Solomon Islands
Ministry of Mines, Energy and Rural Electrification
Solomon Power

Data Collection Survey
on
the Promotion of Renewable Energy
in Solomon Islands

Final Report

March 2019

Japan International Cooperation Agency
(JICA)

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Tokyo Electric Power Services Co., Ltd.

IL
JR
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Location Map

Source: Prepared by JICA Survey Team based on UN Geospatial Information Section and UN Solomon Islands Country Facts

Data Collection Survey
on the promotion of RE in Solomon Island
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Abbreviation

ACT	:	Australian Capital Territory
ADB	:	Asian Development Bank
AFC	:	Automatic Frequency Control
AP3F	:	Asian-Pacific Project Preparation Facility
AusAID	:	Australian Agency for International Development
BEV	:	Battery Electric Vehicle
BU	:	Backup
CAPEX	:	Capital Expenditure
CB	:	Circuit Breaker
CBSI	:	Central bank of Solomon Islands
COI	:	Certificate of Incorporation
CP	:	Cash-power
EAC	:	Energy Advisory Committee
ECD	:	environment and Conservation Division
EDCF	:	Economic Development Cooperation Fund
EIA	:	Environment Impact Assessment
ERU	:	Economic Reform Unit
EV	:	Electric Vehicle
FIC	:	Foreign Investment Certificate
FID	:	Foreign Investment Division
GCF	:	Green Climate Fund
GDP	:	Gross Domestic Product
GHG	:	Greenhouse Gas
GoJ	:	Government of Japan
HEC	:	Hyundai Engineering Company
HO	:	Head Office
ICCT	:	International Council on clean Transportation
IDA	:	International Development Association
IMF	:	International Monetary Fund
IPP	:	Independent Power Producer
IRD	:	Inland Revenue Department
IRENA	:	International Renewable Energy Agency
IRR	:	Internal Rate of Return
ISIA	:	Institute of Solomon Islands Accountants
JICA	:	Japan International Cooperation Agency
KW	:	Korean Water Resources Corporation

MCILI	:	Ministry of Commerce, Industry, Labor and Immigration
MDPAC	:	Ministry of Development Planning and Aid Coordination
MECCDMM	:	Ministry of Environment, Climate Change, and Disaster Management and Metrology
MID	:	Ministry of Infrastructure and Development
MIGA	:	Multilateral Investment Guarantee Agency
MLHS	:	Ministry of Lands, Housing & Survey
MMERE	:	Ministry of Mines, Energy and Rural Electrification
MOFT	:	Ministry of Finance and Treasury
MOU	:	Minutes of Discussion
NDC	:	National Development Contribution
NEXI	:	Nippon Export and Investment Insurance
NTF	:	National Transport Fund
PAYE	:	Pay As You Earn
PHEV	:	Plug-in Electric Vehicle
PPP	:	Public-Private Partnership
PV	:	Photovoltaic
RE	:	Renewable Energy
RESIP	:	Renewable Energy Strategies & Investment Plan
ROW	:	Right of Way
SAIDI	:	System Average Interruption Duration Index
SAIFI	:	System Average Interruption Frequency Index
SBD	:	Solomon Islands Dollar
SCADA	:	Supervisory Control and Data Acquisition
SI	:	Solomon Islands
SIBR	:	Solomon Islands Business Registry
SIEA	:	Solomon Islands Electricity Authority
SIEAREEP	:	Solomon Islands Electricity Access and Renewable Energy Expansion Project
SIG	:	Solomon Island Government
SINEP	:	Solomon Island National Energy Policy
SINEPSP	:	Solomon Islands national Energy policy and strategic Plan
SINPF	:	Solomon Islands National Provident Fund
SIPA	:	Solomon Islands Port Authority
SOE	:	State-Owned enterprise
SP	:	Solomon Power
SVR	:	Step-Voltage-Regulator
SW	:	Solomon Water
T/L	:	Transmission Lines

THL	:	Tina Hydropower Limited
TIN	:	Tax Identification Number
TOU	:	Time of Use
UAE	:	United Arab Emirates
VFM	:	Value For Money
WB	:	World Bank

1 Introduction

1. Introduction

1.1. Background of the Survey

1.1.1. General

The Solomon Islands Government (SIG) requested the government of Japan (GoJ) a technical cooperation of “The Project for Formulating Renewable Energy Road Map” (the Project), whose target is to establish a road map toward renewable energy (RE) 100 % by 2030 in the Honiara Grid. In order to pursue the establishment of the road map, various technical aspects and investment environments have to be studied to reach the challenging goal. Considering the above, the Japan International Cooperation Agency (JICA) determined to conduct the Data Collection Survey on the Promotion Energy in Solomon Islands (the Survey) from November 2018 to March 2019.

1.1.2. Socio-Economic Situation

Solomon Islands (SI) is located in the South Pacific Ocean, and its land area is about 28,900km^2. The population of SI is about 610,000 in 2017; 15% of them resides on Guadalcanal island, where Honiara, the capital city, is located and the rest are on outer islands. The Gross Domestic Product (GDP) and the economic growth rate were 1.303 billion USD and 3.2% in 2017 respectively. The range of the temperature in Honiara is from 23 to 31 degrees Celsius throughout the year. Monsoon brings heavy rainfalls to Honiara from March to December (rainy season) while dry season is from June to September. Bulk transportation from Guadalcanal to outer islands relies mainly on marine transportation and its expenditure is fluctuating with import price of fuel. Therefore, development of outer islands is relatively behind to Guadalcanal. Electrification rate in rural is also affected, which is 12% nationwide, while that in Honiara is about 64%.

1.1.3. Electricity Cost and Security

SI supplies electricity mainly with diesel generators utilizing imported fuel due to the lack of natural resources, poor grid network and small scale of demand. Therefore, the generation cost of electricity is affected by import price of fuel and the electricity tariff is set as significantly high price, which is 65USc/kWh (72JPY) as of 2017, to secure resilient operation and business of Solomon Power (SP; trading name of Solomon Islands Electricity Authority). Thus, reduction of generation cost is one of the keys for lowering electricity tariff and subsequent development in SI.

In addition, environmental problems including global warming is one of the most critical and urgent issues for SI due to its environmental fragility. SI seeks to combat the issues for securing their lands and life. Therefore, the Ministry of Mine, Energy and Rural Electrification (MMERE) and SP aim to introduce RE to SI.

1.1.4. Target of Renewable Energy

MMERE and SP target promotion of RE in order to both enhance energy security and tackle the climate change issue. More specifically, SP has a plan for achieving RE 100% in the Honiara Grid by 2030 as the first step while the MMERE is targeting 100% electricity generation by RE across the nation by 2050 in its Renewable Energy & Strategic Plan. To achieve the target, SP needs to introduce a large amount of solar photovoltaic (PV) and they expect more independent power producers (IPPs) to compensate the huge investment needs.

1.2. Objectives of the Survey

The objective of the Survey is to gather basic information and data regarding the energy sector, RE, and private investment in SI, to analyze the issues toward promotion of RE, to examine the candidate technologies to be introduced to Honiara, and to confirm the objects and the methods for future cooperation by JICA.

1.2.1. Survey Area

The target of this study is the area within the Honiara Grid.

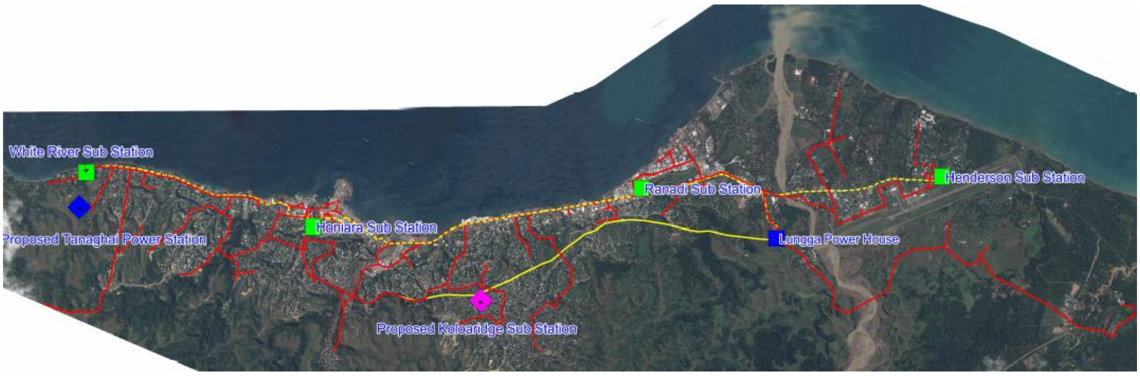

Figure 1-1 The Grid Map in Honiara

Source: SP

1.2.2. Relevant Ministries, Agencies and Organizations

Table 1-1 shows the relevant ministries, agencies and organizations in SI that have essential roles in this study, along with a list of the items confirmed with the respective organizations during the Survey.

Table 1-1 Relevant Ministries, Agencies and Organizations and List of Confirmation Items

Organizations	Confirmation Items
The Counterpart for the Project	
Ministry of Mines, Energy and Rural Electrification (MMERE)	・ Policy and plan related to energy/electricity (ex: progress on updating the RE strategy and investment plan) ・ Potential and strategy on RE of each form of renewable power such as wind, geothermal and biomass power
Solomon Power (SP)	・ Strategy on RE development, generation and distribution records, planning on hydro development, potential sites of solar power, distribution network data, general information (customer, sales, demand, forecast, etc.)
Other Relevant Ministries, Agencies and Organizations	
Ministry of Development Planning and Aid Coordination (MDPAC)	・ Overview of supports from other development partners in relevant areas such as energy, infrastructure development, private sector, etc.
Ministry of Infrastructure Development (MID)	・ Infrastructure development policy ・ Circumstance of human resource such as Equipment, Procurement and Construction (EPC) Contractors in SI
Ministry of Environment, Climate Change, and Disaster Management and Metrology (MECCDMM)	・ The target and progress of climate action(nationally determined contribution: NDC) ・ Comprehensive view of environmental issues such as energy efficiency and disaster management ・ Solar radiation data, wind data at measuring points
Ministry of Finance and Treasury (MOFT)	・ Progress of establishing the Private Partnership (PPP) Unit ・ Pursues policy and project analysis for PPP and implementation of tax reform
Ministry of Lands, Housing & Survey (MLHS)	・ Regulations related to land rights and acquisition ・ Landowner’s information on potential solar power sites
Ministry of Commerce, Industry, Labour and Immigration (MCILI)	・ Laws and regulations related to foreign investment, private investment, tax regulation, or company law

Source: JICA Survey Team

1.2.3. Scope of Work

The scope of the Survey is shown as follows;

Table 1-2 Scope of Study

Category	Study Item
Supply Side	• Review on the existing power demand forecast and power development plan • Rough calculation of necessary amount of renewable energy generation, short-term storage system and long-term storage system to achieve 100% in Honiara in 2030 • Confirmation of potential sites for renewable energy generation • Scenario setting of renewable energy promotion through consultation with relevant stakeholders
Demand Side	• Study on possible resources of Demand Response (DR) measure to promote renewable energy • Study on the situation of electric Vehicle (EV) in Pacific region and its prospect • Organization of a consultation framework with relevant authorities related to DR
Private Investment	• Study on the situation and the main issues of private investment in energy sector in Pacific region • Confirmation on the current activities of other development partners • Basic information collection on private sector investment in Solomon • Hearing from private sector companies interested in investment in Solomon Islands, development partners, PPP center in Solomon and other organization • Organization of a consultation framework with relevant authorities related to promotion of private sector investment in energy sector • Examination on the issues and needs in Solomon islands regarding promotion of private investment in energy sector

Source: JICA

1.3. Schedule of the Survey

The Survey was conducted from 20th November 2018 to 27th March 2019 as shown in Table 1-3.

Table 1-3 Schedule for the Survey

	2018		2019		
	Nov	Dec	Jan	Feb	Mar
Home Survey					
Site Survey					
Milestone				☆ Workshop	☆ Final Report

Source: JICA Survey Team

2 Energy Sector in Solomon Islands

2. Energy Sector in Solomon Islands

2.1 Regulations and Organizations in the Energy Sector

2.1.1 Related Policies, Laws and Regulations in the Energy Sector

(1) Solomon Islands National Energy Policy and Strategic Plan

(a) Solomon Island National Energy Policy 2014

The MMERE formulated the Solomon Islands National Energy Policy and Strategic Plan (SINEPSP) in 2014, which replaces the previous version (2007), reflecting the contents of the "National Development Strategy of Solomon Islands 2011–2020", and the opinions of development partners and non-government organizations (NGOs). The 2014 version comprised of four parts including the main policy, energy efficiency, fuels and renewable energy, as follows:

- Volume 1 Solomon Islands National Energy Policy 2014
- Volume 2 Energy Efficiency and Energy Conservation: A Strategy and Investment Plan (2014 - 2019)
- Volume 3 Petroleum & Alternative Liquid Fuels Strategies and Investment Plan (2014 - 2019)
- Volume 4 Renewable Energy Strategies & Investment Plan 2014

The Solomon Islands National Energy Policy (SINEP), the volume 1 of SINEPSP, stipulates the following seven main targets as broad outcomes below;

- Strengthening the energy sector leadership and planning
- Increasing access to electricity in urban areas to 100% by 2020
- Increasing access to electricity in rural households to 35% by 2020
- Increasing access to safe, affordable and reliable petroleum fuels to outer islands and remote rural locations
- Increasing the use of RE sources for power generation in urban and rural areas to 79% by 2030
- Increasing the development and penetration of gaseous fuels and alternative liquid fuels from indigenous raw materials
- Improving energy efficiency and conservation in all sectors by 10.7% by 2019

The key points relating to RE are quoted and summarized in Table 2-1.

Table 2-1 Key Points relating to Renewable Energy in Solomon Islands National Energy Policy 2014

Policy Outcome
Use of RE sources for power generation in urban and rural areas increased to 50% by 2020

Policy Statements and its Strategies
4.1 Establish an appropriate, reliable, affordable and sustainable RE-based power supply in urban and rural areas
➢ Support the development and implementation of the Tina Rive Hydropower project and the Sava Geothermal project. ➢ Improve the SP energy services through off grids (hydro and solar) and generating plants. ➢ Encourage and promote use of RE technology in rural areas
4.2: Assess, cost, promote and enhance the potential for RE resources
➢ Undertake assessment of potential of wind, geothermal, biofuel based on coconuts, gasification from byproduct and forest waste, and mini hydro ➢ Development training and capacity development on new RE technologies.
4.3: Develop RE policy instruments (standards and regulations, net metering policies, market-based instruments, procurement strategies) to meet the RE targets
➢ Develop a clear policy on fiscal incentives (e.g. tax holiday incentives and duty tax exemptions including loans for RE technology deployment) ➢ Develop clear policy and legislations/regulations on net metering ➢ Establish standards for on-and off-grid connections of RE technologies

Responsible Agencies	Estimated Cost
The SIEA, the Energy Division, prospective IPP, the ADB, RE Service Company, the SPREP, SPC	USD 75 million

Source: SINEP 2014

(b) The Solomon Islands National Energy Policy 2018 (Draft)

The MMERE is currently working on revising the SINEP and the draft will be submitted to the National Parliament of SI for its approval. With regard to RE, the MMERE is planning to set the target of RE sources for power generation at 50% by 2035, downward from the original plan of 79% by 2030. This is due to the delay in the construction project of Tina Hydro Power Plant to be developed by Korean Water and financed by the World Bank (WB), the Asian Development Bank (ADB), the Green Climate Fund (GCF), the Economic Development Cooperation Fund (EDCF), the International Renewable Energy Agency (IRENA) and the Australian Agency for International Development (AusAID). The main revision points are summarized in Table 2-2.

Table 2-2 Revisions relating to Renewable Energy in the SINEP 2018 (Draft)

Policy Outcome
Use of RE sources for power generation in urban and rural areas increased to 50% by 2035

Policy Statements and its Strategies
4.1 Establish an appropriate, reliable, affordable and sustainable RE-based power supply in urban and rural areas
➢ (NEW) Replicate successful private / public partnership models for mini hydro systems and solar PV ➢ (NEW) Develop criteria to prioritize provision and develop maintenance schedule of RE infrastructure (using socio-economic indicators) ➢ (NEW) Develop appropriate frameworks and laws to manage land access for RE projects.
4.2: Assess, cost, promote and enhance the potential for RE projects
➢ (NEW) Undertake an assessment of existing solar energy users and solar energy potentials ➢ (NEW) Complete feasibility studies and reports for all RE potential sites and make them available for planning purposes. ➢ (NEW) Present investment costs against deployment of RE technology at donor roundtable discussions.
(NEW) 4.3: Increase economical productivity in rural communities with the use of RE services.
➢ Encourage the establishment of economical rural centers powered by RE at provincial levels ➢ Encourage RE Services Company (RESCO's) involvement in productive uses of RE sources. ➢ Promote the use of low-cost specific RE technologies (e.g. solar charging stations, solar pico lanterns).
4.4 Develop RE policy instruments (standards, net metering policies, market-based instruments, and procurement strategies) to meet the RE targets
➢ (NEW) Develop enabling instruments and initiatives to encourage RESCO and financial institutions to invest in RE initiatives. ➢ (NEW) Promote benefits to financial institutions to provide concessional loans and term extension funds for RE electrification projects. ➢ (NEW) Promote and support the financing of the RE Investment Plan.
(NEW) 4.5: Facilitate partnerships in development of RE developments.
➢ Development an appropriate framework for access to land for RE developments. ➢ Develop a framework for public and private partnership.

Responsible Agencies	Estimated Cost
The SIEA, the Energy Division, prospective IPP, the ADB, RE Service Company, the SPREP, SPC	USD 75 million

Source: SINEP 2018 (Draft)

(c) The Renewable Energy Strategies & Investment Plan 2014

The Renewable Energy Strategies & Investment Plan (RESIP) 2014 is one of the main parts of the SINEPSP. In order for the SIG to achieve the RE target of 50% in the SINEP 2014, the RESIP 2014 has three main purposes;

- To provide funding requirement guidance for using RE in both rural and urban areas,
- To identify and prove plans for electrification utilizing RE, and
- To provide instruments to pursue policies including standards, regulations and net-metering policies.

The Savo Geothermal, micro-grids, and solar PV for both large scale and small scale are considered in the plan as well as the Tina Hydro. While the targets and guidance are clearly stipulated, land issue, discussed in Chapter 5 of this report, emerge as a key challenge for installing solar PV power stations, meaning home solar systems are considered the best option to circumvent customary land problems for rural area. In terms of investment on RE, $75 million and $ 234 million are required to achieve target household electrification rates of 44% and 71% by 2020 and 2030 respectively.

(2) The Electricity Act (Chapter 128, Laws of Solomon Islands)

The Electricity Act (1969; amended in 1982) and its subsidiary legislation legally underpin the Solomon Islands Electricity Authority (SIEA) (establishment, incorporation, functions, duties and financial provisions) as well as regulating the electricity supply.

(3) Environmental Act (1998)

Under the Environmental Act, the Environment and Conservation Division (ECD) and the Environmental Advisory Committee were established and their functions and jurisdictions were defined. Applications for Environment Impact Assessment (EIA) are submitted to the Director of the ECD and approved by the Minister of Environment, Climate Change, and Disaster Management and Metrology. Prescribed developments are categorized into ten areas, and power projects, including “infrastructure developments” and “hydropower scheme”, are stipulated in ”9. Public Works Sector”.

2.1.2 The Energy Advisory Committee

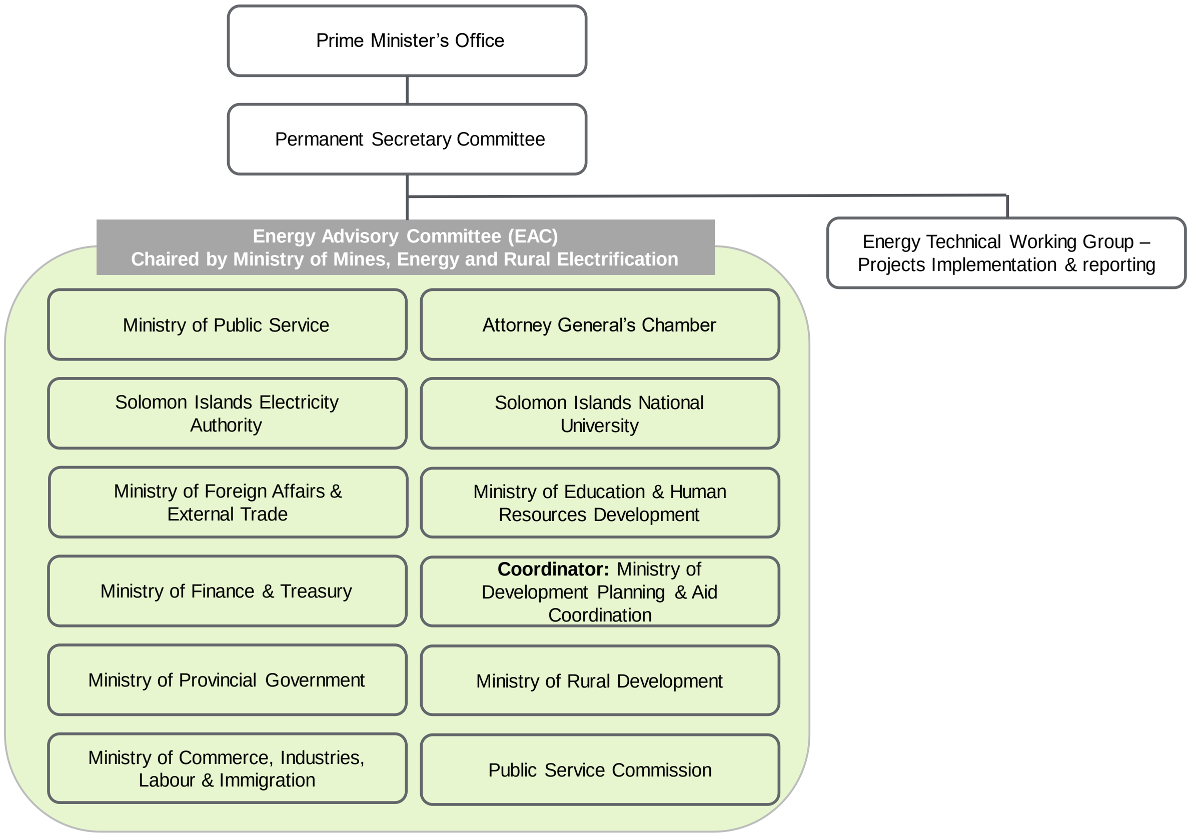

Figure 2-1 Management Structure of the Energy Advisory Committee

Source: prepared by JICA Survey Team based on the information provided by MMERE

Figure 2-1 illustrates the composition and the management structure of the Energy Advisory Committee (EAC). The EAC is a multi-sectoral committee monitoring the Energy Division, which, in turn, oversees the implementation of energy policies. The EAC is chaired by the MMERE and is comprised by 12 ministries, agencies and institutions. The Ministry of Development Planning and Aid Coordination (MDPAC) coordinates the priority of projects among the development partners and the SIG.

