battery charged electric vehicles
	lack of planning, policy work, and policy actions for electric vehicles	5	Setting targets and mandates for EV uptake, as well as developing a national policy on implemented EVs actions	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to formulate planning and suitable national plan for the country
	potential conflict between the adoption of EVs and certain NDC targets	5	promoting non-motorized and cycling transport options, along with encouraging public adoption of 50% EVs, can contribute to sustainable transportation targets	Ministry responsible for Energy/Government/Donors as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to establish national energy or carbon emissions targets to be achieved by EVs compared to other NDC targets
	Policies such as Reduced import taxes on EVs	5	incentivize the adoption of economically viable EV types that offer societal and	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private

			environmental benefits, such as providing tax breaks.	vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to discuss and identify all possible tax incentives and pass effective policies for EVs
	policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market.	5	Transitioning to Low Emissions Vehicles	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to formulate policies aim to reduce GHG emissions through promotion of EV market
	policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid.	5	implementation of an EV insurance policy	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to identify possible sites and charging model of EVs for Tonga in order to make safe and affordable charging stations
	Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations	5	In order to accelerate industry growth and charging infrastructure development, a decisive policy push is necessary.	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to discuss and identify policy, regulatory

				and legislative framework for EVs in Tonga
	policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems.	5	implementing the 26 policy recommendations for Pacific Island Countries (select the most priority policies to start with	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to consider the suitability of EVs policy framework for Tonga.
	lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies.	5	standardizing a battery passport, establishing centralized recycling facilities, and collaborating with international shipping partners	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions and regional institutions to decide a policy framework of EV for Tonga based on exiting successful EVs framework in the region.
Institutional capacity	Institutional capacity and insufficient knowledge production	5	introduction of Electric Vehicles (EVs) in the municipal government fleet can help reduce institutional barriers	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify the on-site training needs and program for the technologies
	reliance on charging infrastructure availability	5	Government/Donors are providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify the

			technology solutions and technology transfer, as well as supplying battery systems and other EV components.	suitable sites for charging stations
	scarcity of charging points can deter consumers from considering purchasing an EV.	5	providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV technology solutions and technology transfer, as well as supplying battery systems and other EV components	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify pros and cons for home charging stations and ensure availability of charging stations for customers
	lengthy charging times can further impact the reliability of charging.	5	the adoption of electric vehicles and vehicle-to-grid services can be particularly advantageous	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify ways to reduce charging time in the charging stations
	limited availability of fast charging stations for public use	5	model these simpler systems, especially in the early stages of vehicle-to-grid development	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify the availability of fast charging stations
	incorporating renewable energy-based transport systems into the long-term planning	5	Forming a regional EV hub with representatives from both local and regional programs can facilitate collaboration and support for	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify any

			appropriate EV actions and programs.	possible renewable energy-based charging stations
Technical	inadequate maintenance of transportation infrastructure contributes to high emissions.	5	education programs focused on developing maintenance capabilities for EVs in Tonga should be coordinated. maintenance course development for technicians, and independent companies Ensuring sustainable maintenance of all vehicles invest in solar generation and promote daytime EV charging through incentives like time-of-use tariffs and workplace charging infrastructure.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to continuously review and maintain the road infrastructure
	safety of electric vehicles (EVs) and charging infrastructure	5	decentralizing services from urban to rural areas to alleviate traffic congestion.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify safety standard for EVs
	concerns about EV models and battery safety	5	implementing vehicle standards and providing incentives for more efficient vehicles through tax breaks,	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to identify

			fees, and import tariffs	suitable models and safety standard for EVs in Tonga
	new technology and limited expertise in service centres	5	The government of Tonga should formally adopt the AC Type 2 standard for public Mode 3 stations and DC CCS Type 2 standard for Mode 4 stations.	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss on site courses for EVs maintenance and operations in Tonga
	lack of expert assistance when encountering technical issues	5	Tonga could benefit from using the EV Charging and Grid Integration Tool developed by the IEA to assess the grid impacts of EVs and implement strategies to mitigate these impacts	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to consider plan for on-site expert training
	the use of cars with large engines and low efficiency	3	Enhancing the efficiency of engine operations	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to discuss and identify suitable car model for Tonga and advise people on EVs vehicle standard for the country
Market	Necessity of decentralizing services	5	Potential locations in Tonga could encompass Fua'amotu International Airport, Vuna Wharf, the Western Bus Terminal, Vaiola Hospital, the Royal Tombs area, a potential future P&R	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions

			lot (Section 3.5), and major churches. would permit other entities to own and operate EV chargers, procuring electricity from Tonga Power Limited at wholesale rates and retailing it to consumers.	
	The lack of a comprehensive review of motivators and barriers in decision-making processes	5	By commencing with EV chargers at government facilities, Tonga's ministries can familiarize themselves with the infrastructure and capitalize on their investment by concurrently transitioning their fleets to electric vehicles (this would also facilitate EV education initiatives	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions
	The limited availability of EV models and designs further hinders adoption.	5	The concept of an "electricity delivery service" for EV charging would likely entail that the ownership and operation of EV chargers would be under the jurisdiction of the national electric utility, Tonga Power Limited	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions
	Underdeveloped EV industry and limited charging infrastructure in	5	specific percentage of imports based on the available resources of the	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity

	the country are also cited as significant market restraints		Ministry of Revenue to assess EVs import. Design and endorse an incentive for private enterprises engaged.	Appliances Companies and training institutions to endorse sites and incentives for EVs
Information & Public Awareness	Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics	5	Enhancing transport data collection and management Promoting awareness and adoption of EVs and associated measures, while monitoring international advancements and staying updated on relevant global technologies	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to identify and release information and public awareness facts about EVs model in Tonga and details of import processes
	Insufficient knowledge and familiarity concerning the safety and performance of EVs	5	Raising consumer awareness through a public information campaign to promote electromobility, and increasing developer awareness by establishing construction requirements for EV charging stations Enhancing the collection and management of energy data to support the development of	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to release public information about safety tasks and guidelines for EVs operation in Tonga

			comprehensive energy information, particularly for the transport sector	
	Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries	5	The public information campaign can also educate EV operators on how to charge their vehicles at public stations and at home, as the charging procedures with tethered and untethered cables vary slightly	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private Electricity Appliances Companies and training institutions to advise public on safety of keeping and operating EVs

9.5.2 Responsible Institutions for Enabling Framework of Hybrid Vehicle

According to Table 54, the Ministry of Energy, Custom Department, Ministry of Finance, Ministry of Economic and Trade are involved in meetings and processes to arrange possible ways to implement a financial and fiscal enabling framework to reduce the high upfront cost of Hybrid vehicles in Tonga. They can consider proper financial and fiscal risk management, such as imposing policy incentives for import tax reductions or exemptions, adopting more coordinated financial policies, setting up targets and mandates as national policy for hybrid vehicles to address the lack of planning and financial policy actions. It is crucial to consider policy incentives or tax incentives to reduce upfront costs, and policy push is necessary to reduce carbon emissions and make the transportation system safer and more resilient. The stakeholders mentioned above must also consider recycling facilities and other financial policy arrangements to address the absence of regulations and standards. For institutional enabling framework, improving the institutional capacity to finance spare parts and other components is essential. The Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, Private vehicle dealers Companies, and training institutions need to discuss and identify on-site training needs and programs for hybrid vehicles to address the lack of institutional capacity and knowledge. In terms of technical enabling framework, the training stakeholders must lead on-site trainings for maintenance work and technical knowledge for technicians and independent private companies. It is also crucial to address inadequate maintenance, limited expertise, and technical knowledge on hybrid vehicles. For market enabling framework, the Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, Private vehicle dealers Companies, and training institutions should identify short-term on-site courses and long-term training courses due to the lack of a comprehensive review of the deployment of hybrid vehicles. The stakeholder must

take into account the limited availability of hybrid models and designs, as well as the technical feasibility of hybrid vehicles, by involving private enterprises in the adoption of hybrid vehicles. Market constraints for the underdeveloped hybrid industry can be addressed through the promotion of adopted models and incentives for institutions that have adopted them. To facilitate information and public awareness, the Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, private vehicle dealers, and training institutions should collaborate to offer short-term on-site courses and long-term training programs to bridge the knowledge gap in deploying hybrid vehicles. Enhancing the capacity for evidence-based data collection is essential to address the lack of stakeholder consultations, as well as the absence of a comprehensive review and coordination mechanism for data collection.

