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Developing Renewable Energy Storage Systems for the Pacific Island Countries

Task 1 and Task 2 Final Report

Report for the World Bank – Selection #1274121

WORLD BANK GROUP

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DEVELOPING RENEWABLE ENERGY STORAGE SYSTEMS FOR THE PACIFIC ISLAND COUNTRIES

FINAL REPORT FOR THE WORLD BANK – TASK 1: POLICY AND TECHNICAL RECOMMENDATIONS REPORT AND TASK 2: REGIONAL STRATEGY ON AUCTION ARRANGEMENTS

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ACRONYMS

ADB	Asian Development Bank
BESS	Battery Energy Storage System
EPC	Engineering, Procurement, and Construction
EV	Electric Vehicle
FSM	Federated States of Micronesia
HNEI	Hawaiʻi Natural Energy Institute
IFC	International Finance Corporation
IPP	Independent Power Producer
LCOE	Levelized Cost of Electricity
PIC	Pacific Island Country
PPA	Power Purchase Agreement
PPIAF	Public-Private Infrastructure Advisory Facility
PPP	Public-Private Partnership
PV	Photovoltaic
RE	Renewable Energy
RFP	Request for Proposal
RMI	Republic of Marshall Islands
TOU	Time of Use
V2B	Vehicle-to-business
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
VRE	Variable Renewable Energy

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The main authors were Eric Shumway, Utsav Adhikari and Vikas Suhag, from Delphos International. HNEI's contributions were made by Leon Roose, Marc Matsuura, and Damon Schmidt.

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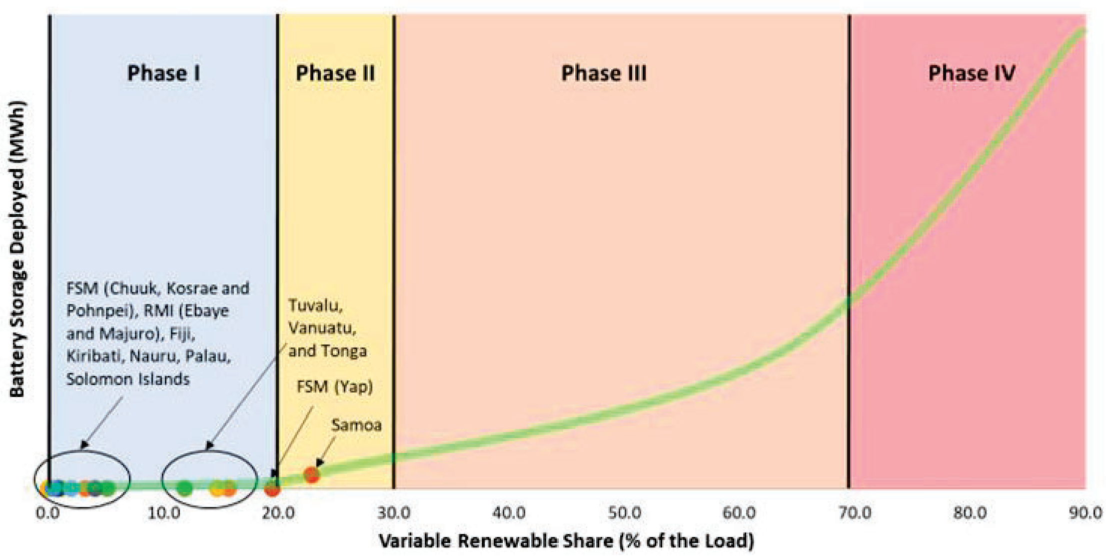
EXECUTIVE SUMMARY

The consulting team developed recommendations to facilitate private investments in Battery Energy Storage Systems (BESS) in the 11 Pacific Island Countries (PICs). All PICs have adopted policies to dramatically increase the share of renewables in the energy mix. Wind and solar (variable renewable energy, or "VRE") are expected to account for the bulk of new generating capacity added in the region, with BESS ensuring system stability and power availability in the face of high VRE penetration. Since VRE and BESS are capital intensive by comparison to conventional generating solutions, whereas most regional utilities cannot afford significant outlays, it is appropriate to consider mobilization of private capital for BESS and related VRE investments through Public Private Partnerships (PPPs).