2.1.3 Ministry of Mines, Energy, and Rural Electrification

The MMERE is the ministry to supervise the energy sector of SI and its Energy Division is responsible for planning energy policies and regulations including the SINEPSP with ten staff members. A few staff are deployed for renewable energy promotion in the Honiara grid system while about half of the staff members are responsible for technical study and commissioning on the outer islands. The energy division also supervises SP.

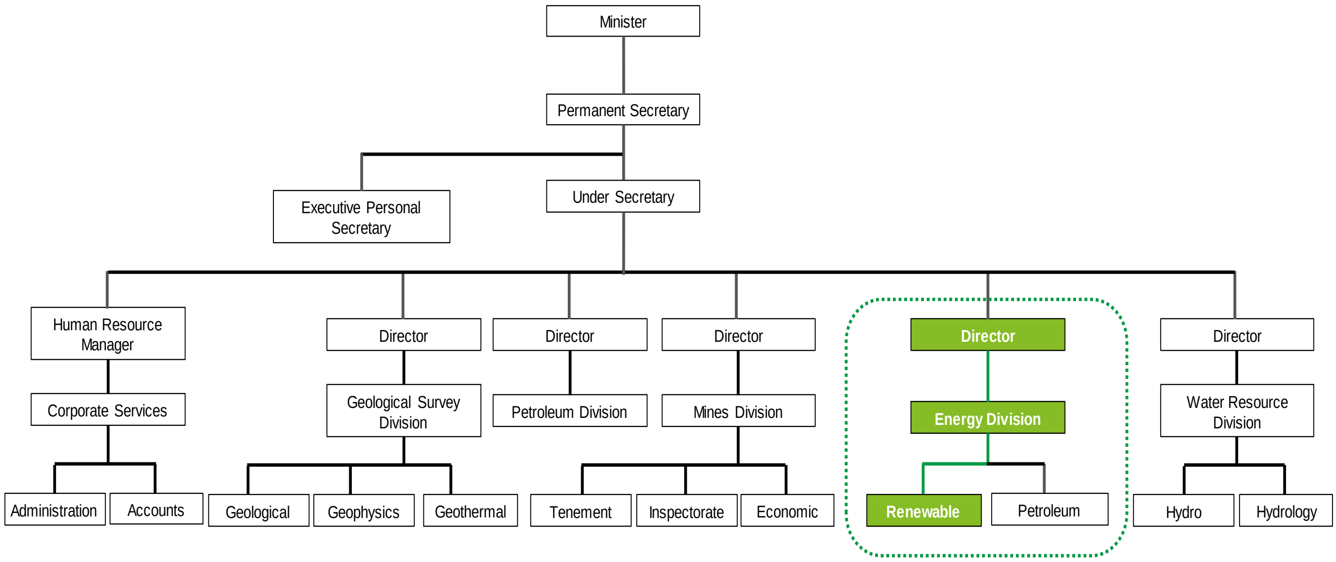

Figure 2-2 Organizational Chart of the Ministry of Mines, Energy and Rural Electrification

Source: MMERE

2.1.4 Solomon Power

(1) History of Solomon Power

Based on the Electricity Act 1969, SIEA has provided electricity to Honiara and other rural cities. In 2007, the State-Owned Enterprises Act 2007 was established and SIEA has been given an autonomy to independently operate from the Government. Currently, SIEA is trading as SP and providing electricity to Honiara and eight cities (Noro, Gizo, Auki, Kirakira, Lata, Buala, Malu'u,Tulagi).

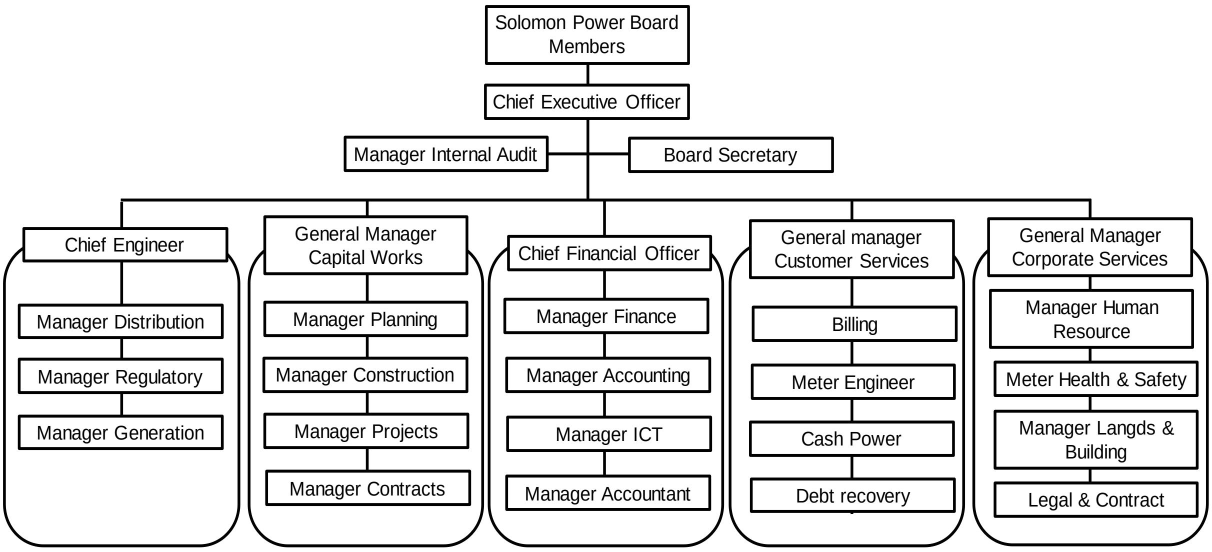

Figure 2-3 Organizational Chart of Solomon Power

Source: Solomon Power

(2) Principle Objective of Solomon Power

In the Annual Report of SP (2017), the principle objective of SP was described as follow, referring to Section 4, the State Owned Enterprises Act 2007 (See Table 2-3).

Table 2-3 The Principal Objective of Solomon Power

Be as profitable and efficient as comparable businesses that are not owned by the Crown: by
➢ Within the State Owned Enterprises Act, installing, operating and maintaining electricity supply systems that meet the needs of connected customers
➢ Developing and implementing capital investment plans, to improve electricity system performance and increase the network coverage of agreed areas
➢ Seeking to recover efficient costs of the service provision
➢ Improving the efficiency of services, whilst improving asset reliability and availability
Be a good employer: by
➢ Maintaining a well-qualified and motivated staff.
➢ Adopting HR policies that treat employees fairly and properly in all aspects of recruitment, retention and employment
➢ Promoting a high level of safety throughout the organization
An organization that exhibits a sense of social responsibility by having regard for the interests of the community in which it operates: by
➢ Building effective relationships with landowners, customer groups and interest groups that are affected by our activities
➢ Improving environmental reporting and performance on issues that are caused by our electricity supply activities
➢ Incorporating sustainability into our business activities, and working to improve sustainable outcomes in terms of resource management

Source: Annual Report 2017, SP

(3) Business Summary of Solomon Power

Business summary of SP (2013-2017) is shown below, with an average electricity price (= Revenue / Sales Electricity) of 5.5 SBD/kWh in 2017. Because the electricity tariff reflects fuel costs, the average electricity price varies from year to year.

Table 2-4 Business Summary of Solomon Power

	2013	2014	2015	2016	2017
Generation (kWh)	81,101,391	84,911,433	86,176,764	93,101,396	94,298,432
Sales Electricity (kWh)	62,376,432	65,838,038	67,101,793	71,168,643	74,298,541
Station Use (kWh)	3,398,954	2,874,229	2,766,760	3,267,241	3,444,953
System Loss (at sending point)	19.7%	19.7%	19.6%	20.8%	18.2%
Out of which, Technical Loss	11%	11%	11%	11%	11%
Revenue (million SBD)	360.88	405.71	427.89	438.56	411.31
Average Electricity Price (SBD/kWh)	5.8	6.2	6.4	6.2	5.5

Source: Data obtained from SP

2.1.5 Electricity Tariff

(1) Tariff System

Electricity mainly comprises of two types of tariff, meter-reading customer's tariff and pre-paid meter customer's tariff (Cash Power Customer) respectively.

Table 2-5 Meter Reading Customer's Tariff (Revised on November 1, 2018)

Category		Network Access Charge	Fuel Charge	Non-Fuel Charge
		SBD/kWh	SBD/kWh	SBD/kWh
Residential	D1 <50kWh	16.09	2.83	3.4
	D2 40-200 kWh	53.64	2.83	3.47
	D3 200-500kWh	107.28	2.83	3.54
	D4 >500kWh	314.57	2.83	3.99
Commercial	C1 <250kWh	42.91	2.83	4.06
	C2 250-600kWh	107.28	2.83	3.66
	C3 600-1,300kWh	214.57	2.83	3.37
	C4 1,300-2,500 kWh	429.13	2.83	3.03
	C5 > 2,500kWh	1,609.25	2.83	2.88
Industrial	I1 < 1,300kWh	107.28	2.83	3.72
	I2 1,300-6,000kWh	429.13	2.83	3.2
	I3 >6,000kWh	3,218.49	2.83	2.85

Source: Data obtained from SP

Table 2-6 Pre-Paid Meter Customer's Tariff (Revised on November 1, 2018)

Category		Fuel Charge	Non-Fuel Charge
		SBD/kWh	SBD/kWh
Residential	D1 <50kWh	2.83	3.8
	D2 40-200 kWh	2.83	2.85
	D3 200-500kWh	2.83	2.87
	D4 >500kWh	2.83	4.43
Commercial	C1 <250kWh	2.83	4.34
	C2 250-600kWh	2.83	3.94
	C3 600-1,300kWh	2.83	3.64
	C4 1,300-2,500 kWh	2.83	3.51
	C5 > 2,500kWh	2.83	3.09
Industrial	I1 < 1,300kWh	2.83	4.21
	I2 1,300-6,000kWh	2.83	3.2
	I3 >6,000kWh	2.83	2.85

Source: Data obtained from SP

(2) Meter

(a) Meter Type

SP has four types of meters, namely Mechanical kWh, Digital kWh, Pre-pay CP (cash-power) and Smart Meter. Although no law stipulates regular meter replacement, SP are making efforts to replace Mechanical kWh Meters to Pre-pay CP Meters to avoid non-technical-loss (= electricity theft in this case). Pre-pay CP customers have to pay the cost of electricity in advance. Customers can obtain a code at SP headquarter or retail shops to utilize a smart-meter.

Photo 2-1 Mechanical kWh Meter

Photo 2-2 Digital kWh Meters

Photo 2-3 Pre-pay CP Meters

Photo 2-4 Smart Meter

Source: JICA Survey Team

(b) Smart Meter

Smart Meters are equipped for large consumers. SP can give operation orders and obtain measurement through this type of meters by its bi-direction communication function. However, SP does not intend control customer facilities at this moment as SP can conduct "load-shedding" in emergency cases except for key facilities.

(c) Number of Meter

Total number of meters installed in Honiara was 14,954 as of 2018, with details as follows.

Table 2-7 Types and Numbers of Installed Meters

Meter Type	No. of Installation
Mechanical kWh Meter	1,000
Digital kWh Meter	246
Pre-pay CP Meter	12,678
Smart Meter	1,030

Source: SP

2.1.6 Standby Charge

The standby charge is a connection fee on daily basis for solar PV to the SP's gird. The purpose of the standby charge is to secure appropriate capacity reserve with backup diesel generators to compensate output fluctuations caused by solar PV. As the charge is imposed on all types of PV, even individual household has to pay the charge provided it has installed rooftop PV.

The amount of charge is calculated based on "value of electricity that would have been generated if a standby generator had operated". SP will apply the charge up to 50% of that value. The applied rate is tabulated as Figure 2-8. As an example, for a 4 kW solar system SP would apply a daily standby charge as follow;

Daily Standby Charge = 50% x [4.4 x (4 kW inverter rating) x (SIEA) Domestic or Commercial Tariff)]

Table 2-8 Standby Charge (a case of 4.0 kW solar PV)

Connection Type	Act Req 50%	kW rating in Times	Inverter Rating (kW)	Rates-Tariff	Daily Standby Charge (SBD)
Domestic Customer	50%	4.4	4.0	6.4685	56.92
Commercial Customer	50%	4.4	4.0	6.9530	61.19
Industrial Customer	50%	4.4	4.0	6.7719	59.59

Source: prepared by JICA Survey Team based on Data obtained from SP

A household with a 4 kW system would be levied SBD 1,707.6 (= SBD 56.92 x 30 days) .

2.1.7 Major Customers

(1) Large Consumer 1 (Solomon Water)

Solomon Water (SW) is one of the biggest customers, pumping up underground water and connecting each homes via pipes. The load capacity is approximately 100 kW, while SW also has an emergency (=stand-by) generator. SW usually supervises 20 facilities via a supervisory control and data acquisition (SCADA) system, where operating system software is programed to pump-up and restock every three hours automatically. SW has to reprogram the software and replace some pipes, if demand response is applied for their pumping system..

(2) Large Consumer 2 (Hotel)

A hotel is a typical private large consumer in SI, with air-conditioners, refrigerators, freezers and lightings. For securing customers' convenience even in the event of an outage, a stand-by generator is usually equipped with an air-switch, which selects the terminal according to grid conditions and runs a stand-by generator in the event of outage.

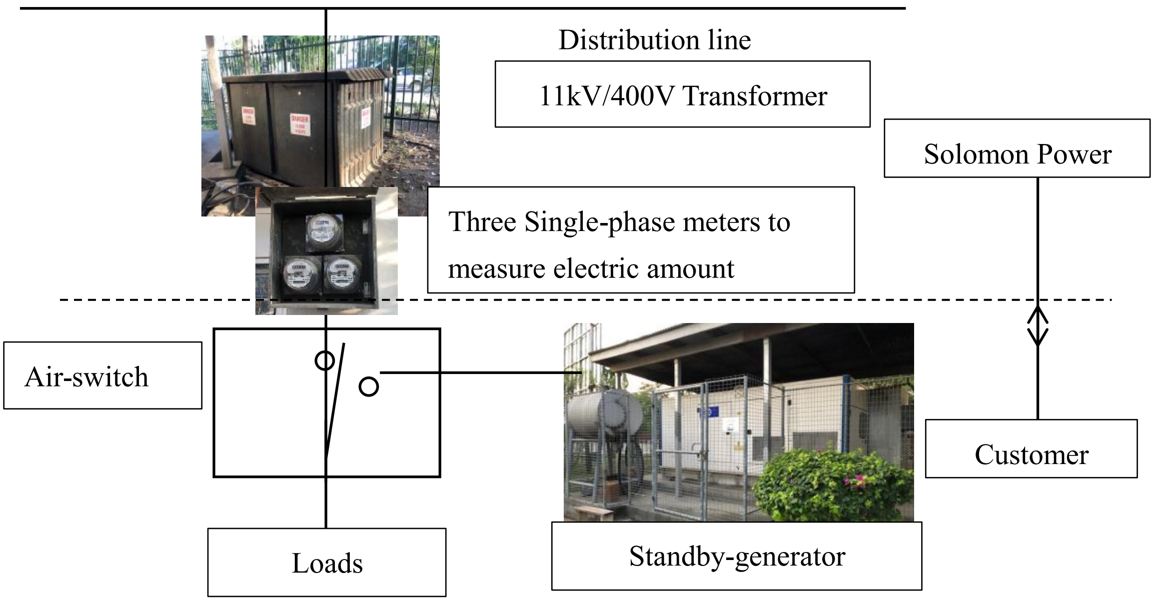

Figure 2-4 Example Connection between Hotel Load to Grid

Source: JICA Survey Team

Although air-conditioners can be utilized for a short demand response, it is difficult to install the equipment with advanced functionality because it takes time to repair when such equipment is broken down.

(3) Residential Consumer

General home appliances, including lightings, TV and a refrigerator, are used at each household.

2.2 Overview of the Honiara Grid

2.2.1 Power Demand in the Honiara Grid

(1) Annual Maximum Demand

The historical records of the maximum demand in the Honiara Grid are shown below, with an average increase rate of 1.7% from 2007 to 2017.

Table 2-9 Historical Record of Maximum Demand in the Honiara Grid

	2007	2008	2009	2010	2011	2012
Maximum Demand (kW)	12,600	12.610	12,880	13,780	13,870	14,240
Generation (kWh)	66,751,190	68,593,693	69,762,062	74,521,980	74,666,984	75,286,311
Load Factor (%)	60.5	62.1	61.8	61.7	61.5	60.4
Increasing Rate (%)		0.1	2.1	7.0	0.7	2.7

	2013	2014	2015	2016	2017
Maximum Demand (kW)	13,620	14,100	14,425	15,469	14,934
Generation (kWh)	72,984,525	77,379,984	78,690,387	83,958,278	84,562,667
Load Factor (%)	51.2	62.6	62.3	62.0	64.6
Increasing Rate (%)	-4.4	3.5	2.3	7.2	-3.5

Source: Data obtained from SP

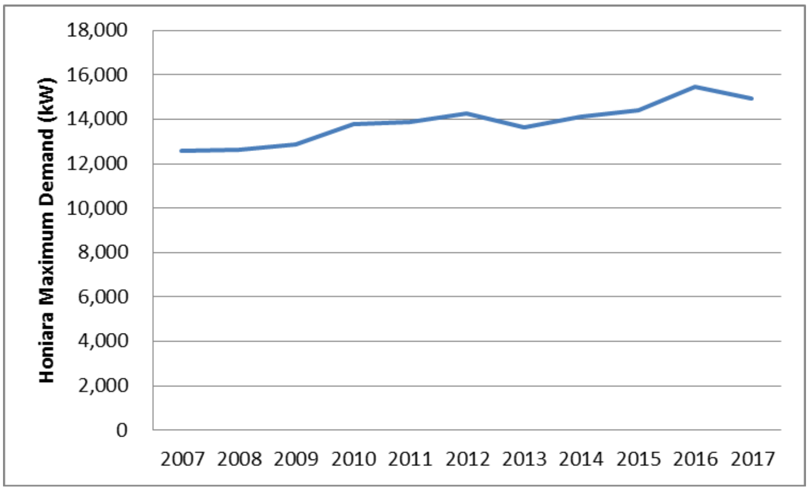

Figure 2-5 Historical Record of Maximum Demand in the Honiara Grid

Source: Data obtained from SP

(2) Monthly Maximum Demand

Monthly maximum demand in the Honiara Grid (2015-2017) is shown below and remains largely unchanged throughout the year.

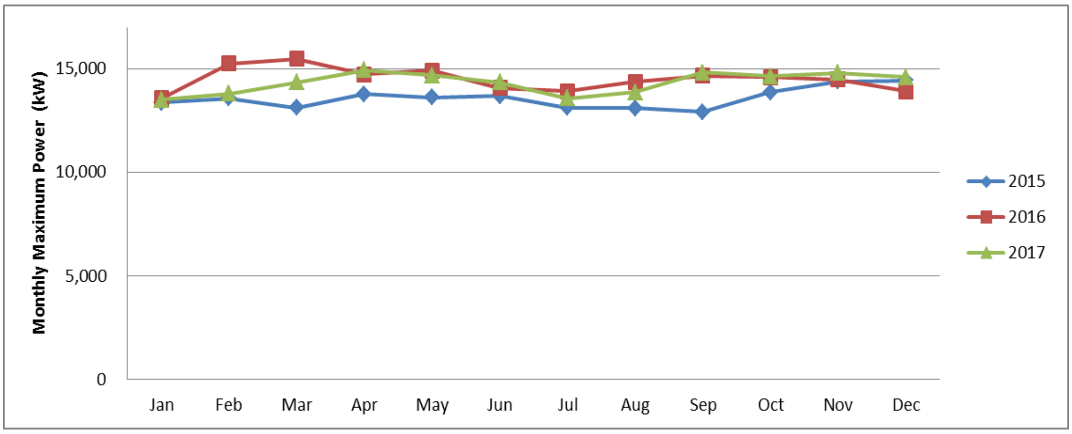

Figure 2-6 Monthly Maximum Demand in the Honiara Grid

Source: Data obtained from SP

(3) Daily Load Curve

Daily load curves for one-week periods in January, April, July and October in 2017 are shown below. This graph shows the similar daily load patterns in all seasons in SI.