According to Table 54, the Ministry of Energy, Custom Department, Ministry of Finance, Ministry of Economic and Trade are involved in meetings and processes to arrange possible ways to implement a financial and fiscal enabling framework to reduce the high upfront cost of Hybrid vehicles in Tonga. They can consider proper financial and fiscal risk management, such as imposing policy incentives for import tax reductions or exemptions, adopting more coordinated financial policies, setting up targets and mandates as national policy for hybrid vehicles to address the lack of planning and financial policy actions. It is crucial to consider policy incentives or tax incentives to reduce upfront costs, and policy push is necessary to reduce carbon emissions and make the transportation system safer and more resilient. The stakeholders mentioned above must also consider recycling facilities and other financial policy arrangements to address the absence of regulations and standards. For institutional enabling framework, improving the institutional capacity to finance spare parts and other components is essential. The Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, Private vehicle dealers Companies, and training institutions need to discuss and identify on-site training needs and programs for hybrid vehicles to address the lack of institutional capacity and knowledge. In terms of technical enabling framework, the training stakeholders must lead on-site trainings for maintenance work and technical knowledge for technicians and independent private companies. It is also crucial to address inadequate maintenance, limited expertise, and technical knowledge on hybrid vehicles. For market enabling framework, the Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, Private vehicle dealers Companies, and training institutions should identify short-term on-site courses and long-term training courses due to the lack of a comprehensive review of the deployment of hybrid vehicles.

Table 54 : Enabling Environment for Prioritized Barriers of the Hybrid Vehicle

TECHNOLOGY: Hybrid Vehicle	Score	Enablers	Responsible Stakeholders/Roles

Financial & Fiscal	high upfront costs due to the expensive manufacturing process	5	Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles incentives primarily come in the form of tax reductions or exemptions	Ministry of Energy and Custom Department and Ministry of Finance. Ministry of Economic and Trade to involve in the meetings and processes and arrangement for possible ways to reduce high upfront cost of Hybrid vehicle in Tonga
	no new financial policy interventions are currently in place	5	incentives primarily come in the form of tax reductions or exemptions	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, Banks and Financial institutions to discuss and develop financial policy package for Hybrid vehicle
Policy, Regulatory, Legislative	Current uncertainties in Policies, Regulation and Legislation have been identified as significant constraints in the market	5	Develop coordinated policies	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to discuss/establish suitable policies for operations, management and

				maintenance of hybrid vehicles
	Lack of planning, policy work, and policy actions for hybrid vehicles	5	Setting targets and mandates for hybrid vehicle uptake, as well as developing a national policy on implemented hybrid vehicle actions	Ministry responsible for Energy as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to formulate planning and suitable national plan for hybrid vehicle in the country
	Policies such as Reduced import taxes on Hybrid Vehicle	5	incentivize the adoption of economically hybrid vehicle that offer societal and environmental benefits, such as providing tax incentives	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to discuss and identify all possible tax incentives and initiate pass of effective policies for hybrid vehicle from Cabinet

	Policies has the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions	5	In order to accelerate industry growth and hybrid vehicle infrastructure development, a decisive policy push is necessary	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions to discuss and identify suitable policy framework for land transport system to push for hybrid vehicle
	absence of EV regulations and standards, and the absence of endorsed regional or national hybrid vehicle strategies	5	standardizing a battery passport, establishing centralized recycling facilities, and collaborating with international shipping partners	Ministry responsible for Energy/Government/Ministry of Customs as well as Ministry of Transport. Ministry of Finance, private vehicle dealers Power Utility, Tonga Electricity Commission, commercial Banks and financial institutions and regional energy institutions to discuss hybrid vehicles policy and standard
Institutional capacity	Lack of institutional capacity on hybrid vehicle can deter	5	providing finance for hybrid vehicle-related initiatives, offering	Ministry Responsible for Energy, Power

	consumers from considering purchasing a hybrid vehicle		innovative solutions and technology transfer, as well as supplying spare parts and other components of hybrid vehicle	Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss and identify the proper institutional capacity for hybrid vehicle
	Institutional capacity and knowledge production	4	introduction of Hybrid Vehicles in the municipal government fleet can help reduce institutional barriers education programs focused on developing maintenance capabilities for Hybrid Vehicle in Tonga should be coordinated	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss and identify the on-site training needs and program for the technologies
Technical	Maintenance course development for technicians, and Independent private companies	5	On-site training on sustainable maintenance of all vehicles	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to continuously review and identify technical training courses for hybrid vehicle

	inadequate maintenance of transportation infrastructure contribute to high emissions	5	Ensuring sustainable maintenance of all vehicles	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to continuously review and maintain the road infrastructure
	new technology and limited expertise in service centres	5	Specific Training Courses and Introduction of hybrid vehicle knowledge and materials in school syllabus Encouraging the adoption of Hybrid Electric Vehicles	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss on site courses for EVs maintenance and operations in Tonga
	lack of expert assistance when encountering technical issues	5	Add services of hybrid vehicles to the core services of the existing service stations	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to consider plan for on-site expert training

Market	The lack of a comprehensive review of motivators and barriers in decision-making processes	5	By commencing with adoption of hybrid vehicle at government facilities, Tonga's ministries can familiarize themselves with the hybrid vehicle infrastructure and capitalize on their investment	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to identify short term on-site courses and long term training courses
	The limited availability of HYBRID models and designs further hinders adoption	5	The concept of an private companies delivery service" for hybrid vehicle dealers would likely entail that the ownership and operation of electric vehicle services would be under the jurisdiction of the well-known vehicle dealers companies	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to identify suitable marketable model for hybrid in Tonga
	Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties	5	as an incentive for private enterprises engaged	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies to identify options of hybrid cars that contribute to reduce emissions
	Underdeveloped Hybrid industry in the country are also cited as	4	specific percentage of hybrid vehicle imports based on the available resources of the	Ministry Responsible for Energy, Power Utility, Tonga

	significant market restraints		Ministry of Revenue and Ministry of Infrastructure to assess Hybrid Vehicle import	Electricity Commission and Private vehicle dealers Companies and training institutions to endorse sites and incentives for hybrid vehicles
Information & Public Awareness	Insufficient knowledge and familiarity concerning the safety and performance of Hybrid Vehicles	5	Raising consumer awareness through a public information campaign to promote hybrid vehicle, and increasing developer awareness by establishing construction requirements for Hybrid vehicle operations and maintenance Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to release public information about safety tasks and guidelines for hybrid vehicle operation in Tonga
	Capacity to establish an evidenced based data collection and analysis of Hybrid Vehicles	5	Coordinated and Effective Institutionalization of data collection , analysis and reporting of evidenced based analyse information and statistics	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to identify and establish the evidenced based

				data collection, analysis and use
	Minimum consultation with local stakeholders on Hybrid Vehicles	4	Public Talk and Involvement on hybrid vehicle maintenance services and operations	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to conduct public awareness programs for hybrid vehicles
	Lack of comprehensive coordination of data collection for policy development	4	Institutionalization of data collection and analysis	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss ways to share data and update data in a more consistent way.

9.5.3 Responsible Institutions for Enabling Framework of On-Grid Electric Vehicle

According to Table 54, stakeholders have identified the necessary enabling frameworks for financial and fiscal support. The Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission, Private vehicle dealers Companies, and training institutions must collaborate to ensure that on-grid EVs are safe, accessible, affordable, and have minimal impact on the electricity grid. Incentives should be offered to reduce upfront costs and import taxes, while policy interventions need to be implemented. Key stakeholders should coordinate policies to address uncertainties, reduce import taxes, and promote the adoption of EV insurance policies. The Ministry of Energy, Custom Department, Ministry of Finance, Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission, Private vehicle dealers Companies, and training institutions must work together to

address the limited availability of charging stations and promote the advantages of on-grid EVs. Developing technical standards, providing maintenance courses, and offering training can help reduce barriers to new technology adoption. Short-term and long-term training courses should be identified to address the lack of comprehensive technology review in the market. The stakeholders involved can collaborate to discuss the appropriate measures to tackle the limited availability of on-grid models and designs. Additionally, they can establish incentives and a technical framework to enhance the underdeveloped state of the industry. These stakeholders can enhance the framework for enabling information and public awareness by promoting the adoption of electric vehicles (EVs) and related measures. They should also keep track of international advancements and stay updated on relevant global technologies to address the challenges associated with new technology adoption and lack of knowledge. Conducting thorough information analysis and implementing public awareness campaigns can help address these issues. Institutionalizing data collection will be crucial in ensuring evidence-based analysis. By raising public awareness, the stakeholders can address the issue of minimal consultation. Furthermore, involving stakeholders in data collection and analysis will enhance the comprehensiveness of data collection and policy development.