The overall engagement covers the three tasks below. The present report covers Tasks 1 and 2.

- Task 1: Policy and Technical Recommendations. Recommend potential PPP structures appropriate to the region and the individual countries, as well as any policy changes and other interventions that would facilitate such structures.
- Task 2: Regional Strategy on Auction Arrangements. Develop a regional strategy for BESS procurement and PPP structuring, including guidance on tendering.
- Task 3: Design detailed BESS development roadmaps for three specific countries: Federated States of Micronesia, Republic of Marshall Islands, and Tuvalu.

Figure 1. Four Phases of BESS Deployment on Island Power Systems



The PICs, with few exceptions, are heavily reliant on expensive diesel-fired generation, with low levels of VRE penetration. Optimized BESS sizing (i.e., capacity and energy) in island systems is a function of the degree of VRE penetration. As shown in the figure above, as VRE penetration increases, the need for energy storage increases, but not on a linear basis. The degree of VRE penetration can be grouped into four phases: (Phase I) grid services and VRE enablement; (Phase II) capacity deferral and/or fossil retirement; (Phase III) energy shifting and curtailment mitigation; and (Phase IV) long duration energy shifting for deep decarbonization. The figure shows very low levels of VRE penetration currently, with all PICs in Phase I or II and, except for Samoa, very little BESS deployed (though some BESS projects are underway elsewhere).

Table 1, below, summarizes key factors and considerations relevant to IPP/PPP BESS projects in the region. As can be seen, four of the PICs (RMI, Tuvalu, Kiribati, and Nauru) have no PPP/IPP framework, IPP experience, or net metering policy. All seven of the remaining PICs feature at least two check marks in the table, though footnotes on some of these check marks should be consulted. For instance, FSM's PPP/IPP framework and net metering policy exist in only one of that country's four States; and Palau has IPP experience but several of its largest VRE IPP projects have failed to close financing.

Table 1. PICs PPP/IPP and Net Metering Policy Summary

Country	Population, 000s	PPP/IPP Framework	IPP Experience	Net-metering Policy	Key Considerations
FSM	106	✓[1]	✗	✓[2]	FSM is a federation of four States (like four separate countries, as regards power sector). High level of donor engagement in power sector. Significant demand on outlying islands. Limited PPP/IPP regulatory framework. Some positive policy and regulatory work ongoing. A "quasi IPP" approach that could be replicated in FSM and elsewhere.
RMI	55	✗	✗	✗	Two main islands, significant demand on several outlying islands. Important ongoing donor work in power sector (World Bank's Sustainable Energy Development Project & ADB's Pacific Renewable Energy Investment Program).
Tuvalu	11	✗	✗	✗	One of world's smallest countries in population and area. Lack of land for solar PV. Lack of scale and PPP regulatory structure offers little scope for most PPP projects.
Fiji	898	✓	✓	✗	The largest PIC in population and power demand, and with most advanced regulatory structure. Good institutional capacity. Extensive IPP experience. Two main islands.
Kiribati	121	✗	✗	✗	Population spread across three main island groups spanning 2,900 miles. Low institutional capacity and no PPP framework. The Kiribati Integrated Energy Roadmap (2017-2025) recommends adding BESS where appropriate.
Nauru	12	✗	✗	✗	One of world's smallest countries in population and area.
Palau	18	✓	✓[3]	✓	Relatively advanced PPP/IPP framework. Several solar IPP PPAs signed but failed to close financing due to rejection of government guarantee arrangements.
Samoa	200	✓	✓	✗	Second largest power market of the PICs, established IPP framework, with multiple successful IPPs. Existing BESS.
Solomon Islands	728	✓	✓	✗	Few IPPs, but recent Tina River hydro project IPP establishes groundwork for future IPPs. Significant hydro resources / hydro plants may reduce scope for BESS on main grids.