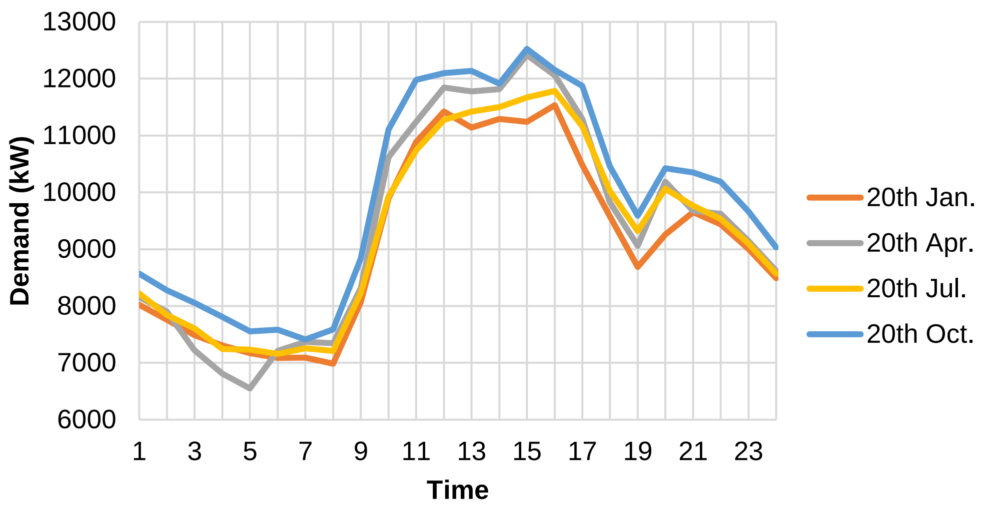

Figure 2-7 Daily One-week Load Curves in January, April, July and October (2017)

Source: Data obtained from SP

2.2.2 Power Supply Facilities

Power supply facilities in the Honiara Grid (2018) are shown below.

Table 2-10 List of Power Units in the Honiara Grid

Name	Unit	Type	Commissioning Year	Nominal Capacity (MW)	Available Capacity (MW)	Start-up Time (min)	Decommissioning Year
Lungga	L1	Diesel	2016	2.5	2.5	1	2039
	L2	Diesel	2016	2.5	2.5	1	2039
	L3	Diesel	2016	2.5	2.5	1	2039
	L4	Diesel	2016	2.5	2.5	1	2039
	L6	Diesel	1998	2.9	2.2	1	2024
	L7	Diesel	2005	4.2	3.8	1	2036
	L8	Diesel	1993	4.2	3	1	2024
	L9	Diesel	1999	4.2	3.8	10	2029
	L10	Diesel	2006	4.2	3.8	10	2036
Honiara	H1	Diesel	2013	1.5	1.5	3	2038
	H2	Diesel	2013	1.5	1.5	3	2027
Fighter One		Solar PV	2016	1	1		2026
Ranadi		Solar PV	2014	0.05	0.05		

Source: SP Network Development Plan 2017

The nominal capacity in the Honiara Grid is 33.75 MW including solar capacity, however, the available capacity is estimated at 30.65 MW. SP adopts the G-1 principle for the power generation operation, in which power can be supplied in case of a sudden drop of one power generation unit. Considering the G-1 principle and maintenance, SP recognizes that a firm capacity is about 25 MW in the Honiara Grid.

2.2.3 Demand and Supply in the Honiara Grid

(1) Demand Forecast and Supply Capacity

Regarding maximum demand forecast, SP assumes four scenarios namely 2, 4, 6 and 8% per year as the increase rate. Over the past decade (2007 - 2017), the maximum increase rate peaked at 7 % which was only recorded several times in specific years. The average increase rate during the period was 1.7% per year. Considering the trend of increase in demand and SP's development plan, 4% per year is regarded as a core scenario for long-term demand forecast, according to the hearing from SP. Other scenarios, however, should also be studied in the course of the road map formulation. Assuming the maximum demand increases by 4% per year, the maximum demand will reach 25 MW in around 2028, which is equivalent to the current firm capacity. If the Tina Hydro does not operate by this time, additional firm capacity will be required.

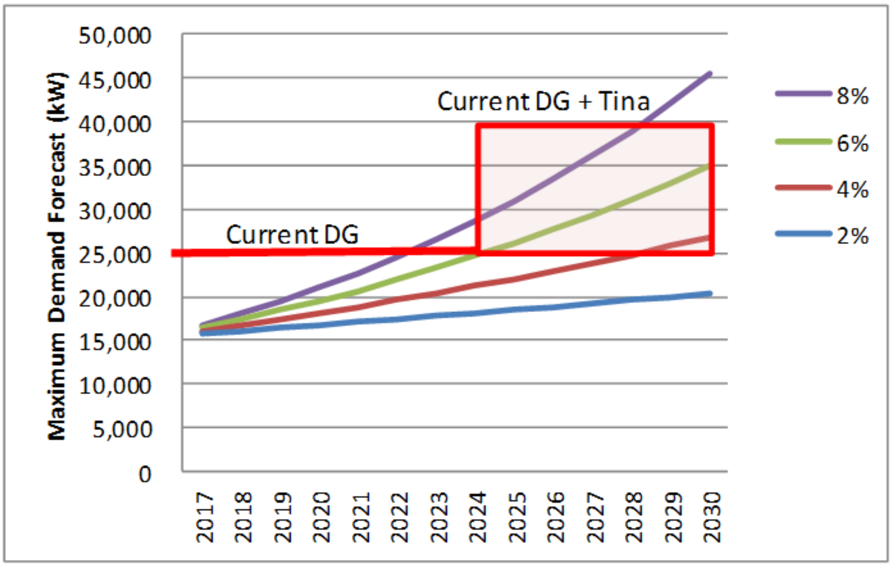

Figure 2-8 Demand Forecast and Supply Capacity

Source: Data based on SP Network Development Plan 2017

SP plans to install additional diesel units and solar PV units by 2025 because L6 and L8 units might be decommissioned by 2024 due to their deterioration.

(2) Capital Budget Plan of Solomon Power

SP prepared a 6-year capital budget plan (2019-2024) as follows (as of December 11, 2018).

Table 2-11 SP's Capital Budget Plan

	Project	2019	2020	2021	2022
Generation	Fighter 1 1-2 MW Solar Extension	39,900,000			
	Solar Ranadi HO Roof and Upgrade	5,500,000	5,000,000		
	Central BESS 3.5 MW	1,000,000	5,000,000	5,000,000	5,000,000
	Solar Tanagai Heights		5,000,000	12,000,000	12,000,000
	Tina River Hydro Project (Human Resources)	1,000,000	5,800,000	5,800,000	5,800,000
Transmission	Old Lungga Electrical Upgrade	2,000,000	10,400,000	10,400,000	10,400,000
	SCADA	63,891,870	9,076,170	5,858,100	34,991,178
	33kV Cable Ranadi-Honiara		4,000,000	4,000,000	3,000,000
	66kV Transmission Tina-Lungga	500,000	33,400,000	33,400,000	33,400,000
	66kV Transmission Lungga-Tanagai			1,000,000	29,200,000
Major Total		113,791,870	77,676,170	77,458,100	133,791,178

	Project	2023	2024	Total (2019-2024)
Generation	Fighter 1 1-2 MW Solar Extension			39,900,000
	Solar Ranadi HO Roof and Upgrade			10,500,000
	Central BESS 3.5 MW	5,000,000	5,000,000	26,000,000
	Solar Tanagai Heights	12,000,000	14,000,000	55,000,000
	Tina River Hydro Project (Human Resources)	5,800,000	5,800,000	30,000,000
Transmission	Old Lungga Electrical Upgrade	10,400,000	10,400,000	54,000,000
	SCADA	33,758,760		147,576,078
	33kV Cable Ranadi-Honiara	3,000,000		14,000,000
	66kV Transmission Tina-Lungga	33,400,000	33,400,000	167,500,000
	66kV Transmission Lungga-Tanagai	29,200,000	29,200,000	88,600,000
Major Total		132,558,760	97,800,000	633,076,078

Source: Data obtained from SP

2.3 Power Facility in the Honiara System

2.3.1 The Lungga Power Station

(1) Summary of the Lungga Power Station

The Lungga Power Station is located in a hilly area 1 km west of the Honiara Airport. It mainly comprises a power station office (blue frame), a power station old building area (green frame), a power station new building area (red frame) and fuel tanks (yellow frame). Power generator units of L1 - L4 and L6 – L10 are installed in new and old building areas of the power plant respectively and the operation order of the Honiara system including the operation of the Honiara Power Station is dispatched from this power station office.

Figure 2-9 The Lungga Power Plant

Source: prepared by JICA Survey Team based on Google Earth

(2) Operation Status of the Lungga Power Station

The operation status of the Lungga Power Station (2017), as obtained from SP is as shown below. The new units (manufactured by MAN) of L1 - L4 are used as the main operating units for base generation and adjustment sources to minute demand fluctuations with high efficiencies. The old-type units of L7 - L10 generate for middle and peak demand, with limited fluctuation in output.

Table 2-12 Operation Status of Each Unit of the Lungga Power Station

	Nominal Capacity (MW)	Maker	JAN	FEB	MAR	APR	MAY	JUN	JUL
L1	2.5	MAN	1,220,710	1,019,146	321,185	578,009	626,125	633,696	604,642
L2	2.5	MAN	1,222,337	1,054,728	1,731,386	786.945	766,741	389,415	819,644
L3	2.5	MAN	582,205	443,541	1,062,220	792,911	466,863	997,604	789,324
L4	2.5	MAN	1,225,425	966,174	1,099,513	746,294	924,852	994,061	713,003
L6	2.9	Mirrless	7,840	7,600	26,110	47,630	-	33,790	-
L7	4.2	Wartsila	594,700	568,430	567,090	914,960	1,140,400	696,020	998,270
L8	4.2	Wartsila	1,481,360	1,050,750	691,210	564,710	1,140,630	781,520	712,730
L9	4.2	Mitsubishi	1,960	864,450	2,022,940	1,799,160	1,175,210	2,621,310	1,556,350
L10	4.2	Niigata	0	100	90	13,130	7,790	12,180	85,220

	AUG	SEP	OCT	NOV	DEC	Total	Capacity Factor (%)	Fuel Consumption Rate (l/kWh)
L1	937,513	574,800	755,482	1,180,116	1,105,139	9,556,563	44	0.24
L2	825,677	1,097,830	1,206,160	1,105,880	943,321	11,950,064	55	0.23
L3	1,051,316	1,147,737	1,139,301	1,164,183	663,446	10,300,651	47	0.23
L4	835,107	967,288	676,790	1,037,660	441,843	10,628,010	49	0.24
L6	-	-	690	5,970	-	129,630	1	0.16
L7	601,770	-	506,520	467,350	914,540	7,970,050	22	0.25
L8	576,890	682,580	759,880	237,690	429,210	9,109,160	25	0.25
L9	1,821,030	1,849,670	2,404,040	1,640,020	25,290	17,781,430	48	0.25
L10	233,470	367,470	146,800	206,260	2,232,330	3,304,840	9	0.27

Source: Data obtained from SP

(3) Interview Result on Operation

Interview result on operation of the Lungga Power Station are summarized as follows:

- The Lungga Power Station controls the entire power quality of the Honiara Grid. The frequency is maintained in the range of 49.9±0.1 Hz.
- The four new units, manufactured by MAN, operate with SCADA monitoring and Automatic Frequency Control (AFC), so that these units mainly deal with fluctuation of demand.
- Operators read measures of operation data, including output, fuel consumption, rotation and exhaust temperature, and fill a datasheet. Technical staff at the Lungga Power Station input and compile the dataset on PC. The dataset of the Honiara Power Station is also sent to and managed at the Lungga Power Station.

- Dispatch for the Honiara Grid is conducted at the Lungga Power Station. Operation time and output of the Honiara Power Station are pre-set and dispatch is not provided time-by-time.

2.3.2 The Honiara Power Station

(1) Summary of the Honiara Power Station

The Honiara Power Station is a small-scale facility located in the center of Honiara, comprising two 1.5 MW units. Soundproof walls surround the power plant as measures to mitigate the impact on nearby residents' lives. The power plant generally operates for nine hours (8 am to 5 pm) taking account of the noise caused by the power station.

Photo 2-5 The Honiara Power Station

Source: JICA Survey Team

(2) Operation Status of the Honiara Power Station

The operation status of the Honiara Power Station as of 2017 is shown below. The Honiara Power Station operates only in daytime (around 8:00 to 17:00) considering operation noise to its surrounding households. The Lungga Power Station mainly supplies for the base generation in nighttime. In the event of an emergency, the generators can start up within minutes.

Table 2-13 Operation Status of each Unit of the Honiara Power Station

	Nominal Capacity (MW)	Maker	JAN	FEB	MAR	APR	MAY	JUN	JUL
H1	1.5	Caterpillar	349,193	256,804	305,574	233,640	299,196	248,433	214,642
H2	1.5	Caterpillar	96,467	236,497	327,281	322,040	223,110	217,795	183,068

	AUG	SEP	OCT	NOV	DEC	Total	Capacity Factor(%)	Fuel consumption Rate (l/kWh)
H1	137,630	164,254	256,531	311,336	173,312	2,950,545	22	0.27
H2	186,129	149,242	178,251	196,699	33,972	2,350,551	18	0.28

Source: Data obtained from SP

(3) Interview Result on Operation

Interview result on operation of the Honiara Power Station are summarized as follows:

- The operation of the Honiara Power Station follows the dispatch order from the Lungga Power Station. The hourly operation data are recorded and sent to the Lungga Power Station once a day.
- The power station can supply within several minutes even with cold start and during nighttime.

2.3.3 The Fighter One Power Station

(1) Summary of the Fighter One Power Station

The Fighter One Power Station has 1 MW of capacity and was installed in 2016 by the grants from New Zealand and the United Arab Emirates (UAE). It is located in 1 km south of the Honiara Airport. The plant covers an area of 1.6 ha and SP purchased the land from the Solomon Telecom. Solar panels, power conditioners and a transformer were installed on the premises.

Photo 2-6 The Fighter One Power Station

Source: Google Earth

(2) Operation Status of the Fighter One Power Station

The operation status of the Fighter One Power Station is as shown below. (Data not stated for Nov. and Dec.)

Table 2-14 Operation Status of the Fighter One Power Station

	JAN	FEB	MAR	APR	MAY	JUN	JUL
Fighter One	131,506	104,799	96,535	113,993	125,986	94,478	119,910

	AUG	SEP	OCT	NOV	DEC	Total
Fighter One	128,066	142,170	132,274			1,189,716

Source: Data obtained from SP

2.3.4 Transmission Lines

As shown as below, the configuration includes overhead (yellow) lines on the mountain side and underground (blue) cables on the seaside and the total length of overhead lines and underground cables is 10 km and 18 km respectively. The voltage of the transmission lines (T/Ls) is 33 kV stepped-up from the 11 kV terminal of generators.

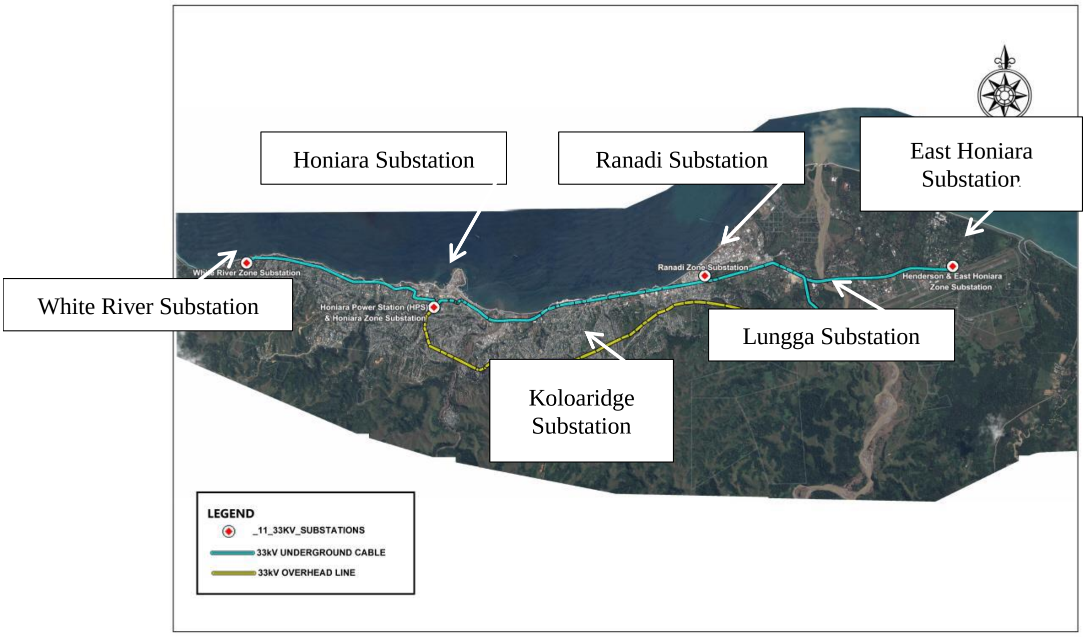

Figure 2-10 The 33 kV Transmission Lines in Honiara

Source: SP Network Development Plan 2017

2.3.5 Substation Facility

The Lungga, Honiara and Ranadi substations are in a loop connection, with the White River Substation connected to the Honiara Substation and the East-Honiara Substation connected directly to the Lungga Substation. The loop configuration of three substations sees two at 12.5 MVA and the other at just 3.5 MVA.

The Ranadi Substation is located in the headquarter premises. Circuit breakers (CBs) and SCADA system are on the left of the structure, while transformers are on the right (See Photo 2-7). The left structure is a high-mounted configuration to avoid deterioration from floods.

Photo 2-7 Ranadi Substation

Source: JICA Survey Team

Photo 2-8 SCADA Screen

Source: JICA Survey Team

Photo 2-9 Circuit Breakers

Source: JICA Survey Team

Photo 2-10 Transformer

Source: JICA Survey Team

The SCADA system is in the operation at the Ranadi Substation and when accidents occur, linemen come to check the SCADA to find out what has happened and identify which distribution lines are down. The limited length of each distribution line in SI makes it easier for the linemen to determine precisely where any accident occurs. It can be considered as a reasonable option to install an automatic distribution system that reduces system average interruption duration index (SAIDI) and system average interruption frequency index (SAIFI), just like those installed in Japan. SP plans to extend SCADA in the Honiara Grid, whereupon a dispatch center in the Lungga Power Station will be able to supervise and to directly control the grid. The plan of optical cable between the Honiara and the Ranadi substations will also be implemented simultaneously.

2.3.6 Distribution Line

(1) General

11kV lines and low-voltages lines (three-phase 415 V and single-phase 240 V) cover more than 100 km in total, with concrete, galvanized or wooden poles. About 150 transformers are energized; placed on the groundand surrounded by wire nettings in the city center, and mounted on some channels between two poles outside the city center. Low-voltage lines are constructed at points of high demand density as required and the infrastructure of distribution lines is designed and constructed based on the "STANDARD DESIGN & CONSTRUCTION MANUAL".

Photo 2-11 Concrete Poles

Photo 2-12 Galvanized pole

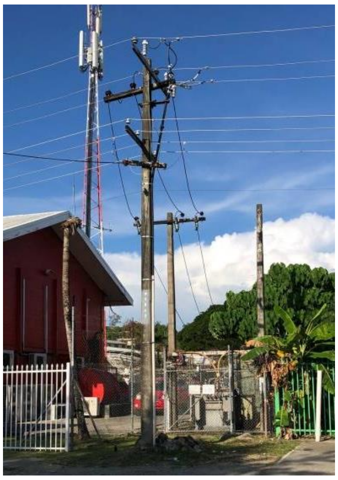

Photo 2-13 Transformer in urban area

Source: JICA Survey Team

(2) Quality of Electricity

Electrical standards on frequency and voltage are shown in the following table.

Table 2-15 Electrical Standards

	33kV system	11kV system	415V system
Frequency variation (normal)	50Hz±2%		
Frequency variation (emergency)	50Hz±4%,and never without ±3% limits for more than 0.5S		
Voltage variation (normal)	±7%	±7%	±7%

Source: SP

SAIDI and SAIFI are usually regarded as energy quality management indicators and include both accident and planned outages. SAIFI and SAIDI in Honiara areas are tabulated as below.

Table 2-16 SAIFI and SAIDI in Honiara

Index	Outline	2012	2013	2014	2015	2016	2017
SAIDI	Annual average outage time (minute)	619	486	422	217	381.9	155.9
SAIFI	Annual outage times over two minutes (times)	12.9	8	7	3.2	3.8	2

Source: SP

(3) Balance of the Supply and Demand (Load-Shedding)

SP opens air switches in distribution lines to retain the balance of the supply and demand in case a serious unbalance occurs, as SP has limited options to deal with such a situiation. Consequently, customers in disconnected areas would suffer outages. The dispatch center in Lungga station calls a switch coordinator in the distribution department when the grid does not balance, who then has to decide whether to proceed with load-shedding. After 2014, however, load-shedding declined drastically because SP had sufficient potential to serve.