Table 55 : Enabling Environment for Prioritized Barriers for On-Grid Electric Vehicle

TECHNOLOGY: On-Grid Electric Vehicle		Score	Enablers	Responsible Stakeholders/Roles
Financial and Fiscal Barriers	policies that ensure that On-Grid EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	5	Design and formulate the financial policy framework for On-grid EVs	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions
	acquisition costs have been identified as major market restraints	5	Design and offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles	Ministry Responsible for Energy, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions

	high upfront costs due to new infrastructures	4	Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles incentives primarily come in the form of tax reductions or exemptions countries apply various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade to make on-grid electric vehicles infrastructure imports more affordable and attractive The exemption of vehicle registration or import fees is suggested as a targeted policy for particular groups that would derive the most benefit from a reduction in vehicle prices Offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to involve in the meetings and processes and arrangement for possible ways to reduce high upfront cost of on-grid EVs in Tonga
	no new policy interventions are currently in place	3	formalize the policy package for on-grid EV in an official strategic document	Ministry of Energy and Custom Department and Ministry of Finance

				. Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss and develop financial policy package for on-grid e-vehicles
Policy, Regulatory, Legislative	current uncertainties in policies, have been identified as significant constraints in the market	5	Develop coordinated policies	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss/establish suitable policies for operations, management and maintenance of on-grid electric vehicles
	lack of planning, policy work, and policy actions for electric vehicles	5	Setting targets and mandates for on-grid EV uptake, as well as developing a national policy on implemented on-grid EVs actions	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle

				dealers Companies and training institutions to formulate national planning and national plan for the country
	Policies such as Reduced import taxes on technology	5	incentivize the adoption of economically viable EV types that offer societal and environmental benefits, such as providing tax breaks	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss and identify all possible tax incentives and pass effective policies for on-grid EVs
	policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	5	implementation of an EV insurance policy	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to identify possible sites and charging model of on-grid EVs for Tonga in order to make safe

				and affordable charging stations
Institutional capacity	Full reliance on charging infrastructure availability	5	Advantage of on-grid charging facility	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to promote the advantage of on-grid EVs
	Limited availability of fast charging stations for public use	5	Advantage of on-grid charging facility	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to form up institutional change from on-grid EVs
	Insufficient institutional capacity and knowledge production	4	introduction of Electric Vehicles (EVs) in the municipal government fleet can help reduce institutional barriers model these simpler systems, especially	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and

			in the early stages of vehicle-to-grid development 24 hours services on-grid EV	Private vehicle dealers Companies and training institutions to discuss and identify the on-site training needs and program for the technologies
Technical	Absence of vehicles regulation and standards, and the absence of endorsed regional or national e-mobility strategies	4	Develop Standard for on-Grid Electric Vehicle	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to develop technical standard and guidelines for on-grid EVs
	inadequate maintenance of transportation infrastructure contribute to high emissions	4	Ensuring sustainable maintenance of all vehicles maintenance course development for technicians, and Independent companies invest in solar generation and promote daytime EV charging through incentives like time-of-use tariffs and workplace charging infrastructure	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to continuously review and maintain the all road infrastructure in preparation for penetration of on-grid EVs

	new technology and limited expertise in service centres	4	Government of Tonga and Private Companies to formally adopt the right model of on-grid vehicle Tonga could benefit from using the EV Charging and Grid Integration Tool developed by the IEA to assess the grid impacts of EVs and implement strategies to mitigate these impacts Promotion and Encouraging the adoption of on-grid Electric Vehicles	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss and identify on site courses for on-grid EVs maintenance and operations in Tonga
Market	The lack of a comprehensive review of motivators and barriers in decision-making processes	5	Government review of market barriers and existing decision making processes for on-grid vehicle	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to identify short term on-site courses and long term training courses
	The limited availability of On-grid models and designs further hinders adoption	5	Government Ministries and Private Sector Companies to jointly	Ministry of Energy and Custom Department and Ministry of Finance

			discuss the issues and come up with solutions	. Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to identify suitable marketable model for on-grid in Tonga
	Underdeveloped industry is also cited as significant market restraints	5	Multi-stakeholders decision making processes on the issue	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to endorse sites for on-grid and initiate the Cabinet approval for incentives for on-grid EVs
Information & Public Awareness	Novelty of On-Grid electric vehicle (EV) technology and its limited adoption among certain demographics	5	Promoting awareness and adoption of EVs and associated measures, while monitoring international advancements and staying updated on relevant global technologies	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training

				institutions to identify and release information and public awareness facts about on-grid EVs model in Tonga and details of import processes
	Insufficient knowledge and familiarity concerning the safety and performance of on-grid electric vehicles	5	Raising consumer awareness through a public information campaign to promote electromobility, and increasing developer awareness by establishing construction requirements for EV charging stations Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to release public information about safety tasks and guidelines for on-grid EVs operation in Tonga
	Capacity to establish an evidenced based data collection and analysis	5	Institutionalization of data collection and analysis of data Enhancing transport data collection and management	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions

	Minimum consultation with local stakeholders on on-grid EVs	5	Public Awareness Programs on on-grid EVs	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions
	Lack of comprehensive coordination of data collection for policy development	5	Involvement of key stakeholders in data collection and analysis as well as production of evidenced based decision making	Ministry of Energy and Custom Department and Ministry of Finance . Ministry of Economic and Trade, Power Utility, Tonga Electricity Commission and Private vehicle dealers Companies and training institutions to discuss and identify possible ways to share data through comprehensive stakeholders coordination and to discuss and use such data to analyses evidences for decision making

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11 Annexes

11.1 Annex 1: WORKSHEETS FOR SCORING/SCALING BARRIERS

Table A: Financial and Fiscal Barriers and Score for the Diffusion of Utility On-Grid Solar Powered Generation

Technology: Utility On-Grid Solar Powered Generation		
Barrier Economic & Financial	Description	Score
Financial & Fiscal	• High upfront cost for solar equipment/parts: Panels, Batteries and Storage Capacity. • Local Tax Policy-Duty Free Diesel for Power Generation • Reliance and Dependence on donor funding/Lack of full cost recovery investment from Private Sector • Insufficient and Uncertain demand from the grid • Limited access to capital to finance utility scale solar project. • Inflation of prices triggered by increasing oil prices and other reasons • High perceived risk by investors in absence of government guarantee for payments and grid connectivity. • Economic feasibility due to subsidized cost of electricity to the consumer • Inflation due to Labour Shortage and cyclone recovery	

Table B: Non-Financial Barriers and score for the On-Grid Solar Powered Generation

TECHNOLOGY: Utility On-Grid Solar Powered Generation		Score
Policy, Regulatory, Legislative	• Permits, licensing issues, PPA contract. • Insufficient Legislative and Regulatory Aspects and specifics types of • Poor incentives/support mechanisms for the development does not exist to promote wide spread adoption.	

	• Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams. • Difficulty establishing Power Purchase Agreements (PPAs) due to Unclear Policy for regulation of PV	
Institutional capacity	• Insufficient Privatization Arrangements by Power Utility • Insufficient Grid connection agreements/arrangements to • Insufficient Development of Solar PPA with IPP contracts	
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations • Insufficient knowledge regarding RE power generation • Scarcity of spare parts due to lack of private sector investment • Insufficient battery storage leading to ,loss of revenue at night	
Market	• Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate. • Understanding factors that influenced supply and demand in Tonga • Tonga Market prices are highly vulnerable to oil prices fluctuation • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate.	

Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable • Capacity to establish an evidenced based data collection and analysis • Effective use of evidence to guide decision making • Lack of community involvement in solar installation decision making • Minimum consultation with local stakeholders on RE technologies • Lack of comprehensive coordination of data collection for policy development	

Table C: Prioritized Barriers for Utility On-Grid Solar Powered Generation

TECHNOLOGY: Utility On-Grid Solar Powered Generation		Score
Financial Barriers	• High upfront cost for solar equipment/parts: Panels, Batteries and Storage Capacity. • Local Tax Policy-Duty Free Diesel for Power Generation • Reliance and Dependence on donor funding/Lack of full cost recovery investment from Private Sector • Insufficient and Uncertain demand from the grid • Limited access to capital to finance utility scale solar project. • Inflation of prices triggered by increasing oil prices and other reasons • High perceived risk by investors in absence of government guarantee for payments and grid connectivity. • Economic feasibility due to subsidized cost of electricity to the consumer • Inflation due to Labour Shortage and cyclone recovery	
Policy, Regulatory, Legislative	• Permits, licensing issues, PPA contract. • Insufficient Legislative and Regulatory Aspects and specifics types of • Poor incentives/support mechanisms for the development does not exist to promote wide spread adoption.	

	• Insufficient tariffs and other direct and indirect financial supports roles to play in the viability of the technology deployment and affect revenues streams. • Difficulty establishing Power Purchase Agreements (PPAs) due to Unclear Policy for regulation of PV	
Institutional capacity	• Insufficient Privatization Arrangements by Power Utility • Insufficient Grid connection agreements/arrangements to • Insufficient Development of Solar PPA with IPP contracts	
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of solar installations • Insufficient knowledge regarding RE power generation • Scarcity of spare parts due to lack of private sector investment • Insufficient battery storage leading to ,loss of revenue at night	
Market	• Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate. • Understanding factors that influenced supply and demand in Tonga • Tonga Market prices are highly vulnerable to oil prices fluctuation • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate.	

Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable • Capacity to establish an evidenced based data collection and analysis • Effective use of evidence to guide decision making • Lack of community involvement in solar installation decision making • Minimum consultation with local stakeholders on RE technologies • Lack of comprehensive coordination of data collection for policy development	

Table D : Financial and Fiscal Barriers and Score for the Diffusion of Utility On-Grid Wind Powered Generation

Technology: Utility On-Grid Wind Powered Generation		
Barrier Economic & Financial	Description	Score
Financial & Fiscal	• Insufficient Access for Finance and lack of de-risking guarantees available • High upfront cost for wind equipment/parts. • Local Tax Policy-Duty Free for Government wind projects • Reliance and Dependence on donor funding/Lack of Access for Finance • Lack of Full cost recovery investment from Private Sector • Limited access to capital to finance utility scale solar project. • Inflation of prices triggered by increasing oil prices and other reasons • Economic feasibility due to subsidized cost of electricity to the consumer • Inflation due to Labour Shortage and cyclone recovery	

Table E: Non-Financial Barriers and Score for the Diffusion of Utility On-Grid Wind Powered Generation

TECHNOLOGY: Utility On-Grid Wind Powered Generation		Score
Policy, Regulatory, Legislative	• Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote wide spread adoption. • Unclear permitting process for wind power and electricity market design • Ineffective Public Policies leading to Infrastructure Development • Lack of Transparency in regulatory and monitoring activities • Difficulty establishing Power Purchase Agreements (PPAs) for wind due to Unclear Policy for regulation of PV	
Institutional capacity	• Insufficient Grid connection agreements/arrangements to • Insufficient Development of Wind PPA with IPP contracts • Unclear and low transparency of wind power project financing and permitting processes of wind power to the grid	
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of wind power installations • Insufficient knowledge regarding wind power generation • Scarcity of spare parts due to lack of private sector investment • Grid Stability and permitting process for wind power	

Market	• Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate. • Understanding factors that influenced supply and demand in Tonga • Tonga Market prices are highly vulnerable to oil prices fluctuation • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate.	
Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable • Capacity to establish an evidenced based data collection and analysis • Minimum consultation with local stakeholders on wind technologies • Lack of comprehensive coordination of data collection for policy development	

Table F: Prioritized Barriers for On-Grid Wind Power Generation

TECHNOLOGY: Utility On-Grid Wind Powered Generation		Score
Financial Barriers	• Insufficient Access for Finance and lack of de-risking guarantees available • High upfront cost for wind equipment/parts. • Local Tax Policy-Duty Free for Government wind projects • Reliance and Dependence on donor funding/Lack of Access for Finance	

	• Lack of Full cost recovery investment from Private Sector • Limited access to capital to finance utility scale solar project. • Inflation of prices triggered by increasing oil prices and other reasons • Economic feasibility due to subsidized cost of electricity to the consumer • Inflation due to Labour Shortage and cyclone recovery	
Policy, Regulatory, Legislative	• Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote wide spread adoption. • Unclear permitting process for wind power and electricity market design • Ineffective Public Policies leading to Infrastructure Development • Lack of Transparency in regulatory and monitoring activities • Difficulty establishing Power Purchase Agreements (PPAs) for wind due to Unclear Policy for regulation of PV	
Institutional capacity	• Insufficient Grid connection agreements/arrangements to • Insufficient Development of Wind PPA with IPP contracts • Unclear and low transparency of wind power project financing and permitting processes of wind power to the grid	
Technical	• Difficulty in site selection: for compatibility of infrastructure and distribution lines and time-consuming nature of wind power installations • Insufficient knowledge regarding wind power generation • Scarcity of spare parts due to lack of private sector investment • Grid Stability and permitting process for wind power	

Market	• Complexity in technical aspects such as plant design, and energy yield are directly linked to with efforts to access to permits/licenses and financing • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate. • Understanding factors that influenced supply and demand in Tonga • Tonga Market prices are highly vulnerable to oil prices fluctuation • Limited feasibility studies to understand key requirements need for utility scale deployment and the efficiency gains of the technology in current climate.	
Information & Public Awareness	• Insufficient data to support fixed tariff for all and insufficient data to support a tariff level that is affordable for users and profitable • Capacity to establish an evidenced based data collection and analysis • Minimum consultation with local stakeholders on wind technologies • Lack of comprehensive coordination of data collection for policy development	

Table G: Fiscal and Financial Barriers and Score for the Diffusion of the energy efficient home appliances

Technology: Energy Efficient Home Appliances		
Barrier Economic & Financial	Description	Score

Financial & Fiscal	• Insufficient Access for Finance and lack of de-risking guarantees available • High upfront cost for small and remote market. • Local Tax Policy-Duty Free for Government wind projects • Reliance and Dependence on donor funding/Lack of Access for Finance • Lack of Full cost recovery investment from Private Sector • Inflation of prices triggered by increasing oil prices and other reasons	

Table H: Non-Financial Barriers and Score for the Diffusion of the energy efficient home appliances

TECHNOLOGY: Energy Efficient Home Appliances		Score
Policy, Regulatory, Legislative	• Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote wide spread adoption. • Absence of Energy Efficiency Legislation • Ineffective Public Policies leading to adoption of energy efficient home appliances • Lack of regulatory and monitoring activities on energy efficient home appliances	
Institutional capacity	• Insufficient Capacities in Energy Institution • Lack of technical and management capacity • Lack of training capacity for business management • No entity with mandate and capacity to oversee electricity and petroleum • Need for clear and effective institutional arrangements • Lacks of guidelines, milestones and performance benchmarks • Insufficient institutions and mechanisms to address threats of climate change	

Technical	• Insufficient knowledge regarding energy efficient home appliances • Scarcity of spare parts due to lack of private sector investment • Lack of experiences with energy efficient home appliances • building design, appliance use, and energy consumption behavior revolving around cheap and low energy efficiency appliances	
Market	• Complexity in technical aspects such as appliances design, and energy consumption • Limited feasibility studies to understand key requirements need energy efficient home appliances • Understanding factors that influenced supply and demand in Tonga • challenges in accessing rural sites • Need to confirm environmental viability of In-depth analysis of contribution of energy efficiency in the demand side to align with NDC, TERM ,SDG • Lack of knowledge on opportunities and Challenges for EE investments	
Information & Public Awareness	• Capacity to establish an evidenced based data collection and analysis • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development • Lack of information and knowledge on energy efficiency	