[1] The framework exists in one of the four States comprising FSM.

[2] The policy exists in one of the four States comprising FSM.

[3] Several VRE IPPs have failed to close financing due to lack of appropriate risk mitigation.

Country	Population, 000s	PPP/IPP Framework	IPP Experience	Net-metering Policy	Key Considerations
Tonga	100	✓	✓	✓[4]	Established IPP framework, several current/planned IPPs. Several BESS projects. "Gross metering" policy allows sale to grid at wholesale prices.
Vanuatu	301	✓[5]	×	✓[6]	Two private companies operate vertically integrated utility concessions covering most demand. While there is an IPP framework, its details have been contested and do not appear to mesh well with the utility concession structure.

Five PPP structures, outlined in Figure 4, were evaluated for each PIC, together with indications of required levels of legal/regulatory foundations and institutional capacity. There are three on-grid structures: VRE + BESS IPP, BESS Lease/Rental, and Standalone BESS IPP, and two other structures, Mini Grid Concession and C&I Customer Sited BESS.

Table 2. PPP Structures Evaluated for PICs

Project Structure	Project Length	Structure Overview	Legal / Regulatory Requirements	Institutional Capacity Needed	Typical Sources of Capital
VRE + BESS IPP	20 + years	Private party finances, builds & operates VRE+ BESS facilty, sells electricity and other power services to utility	Very High	Very High	Project-financed
BESS Lease/Rental	5 – 10 years	Private party finances, builds & operates BESS facility, sells power services to utility	Medium	Low	Corporate financed
Standalone BESS IPP	20 + years	Private party finances, builds & operates BESS facilty, sells power services to utility	Very High	Very High	Project financed
Mini Grid Concession	5 + years for exclusivity	Private party builds/improves & operates a mini-grid under a concession arrangement with utility	High	High	Corporate financed + capital grant
C&I Customer-Sited BESS	10 – 20 years	Under special regulations, private party finances, builds & operates behind-the-meter BESS facility	Low	Medium	Corporate financed + subsidy

Within the on-grid category, the BESS Lease/Rental structure is very similar to the Standalone BESS IPP structure, the key difference being the duration of the initial contract, though it is noted that lease/rental contracts almost always allow extension. The BESS Lease/Rental structure also benefits from significantly simpler legal/regulatory and institutional capacity requirements since project financing is not required. While lease/rental arrangements may be regarded negatively in the power industry given their association with high-cost emergency diesel rentals, it is noted that the high cost of these projects relates primarily to the technology and fuel, rather than to the structure itself. The

[4] Tonga has a gross, not net, metering policy.

[5] There is no real IPP framework, the market being organized around vertically integrated private concessions. However, the concession framework constitutes a PPP framework. Outside of concession areas, private parties can sell and buy power, and in this sense, IPPs are permitted; but there are few details and little demand outside concession areas.

[6] The policy exists for one of the two concession areas.

consulting team believes the Lease/Rental structure, which is already familiar to PICs, can yield competitive costs for BESS projects in the region.

A two-stage screening approach was used to select structures appropriate to a given PIC, as shown in Figure 2. First, negative screens were applied to screen out structures that would not make sense; second, positive screens were applied to determine whether a given structure could work (the figure does not show all positive screens). Note that no screens were applied for the BESS/Lease Rental structure, as this structure is already employed in the region for diesel gensets; it is an option for all PIC markets looking to add BESS.