3 Study on the Potential of Renewable Energy

3. Study on the Potential of Renewable Energy

3.1 Climate Conditions

SI is classified as a tropical rainforest climate under the Köppen climate classification, with average monthly temperatures shown below. The monthly average temperature is around 26 ºC in Honiara and remains relatively steady the whole year around.

Table 3-1 Monthly Average Temperature in Honiara

	JAN	FEB	MAR	APR	MAY	JUN	JUL
Daily Average Temp. (°C)	26.8	26.7	26.6	26.6	26.6	26.3	26
Average Maximum Temp. (°C)	30.6	30.3	30.4	30.6	30.7	30.5	30.1
Average Minimum Temp. (°C)	23.1	23.1	22.8	22.8	22.4	21.9	21.5

	AUG	SEP	OCT	NOV	DEC	Year
Daily Average Temp. (°C)	26	26.3	26.5	26.6	26.7	26.5
Average Maximum Temp. (°C)	30.2	30.4	30.9	30.7	30.7	30.5
Average Minimum Temp. (°C)	21.5	21.8	22	22.5	22.8	22.3

Source: World Climate Website

The rainfall amount differs largely by seasons. Although rain is scarce during the dry season from May to October, frequent squalls are observed in the rainy season (from November to April). Cyclones hit on Honiara once every few years.

Table 3-2 Monthly Rainfall in Honiara

	JAN	FEB	MAR	APR	MAY	JUN	JUL
Rainfall. (mm)	281.5	293	316.6	201.6	130.9	82.6	97.7

	AUG	SEP	OCT	NOV	DEC	Year
Rainfall (mm)	97.6	98.3	129.7	155.8	220.4	2,094

Source: World Climate Website

3.2 Potential of Renewable Energy

3.2.1 Potential of Solar Power

The solar irradiation in Honiara is estimated to be about 4.7 to 5.0 (kWh/m^2/day) year-round according to the two past documents, while solar irradiation of 5.5 to 6.5 (kWh/m2/day) is adopted in the SINEP

Table 3-3 Assumption of Solar Irradiation from Past Documents

	Source	Unit	JAN	FEB	MAR	APR
Demonstration Project for System Connected Solar Power in Solomon Islands. (2015, JICA)	N.A.	kWh/m2/Day	5.25	4.99	5.05	4.91
Master Plan Study of Power Development Plan in Solomon Islands (2001, JICA)	Measured (12.5 degree inclined)	kWh/m2/Day	3.92	4.04	4.43	4.86

	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Average
2015, JICA	4.39	4.19	4.12	4.67	5.21	5.67	.5.64	5.35	4.95
2001, JICA	5.12	5.38	4.79	5.01	4.73	4.94	5.01	4.27	4.71

Source: JICA Survey Team

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50 kW solar power generation system was installed through the "Demonstration Project for System Connected Solar Power in Solomon Islands (2015, JICA)", and its recorded amount of power generation was 7,616 kWh in October 2014 and 7,011 kWh in November 2014.

The generation of solar PV is calculated by the following formula;

Generated Power (kWh) = Designed Output × Solar Radiation × Loss factor × Days

The loss factor was given as 0.82 by the generation data in November 2014. The concept of loss factor embodies numerous factors, including the conversion loss of power conditioners and the surface contamination of panels. According to the guideline published by Japan's Ministry of the Environment, a loss factor of 0.80 is recommended for designing solar PV system in consideration of degradation in conversion efficiency of solar panels. As the calculated value of 0.82 and the recommended value of 0.80 are close enough, 0.80 is adopted for the Survey for conservative estimation.

3.2.2 Potential of Wind Power

There is no official study result regarding wind power in SI, nor is wind power considered as a major energy source in the current SINEP. According to the Global Wind Atlas (below figure), published by WB and the Technical University of Denmark, the average wind speed is estimated as 3 to 4 m/s around Honiara at a height of 50 m above the ground, while areas with high wind power potential are scattered around the mountain in the Guadalcanal Island. Beacause of the limitations in grid connection, wind power may only be utilized for isolated facilities such as radio masts and towers.

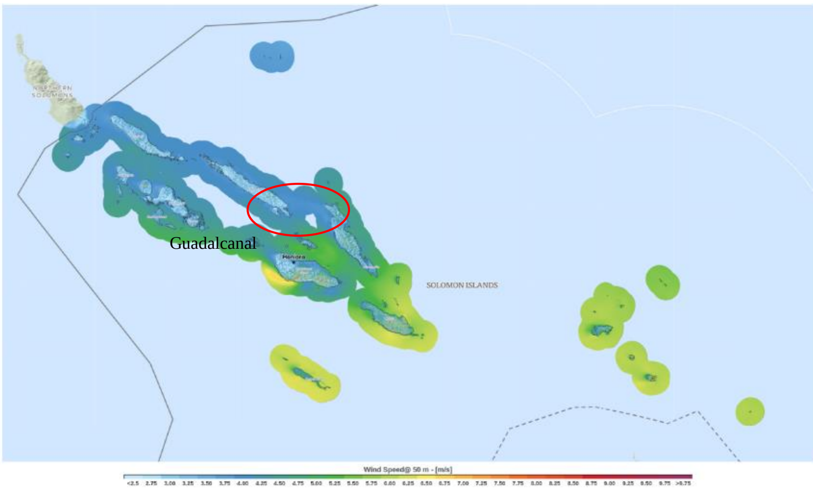


Figure 3-1 Wind Potential Map

Source: Global Wind Atlas

3.2.3 Other Renewable Energy Potential

There are no plan of hydropower development within Honiara grid other than the Tina project, at the time of the Survey.. Regarding geothermal power, potential of 20 MW exists at Savo Island, 20 km north of the Guadalcanal Island. However, it lacks feasibility given the costs of constructing the geothermal plant, T/Ls and submarine cables. Therefore, the geothermal is not considered as the option in the Survey either.

3.3 Potential Site of Solar Power

3.3.1 Assumption of Potential Site

Solar PV power stations generally require 1.0 ha to 1.5 ha of land for each 1 MW of output, although the required space varies on a case by case basis depending on land shape or temporary construction space, etc. The existing Fighter One power station used 1.6 ha for 1 MW of output. In the Survey, 1.5 ha for 1 MW is assumed, including the temporary construction space. A potential site survey is conducted based on information obtained from SP.

3.3.2 Potential Solar PV Site

(1) Development Plan of Solomon Power

SP's Capital Budget Plan (2019-2024) listed the Fighter One extension (Additional 2 MW), the Tanagai (1.5 MW) and SP Head Office (220 kW) for solar power projects. Besides, a battery system (3.3 MW) is also planned to compensate solar power fluctuation.

(2) Other Potential Sites

In the Survey, the followings potential sites were confirmed:

- Site possessed by a church (at least 5 ha)
- Site offered by a private company (about 3 ha)
- Site possessed by 2 individual families (at least 3 ha)

3.3.3 Individual Site

(1) Fighter One Site (Upgrade Additional 2 MW)

(a) Overview

- The site is located next to the existing Fighter One and is assumed to add 2.0 MW capacity. SP completed the negotiation to acquire the land.
- WB plans to finance a part of the project. (Request for Bids was issued on 18th March, 2019)
- Cables from the additional facilities are connected to the existing transformer and distribution line of the Fighter One. The existing transformer and distribution line have enough capacity to accommodate additional power generation.
- The existing T/L is directly connected to the Lungga P/S except for small local distribution. In future, the T/L will be an all-exclusive line and not require any voltage control.

(b) Site Location

The site location map is shown below.

Figure 3-2 Location of the Fighter One Site (Additional)

Source: prepared by JICA Survey Team based on Google Earth

(c) Transmission Line Capacity

The existing 11 kV T/L has enough capacity for 3 MW PV.

(d) Priority

No specific difficulty is expected because the existing facilities will be utilized. Negotiation to acquire land is completed and the WB's assistance is expected. The project priority is high.

(2) Tanagai Site

(a) Overview

- The area of the Tanagai site is equivalent to 1.5 MW and SP completed the negotiation to acquire the land.
- A substation will be newly constructed and connected to the power station by an exclusive line.
- There are two options for the route to connect to a new substation; A (Short Route) and B (Detour Route). The acquisition of land for Route A may be problematic, because it traverses a residential area. Route B may be easier in terms of land acquisition because it runs along a road.

(b) Site Location

The site location map is shown below.

Figure 3-3 Location of Tanagai Site

Source: prepared by JICA Survey Team based on Google Earth

(c) Capacity of Transmission Line

A dedicated line will be newly constructed to connect to the nearby substation.

(d) Priority

Negotiation to acquire the land for Route A (short route) may face difficulties since it traverses a residential area. However, negotiations to acquire the land for the solar power station site have been completed and the priority is high.

(3) SP's HO

(a) Overview

- Installation of 220 kW PV is planned for the rooftop of SP's Head Office
- It will be connected to the substation next to the HO
- The WB's assistance is planned. (Request for bids was issued on 18th March, 2019)

(b) Site Location

The site location map is shown below.

Figure 3-4 SP's HO Site

Source: prepared by JICA Survey Team based on Google Earth

(c) Capacity of Transmission Line

The nearest substation has enough capacity to accommodate.

(d) Priority

It is a significant project as a demonstration because it is located in SP's HO.

3.4 Overview of Tina Hydro Power Project

3.4.1 Project Overview

(1) Project Overview

The project overview is summarized from the Project Appraisal Report (May 24, 2017) documented by WB. WB started a desktop study in 2006 and then conducted the feasibility study. The project will be implemented under IPP scheme. As the private sector participation, the Korean Water Resources Corporation (KW) and the Hyundai Engineering Company (HEC) made a special purpose company, the Tina Hydropower Limited (THL), which will construct and operate the main facilities of the Tina Hydro Project.

On December 6, 2018, the one of the major financers, the International Development Association (IDA) concluded a financial agreement with the SIG and THL, and at the same time, THL concluded the Power Purchase Agreement (PPA) with SP as the off-taker. However, because land in some areas has not been acquired yet, some financial agreements also remain pending.

Item	Description
River	Tina River
Catchment Area	125 km2
Average Inflow	13.1 m3/s
Dam Type	Roller Compacted Concrete (RCC)
Dam Height and Length	72m, 207m
Dam Volume	199,000 m3
Maximum Water Level	175 m
Effective Water Storage	1.42 million 3
Water Way	3.3 km
Penstock	116 m
Maximum Water Use	18 m3/s
Maximum Head	102 m
Generation Capacity	5MW x 3 Units
Annual Generation	78.35 GWh

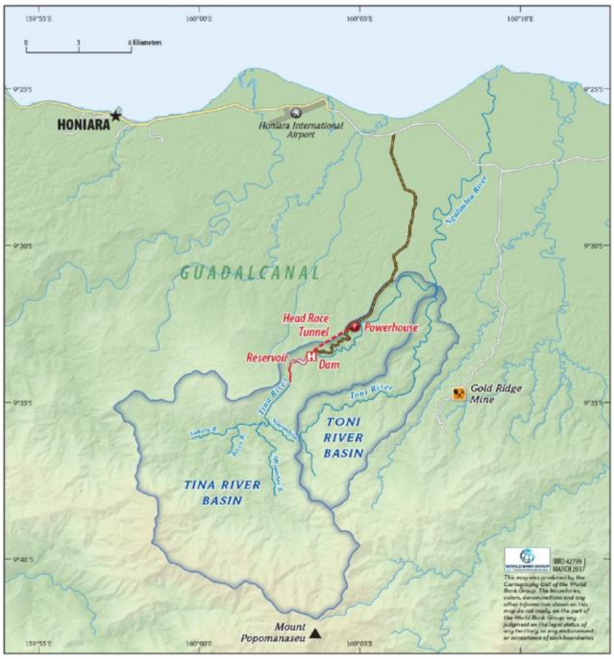


Figure 3-5 Summary of Tina Hydro Project

Source: Project Appraisal Report, May 24, 2017

(2) Project Component

Various development partners have assisted the Tina Hydro project; concessional loans and grants have been committed by development partners to the THL and the SP via the SIG. The details are summarized in Table 3-4.

Table 3-4 Project Component and Financial Sources

Component		Financer	Type	Amount	Borrower
Component 1: Tina River Hydro Power Facilities	Dam, waterway, Power Station, etc	ADB	Loan	18 million US$	THL
		ADFD	Grant	12 million US$	
		EDCF	Loan	15 million US$	
		GCF	Loan	31.6 million US$	
		IDA	Loan	70 million US$	
		IDA	Loan	21.304 million US$	
Component 2: Access Road	Access Road from Black Post to Managikiki Access Road from Managikiki to the Dam Site	APIP	Grant	5.36 million SBD	
		GCF	Grant	10 million US$	THL
Component 3: Transmission Line	66kV Transmission Line from Tina P/S to Lungga P/S (21.6km) 66kV Transmission Line to White River S/S (12.4km)	IDA	Grant	16 million US$	
		SP Counterpert Fund	Loan	2.071 million US$	SP
		APIP	Self	20.75 million US$	
Component 4: Technical Assistance	Dam Safety Advisory Panel (DS/AP), Environmnet and Social Experts, Independent Social and Environmental Monitoring Agent, NGO to engage with landowning tribe	IDA	Grant	2.7 million US$	SIG
		SP Counterpert Fund	Grant	2.12 million SDR	
		Investor	Self	1.4 million US$	

Investor (Equity to THL)	Amount	Borrower
KW	8.64 million US$	THL
HEC	2.16 million US$	

Source: Financial Agreement between the SIG and the IDA, December 6, 2018

Note:

ADB (Asian Development Bank)

ADFD (Abu Dhabi Fund for Development)

APIP (Australia-Pacific Islands Partnership Trust Fund)

EDCF (Economic Development and Cooperation Fund of the Republic of Korea)

GCF (Green Climate Fund)

HEC (Hyundai Engineering Company)

IDA (International Development Association)

KW (Korean Water Resources Corporation)

SIG (Solomon Islands Government (Ministry of Finance and Treasury))

* SDR: Special Drawing Rights

As of 2018, the value of SDR is calculated by summation of 0.58252 US$, 0.38671 Euro, 11.900 JY, 0.085946 GBP and 1.0174 CNY (equivalent to 1.39 US$).

(3) Feature of Finance for the Tina Hydro

As mentioned above, most of the finance sources will be concessional loans and grants. About 90% of the total project costs (231 million US$) is covered by such assistance from many development partners.

(4) Construction Schedule

Negotiations with two tribes to acquire land remain uncompleted as of February 2019. The construction work is expected to start from September 2019 and be completed in 2024, assuming the negotiation is completed by June 2019.

3.4.2 Consideration of Tina Hydro Adjustment Capacity

(1) Features of Pondage-Type of Hydropower

Tina Hydro project plans to install AFC that can adjust output in response to sudden fluctuations within one minute using the spinning reserve of each unit. Approx. five minutes are required from non-operation status to reach the intended output level. If several large-scale solar PV plants exist in different areas, all solar PV plants rarely simultaneously drop due to sudden weather changes. In this context, Tina Hydro can follow up sudden fluctuation within one minute. Accordingly, Tina Hydro adjustment capacity depends on the operation status of each unit. During the nighttime, if the power demand is under 10 MW, the power supply can be made by only two units, which means one unit may be used for maintenance and inspection.

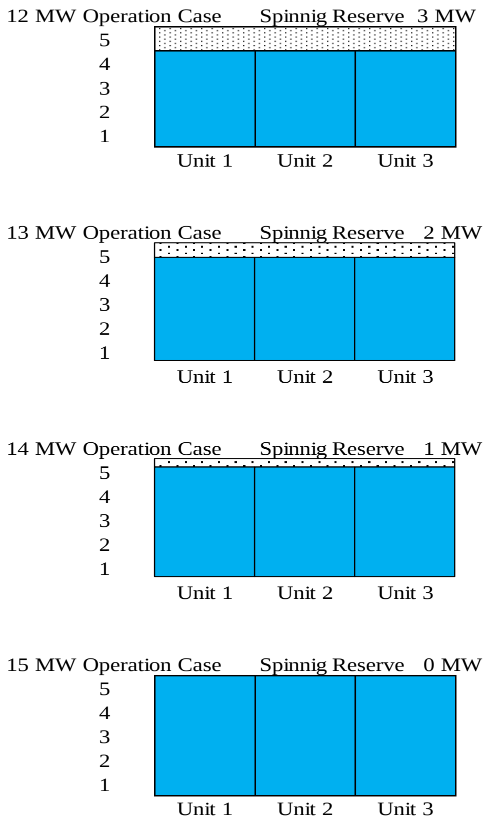


Figure 3-6 Tina Hydro Adjustment Capacity (Image)

Source: JICA Survey Team

(2) Dispatching Operation of the Tina Hydro

SP has concluded a capacity payment contract with the THL, which does not depend on generation volume for payment under the contract, and SP can order the dispatch of the Tina Hydro units. Accordingly, SP can dispatch the orders for these hydro units to secure a spinning reserve to adjust for fluctuation. However, there is a possibility of such spinning reserves not being secured when the water level in the reservoir peaks during the rainy season, for maximizing the use of water resource for power generation.

(3) Generation Forecast of the Tina Hydro

(a) Projected Generation

Annual generation duration curve was projected in Figure 3-7 Projected Annual Generation Duration Curve based on the average daily inflow data (2010-2012) at the Tina Hydro site provided by SP.

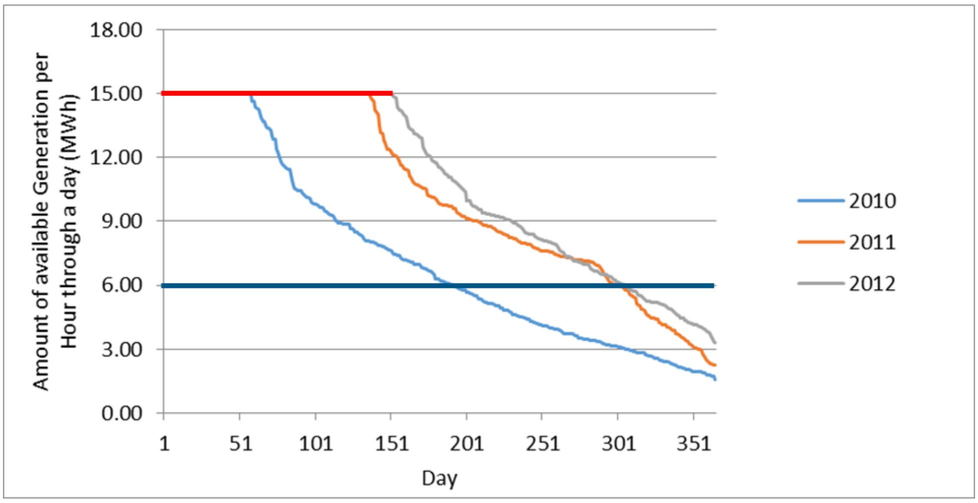


Figure 3-7 Projected Annual Generation Duration Curve

Source: Prepared by JICA Survey Team based on the data from SP

The Tina Hydro would generate at its maximum output of 15 MW for 50-150 days depending on weather conditions while only 6 MW or less for 50 – 150 days.

(b) Daily Operation

Tina Hydro would supply at remarkably low capacity depending on weather conditions. The optimal operation pattern in low capacity period should be examined further in consideration of expected daily loads and suitable combinations among Tina Hydro, solar PV and batteries (e.g. Dedication for generating nighttime during dried seasons to suppress the shift from daytime to nighttime).

3.5 Trial Calculation of Renewable Energy Introduction

3.5.1 Concept of Power Development

Power demand in the Honiara Grid peaks at about 15 MW and if it increases at 4% per year, it will reach 25 MW in 2028. The current firm capacity of diesel is 25 MW in G-1 principle. Solar power does not count for additional firm capacity without any backup (BU) sources. When a battery or surplus diesel can absorb sudden fluctuation of solar power and can secure power supply to meet the peak demand, such combination of solar power and BU can be regarded as firm capacity.
As there is sufficient capacity of diesel units to compensate PV fluctuation, certain amount of PV, in combination with diesel units, can contribute to the firm capacity without backed-up by battery storages. This is especially true after Tina Hydro comes in the grid, when surplus diesel capacity may soar. The key issue here, however, is the extent to which diesel capacity is allowed to be BU for compensate PV fluctuation, considering the SIG and SP's intent to promote renewable contribution. To reduce diesel generation as BU for PV, BU battery charged by surplus solar PV is considered as an alternative source. This issue should be discussed further in the course of the roadmap formulation.

3.5.2 Measures to Counter Sudden Fluctuations

If significant capacity of solar power were installed in the Honiara Grid, existing diesel units would be the sole option to respond to sudden fluctuations under the current situation. After the Tina Hydro and battery storage systems are introduced, these can be additional countermeasures. However, because a battery can not operate unless charged, surplus power from solar power or Tina Hydro will be necessary for a battery to respond to the fluctuations.

3.5.3 Trial Calculation of Installation of Solar Power

(1) Renewable Introduction by 2030

In this section, the trial calculation of PV capacities to be installed by 2030 for respective contribution levels of renewable energy is attempted, for roughly grasping the pictures of future development. The trial calculation assumes the following conditions.

<u>*Assumption*</u>

- At least 5 MW PV will be installed by 2030, in accordance with the current budget plan (2019-2024).
- To get closer to RE 100% target, diesel generation will be gradually replaced by solar PV/battery depending on each cases.
- While the maximum capacity of the Tina Hydro is 15 MW, the effective year-round capacity is estimated at 10 MW.
- Solar power is counted as part of the effective capacity when backup capacity is secured. The existing diesel units or a newly installed battery is expected as a backup.
- The effective capacity of diesel units is fixed at 25 MW by 2030.
- Peak demand increases at 4% per year by 2030.