Table I: Prioritized Barriers for Energy Efficient Home Appliances

TECHNOLOGY: Energy Efficient Home Appliances		Score
Financial	• Insufficient Access for Finance and lack of de-risking guarantees available • High upfront cost for small and remote market. • Local Tax Policy-Duty Free for Government wind projects	

	• Reliance and Dependence on donor funding/Lack of Access for Finance • Lack of Full cost recovery investment from Private Sector • Inflation of prices triggered by increasing oil prices and other reasons	
Policy, Regulatory, Legislative	• Insufficient Legislative and Regulatory Aspects and specifics types of incentives/support mechanisms for wind development does not exist to promote wide spread adoption. • Absence of Energy Efficiency Legislation • Ineffective Public Policies leading to adoption of energy efficient home appliances • Lack of regulatory and monitoring activities on energy efficient home appliances	
Institutional capacity	• Insufficient Capacities in Energy Institution • Lack of technical and management capacity • Lack of training capacity for business management • No entity with mandate and capacity to oversee electricity and petroleum • Need for clear and effective institutional arrangements • Lacks of guidelines, milestones and performance benchmarks • Insufficient institutions and mechanisms to address threats of climate change	
Technical	• Insufficient knowledge regarding energy efficient home appliances • Scarcity of spare parts due to lack of private sector investment • Lack of experiences with energy efficient home appliances • building design, appliance use, and energy consumption behavior revolving around cheap and low energy efficiency appliances	

Market	• Complexity in technical aspects such as appliances design, and energy consumption • Limited feasibility studies to understand key requirements need energy efficient home appliances • Understanding factors that influenced supply and demand in Tonga • challenges in accessing rural sites • Need to confirm environmental viability of In-depth analysis of contribution of energy efficiency in the demand side to align with NDC, TERM ,SDG • Lack of knowledge on opportunities and Challenges for EE investments	
Information & Public Awareness	• Capacity to establish an evidenced based data collection and analysis • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development • Lack of information and knowledge on energy efficiency	

Table J: Financial Barriers and Score for the Diffusion of the Battery powered Electric Vehicle

Technology: Battery Powered Electric Vehicle		
Barrier Economic & Financial	Description	Score

Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • acquisition costs have been identified as major market restraints • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new policy interventions are currently in place • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	

Table K: Non-Financial Score for the Diffusion of the Battery powered Electric Vehicle

TECHNOLOGY: Battery Powered Electric Vehicle		Score
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on EVs • policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid • policies has the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and	

	standards, and the absence of endorsed regional or national e-mobility strategies	
Institutional capacity	• knowledge production • reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV • lengthy charging times can further impact the reliability of charging • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning	
Technical	• maintenance course development for technicians, and Independent companies • inadequate maintenance of transportation infrastructure contribute to high emissions • safety of electric vehicles (EVs) and charging infrastructure • concerns about EV models and battery safety • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • the use of cars with large engines and low efficiency • Encouraging the adoption of Hybrid Electric Vehicles	
Market	• Necessity of decentralizing services • Driving range, which frequently raises concerns • The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of EV models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties • Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	

Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of EVs • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries • Capacity to establish an evidenced based data collection and analysis • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	

Table L: Prioritized Barriers for Battery Powered Electric Vehicle

TECHNOLOGY: Battery Powered Electric Vehicle		Score
Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • acquisition costs have been identified as major market restraints. • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new policy interventions are currently in place. • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits	
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on EVs	

	• policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. • policies have the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies	
Institutional capacity	• knowledge production • reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning	
Technical	• maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • concerns about EV models and battery safety • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • the use of cars with large engines and low efficiency • Encouraging the adoption of Hybrid Electric Vehicles	

Market	• Necessity of decentralizing services • Driving range, which frequently raises concerns. • The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of EV models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints	
Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of EVs. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	

TableM: Financial Barriers and Score for the Diffussion of the Hybrid Vehicle

Technology: Hybrid Vehicle		
Barrier Economic & Financial	Description	Score

Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new financial policy interventions are currently in place. • EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits.	

TableN: Non-Financial Score for the Diffussion of the Hybrid Vehicle

TECHNOLOGY: Hybrid Vehicle		Score
Policy, Regulatory, Legislative	• Current uncertainties in Policies, Regulation and Legislation have been identified as significant constraints in the market. • Lack of planning, policy work, and policy actions for hybrid vehicles • potential conflict between the adoption of Hybrid and certain NDC targets • Policies such as Reduced import taxes on Hybrid Vehicle • Policies has the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems	
Institutional capacity	• reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use	

Technical	• Maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • Encouraging the adoption of Hybrid Electric Vehicles	
Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of HYBRID models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped Hybrid industry in the country is also cited as significant market restraints	
Information & Public Awareness	• Insufficient knowledge and familiarity concerning the safety and performance of Hybrid Vehicles • Capacity to establish an evidenced based data collection and analysis of Hybrid Vehicles • Minimum consultation with local stakeholders on Hybrid Vehicles • Lack of comprehensive coordination of data collection for policy development	

Table O: Prioritized Barriers for Hybrid Vehicle

TECHNOLOGY: Hybrid Vehicle		Score
Financial & Fiscal	• high upfront costs due to the expensive manufacturing process • upfront costs, fuel/charging costs, maintenance costs, and environmental costs • no new financial policy interventions are currently in place.	

	• EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits. •	
Policy, Regulatory, Legislative	• Current uncertainties in Policies, Regulation and Legislation have been identified as significant constraints in the market. • Lack of planning, policy work, and policy actions for hybrid vehicles • potential conflict between the adoption of Hybrid and certain NDC targets • Policies such as Reduced import taxes on Hybrid Vehicle • Policies has the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems	
Institutional capacity	• reliance on charging infrastructure availability • scarcity of charging points can deter consumers from considering purchasing an EV. • lengthy charging times can further impact the reliability of charging. • limited availability of fast charging stations for public use	
Technical	• Maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • new technology and limited expertise in service centres • lack of expert assistance when encountering technical issues • Encouraging the adoption of Hybrid Electric Vehicles	

Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of HYBRID models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped Hybrid industry in the country is also cited as significant market restraints	
Information & Public Awareness	• Insufficient knowledge and familiarity concerning the safety and performance of Hybrid Vehicles • Capacity to establish an evidenced based data collection and analysis of Hybrid Vehicles • Minimum consultation with local stakeholders on Hybrid Vehicles • Lack of comprehensive coordination of data collection for policy development	

TableP: Financial Barriers and Score for the Diffussion of the On-Grid Electric Vehicle

Technology: On-Grid Electric Vehicle		
Barrier Economic & Financial	Description	Score

Financial & Fiscal	• high upfront costs • acquisition costs have been identified as major market restraints. • no new policy interventions are currently in place. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations. • policies that ensure that On-Grid EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	

TableQ: Non-Financial Barriers and Score for the Diffussion of the On-Grid Electric Vehicle

TECHNOLOGY: On-Grid Electric Vehicle		Score
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. • lack of planning, policy work, and policy actions for electric vehicles • potential conflict between the adoption of EVs and certain NDC targets • Policies such as Reduced import taxes on technology • Policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an On-Grid EV market. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid	
Institutional capacity	• knowledge production • reliance on charging infrastructure availability • limited availability of fast charging stations for public use • incorporating renewable energy-based transport systems into the long-term planning incorporating renewable energy-based transport systems into the long-term planning	

Technical	• absence of Hybrid Vehicle regulations and standards, and the absence of endorsed regional or national e-mobility strategies. • maintenance course development for technicians, and independent companies • inadequate maintenance of transportation infrastructure contributes to high emissions • safety of electric vehicles (EVs) and charging infrastructure • new technology and limited expertise in service centres • Encouraging the adoption of Hybrid Electric Vehicles	
Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes • The limited availability of On-grid models and designs further hinders adoption, • Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties. • Underdeveloped industry is also cited as significant market restraints	
Information & Public Awareness	• Novelty of On-Grid electric vehicle (EV) technology and its limited adoption among certain demographics • Insufficient knowledge and familiarity concerning the safety and performance of on-grid electric vehicles. • Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries. • Capacity to establish an evidenced based data collection and analysis. • Minimum consultation with local stakeholders on energy efficient home appliances • Lack of comprehensive coordination of data collection for policy development	

TableR: Enabling Environment (RED FONT) for Prioritized Barriers (BLACK FONT) for Battery Powered Electric Vehicle

TECHNOLOGY: Battery Powered Electric Vehicle		Score

Financial & Fiscal	• high upfront costs due to the expensive manufacturing process
	  ○ Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles
	  ○ incentives primarily come in the form of tax reductions or exemptions.
	  ○ countries apply various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade to make EV imports more affordable and attractive.
	  ○ The exemption of vehicle registration or import fees is suggested as a targeted policy for particular groups that would derive the most benefit from a reduction in vehicle prices.
	• acquisition costs have been identified as major market restraints.
	  ○ Offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles
	• upfront costs, fuel/charging costs, maintenance costs, and environmental costs
	  ○ offering incentives or subsidies for charging stations in specific areas
	• no new policy interventions are currently in place.
	  ○ formalize the policy package for charging station locations in an official strategic document.
	• EVs are not economically viable in most Pacific Island Countries due to their higher upfront costs and limited environmental benefits.
	  ○ reduced or free EV charging at public charging stations, including battery swap stations if applicable, to encourage early EV adoption and investment in public charging infrastructure	

Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. ○ Develop coordinated policies. • lack of planning, policy work, and policy actions for electric vehicles	

	○ Setting targets and mandates for EV uptake, as well as developing a national policy on implemented EVs actions. • potential conflict between the adoption of EVs and certain NDC targets ○ promoting non-motorized and cycling transport options, along with encouraging public adoption of 50% EVs, can contribute to sustainable transportation targets. • Policies such as Reduced import taxes on EVs ○ incentivize the adoption of economically viable EV types that offer societal and environmental benefits, such as providing tax breaks. • policies aim to reduce GHG emissions by improving vehicle fuel economy, diversifying transportation modes, and developing an EV market. ○ Transitioning to Low Emissions Vehicles • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. ○ implementation of an EV insurance policy • policies have the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions ○ In order to accelerate industry growth and charging infrastructure development, a decisive policy push is necessary. • policy framework could be adapted for use in other Pacific Island nations, tailored to suit their specific transportation systems. ○ implementing the 26 policy recommendations for Pacific Island Countries (select the most priority policies to start with • lack of charging infrastructure, limited EV financing options and subsidies, absence of EV regulations and standards, and the absence of endorsed regional or national e-mobility strategies. ○ standardizing a battery passport, establishing centralized recycling facilities, and collaborating with international shipping partners	
Institutional capacity	• knowledge production ○ introduction of Electric Vehicles (EVs) in the municipal government fleet can help reduce institutional barriers.	

	• reliance on charging infrastructure availability
	  ○ Government/Donors are providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV technology solutions and technology transfer, as well as supplying battery systems and other EV components.
	• scarcity of charging points can deter consumers from considering purchasing an EV.
	  ○ providing finance for charging infrastructure and other EV-related initiatives, offering innovative EV technology solutions and technology transfer, as well as supplying battery systems and other EV components
	• lengthy charging times can further impact the reliability of charging.
	  ○ the adoption of electric vehicles and vehicle-to-grid services can be particularly advantageous.
	• limited availability of fast charging stations for public use
	  ○ model these simpler systems, especially in the early stages of vehicle-to-grid development.
	• incorporating renewable energy-based transport systems into the long-term planning
	  ○ Forming a regional EV hub with representatives from both local and regional programs can facilitate collaboration and support for appropriate EV actions and programs.
	• Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations.
	  ○ education programs focused on developing maintenance capabilities for EVs in Tonga should be coordinated	

Technical	• maintenance course development for technicians, and independent companies
	• inadequate maintenance of transportation infrastructure contributes to high emissions
	  ○ Ensuring sustainable maintenance of all vehicles
	  ○ invest in solar generation and promote daytime EV charging through incentives like time-of-use tariffs and workplace charging infrastructure.	

	• safety of electric vehicles (EVs) and charging infrastructure
	  ○ decentralizing services from urban to rural areas to alleviate traffic congestion.
	• concerns about EV models and battery safety
	  ○ implementing vehicle standards and providing incentives for more efficient vehicles through tax breaks, fees, and import tariffs.
	• new technology and limited expertise in service centres
	  ○ The government of Tonga should formally adopt the AC Type 2 standard for public Mode 3 stations and DC CCS Type 2 standard for Mode 4 stations.
	• lack of expert assistance when encountering technical issues
	  ○ Tonga could benefit from using the EV Charging and Grid Integration Tool developed by the IEA to assess the grid impacts of EVs and implement strategies to mitigate these impacts.
	• the use of cars with large engines and low efficiency
	  ○ Enhancing the efficiency of engine operations	

Market	• Necessity of decentralizing services
	  ○ Potential locations in Tonga could encompass Fua‘amotu International Airport, Vuna Wharf, the Western Bus Terminal, Vaiola Hospital, the Royal Tombs area, a potential future P&R lot (Section 3.5), and major churches
	• Driving range, which frequently raises concerns.
	  ○ access service" interpretation would permit other entities to own and operate EV chargers, procuring electricity from Tonga Power Limited at wholesale rates and retailing it to consumers.
	• The lack of a comprehensive review of motivators and barriers in decision-making processes
	  ○ By commencing with EV chargers at government facilities, Tonga's ministries can familiarize themselves with the infrastructure and capitalize on their investment by concurrently transitioning their fleets to electric vehicles (this would also facilitate EV education initiatives	

	• The limited availability of EV models and designs further hinders adoption.
	  ○ The concept of an "electricity delivery service" for EV charging would likely entail that the ownership and operation of EV chargers would be under the jurisdiction of the national electric utility, Tonga Power Limited
	• Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties.
	  ○ as an incentive for private enterprises engaged
	• Underdeveloped EV industry and limited charging infrastructure in the country are also cited as significant market restraints.
	  ○ specific percentage of imports based on the available resources of the Ministry of Revenue to assess EVs import	

Information & Public Awareness	• Novelty of electric vehicle (EV) technology in several nations and its limited adoption among certain demographics
	  ○ Enhancing transport data collection and management
	  ○ Promoting awareness and adoption of EVs and associated measures, while monitoring international advancements and staying updated on relevant global technologies.
	• Insufficient knowledge and familiarity concerning the safety and performance of EVs.
	  ○ Raising consumer awareness through a public information campaign to promote electromobility, and increasing developer awareness by establishing construction requirements for EV charging stations.
	  ○ Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector.
	• Potential explosions in extreme circumstances or the potential risks associated with the unique components of EV batteries.
	  ○ The public information campaign can also educate EV operators on how to charge their vehicles at public stations and at home, as the charging procedures with tethered and untethered cables vary slightly	

TableS: Enabling Environment for Prioritized Barriers of the Hybrid Vehicle

TECHNOLOGY: Hybrid Vehicle		Score

Financial & Fiscal	• high upfront costs due to the expensive manufacturing process
	  ○ Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles
	  ○ incentives primarily come in the form of tax reductions or exemptions.
	• no new financial policy interventions are currently in place.
	  ○ incentives primarily come in the form of tax reductions or exemptions.	

Policy, Regulatory, Legislative	• Current uncertainties in Policies, Regulation and Legislation have been identified as significant constraints in the market.
	  ○ Develop coordinated policies.
	• Lack of planning, policy work, and policy actions for hybrid vehicles
	  ○ Setting targets and mandates for hybrid vehicle uptake, as well as developing a national policy on implemented hybrid vehicle actions.
	• Policies such as Reduced import taxes on Hybrid Vehicle
	  ○ incentivize the adoption of economically hybrid vehicle that offer societal and environmental benefits, such as providing tax incentives.
	• Policies has the potential to enhance Tonga's land transportation system by making it safer, less congested, more equitable, and more resilient, while also reducing greenhouse gas emissions
	  ○ In order to accelerate industry growth and hybrid vehicle infrastructure development, a decisive policy push is necessary	

Institutional capacity	• Institutional capacity and knowledge production ○ introduction of Hybrid Vehicles in the municipal government fleet can help reduce institutional barriers. • Policy, regulatory, and legal obstacles stemming from the necessity to enforce existing regulations.	