Following 3 cases are examined for a reference.

- Base Case: 5 MW solar PV capacity installed.
- Capacity Base RE 100% Case: 10 MW solar PV capacity installed.
- RE100% Case: Solar PV capacity equivalent to 63 GWh generation installed.

(2) Base Case

In the Base Case, 5MW solar PV, which is planned under the current budget plan, is assumed to be the only RE power source newly developed other than the Tina Hydro. Annual generation of 5 MW PV is calculated as follows;

Solar Power Generation = Rated Output x Solar Radiation x Loss Factor x Days

= 5 MW x 4.7 kWh x 0.80 x 365

= <u>6.9 GWh/year</u>

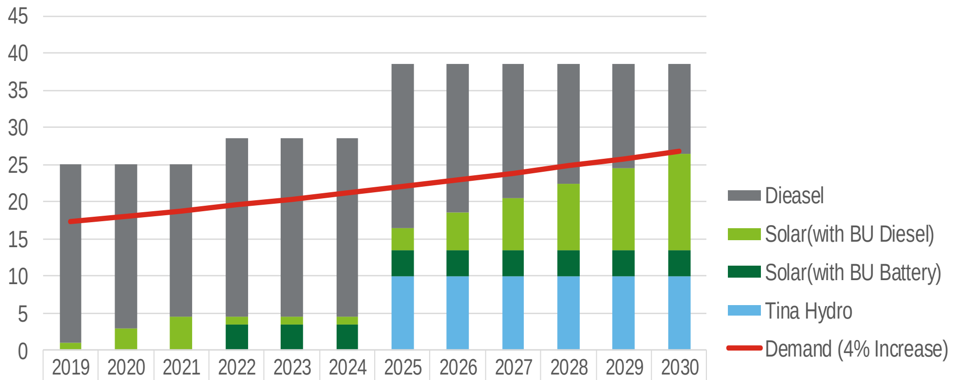
As the Tina Hydro is expected to generate 78 GWh/year, 84.9 GWh/year in total can be generated by RE power sources if the Tina Hydro and 5 MW solar power are installed. Assuming the maximum demand of 26.8 MW in 2030, the required power generation will be 151.7 GWh based on a load factor of 64.6% recorded in 2017. In this case, the contribution of renewable energy in the Honiara Grid is 56%.

(3) Capacity Base RE 100% Case

This case shows a sample picture for moderate RE development, where the effective generation capacity by RE power source almost reaches the maximum demand in 2030. In addition to the common assumptions, the following conditions are assumed for this case.

<u>Assumptions</u>

- Before introducing the Tina Hydro, a total of 4.5 MW solar power and 3.5 MW battery would be installed by 2024.
- After 2025, 2 MW of solar power would be installed every year by 2030.



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Dieasel	24	22	20.5	24	24	24	22	20	18	16	14	12
Solar(with BU Diesel)	1	3	4.5	1	1	1	3	5	7	9	11	13
Solar(with BU Battery)				3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Tina Hydro							10	10	10	10	10	10
Demand (4% Increase)	17.4	18.1	18.8	19.6	20.4	21.2	22	22.9	23.8	24.8	25.8	26.8

Figure 3-8 Simulation for Capacity Base RE 100%

Source: JICA Survey Team

In this case, 16.5MW solar PV generates 22.6GWh/year, and 100.6GWh/year in total will be produced by RE. Therefore, RE contribution in this case will be 66.3%. More batteries and surplus solar power to charge the batteries are necessary to achieve RE 100% in the generation base.

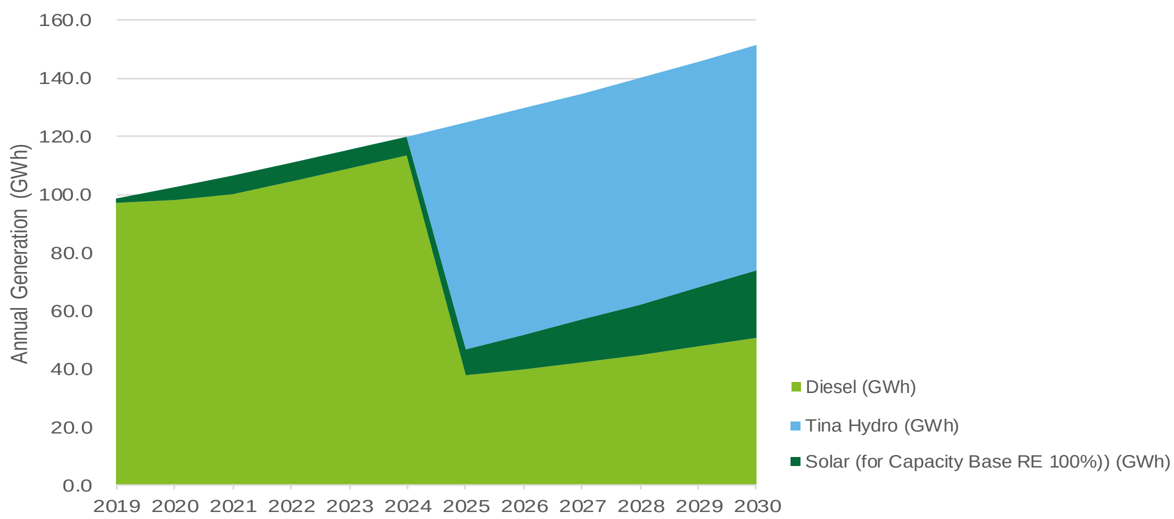


Figure 3-9 Annual Generation for Capacity Base RE 100% Case

Source: JICA Survey Team

(4) RE 100% Case

The case which achieves RE 100 % in the generation base for the projected power demand of the Honiara Grid in 2030 was also calculated.

As the prior case (RE 66.3%) lacks approximately 50GWh/year to reach 100% RE contribution, additional 36.5 MW solar PV (equivalent to 50GWh/year) needs to be developed under this case. In total, at least 53MW solar PV is expected to reach 100% contribution throughout a year. Difference in annual generation between the prior case and this case is shown in Figure 3 10. In addition, battery storage system needs to be developed in a large scale to shift the surplus power generation, which falls out of the scope of this trial calculation. A brief image of how surplus power will be shifted under high penetration of PV is shown in the following section.

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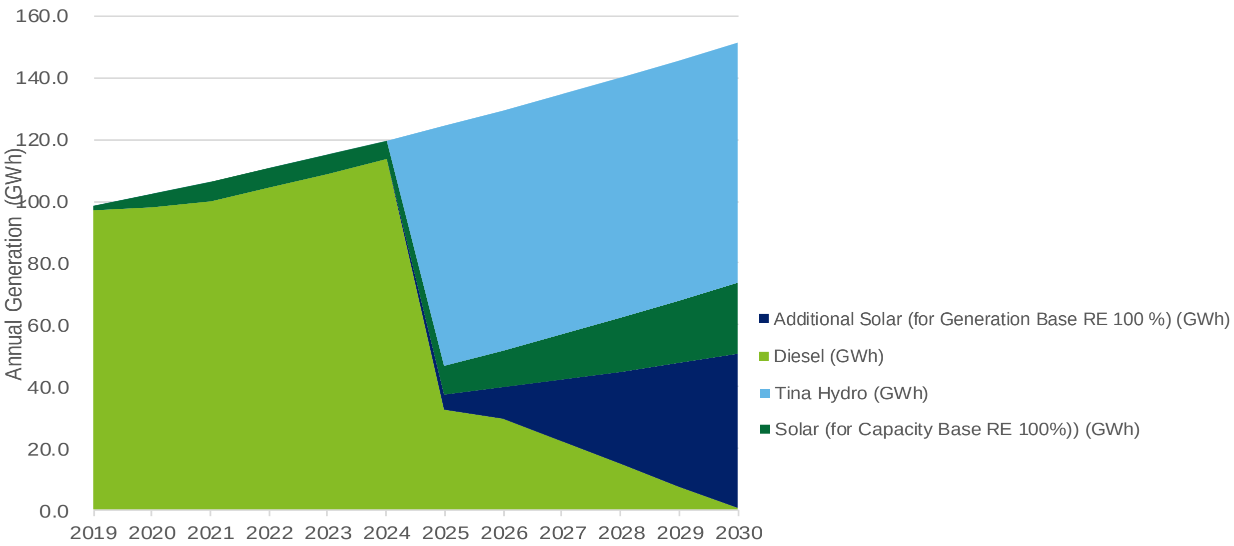


Figure 3-10 Annual Generation for RE 100% Case

Source: JICA Survey Team

3.5.4 Image of Generation Pattern

This section shows the brief images of how each power source should be operated in respective RE penetration levels. It is noted that the following figures are only images of generation pattern to show functions of each generation source, and does not based on a detailed examination.

(1) Moderate RE Penetration

This level sees RE 100% achieved in daytime by the Tina Hydro and solar power with BU battery. In case of a deficit in the power supply, existing diesel will supply power to meet the shortfall.

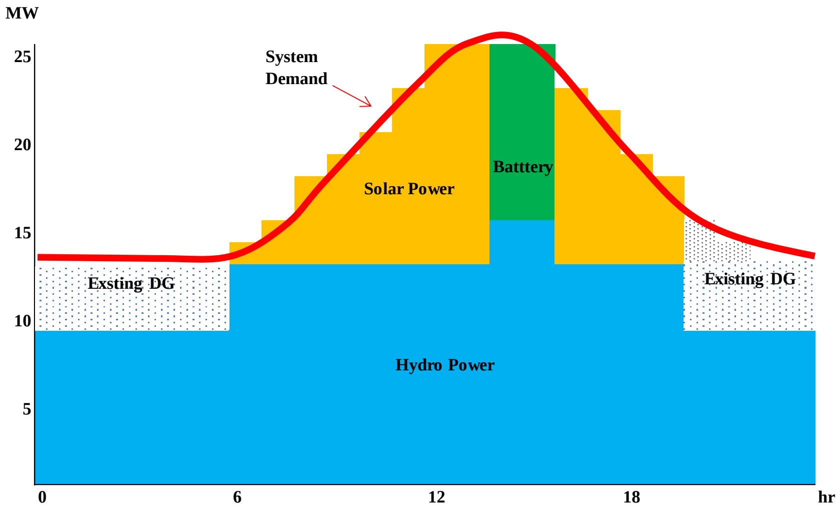


Figure 3-11 Moderate Penetration

Source: JICA Survey Team

(2) High RE Penetration

This level sees RE 100 % achieved in a whole day by installing battery without BU diesel. The battery is operated not only for nighttime supply but also for sudden fluctuations in solar power. Surplus power or the Tina Hydro is expected to bolster the sources for battery charging. The existing diesel units do not operate except in emergencies. However, the following challenges needs to be tackled to achieve RE 100%:

- Considerable surplus power to charge battery is required to fully meet the gap.
- As the power demand increases year-by-year, additional facilities must be constructed on an ongoing basis to meet the demand.
- The facilities designed for dry seasons will be overcapacity in rainy seasons.

Key technical issues/challenges for achieving high RE penetration are examined further in the next section.

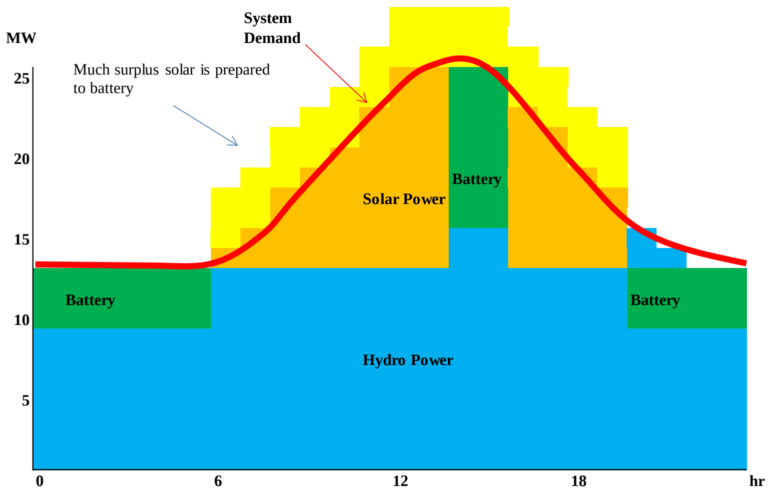


Figure 3-12 High Penetration

Source: JICA Survey Team

3.6 Technical Consideration in Introduction of Renewable Energy

3.6.1 Technical Consideration in the Generation

(1) Introduction of Substantial Capacity of Solar Power

To achieve RE 100%, installed capacity of solar PV must be more than daytime peak to charge surplus power to batteries and shift it to nighttime.

(2) Variation of Generation of Tina Hydro

As projected in Section 3.4.2, generation of Tina Hydro is supposed to vary from less than 3 MW to 15 MW through a year. Thee operation of Tina Hydro must deeply affect the planning of battery capacity for the energy shift from daytime to nighttime. To study optimum cost for introducing solar PV and battery, more data of the inflow shall be collected and analyzed in the road map formulation.

3.6.2 Technical Consideration in the Operation Grid

Acceptable capacity of RE into operation grids depends on conditions and specifications of each grid. In general, issues such as those explained below must be considered when RE such as large-scale solar farms come into grids.

(1) Distribution Operation Capacity and Voltage Control

Each distribution line operates under its flow capacity except the times of accidents, and the voltage shall be maintained within the voltage range regulated by law or indicated by utilities. For solar PVs, currently SP plans to have dedicated distribution lines to substations, which means that overhead lines or underground cables' capacity can be designed only over PV capacity. SP also needs not focus on daily fluctuation in voltage because no customers connect to the dedicated lines.

Secondary voltage at substations would change with tap-changers depending on demands, which means all distribution lines that connect to a transformer would be in a same secondary voltage. If there is a need to control voltage on specific lines, a Step-Voltage-Regulator (SVR) may be useful.

(2) Decrease Inertia Function

Synchronized generators are expected not only to supply electricity but also to maintain a stable frequency, even in the event of fluctuation. Synchronized generators are supposed to change output by adjusting the rotor speed with changes in demand, which is called inertia and helps grids keep steady operation. Synchronized generators are required in order to capitalize on inertia. The greater number of synchronized generators provides more inertia in a grid.

General solar power inverters lack any function to maintain frequency. Even in case PV inverter has this inertia function, the following points would require consideration; a combination with stable power supply sources like a battery and; a combination with other inverters.

In considering the issue of inertia, the ratio of inverters to synchronized generators is remarkably important because the stable operation is disturbed when the ratio reaches a certain limit. However, the limit for the ratio can only be identified based on the situation of each grid (number of synchronized generators, demand, grid capacity and so on). Generally, around 50% can be assumed as the limit for the ratio without some countermeasures, e.g. to balance supply and demand, while the number is just a rough estimate. In the Honiara Grid, this would not be problematic, because the Tina Hydro will have a majority in supply.

These days, new technologies are emerging such as an MG-set and a vertical inertia inverter. The former is an organized generator connected to a mechanical rotary machine supplied by RE and battery. The MG-set is free from the issues of inertia or accident current as it can be treated as large-scale generators, and of course, it generates electricity from RE. On the other hand, sufficient capacity of batteries and installation space are required. A virtual inertia inverter can function as a generator by pre-installed programming. The inverter has to be ready for responding to inertia and for multi-unit operation, therefore, the inverter always operates under the rated capacity and needs to respond quickly without communication control.

(3) Supply of No-Short Accidents Current

When a short accident affects transmission or distribution lines, the affected short accidents current can be supplied via synchronized generators. Once the short-accident current flows into an accident point, a CB on the nearest upper side opens automatically via a relay, whereupon the accident point is disconnected. Inverters are designed not to operate over capacity to avoid breakdowns. Thus, as the ratio of inverters grows up, the risk of familiar in CBs' work intensifies because inverters stop immediately after an accident and do not supply accident current. However, as the Tina Hydro will occupy supply in Honiara, this issue could be handled.

3.6.3 Other Optional Measures

MW-class solar PVs and Tina Hydro have been considered as the major sources for promoting RE development in Honiara. MW-class solar PVs, however, may have difficulties in securing good potential sites in terms of technical and administrative aspects, considering land issues (discussed in Chapter 5). Therefore other measures should also be considered in the road map formulation. Samples of other measures are tabulated below.

Table 3-5 Other Optional Measures for RE 100% in Generation Base

Type	Meaures	Current Situation	Assumption for Introduction	Effect in 2030		Contribution to RE 100% (%)
				Peak Capacity (MW)	Generation (GWh)	
Solar PV	Middle Scale Solar Power (Industry)	50 kW (Ranadi)	100 kW x 30 sites	3	4.2	2.8
	Roof Top Solar Power (Residential)	0	5 kW x 500 sites	2.5	3.5	2.3
Energy Efficiency	Distribution Loss Reduction	11 %	25 MW x (4% reduction) 140 GWh x (4% reduction)	- 1	-5.6	3.7
	Demand Side Efficiency	-	10 %Improvement from the Reference plan	-2.6	-15	10.0

Source: JICA Survey Team

4 System Stability and Demand Response

4. System Stability and Demand Response

4.1 Battery

4.1.1 Battery Introduction

A battery is an inevitable technology for realizing RE 100%. The batteries shall cover a part of nighttime supply even after the Tina Hydro goes into operation, to compensate the capacity of solar PV. Batteries can also be expected to mitigate sudden instability and fluctuations caused by solar PV.

4.1.2 Types of Battery Systems

Various types of batteries are utilized in grid operation, namely, Lead, NaS, Lithium-Ion and Red-Ox Flow. They are selected depending on the purpose for use; for instance, NaS battery is suitable for long duration compensation and Lithium-Ion battery is not beneficial for long duration but for short duration compensation. Therefore, types of batteries should be selected in accordance with the specific purpose for introducing the battery.

Table 4-1 Comparison of Battery Types

	Lead	NaS	Lithium Ion	Red-Ox Flow
Suitable use	Long duration		Short duration	Long duration Short duration
Efficiency	75~87%	90%	94~96%	80~90%
Cycle Lite	1,000~5,400	4,500	3,500	3,000
Energy Density	167 (Wh/kg)	780 (Wh/kg)	360 (Wh/kg)	103 (Wh/kg)

Source: NEDO

Recently, reuse battery system, which utilizes second-hand EV battery, are under tests in Japan. This is introduced in Section 4.5.2.

4.2 Energy Management System

4.2.1 Energy Management System

Energy management system (EMS) has been in use as an operating system to control multi energy facilities so far. Nowadays EMS get to be utilized for automatically maintaining stability where RE is installed in a large extent. In particular, EMS calculates economically optimal operation of the whole system while maintaining frequency.. There are many similar EMS systems in the world and demonstrations are made to evaluate the feasibility to introduce into grids.

EMS can contribute appropriate operation of generators and efficient utilization of batteries by monitoring and projecting output of RE. In the event of unbalance of demand and supply, EMS limits outputs of batteries and RE and balances them. EMS adopts RE output forecasting system, for which both past weather data obtained from a regional meteorological center and present weather data obtained from weather sensors are utilized. Thus, the accuracy of sensors' measuring needs to be maintained.

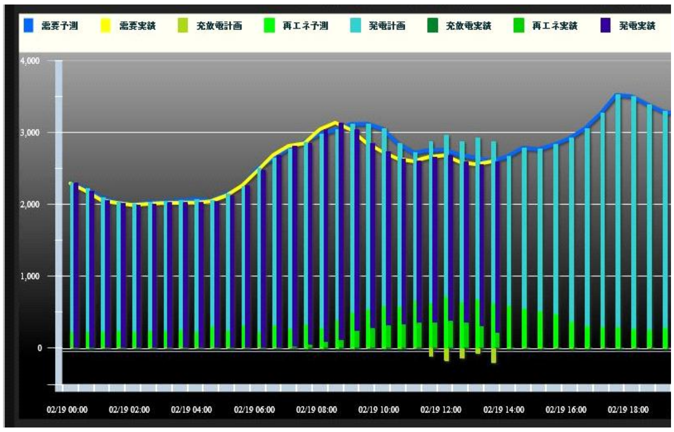


Figure 4-1 Sample Image of EMS Control Application

Source: TEPCO

4.2.2 Weather Forecasting System

Weather forecasting system can grasp a sudden fluctuation of solar power beforehand and help adjust generation operation. It may facilitate stable grid operation when considerable capacity of solar power is introduced to a grid. Some Japanese utilities have already utilized and adapted weather forecasting system into demand-supply control system at dispatch centers.