	○ education programs focused on developing maintenance capabilities for Hybrid Vehicle in Tonga should be coordinated. • Lack of institutional capacity on hybrid vehicle can deter consumers from considering purchasing a hybrid vehicle ○ providing finance for hybrid vehicle-related initiatives, offering innovative solutions and technology transfer, as well as supplying spare parts and other components of hybrid vehicle	
Technical	• Maintenance course development for technicians, and Independent private companies ○ On-site training on sustainable maintenance of all vehicles • inadequate maintenance of transportation infrastructure contributes to high emissions ○ Ensuring sustainable maintenance of all vehicles • new technology and limited expertise in service centres ○ Specific Training Courses and Introduction of hybrid vehicle knowledge and materials in school syllabus ○ Encouraging the adoption of Hybrid Electric Vehicles • lack of expert assistance when encountering technical issues ○ Add services of hybrid vehicles to the core services of the existing service stations	
Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes ○ By commencing with adoption of hybrid vehicle at government facilities, Tonga's ministries can familiarize themselves with the hybrid vehicle infrastructure and capitalize on their investment. • The limited availability of HYBRID models and designs further hinders adoption. ○ The concept of a private companies delivery service" for hybrid vehicle dealers would likely entail that the ownership and operation of electric vehicle services would be under the jurisdiction of the well-known vehicle dealers companies	

	• Viability of hybrid cars and trucks to comply with federal fuel economy and emissions standards and avoid costly penalties.
	  ○ as an incentive for private enterprises engaged
	• Underdeveloped Hybrid industry in the country is also cited as significant market restraints
	  ○ specific percentage of hybrid vehicle imports based on the available resources of the Ministry of Revenue and Ministry of Infrastructure to assess Hybrid Vehicle import	

Information & Public Awareness	• Insufficient knowledge and familiarity concerning the safety and performance of Hybrid Vehicles
	  ○ Raising consumer awareness through a public information campaign to promote hybrid vehicle, and increasing developer awareness by establishing construction requirements for Hybrid vehicle operations and maintenance.
	  ○ Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector.
	• Capacity to establish an evidenced based data collection and analysis of Hybrid Vehicles
	  ○ Coordinated and Effective Institutionalization of data collection, analysis and reporting of evidenced based analyse information and statistics
	• Minimum consultation with local stakeholders on Hybrid Vehicles
	  ○ Public Talk and Involvement on hybrid vehicle maintenance services and operations
	• Lack of comprehensive coordination of data collection for policy development
	  ○ Institutionalization of data collection and analysis	

TableS: Enabling Environment for Prioritized Barriers for On-Grid Electric Vehicle

TECHNOLOGY: On-Grid Electric Vehicle		Score
Financial and Fiscal Barriers	• high upfront costs due to new insfrastructures ○ Enhancing Financial Risk Management to Overcome Fiscal and Financial Obstacles	

	○ incentives primarily come in the form of tax reductions or exemptions. ○ countries apply various incentives such as import duties, customs taxes, excise taxes, and other tariffs related to international trade to make on-grid electric vehicles infrastructure imports more affordable and attractive. ○ The exemption of vehicle registration or import fees is suggested as a targeted policy for particular groups that would derive the most benefit from a reduction in vehicle prices. • acquisition costs have been identified as major market restraints. ○ Offering incentives to reduce upfront costs is crucial, as the price difference between electric vehicles • no new policy interventions are currently in place. ○ formalize the policy package for on-grid EV in an official strategic document. • policies that ensure that On-Grid EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. ○ formalize the policy package for on-grid EV in an official strategic document	
Policy, Regulatory, Legislative	• current uncertainties in policies, have been identified as significant constraints in the market. ○ Develop coordinated policies. • lack of planning, policy work, and policy actions for electric vehicles ○ Setting targets and mandates for on-grid EV uptake, as well as developing a national policy on implemented EVs actions. • Policies such as Reduced import taxes on technology ○ incentivize the adoption of economically viable EV types that offer societal and environmental benefits, such as providing tax breaks. • policies that ensure that EVs and charging are safe, accessible, affordable, and have minimal or positive impacts on the electricity grid. ○ implementation of an EV insurance policy	
Institutional capacity	• knowledge production ○ introduction of Electric Vehicles (EVs) in the municipal government fleet can help reduce institutional barriers. • reliance on charging infrastructure availability ○ 24 hours services on-grid EV	

	• limited availability of fast charging stations for public use
	  ○ model these simpler systems, especially in the early stages of vehicle-to-grid development.
	• incorporating renewable energy-based transport systems into the long-term planning incorporating renewable energy-based transport systems into the long-term planning
	  ○ Forming a regional EV hub with representatives from both local and regional programs can facilitate collaboration and support for appropriate EV actions and programs.	

Technical	• absence of Vehicle regulations and standards, and the absence of endorsed regional or national e-mobility strategies.
	  ○ Develop Standard for on-Grid Electric Vehicle
	• inadequate maintenance of transportation infrastructure contributes to high emissions
	  ○ Ensuring sustainable maintenance of all vehicles
	  ○ invest in solar generation and promote daytime EV charging through incentives like time-of-use tariffs and workplace charging infrastructure.
	  ○ maintenance course development for technicians, and independent companies
	• new technology and limited expertise in service centres
	  ○ Government of Tonga and Private Companies to to formally adopt the right model of on-grid vehicle.
	  ○ Tonga could benefit from using the EV Charging and Grid Integration Tool developed by the IEA to assess the grid impacts of EVs and implement strategies to mitigate these impacts.
	  ○ Promotion and encouraging the adoption of on-grid Electric Vehicles	

Market	• The lack of a comprehensive review of motivators and barriers in decision-making processes ○ Government review of market barriers and existing decision-making processes for on-grid vehicle	

	• The limited availability of On-grid models and designs further hinders adoption,
	  ○ Government Ministries and Private Sector Companies to jointly discuss the issues and come up with solutions.
	• Viability of on-grid EV to comply with federal fuel economy and emissions standards and avoid costly penalties.
	  ○ as an incentive for private enterprises engaged
	• Underdeveloped industry is also cited as significant market restraints.
	  ○ Multi-stakeholders' decision making processes on the issue	

Information & Public Awareness	• Novelty of On-Grid electric vehicle (EV) technology and its limited adoption among certain demographics
	  ○ Enhancing transport data collection and management
	  ○ Promoting awareness and adoption of EVs and associated measures, while monitoring international advancements and staying updated on relevant global technologies.
	• Insufficient knowledge and familiarity concerning the safety and performance of on-grid electric vehicles.
	  ○ Raising consumer awareness through a public information campaign to promote electromobility, and increasing developer awareness by establishing construction requirements for EV charging stations.
	  ○ Enhancing the collection and management of energy data to support the development of comprehensive energy information, particularly for the transport sector.
	• Capacity to establish an evidenced based data collection and analysis.
	  ○ Institutionalization of data collection and analysis of data
	• Minimum consultation with local stakeholders on on-grid EVs
	  ○ Public Awareness Programs on on-grid EVs
	• Lack of comprehensive coordination of data collection for policy development
	  ○ Involvement of key stakeholders in data collection and analysis as well as production of evidenced based decision making.	

Annex 2: Participants List for 2 days BAEF Mitigation Worksh

TNA BAEF WORKSHOP SIGNUP SHEET 16th May 2024

	Name	Gender (Male/Female)	Organization	Email
1	Filimone Fifita	M	Dept Energy	manefifita@gmail.com
2	Ofa Sefana	M	~ ~	ofasefana@yahoo.com.
3	Moses. M. Vaipulu	M	TEC	m_vaipulu@yahoo.com
4	Melisieni Vaikona	F	TCCI	melisieni@tongachamber.to
5	Rameez Rafiq	M.	Spare Parts Zone	razak@spareparts2one.to
6	Sione Tuki	M	Dept of Env	mutitiloz96@gmail.com
7	Samoni Tupou	M	DCC	samoniammunitupou@gmail.com
8	Patelisio Hoponoa	M	ICAT - DCC	patelisio hoponoa@gmail.co
9	Maria . Vuni	F	DCC - ICAT	helenavuni96@gmail.com
10	TEVITA TUKUAFU	M	Consultant	
11	Alifeleti Lyneta	M	CUSTOMS	feleti189@gmail.com
12	Fiva Tuionetoa	M	TPL	fiuionetoa@tongaports.to
13	Ifalemi Mau	M	Pacific Energy	ifalemi.mau14@gmail.com
14	GATTON TONGA	M	Dept of Climate Change	kstonga@gmail.com
15	Pipiena Tavale	F	MoRC	ptavale@revenue.gov.to
16	Tevita Pakavi	M	TOTAL ENERGIES	tevita.pakavi@totalenergies.com
17	Sosefo Tofu	M	Dept of Energy / PCREEE	sosefo.tofu@gmail.com
18	Tevita Kalisi	M	Kalisi	Tevitakalisi@gmail.com
19	Siale Hola	M	NECAT	sialehola@gmail.com.
20	Lano Fonua	M	GGGI	lano.fonua@gmail.com
21	SIONE MISI	M	DOE - MEIDECC	sionefinisi93@gmail
22	Tupou Tevi	F	DOE - MEIDECC	tevitupou@gmail.com
23	Sam Matakaiongo	M	✓	sam.matakai@gmail.com
24	Kafoluna Lui	F	✓	[illegible]
25	Winnie Laumaka	F	✓	[illegible]
26	Eliate Tonkinpeesiha	M.	✓	[illegible]
27	Mele Mcleod	F	—	melelupe.mcleod94@gmail.com

1

	Name	Gender (Male/Female)	Post/Workplace	Email
28	Leeveva Ulakoto	F	MEIDECC	[illegible]
29	Vilisaki Taufatofua	M	MEIDECC	Taufatofuavilisaki@gmail.com
30	Sione Finau	M	MEIDECC	[illegible]

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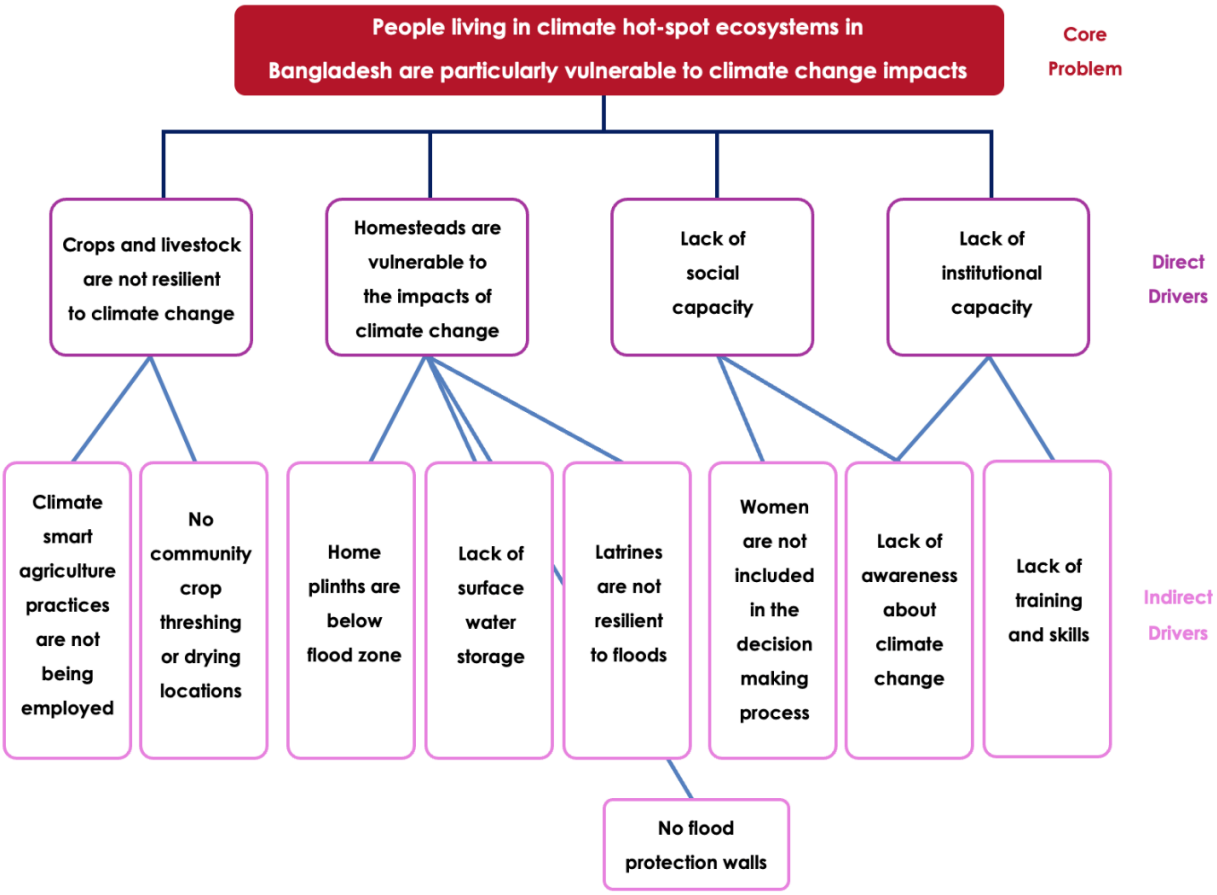
11.2 Annex 3: Problem Tree



TNA BAEF WORKSHOP SIGNUP SHEET 17th May 2024

	Name	Gender (Male/Female)	Organization	Email
1	Rameez Rafiq	M	Spare Parts Zone	razak@sparepartszone.to
2	Sosefo Tofu	M	DoE / PEREEE	sosefo.tofu@gmail.com
3	Mosese . M . Vaipulu	M	TEC	m-vaipulu@yahoo.com
4	Tevita Palavi	M	TOTAL ENERGIES	tevita.palavi@totalenergies.com
5	'Eleiate Laulaupeaalu	M	DoE	[illegible]@gmail.com
6	Finenla Tu'ionetoa	M	TPL	ftuionetoa@gmail.com
7	Sandra F	F	MTED	sandraf@mted.gov.to
8	Pipiena Tanaki	F	MoRC	ptanaki@revenue.gov.to
9	Maria Vuni	F	CCD - ICAT PROJECT	helenavuni76@gmail.com
10	Melisieni Vaitom	F	TCCI	melisieni@tongachamber.to
11	Alifeleti [illegible]	M	Customs	feleti189@gmail.com
12	Feauini Laumanu	F	Energy Department	feauinive@yahoo.com
13	Ifalemi Mau	M	Pacific Energy	ifalemi.mau[illegible]@gmail.com
14	Filimone Fifita	M	DOE	monefifita@gmail.com
15	Samisoni [illegible]	M	DCC	samisoni.[illegible]@gmail.com
16	Sam Matakaionga	M	DEPARTMENT OF ENERGY	sam.matakai@gmail.com
17	Mele Mcleod	F	"	melelupe.mcleod[illegible]@gmail
18	'Opeti Moala	M	"	opetimoala32@gmail.com
19	Lavinia Malolo	F	"	[illegible]@gmail.com
20	Kipola Sa'itanga	M	"	kipolasaitanga@gmail.com
21	Tupou Devi	F	"	tevitupou@gmail.com
22	Vilipatu Taufakelele	M	"	taufakelevilipatu@gmail.com
23	Palelesio Hoponoa	M	ICAT - DCC	hoponoap@gmail.com
24	Tevita Tukunga	M	Consultant	ttukunga@gmail.com
25	Tevita Kalu	M	Kalu	tevitakalu@gmail.com
26	Siale Hola	M	MCAT	sialehola[illegible]@gmail.com
27	'Ofa Sefana	M	DOE	ofa.sefana@yahoo.com

1

	Name	Gender (Male/Female)	Post/Workplace	Email
28	Gaston Tonga	M	DCC	[illegible]tonga@gmail.com
29	Lano Fonua	M	GGGI	lano.fonua@gmail.com
30	Sione Fusitu'a	M	MEIDECC	s[illegible]@yahoo.com

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