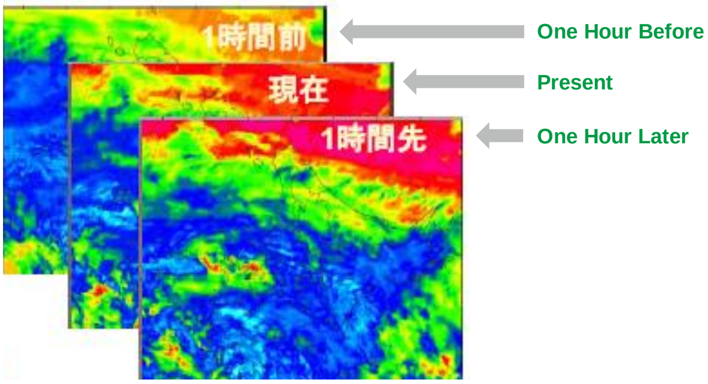
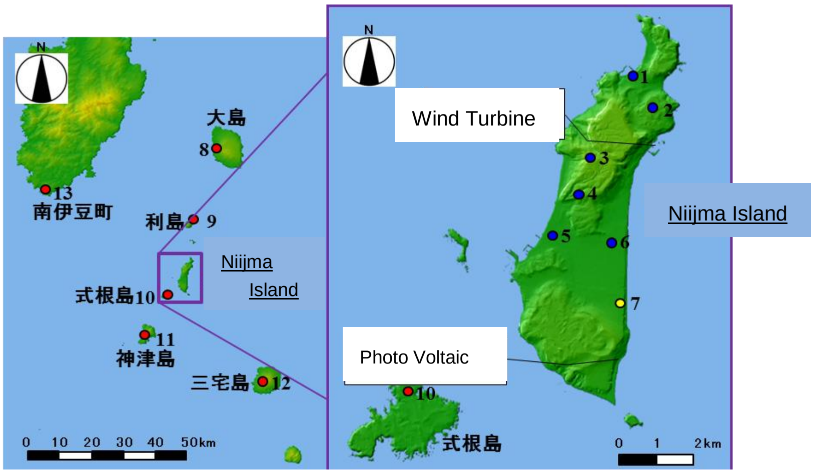


Figure 4-2 Weather Forecasting System (Image)

Source: Japan Weather Association

New forecast system is being tested in Niijima Island, Tokyo under the demonstration project of New Energy and Industrial Technology Development Organization (NEDO), which can minimize forecast errors by adapting statistical calculation with measured weather data.



- Observation Points (Wind-direction and velocity, Global irradiance, Temperature. Omnidirectional camera)
- Observation Points (Wind-direction and velocity)
- Observation Points (Wind-direction and velocity, Global irradiance)

Figure 4-3 Weather Forecasting System (Image)

Source: The Institute of Electrical Engineers of Japan

4.3 Smart Invertor

Conventional inverters for solar PV are designed to maximize output as per irradiation level and overall system conversion efficiency. Such design concept is reasonable from the perspective of efficient utilization RE, while the system does not embrace the concept of grid stability. A smart-inverter, which harmonizes more sophisticatedly with grids, is being commercialized worldwide. A smart-inverter has many functions, including active-power, reactive power and frequency control. The parameters, which are essential for connecting to the grid, changes based on two-way communication; from solar PV to the grid and vice versa. These functions must be programmed when a smart-inverter is installed.

A smart-inverter will help control power output from plants, and help balance demand and supply when applied to large-scale solar PVs. Moreover, the smart-inverter is expected to play a key role in controlling active and reactive power adjustment in case small-scale solar PV systems are widely installed into the gird.

4.4 Measures of Demand Response

Demand side response measures are categorized mainly into two; short duration response and long duration response. Measures are discussed below by these two categories.

4.4.1 Measures for Short Duration Response

(1) Output Curtailment

In Japan, a law enacted in 2015 allows a power utility to request solar PV owners to limit their output by 360 hours per annum without compensation, in case power supply is estimated to exceed power demand even after the utility takes necessary measures to avoid output restriction (such as output restriction of the utility's facilities). The dispatch condition applies to IPPs that apply for feed-in-tariff after the enactment of the law..

(2) Electric vehicle

Electric Vehicles (EVs) are expected as one of the instruments to improve energy efficiency in the global transportation sector. EVs are also expected to contribute to grid stability, and a demonstration project has started in Japan, in which EV is used not only for transportation purpose but also for grid stability purpose. There are two ways to utilize EVs for grid stability; EVs are regarded as a load in the grid when the batteries are charged, while they can supply power by discharging the batteries-The latest EV has a 40 kWh battery and it can charge at about 30 kW and discharge at about 6 kW within a short period. The battery of EV can be utilized for a long duration response likewise. Detailed examination of the possibility to utilize EVs in SI is contained in Appendix 5.

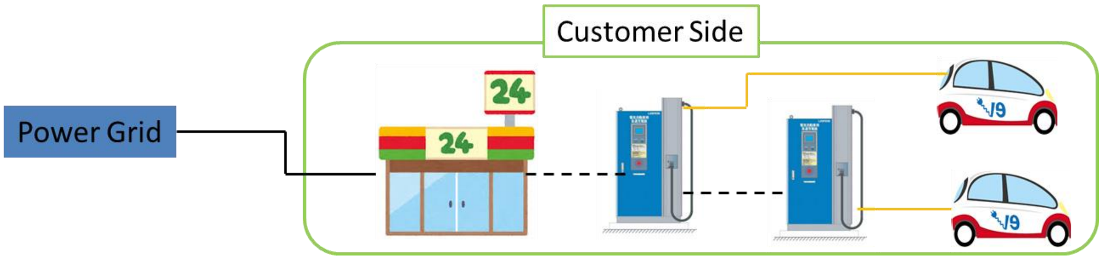


Figure 4-4 Image of EV Charge in Japan

Source: JICA Survey Team

(3) Nega-Watt Trading System

(a) General

Demand can be reduced instantaneously under orders from the grid by installing control instruments with electric appliances provided power shortage happens. Those electric appliances are generally selected upon customers' consents, not to affect economic activities and life of customers. Incentives are provided in a supply contract to enlist cooperation from customers.

(b) Target Equipment for Nega-Watt

Air-conditioners in business centers and electric water heaters at households are generally preferable for

Nega-Watt equipment. The more controllable demands are gathered, the more sufficient effect is expected. Thus, large consumers (e.g. factories) are suitable for Nega-Watt.

There are obstacles for the promotion of Nega Watt control. To encourage customers to purchase those appliances, incentives are essential to drive Nega-Watt control. In addition, a highly reliable communication system must be equipped to control appliances via smart meters.

4.4.2 Measures for Long Duration Response

(1) On-Demand Adjustment Contract

In Japan, "On-Demand Adjustment Contract" has been adapted for large consumers on a voluntary basis, where consumers reduce the load in response to requests from a power utility in the event of supply shortfalls. This can avoid a shortage of power sources in an emergency. To prepare for a power deficit, a request for reduction of power consumption shall be put several hours before the expected timing of the power deficit.

(2) Time of Use Tariff

Time of Use (TOU) tariff is applied for encouraging a peak shift. By shifting the peak, maximum capacity that must be managed by a utility can be reduced to some extent and investment cost for new power plants can be suppressed likewise. Different tariffs are set time by time and customers can select a cheaper tariff option considering their life styles. As a result, a daily load curve is intentionally adjusted to minimize the operation and construction costs.

(3) Ice Storage Air-Conditioner

Ice Storage is one of cooling systems for building which utilizes ice generally produced during nighttime in cheaper electricity tariff. This shifts demand from daytime to nighttime. However, a load capacity has to be larger if the cooling system runs whole day.

4.5 Adaptable Technology for Solomon Islands

4.5.1 Recommended Measures

Batteries and weather forecasting systems are effective measures to install solar PV in the grid to achieve RE 100%. Installation of battery systems, however, should be carefully planned in accordance with the pace of installation of solar PV, the variation in annual generation of Tina Hydro and demand forecast in order to avoid inefficient investment. Daily operation patterns of Tina Hydro shall also be studied for planning an appropriate mix with solar PV and battery from the viewpoint of optimizing proportions of each RE sources. Moreover, smart invertor is a viable option likewise when the power quality becomes unstable due to a large amount of solar PV in the grid.

4.5.2 Applicable Measures

Out of the aforementioned short duration response measures, “Output Curtailment” is technically easier to be introduced in SI.

“On-Demand Adjustment Contract” is also a salutary concept when the power deficit is expected in the next day. Facilities and equipment that can be shut down or run in lower power must be agreed with customers beforehand. Upon SP’s request, power consumption by the customers can be reduced on the day of tight balance in demand and supply. Customers who equip an emergency generator would agree the contract if SP offers attractive price because they can utilize their generator for the time instead of supply from the grid.

“EV” is another option for SI. The transport distance of cars is relatively short due to the size of the islands, which is why the number of charging stations seems less important in SI than in other larger countries. The car sales prices are relatively high in SI due to import costs, including transportation and import duty. If tax exemption is applied to EV import duties, the sales price will drop and EVs may become competitive with gasoline and diesel cars. Accordingly, incentives for EV drivers, including subsidized electric bills and reduced car registration cost will spark further EV demand. Moreover, government policy, such as imposing additional taxation on gasoline and diesel cars and limiting their numbers will further promotes EVs.

Considering high sales prices and current income, the prevalence of new EVs in SI is not realistic in the near future. Besides, in consideration of the short inland transport distance in the nation and the relatively low sales price, second-hand EVs are more suitable. Furthermore, the capitalization of second-hand EVs can elicit another benefit; introduction of reuse batteries for RE 100%. The reused battery utilizes recycled EV battery after dismounting from EVs and inspecting the remained life cycles. The greater the number of second-hand EVs introduced, the more available reused batteries become. The reused battery functions as an energy source in the grid and supports the RE 100% goal. More study about EV is described in Appendix 5

Photo 4-1 Reuse Battery: (left) Exterior, (right) Inside of package

Source: 4R Energy

5 Promotion of Private Investment

5. Promotion of Private Investment

5.1 Assumption of the Issues in Private Investment in Solomon Islands

The key to accelerate private investment in the RE business is not the Feed-in-Tariff (FIT) but the business environment to attract private investors such as IPPs. In SI, where the IPP law is not regulated, the contents of not only the electricity law but also foreign investment law, company law, and tax law and the risk allocation in PPA between the SP and IPPs becomes essential as the barriers in terms of both regulation and market condition should be clarified. In the Survey, assumed risks for private investment in SI were examined and identified study points for road map formulation.

5.1.1 Regulation

The barriers of IPP business in developing countries are, for instance, restriction on foreign investment, the condition of company establishment, unclear risk allocation between IPP and governments, government guarantees, convertibility guarantees, or tax benefits. SI is assumed to have the same issue likewise.

5.1.2 Finance

Many developing countries have obstacles for financing, including local banks' inability to evaluate the RE risks, loan conditions, availability of opening bank accounts by foreigners, government guarantees, or convertibility guarantees. SI would face the same problems with other developing countries.

5.1.3 Capability of Local Contractor

Capability of EPC contractor is one of critical matters for the project implementation. Poor capability of contractor causes project delay and budget overrun in many cases. Construction cost would rise if EPC contractor is selected overseas due to the lack of 'good enough' EPC contractors in SI. In addition, EPC contractors would often serve operation and management (O&M) after construction works. It is assumed that a highly qualified EPC contractor does not exist in SI as well as many other developing countries.

5.1.4 Infrastructure

Infrastructure is also an important component to promote the IPP business. For instance, the deteriorated port and road infrastructure could become risks to manage construction project by the IPP owner because SI mainly depends on marine and car transportation for import and inland transportation respectively.

5.2 Foreign Investment in the Private Sector

5.2.1 Related Institutions and Processes

There are several steps needed for foreign investors to receive approval and establish a new business entity in SI; obtainment of Foreign Investment Certificate (FIC), Certificate of Incorporate (COI), Tax Identification Number (TIN), work permit and business license. Figure 5-1 summarizes the flow for foreign investors.

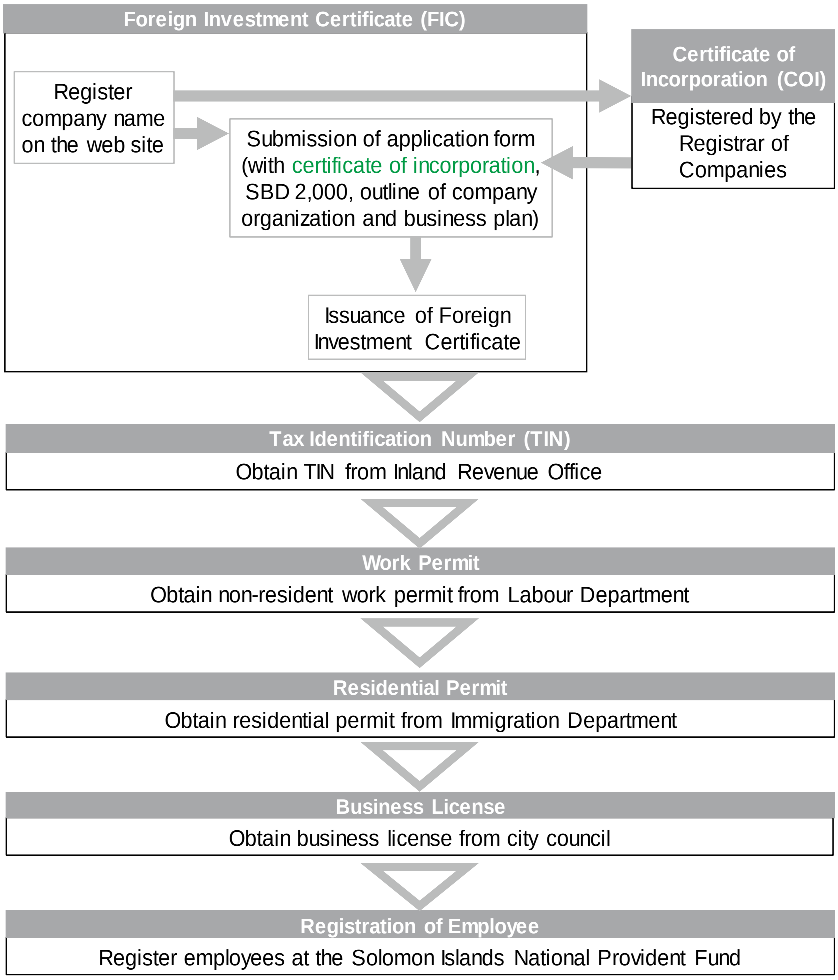


Figure 5-1 Registration Flow for Foreign Investors

Source: JICA Survey Team

(1) Foreign Investment Certificate

The first step for foreign investors is to obtain FIC to set up a new business in SI. Without FIC, no other business activities are allowed, including investment, negotiation and moving onto any other steps for setting up its business. First, a new business should register their business entity name or company name on the website of the Solomon Islands Business Registry (SIBR)[1]. The application form should be submitted with related information and document such as a brief business plan of the proposed business, the company's certificate of incorporation and an outline of the company's organization structure/business plan[2]. The fee levied to register the foreign investment is currently Solomon Islands Dollar (SBD) 2,000 increased from the previous SBD 200 to reflect the appropriate cost of screening and processing foreign investment applications. The SIBR is a newly established institution in November 2016 supported by the Pacific Private Sector Development Initiative, the ADB's technical assistance program and the Government of Australia and New Zealand. COI is also required with the application form if the applicant is a company.

Second, the Foreign Investment Division (FID) assesses investment applications. On receipt of applications with the fee charge which comply with the Foreign Investment Act, the registrar will assess whether or not the application specifies all required information sufficing to determine the nature of the business. If the information given to the FID is insufficient, the registrar may request additional information from the foreign investors and reassess with the additional documents. If all the information and documents provided by the investor suffice and meet the requirements, FID issues the certificate with an approval letter and this process may be completed within five working days.

(2) Certificate of Incorporation

The foreign investors should obtain a COI after registering the company name as a parallel process with FIC. Applications for registration must also be submitted with a copy of the company rules if the rules differs from the model rules[3]. Approvals from shareholders, which should be fewer than 50, are also required before submission, then, upon the approval of the registrar, a COI is issued. Applicants of company registration must have a register office and a postal address in SI. The postal address may be a company's registered office or other working place, including a PO Box and a private bag, whereas the registered office may be at the company's place but it must not be a PO Box or a private bag. For an auditor, if the company appoints an external auditor for an internal audit, the auditor should register with Institution of Solomon Islands Accountant (ISIA) as well as an external audit. If the company directly employees an auditor for internal audit, this is not a case.

(3) Tax Identification Number

Investors should register the company for consumption taxes, including income tax, sales tax, goods tax and Pay As You Earn (PAYE) purposes to the Inland Revenue Department (IRD). The IRD then issues a TIN provided enterprises to comply with the requirements.

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1 https://www.solomonbusinessregistry.gov.sb

2 If an applicant is individual, copy of ID and curriculum vitae are required instead of company's certificate and organization structure.

3 The model rules are attached to the Company Act.

(4) Work Permission and Residential Permit

Investors should also apply for a non-resident work permit to the Labor Department and a residential permit to the Immigration Department.

(5) Business License

Foreign investors need to obtain a business license from a city council and register employees and directors with the Solomon Islands National Provident Fund (SINPF).

5.2.2 Laws and Regulations

(1) Foreign Investment Act

The Foreign Investment Act was enforced in 2005 and amended in 2009 to provide for registering and monitoring foreign investors in SI.

(2) Companies' Act

The Companies' Act was put in force in 2009 to provide for the formation and governance of private, public and community companies.

5.2.3 Taxation

The Income Tax Act (Cap. 123) is consolidated to November 2012 by the IRD, the MOFT. Tax relating to company profit, dividend and others relating to business profit in SI are taxed mainly based on the Income Tax Act.

(1) Corporate Taxation

Some tax rates differ between resident and non-resident corporations; a resident corporation is deemed residents in SI if the company is incorporated in SI and (i) its central management are in Sl or (ii) it runs a business in SI shareholders who control voting power resides in SI. Otherwise, the others are non-resident corporations.

Resident corporations pay tax on their worldwide income while non-resident corporation are taxed only on income in SI. The rates are 30% and 35% for resident- and non-resident corporations respectively. There is no capital gain tax in SI but when business assets have been depreciated, any gains obtained through the disposal of the assets will be taxed as a balancing charge. Tax losses can be carried forward for a limit of five years.

(2) Withholding Tax

Withholding tax is applied to gross payments such as Dividends, Interest Royalties, Technical or Professional services fee, Contracting income, lease payments and certain management services fees.

(3) Other Tax

Social security or Contribution Liability is paid to the SINPF. Employers and employees are required to contribute 7.5% and 5% respectively. Stamp duty is imposed on a variety of written instruments in SI, at rates that vary depending on the type of document.

(4) Tax Exemption

Tax exemptions are available for development partners and private investors in SI upon an exemption application. The Tax Exemption Committee is the entity responsible for tax exemption, members of which comprise of representatives from the IRD, the FID and the Customs and Excise Division. Depending on the nature of the application, experts are appointed to the committee from a relevant ministry or organization. For power projects, energy specialists can be assigned from the MMERE (e.g. the Tina Hydro project exemption application).

Expected national interests of projects are importantly assessed and tax exemptions and rates determined accordingly (see Appendix 5 Exemption Application Form). From this perspective, RE projects may benefit from tax exemptions because RE 100% is one of the key national strategies. The committee provides recommendations to the Minister of Finance and Treasury and then, the Minister is responsible for granting n full, part, or not granted.

(5) Tax Reform

Tax Reform was underway as of March 2019 and it is expected to be completed by the end of 2019. After a one-year transition period, a new tax system will be rolled out in 2021. The SIG has recognized the fact that many parts remain outdated, inefficient and complex to administer, levying a high tax burden to the nation compared to other Pacific countries (tax revenue constituted 32% of GDP in 2016).

5.3 Public-Private Partnership

5.3.1 Economic Reform Unit

The Economic Reform Unit (ERU) is a government institution that pursues policy and project analysis for Public-Private Partnerships (PPPs) and is currently working on tax reform, as explained above.

5.3.2 PPP Unit and its Tasks

The PPP Unit launched under the Project Funding and Development Division, MOFT in October 2018, was supported by the ADB through the Asian-Pacific Project Preparation Facility (AP3F)[4]. ADB's support covered the documents of the PPP Unit (operation manual and organization chart), the PPP relating works (PPP knowledge, Value for Money (VFM) concept, training) and PPP project pipeline. The ADB's support for the Unit completed in January 2019.

The main function of the PPP Unit is to support ministries and state-owned enterprises (SOEs) in order to assist accessing private funds and conducting procurement through PPP scheme. The Unit also supports to develop procurement guidelines, whereas the Unit does not intend to establish PPP law or regulation as a policymaking or lawmaking body at this moment. Promoting the "PPP" concept is also an important function for the PPP Unit.

5.4 Current Situation and Problems

5.4.1 Current Situation of Foreign Private Investment in Solomon Islands

In the previous sections, regulations and taxes that are related to foreign investment were researched. To establish a corporation, foreign investors must have a registered office that is located in SI. Thus, foreign investors shall obtain their own land in SI or find a business partner who possesses land and property in SI. Looking at the difficulty to acquire land, which is explained in the next section, it is better for foreign investors to establish a partnership with a Solomon Islander or a company based in SI. Little information of local companies, however, are available in the public (on the Internet and other sources). According to FID, limited number of foreign companies (about 30 to 50) have registered in SI and the majority of their nationalities is Singapore, Malaysia and other South Asian countries.

Turning onto tax, the tax system has not established comprehensively and taxes rate in SI is higher than that in other Pacific countries. Although the tax reform is undergoing, the details have not been publicized and investors cannot estimate their business balance with the new tax. From these viewpoints, tax exemption/holiday are significantly preferred for their investment. Although the tax exemption criteria are not transparent in terms of the evaluation of national interests, RE project may have some rooms to be granted for the exemption.

For PPP scheme, PPP Unit just launched and ADB's support project completed in January 2019; the Unit has not experienced any PPP project yet. More experiences of the PPP Unit might be preferably expected by foreign investors given that they plan to use the PPP scheme for their business.
Considering credit risks, SP has high Counterparty Credit Risk (CCR), with the international standard for credit security in mind while SI also has a high CCR with a rating of B- ~ B+ that is far below the

[4] AP3F launched in 2014 to assist Development Member Countries gov'ts and their public sector agencies in preparing and structuring infrastructure projects with private sector participation

of BBB- threshold rating. Besides, there is no comprehensive guideline for foreign investors to invest in SI whereas they need to clarify all relating risks to scrutinize their business plan. With the above situations in mind, the period seems relatively short and the loan amount is only to pay the operational cost of businesses provided foreign investors negotiate with foreign-based commercial banks as things stand.

Indicators for interest rate are the interest rate for a retail customer of the South Bank of Pacific, as publicized on the website and the GDP growth rate. The interest rates for SOEs including SP, are lower than other retail customers and private companies in SI but a long repayment period may not be accepted by banks, as the renewable energy project includes a decade-long repayment period.

5.4.2 Interviews to Potential Investors

Several interviews to potential investors in Japan were conducted during the Survey period.

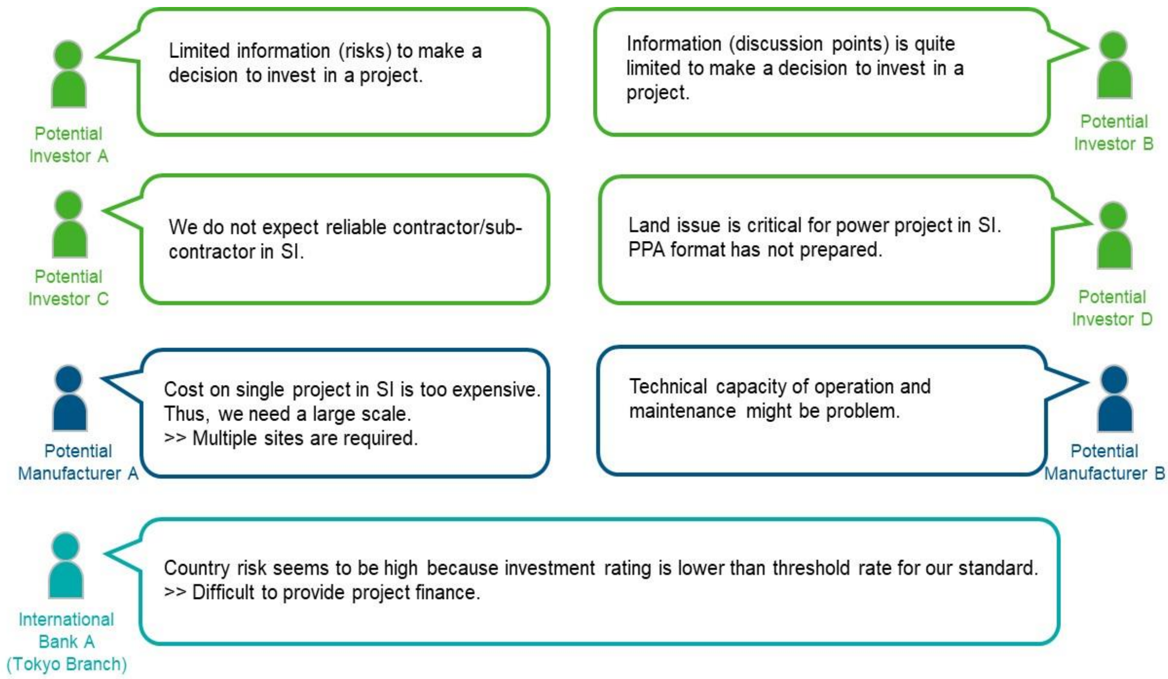

Figure 5-2 Interview Result with Potential Investors

Source: JICA Survey Team

Potential investors were mainly concerned about limited information for risks, contractors' capability, land issues, PPA and financial situation of SI and SP as we assumed. In a nutshell, a clear guideline for investment, including business risks in SI, are demanded to attract foreign investors. Thus, a lack of clarity for risks were further examined in the next section.

5.4.3 Issues of Private Investment to the Energy Sector

●	Considerable Risk in Solomon
●	General Risks of project implementation
	Relatively low risk- keep monitoring

Table 5-1 Risk Patterns in power Development and Business

Risk Patterns in Power Plant Development and Business		Development Flow for Power Project												
											O&M		Business	
		FS	Approval	Land Acquisition	PPA	Spec	EPC Contract	Loan Contract	SPC formation	Construction	Operation	Maintenance	Collection	Debt Repayment
(1)	Sponsor risk								●					
(2)	Project delay risk		●	●	●	●	●	●						
(3)	Risk on construction completion									●				
(4)	Operational risk										●	●		
(5)	Sales risk				●								●	
(6)	Interest rate risk							●						●
(7)	Foreign exchange risk							●					●	●
(8)	Cash flow risk													●
(9)	Social / Environmental risk	●	●							●				
(10)	Disaster risk									●	●			
(11)	Country risk	The Risk can be caused through all stages.												

Source: JICA Survey Team

Table 5-2 Considerable Risk in Solomon Islands

Category		Description
Project Delay Risk	Land Acquisition	• **Land ownership issues**- customary and registered land- can cause not only **delay** but also **suspension and cancellation** of projects. ➢ Limited numbers of boundaries and owners are registered at Register Title Officer. ➢ Customary lands take a longer time to negotiate for use.
	PPA Negotiation	• Development of PPA format- in consideration of business and environment in the Solomon Islands • Few experience of PPA with IPP players • Intra-relation in terms of dealing with PPA
	Loan Contract	• **Credit risk for SP and the Government of Solomon Islands** can cause difficulty for negotiations for the loan agreement. • A possibility of Sovereign Guarantee by the Government of Solomon Islands
Risk on Construction Completion	Capacity of Local Subcontractors	• Well-being financial structure • Technical knowledge and management skills • Deployment of appropriate numbers of skilled labours • Procurement of local materials on time
	Peripheral Infrastructure	• The capacity of port facilities and arrangement loading and unloading of construction materials and equipment • Access to the construction site from the port- access road • **Connection to the grid**- the distance from the existing distribution lines • **Responsibility for connection**- process, required time and burden of expense on construction and materials
Sales Risk	Off-taker	• The stable power purchase by SP from IPPs. This strongly connects to the financial structure of SP. • The technical capacity of the power system management-planned outage and accidental outage • Business strategy for SP - The concept of market share of SP and IPPs • Development Plan for power plants and transmission/distribution lines can affect the future sales of IPPs.
Foreign Currency Risk	Securing Foreign Exchange and Convertibility	• Payment collection is based on Solomon Island Dollars whereas expenditure for the project is mainly in foreign currency; US dollars, Australian dollars and/or others. Some amount of **sovereign guarantee** is preferred for **securing exchange risk** in order to attract IPPs. (e.g. capitalizing MIGA's credit enhancement) • The sovereign guarantee for the convertibility is preferable. Otherwise, the certain amount of **foreign currency reserve** should be secured at the central bank.

Source: JICA Survey Team

As mentioned in Section 5.4.1, relevant risks for new business should be clarified for foreign investors to attract their appetite for new businesses. Table 5-1 summarizes the risk patters for development in power projects, while Table 5-2 sets out considerable risks in SI. Each issue is discussed in the followings:

(1) Land Acquisition

Land acquisition issues are the biggest barrier in SI.

(a) Laws and Regulations

The Land and Title Act (1988: amended in 1996) prescribes landownership, the legitimate land acquisition process for customary land and the function and power of relating agents including land registry, the Registrar and the Commissioner of Land, the Adjudication Officer and the Acquisition Officer. Under the Act, all registered lands in Honiara and in eight provincial headquarters and almost all the commercial plantations are owned by the SIG under the administration of the Commissioner. Perpetual estates are also owned by the SIG and leased out to private tenants and industry for a fixed term of up to 75 years other than customary land.

(b) The Overview and Issues

The land availability issue is one of the bottlenecks affecting infrastructure development projects in SI, with lands clarified into two categories; customary and registered land. Registered land is recognized by SIG as covering appropriate areas, boundaries and owners under the statutory procedure. The mapping office manages registered land and all related information (e.g. GIS data) of registered land is owned by the SIG and administrated by the Register Title Office that is under the jurisdiction of the Ministry of Justice. Only approx. 20% of available land in SI is registered under the Act. In case the land is registered and leased out, new businesses and investors need to negotiate with the lessee of the land. After negotiation is settled, new businesses and investors have to submit the application to the Commissioner of Land in order to change lessee of the land.

For customary land, which comprises approx. 80% of available land, is owned by clans or tribes and inherited from one generation to the next, with no record at the Land Registry in terms of land boundaries. When candidate land constitutes customary land, an Acquisition Officer goes to the site and identifies landowners and their parcel number after a public hearing with clans. After identifying the owners, the officer starts negotiations, which takes at least four to five months, depending on the conditions that the candidate sites face. The parcel numbers of those whom the officer identify as a landowner are registered with the Register Title Office. Besides, if the lessee of the candidate site is a SOE mainly located in Honiara, negotiation for land use is direct to SOE, not via the Register Title Office. After the SIG obtains the land, registered land is leased out, for up to 75 years, pursuant to the Land and Title Act stipulates. Provided the land is leased for public non-profit use (e.g. by SOEs), the lease fee is waived for lessees. Figure 5-3 summarizes the conceptual flow of customary land. A more detailed process of land acquisition (non-compulsory) is illustrated in Figure 5-4.

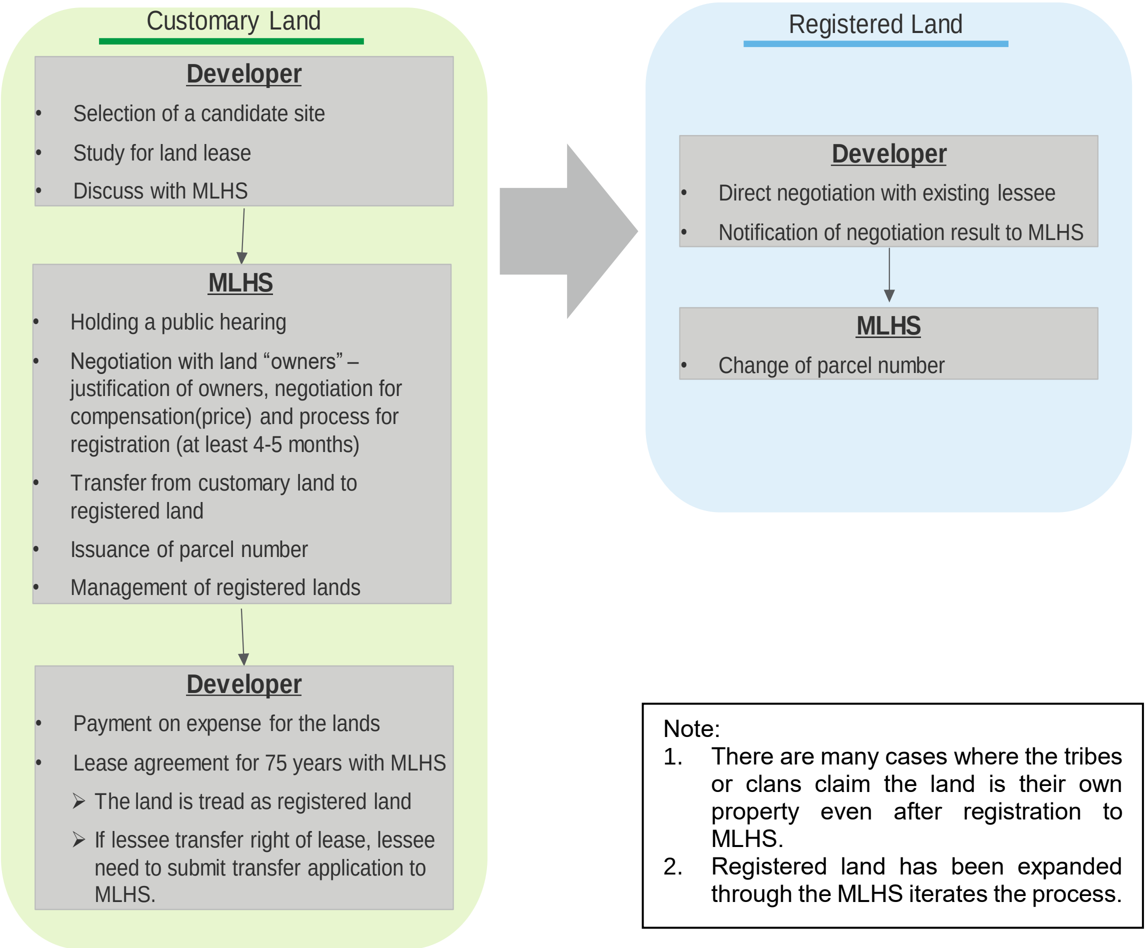

Figure 5-3 Conceptual Flow of Customary Land Acquisition

Source: prepared by JICA survey team based on interviews with MLHS

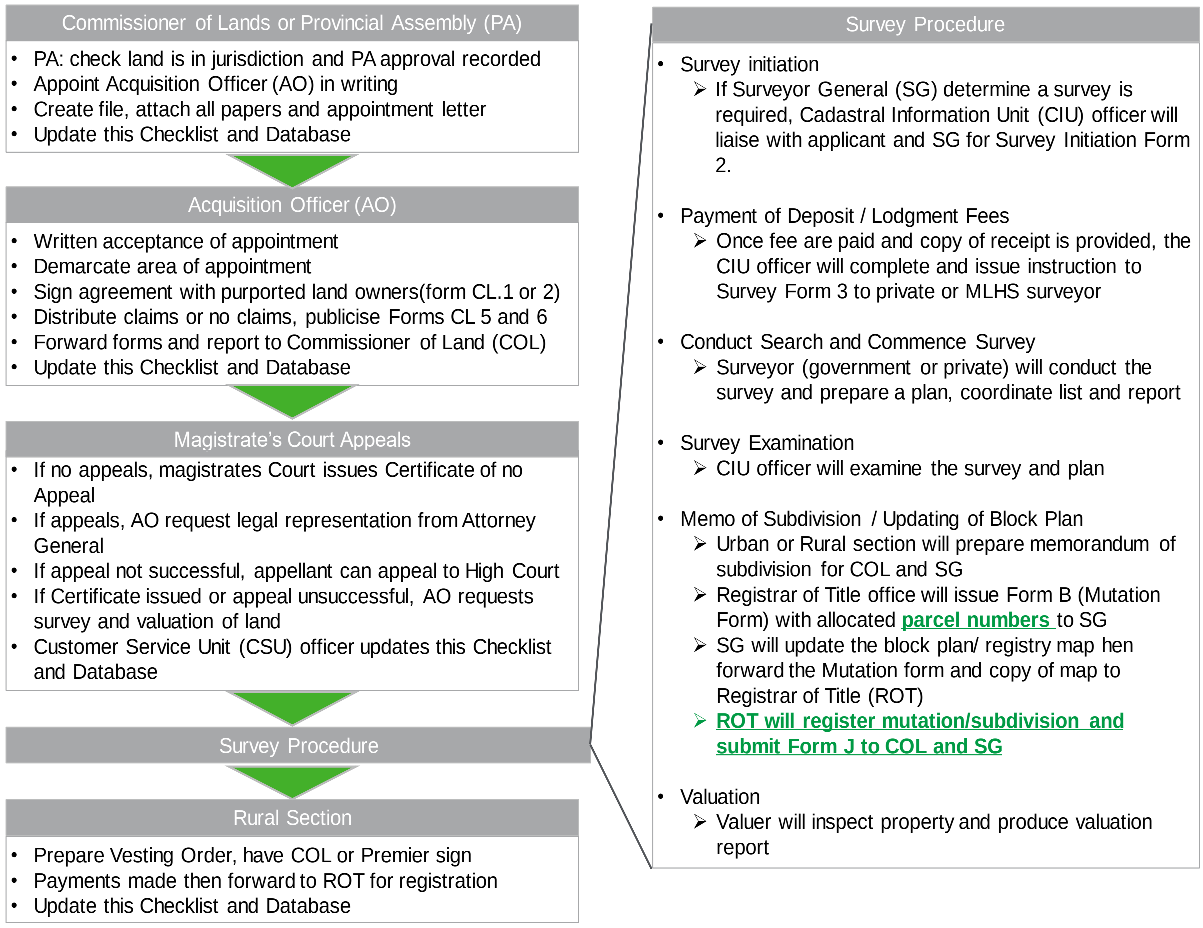

Figure 5-4 Detailed Land Acquisition Process (non-compulsory)

Source JICA Survey Team

(2) Negotiation on Power Purchase Agreement

SP has been a single power producer in SI to date mainly with diesel generators. On completion of the Tina Hydro construction, scheduled for 2024, the project will be the first IPP in the nation. Accordingly, the off-taker, SP has only experienced negotiation on power purchase agreements PPAs with the Tina project. Critically, the project involves support from development partners and the all PPA conditions are unique compared to PPA with private investors elsewhere in terms of risk allocations. From this perspective, SP needs to develop the knowledge of PPA and risk allocation with private investors. For private investors, the lack of any track record of PPA for SP with purely private investors means investors cannot identify what should be carefully handled in PPA negotiation. To attract private investors, it is strongly recommended that PPA format or contents be publicized on a website or any media.

(3) Loan Contract

The economic weakness and lack of clarity of SI project risks hampers efforts by investors to negotiate project finance based on a PPA with commercial banks. IPP projects in SI may be less suitable and attractive for commercial banks because of the scale of the project and unclear project risks at this moment. The expected scale of potential renewable projects in SI is a few MW, equivalent to less than USD 90 million, whereas the minimum project finance would be approximately USD 450 million. In terms of local currency risk, a forward market will not handle USD 450 million over the next 20 years and the financial risk would not be circumvented, hampering efforts to arrange project finance.

Accordingly, to pursue the project finance, project risks should be clarified and allocation negotiated. For an example to clarify the risks and their allocation, it is recommended to establish and publish a guideline. In addition, guarantees to both the nation, SP and private investors should be conveyed; investment guarantees (e.g. the Multilateral Investment Guarantee Agency (MIGA)) and trading guarantees (e.g. Nippon Export and Investment Insurance (NEXI)). Otherwise, commercial banks can arrange corporate finance with investors' own CCR other than SPC. In case an investor utilizes corporate finance, the interest rate would be generally less than that for project finance.

It is noted that the above-mentioned loan contract is based on interviews with banks and potential investors located in Japan. Thus, in order to broaden the viewpoint, it is strongly recommended that this risk be examined in the road map formulation (e.g. interviews to banks in Singapore, Malaysia and other Southeast Asian countries where foreign company have come from into SI).

(4) Capacity of Local Contractor

There is a concern over local contractors for private investors. When implementing a power project, construction and installation works may be significantly affected and delayed if the contractors lack EPC capacity. According to SP, no contractor performed satisfactorily on construction works for a power plant in SI. The CBS and the Clay Energy, both based in Fiji, have been awarded as an EPC contractor in many power projects of SP, as well as other projects financed by development partners; not only in SI but also Pacific island countries. Even for civil works for the road (Kukum highway project) project funded by JICA, a part of labors were mobilized from South Asian countries, including Bangladesh, Sri Lanka and others, with a lack of local labor.

Mobilization of contractors and subcontractors from foreign countries makes construction projects costlier, requiring a high sales price for PPA. This may cause difficulty to agree for PPA negotiation and result in no IPP. It is strongly recommended to support the capacity of local contractors for the future, otherwise foreign contractors should be carefully scrutinized and the proposed EPC price should be carefully evaluated while significant effort to reduce capital cost is required on the part of private investors.

(5) Peripheral Infrastructure

(a) Port

For a construction project, peripheral infrastructure should also be secured. Considering the construction project for solar and other RE projects in SI, most construction material is going to be imported from outside SI. As of 2019, the capacity of handle bulk freight and containers at the Honiara Port, operated by the Solomon Islands Port Authority (SIPA), is confirmed and a description of the SIPA is shown in the below table.

Table 5-3 Description of the Honiara Port

Description of Honiara Port		
Berths	No.1	Draft: 11 m Length of Berth: 120 m Handy-max can access
	No.2 (funded by JICA)	Draft: 13 m Length of Berth: 150 m Panamax can access
No. of Regular Services		12 ships per month (2 come from Japan: NYK and KYOWA)
Handling facilities (for loading and unloading)		None (ship gears are utilized)
Handling Facilities (for Containers handling)		Karmer (5) and OMEGA (8)
No. of Employees		480 (at Honiara port)
Action of Climate Change	LED	All lighting at Honiara Port were replaced to LED. The electricity cost substantially decreased by 100 million SBD.
	Solar	Solar LED lights are installed at the storage yard. (Stand alone)

Source: JICA Survey Team

The SIPA is also aiming to "Become Green" as their company strategy, which involved them replacing all their lightings with LED. They also plan to install 1MW of Solar PV plants at the Noro Port in the Western Province, which is currently powered by its own diesel generators. Considering the development of the canned tuna industry in Toro, they started FS for the solar PV under an Minutes of Discussion (MOU) with MAERSK and Trinary. The construction will be implemented as part of a Joint Venture (JV) with MAERSK.

(b) Access Road

Site access is crucial for construction projects and a land acquisition process is sometimes required, where the available land is inaccessible and construction work for access roads is needed. The route should be carefully analyzed from perspectives of land, bridge loads, slopes and road curves. Public roads belong to the SIG so that investors should consult with the MID for the detailed information of roads.

(c) Grid Connection

According to SP, SP may provide the grid connection (by CBs). IPPs should arrange discussions for grid connections with SP, which may also be delayed depending on land availability. If extended distribution lines are constructed within Right of Way (ROW) of roads, the government will provide land for poles and distribution facilities and land acquisition should proceed smoothly.

(6) Off-Taker

SP is the single company that provides distribution lines and facilities in SI. They are also a single off-taker at least this moment; stable power purchases and a robust financial structure of SP are required. According to interviews with local banks (local branches of international banks), SP is one of the most profitable companies in SI to date and faces fewer financial risks. Conversely, as mentioned in Section 5.4.1 and 5.4.2, foreign investors based outside of SI consider SP as a high CCR firm due to the country risk. As for the future development plan of power plants, SP forecasts more than 20 MW renewable energy with outdated diesel generators and expansion of demands. From this perspectives and the huge capital expenditure (CAPEX) involved, SP expects more IPPs as well as the Tina Hydro.

(7) Currency Convertibility

In general, electricity bills are paid in local currency to IPPs while foreign investors tend to run businesses outside SI. In accordance with the cash availability for the investors, they seek to exchange SBD to USD, AUD or any other currency in which credit is robust. With this in mind, a sovereign guarantee for currency convertibility is preferable for investors. According to the Central Bank of Solomon Islands (CBSI), however, no sovereign guarantee is given to any private investors nor there no case in other Pacific Ocean countries. Even so, as of Feb 27th 2019, CBSI foreign reserves amounted to approx. SBD 5,314 million[5], equivalent to USD 655.2 million) which is three times of the International Monetary Fund (IMF) recommendation[6].

In order to circumvent the currency risk, PPA in foreign currency (e.g. AUD, US and others) with SP is another option for foreign investors. To realize the sales condition, the benefits and the drawbacks for both SP and IPP shall be carefully weighed.

5.4.4 The Perspective in Private Investment in the Energy Sector

As discussed above, private investors scrutinize many risks for project feasibility. To attract private investors, risk allocation among the SIG, SP, and private investors shall be carefully studied and discussed. Investors can estimate the risk they have to contend with and decide whether or not to invest

[5] http://www.cbsi.com.sb/
[6] IMF strongly recommends reserving three months' worth of trade, while CBSI reserves nine months' worth of trade.

in the project provided the risks are identified clearly (e.g. guidelines) and their allocation among stakeholders are clarified. Considering the above, the following points should be discussed for the road map formulation, or be handled in future cooperation;

<u>Formulating IPP guideline</u>

- Review of risks in SI- *e.g. interviewing private investors in South East Asia or Oceania*
- Supporting land preparation within registered land by SP- *e.g. Public invitation for the land*
- Study of PPA contents- *e.g. soft or hard PPA*
- Clarification of subcontractors' capacity- *e.g. Capacity building for contractors in SI or investigation of subcontractors in Fiji or other countries within the Pacific Ocean*
- Case study of private investment and IPPs elsewhere in the Pacific Ocean- *e.g. Palau and Fiji*
- Study of regulatory and institutional framework of foreign investment in SI
- Study on risk allocation among stakeholders-*referencing PPP*

6 Support from Other Development partners

6. Support from Other Development partners

6.1 Aid Management and Development Policy

The Aid Management and Development Policy (Aid Policy) is enacted to reaffirm the tasks and responsibilities of related ministries and agencies regarding project implementation, external resource mobilization and aid coordination. The MDPAC considers that the lack of a comprehensive, coherent and official aid policy framework will hamper development.

6.2 Trend of Development Assistance by Other Development Partners

The mapping of aid by the main development partners in SI is shown in Table 6-1 Project Mapping supported by Development Partners. This section mainly focuses on ongoing energy sector projects while the table includes supports in various sectors.

6.2.1 World Bank

WB is one of the most aspirational SI's development partners. In the energy sector, the Tina Hydro project, flagship in the sector, remains in the preparation stage, with details described in Chapter 3. Besides, WB is supporting several projects through 'Electricity Access and Renewable Energy Expansion Project (SIEAREEP)', targeting an increase in the electrification rate and utilization of renewable energy. SIEAREEP is comprised of three components; the component one and two deal with off-grid rural electrification, while the component three includes the Fighter One expansion project with additional capacity of 2MW, and the rooftop PV system of 220 kW at SP headquarters. As for the Fighter One expansion project, WB will fund half the capacity and SP will shoulder the remainder themselves. These two projects within the Honiara Grid are summarized in Section 3.3.3. On the March 18th 2019, the request for bids for the two sites (IDA-D3270) were issued and the deadline for the bids is 3rd May 2019.

6.2.2 Asian Development Bank

The ADB is also a key development partner for SI and have provided a range of support in many sectors, including transportation, water sanitation, PPP (explained in Section 5.3 and waste management. As for the energy sector, five projects are ongoing in rural provinces other than Honiara and Guadalcanal Island; 320 kW in Kirakira, Makir-Ulawa, 290 kW in Lata, Temotu, 140 kW in Malu'u, Malaita, 1000 kW in Munda, Western and 250 kW in Tulagi, Central respectively. The ADB and SP signed the agreement in Feb 2017 and Contract signing was completed by the end of 2018. All title transfers for land are expected by June 2019. In addition, the ADB is also one of the co-financiers of the Tina Hydro project.

6.2.3 Australia

The Australian government is mainly supporting roads and ports through the National Transport Fund (NTF) funded by the Australian government, the ADB and the SIG and the Coral Sea Cable System (international submarine telecommunication cable from Sydney to Honiara and Port Moresby rather than energy projects. The Australian government will invest up to US$144 million in the project.

Table 6-1 Project Mapping supported by Development Partners

<table>
<tr><th rowspan="2"></th><th colspan="3">Energy</th><th rowspan="2">Transportation</th><th rowspan="2">Airport</th><th rowspan="2">Port</th><th rowspan="2">Tele-com IT</th><th rowspan="2">Rural Development</th><th rowspan="2">Capacity Building</th></tr>
<tr><th>Hydro</th><th>Solar PV</th><th>Mini-Grid</th></tr>
<tr><td>JICA</td><td colspan="3">Establishment of Road Map</td><td></td><td>○(Honiara Rehabilitation)</td><td></td><td></td><td></td><td>○(health, waste management, Forestry Management)</td></tr>
<tr><td>WB</td><td>○(Tina)</td><td>▲
(Fighter one expansion)</td><td>▼
(Rural Electrification)
▼
Road map (SIEAREEP)</td><td>▼(Road and Airport)</td><td></td><td></td><td></td><td>○(Rural Development program part2)</td><td></td></tr>
<tr><td>ADB</td><td>○(Tina)</td><td>○(5 sites in rural provinces)</td><td></td><td rowspan="2">Under NTF
○(Road)
△(Road)</td><td rowspan="2">Under NTF
○
(3 landing ramps)</td><td rowspan="2">Under NTF
○
(13 wharves)</td><td></td><td></td><td>Just Finished (Launch of PPP center)
▲(Port)</td></tr>
<tr><td>Australia</td><td></td><td></td><td></td><td>○(Int'l Tel-com cable)</td><td></td><td>○(Water Supply)</td></tr>
<tr><td>NZ</td><td></td><td></td><td>▲(mini-grid)</td><td></td><td>○(Munula, Gizo, Sege)</td><td></td><td></td><td></td><td></td></tr>
<tr><td>EU</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>○(Water Sanitation)</td><td>○(Electoral system)</td></tr>
</table>

Remarks: ○ On-going, △ Effective but not approved yet, ▲ Pipeline, ▼ under FS
NTF: National Transportation Fund by ADB, Australian Gov't and Solomon Islands Gov't

Source: JICA Survey Team

7 Recommendation for Development Cooperation Project in Renewable Energy

7. Recommendation for Development Cooperation Project in Renewable Energy

7.1 Summary

7.1.1 Overview of the Survey

In the Survey, basic data and information in terms of the business environment of private investment and an overview of the power sector were collected. Examining current circumstances in both cases, the Survey team proposes several options for the road map formulation and future cooperation for the SIG and SP.

7.1.2 Progress on Solomon Islands National Energy Policy

Progress and delays on power and its related sectors were confirmed through the Survey. Comparing to the current version of SINEP (2014), progresses and delays (described in *Italic font*) were summarized as followings;

Table 7-1 Progress on SINEP 2014

Policy Outcome
Use of RE sources for power generation in urban and rural areas increased to 50% by 2020 ***>> As changed in SINEP 2018 (Draft), overall progress would be delayed due to the delay on the Tina Hydro project.***
Policy Statements and its Strategies
4.1 Establish an appropriate, reliable, affordable and sustainable RE-based power supply in urban and rural areas
➢ Support the development and implementation of the Tina Rive Hydropower project and the Sava Geothermal project. ***>> Tina is ongoing but Savo Geothermal has been stack due to the problem on grid connection.*** ➢ Improve the SP energy services through off grids (hydro and solar) and generating plants. ***>> Solar PVs at outer islands (5 sites) by ADB and WB SIEAREEP*** ➢ Encourage and promote use of RE technology in rural areas
4.2: Assess, cost, promote and enhance the potential for RE resources
➢ Undertake assessment of potential of wind, geothermal, biofuel based on coconuts, gasification from byproduct and forest waste, and mini hydro ***>> Wind condition is not suitable for Wind power in SI. Geothermal has a grid connection problem.*** ➢ Development training and capacity development on new RE technologies.
4.3: Develop RE policy instruments (standards and regulations, net metering policies, market-based instruments, procurement strategies) to meet the RE targets
➢ Develop a clear policy on fiscal incentives (e.g. tax holiday incentives and duty tax exemptions including loans for RE technology deployment) ***>> Tax reform is undergoing.*** ➢ Develop clear policy and legislations/regulations on net metering ***>> Electricity Act is under Review for encouraging installation of small and middle scale of solar PV.*** ➢ Establish standards for on-and off-grid connections of RE technologies

Source: JICA Survey Team

7.2 Cooperation to boost Renewable Energy

7.2.1 Technical Challenges toward Renewable Energy 100%

Through the Survey, several technical challenges toward RE 100% have been identified from the study on potential of RE and on system stability and demand response. These technical challenges were summarized below.

Table 7-2 Challenges toward Renewable Energy 100%

Challenge	Assumption	Consideration Points
Solar Power Introduction	RE 100 % in the generation base is achieved by solar power introduction incorporated with Tina Hydro.	➢ Optimum battery plan is studied in parallel with solar power introduction. ➢ Battery is expected as both short duration for fluctuation of solar and long duration.
Variation in Tina Hydro Generation	Daily generation of Tina Hydro is supposed to vary from less than 3 MW to 15 MW through a year according to the data of 2010-2012.	➢ Daily operation patterns affect planning of solar power as well as battery. ➢ More data shall be collected for analysis of minimum costs of solar and battery introduction.
Distribution Operation Capacity and Voltage Control	If dedicated lines are not planned for specific solar power plants, some countermeasures for cable capacity and voltage would be required.	➢ Cable capacity and voltage shall be studied according to the volume of installed capacity of solar power. ➢ Countermeasures would be introduced if any specific problem is foreseen.
Decrease Inertia Function	The total invertor capacity surpass synchronized generators capacity in a whole rated capacity of the grid, the grids couldn't be always kept stable.	➢ A ratio of these two generators has to be clarified by static and dynamic simulation. ➢ If the ratio of inverter to generator increases, new forthcoming technology must need in the grid.
Supply No-Short Accidents Current	Short circuit current wouldn't flow into any relays provided the supply ratio of invertors surpass that of synchronized generators in total.	
Other Optional Plans	To be close to RE 100 % other than mega-scale solar PV projects, other optional supports are also considered.	➢ Middle- and small-scale solar PV shall be promoted with financial incentives. ➢ Loss reduction and energy efficiency shall be also considered to reduce required generation volume.

Source: JICA Survey Team

7.2.2 Technical Study in Road Map Formulation

The following technical study items are recommended for the road map formulation toward RE 100%.

- **Reinforcing Basic Data**
  - ➢ Hydrological data of Tina Hydro
  - ➢ Equipment of major customers
  - ➢ Targets of distribution loss and energy efficiency
  - ➢ Factors which affect power demand, etc

- **Review of Enabling Technology**
  - Battery
  - Weather forecasting system
  - Smart invertor
  - Demand response equipment
  - Demand side management program

- **Setting Preconditions for Simulation Model**
  - Study on possibility of energy efficiency and loss reduction
  - Demand forecast considering potential of energy efficiency and loss reduction
  - Review of operation of the existing diesel generators
  - Review of operation patterns of Tina Hydro
  - Review of the 3.5 MW battery project
  - Study of potential of solar PV sites and grid connectivity

- **Scenario Analysis on RE 100%**
  - Setting scenarios and initial analysis
  - Least generation cost analysis
  - Setting core scenario
  - Generation investment plan
  - Recommendation on operation of diesel generators
  - Recommendation on optimal Tina Hydro operation and battery operation
  - Identification of necessary functions of battery and investment plan

- **Planning of Transmission Line**
  - Grid stability analysis by each core scenario
  - Cost analysis for each core scenario
  - Transmission investment plan for each core scenario

- **Road Map Formulation**
  - Optimal investment plan considering generation and transmission
  - Economic and financial analysis
  - Implementation plan with necessary budget

7.3 Cooperation in Promotion of Private Investment

7.3.1 Initial Assumption before the Survey

The Survey team assumed there were several risks for private investors in SI before the Survey; regulation risks, financial risks, local contractor risks, and infrastructure risks. For regulation risks, the restriction on foreign investment, the condition of company establishment, unclear risk allocation between IPP and governments, government guarantees, convertibility guarantees, or tax benefits were postulated.

For financing, the Survey team made an assumption that SI would have obstacles for financing, including local banks' inability to evaluate the RE risks, conditions, availability of opening bank account by foreigner, government guarantees, or convertibility guarantees.

In terms of capability of local contractors, it was assumed that highly qualified EPC contractor does not exist in SI as well as many other developing countries. Turning onto infrastructure, SI mainly depends on marine and car transportation for import and inland transportation respectively so that they would be barriers for construction projects.

7.3.2 Verification of Assumption

The Survey team collected a lot of information about laws, regulations and taxation and interviewed potential investors in Japan. Through the fact-findings, we identified the risk patterns in power development and business in SI as discussed in Section 5.4.3. Risk allocation among stakeholders are not clearly mentioned in any public document for implementing power project in SI. Thus, private investors hesitates to invest in SI due to unpredictable risks. The risk allocation shall be studied for land acquisition, PPA negotiation, sovereign guarantee, off-taker, currency convertibility, capability of contractors, and peripheral infrastructure as we assumed initially.

7.3.3 Discussion Points in Road map Formulation

As discussed above, private investors scrutinize many risks for project feasibility. To attract private investors, risk allocation among the SIG, SP and private investors shall be carefully studied and discussed. Investors can estimate the risk costs that they themselves should shoulder and then decide whether or not to invest in the project provided such risks are clearly identified (cf. in the guidelines) and its allocation among stakeholders is clarified. Considering the above, the following points should be discussed for the road map formulation, or be handle in future cooperation;

- **<u>Formulating IPP guideline</u>**
  - Review of risks in SI- *e.g. interviewing private investors in South East Asia Oceania (e.g. Singapore and Malaysia: countries where foreign investors have entered the market of SI from)*
  - Supporting land preparation within registered land by SP- *e.g. Public invitation for the land*
  - Study of PPA contents- *e.g. soft or hard PPA*
  - Clarification of subcontractors' capacity- *e.g. Capacity building for contractors in SI or investigation of subcontractors in Fiji or other countries within the Pacific Ocean*
  - Case study of private investment and IPPs elsewhere in the Pacific Ocean- *e.g. Palau and Fiji*
  - Study of regulatory and institutional framework of foreign investment in SI
  - Study on risk allocation among stakeholders-*referencing PPP*

A Sample of conceptual risk allocation is shown in the below table. In the road map formulation, this concept shall also be studied and discussed with SI side.

Table 7-3 Conceptual Risk Allocation (Sample Image)

Category		Risk Taker		Description
Project Delay	Land Acquisition	SP		The issue roots from historical background and it is quite challenging for investors to combat the issue.
	PPA Negotiation	Negotiable		The contents of PPA is depending on business environments in each countries..
	Loan Contract	Gov't		Sovereign Guarantee supported by Insurance by MIGA or other insurance agency would be available to cap the risk.
Sales Risk	Off-taker	Negotiable		An adaption of output suppression control shall be discussed. If so the condition for the suppression shall also negotiated.
Currency Convertibility	Foreign Exchange		Private Investor	Decision by private investors if the foreign reserve is affordable for their projects.
Construction Completion	Local Subcontractors		Private Investor	Scrutinizing if the extra cost for foreign EPC is feasible for their projects. Or, investors take EPC risk on their own.
	Peripheral Infra	Gov't / SP		Peripheral infrastructure is provided as public service or not.
Economy of Scale		Gov't / SP		It is preferable for investors to be secured a multiple candidate sites / a bunch of rooftops. *e.g. Public Invitation.*

Source: JICA Survey Team

In order to pursue RE 100% in generation base, the proportion of each financial resources should be studied among SP, development partners, IPPs and others because of a large volume of solar PV - 50 MW. From the perspective, distributed solar PV system in small-scale shall also be considered as one of RE sources. The appropriate volume of each source is to be examined in accordance to investment capability of SP as well as study on risk allocation.

- **<u>Study of appropriate proportion in RE installation among financial resources</u>**
  - Analysis of investment capability of SP- *analyzing balance sheet and investment plan*
  - Study of the ideal IPPs and development partners' proportion
  - Financial analysis for feasibility of IPP projects
  - Study on the potential of distributed solar PV (small- and medium-scale)- *including study of deregulation of standby charge or reduction of standby charge rate*

An sample snapshot for additional RE toward generation base RE 100% excluding Tina Hydro is shown in Figure 7-1. "Others" may include distributed solar PV.

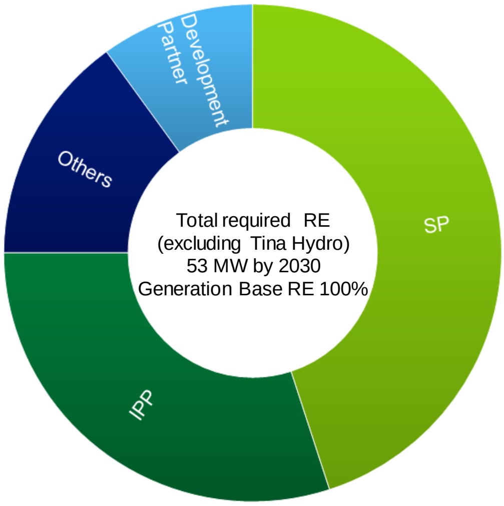

Figure 7-1 Sample Snapshot for Proportion of additional Renewable Energy toward RE 100% (Generation Base)

Source: JICA Survey Team

7.4 Coverage of JICA's Road Map for Solomon Island National Energy Policy 2018 (Draft)

The coverage areas of proposed output of the road map would be summarized in the below table.

Table 7-4 Coverage Area of JICA's Road Map for SINEP 2018 (Draft)

Policy Statements and its Strategies
4.1 Establish an appropriate, reliable, affordable and sustainable RE-based power supply in urban and rural areas
➢ (NEW) Replicate successful private / public partnership models for mini hydro systems and solar PV ***>> Not covered*** ➢ (NEW) Develop criteria to prioritize provision and develop maintenance schedule of RE infrastructure (using socio-economic indicators) ***>> would be covered by the JICA Road Map Formulation*** ➢ (NEW) Develop appropriate frameworks and laws to manage land access for RE projects. ***>> would be covered by the JICA Road Map Formulation***
4.2: Assess, cost, promote and enhance the potential for RE projects
➢ (NEW) Undertake an assessment of existing solar energy users and solar energy potential ***>> would be covered by JICA Road Map Formulation*** ➢ (NEW) Complete feasibility studies and reports for all RE potential sites and make them available for planning purposes ***>> Not covered.*** ➢ (NEW) Present investment costs against deployment of RE technology at donor roundtable discussions. ***>> Not covered***
(NEW) 4.3: Increase economical productivity in rural communities with the use of RE services ***>> Not covered.***
➢ Encourage the establishment of economical rural centers powered by RE at provincial levels ➢ Encourage RE Services Company (RESCO's) involvement in productive uses of RE sources. ➢ Promote the use of low-cost specific RE technologies (e.g. solar charging stations, solar pico lanterns).
4.4 Develop RE policy instruments (standards, net metering policies, market-based instruments, and procurement strategies) to meet the RE targets
➢ (NEW) Develop enabling instruments and initiatives to encourage RESCO and financial institutions to invest in RE initiatives. ***>> would be covered by the JICA Road Map Formulation*** ➢ (NEW) Promote benefits to financial institutions to provide concessional loans and term extension funds for RE electrification projects ***>> Not covered.*** ➢ (NEW) Promote and support the financing of the RE Investment Plan ***>> would be covered by the JICA Road Map Formulation***
(NEW) 4.5: Facilitate partnerships in development of RE developments.
➢ Development an appropriate framework for access to land for RE developments ***>> would be partially covered*** ➢ Develop a framework for public and private partnership. ***>> would be partially covered***

Source: JICA Survey Team

Appendix 1
Executive Summary of the Report

Appendix 2

Workshop Slide (Private Investment)

Appendix 3
Workshop Slide (Technical Introduction)

Appendix 4
Summary of Questionnaire Answers
(provided at the workshop)

Appendix 5
Electric Vehicle

Appendix 6

Tax Exemption Form

Appendix 7
Boundaries between registered and customary land (on Map)

Appendix 8
Output image of the next phase