Figure 2. Approach to Selecting Structures

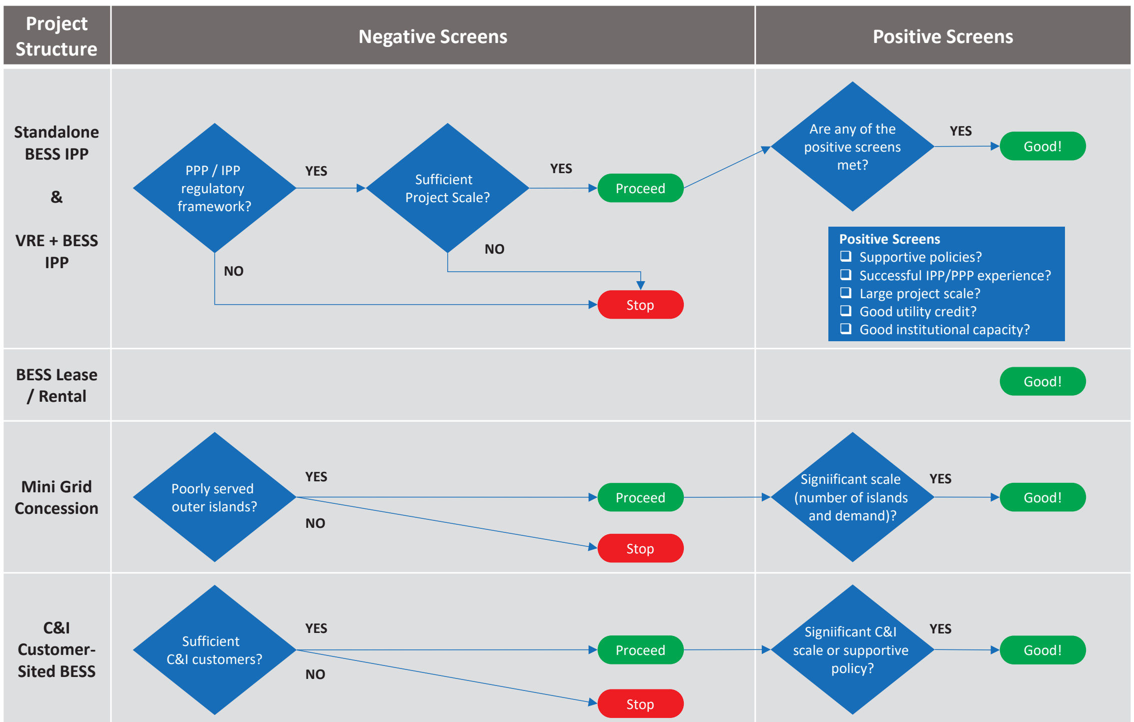


Table 3 shows main recommended PPP structures for each PIC and their constituent islands. These recommendations reflect factors such as legal/regulatory and institutional capacity requirements, as well as the findings from the technical analysis. Note that the table shows what the team concluded are the most appropriate structures, rather than the full set of potentially workable structures, for each market.

Table 3. Recommended PPP Structures for Each PIC

	VRE + BESS IPP	Standalone BESS IPP	BESS Lease/Rental	Mini Grid Concession	C&I Customer-Sited BESS
Federated States of Micronesia			All four main grids as well as outer islands in Pohnpei	Outer islands in Chuuk, Kosrae, and Yap	All four main grids
Republic of Marshall Islands	Both main grids		Both main grids	Outer islands in Majuro	
Tuvalu			Funafuti and outer islands		

	VRE + BESS IPP	Standalone BESS IPP	BESS Lease/Rental	Mini Grid Concession	C&I Customer-Sited BESS
Fiji	Viti Levu and Vanua Levu (Lavasa)	Viti Levu	All systems		Viti Levu and Vanua Levu (Lavasa)
Kiribati			Tarawa		
Nauru			Nauru		
Palau	Babeldaob	Babeldaob			
Samoa	Upolu	Upolu	Upolu		
Solomon Islands	Guadalcanal		Guadalcanal	Other islands	
Tonga		Tongatapu	Tongatapu	Other islands	
Vanuatu			Efate and Espiritu Santu	Other islands	Efate

The team conducted a technical analysis of island systems and BESS needs under various VRE penetration scenarios. The analysis was centered upon a spreadsheet-based algorithm (an example for one PIC is shown in Figure 3) to identify combinations of VRE and BESS capable of meeting various RE targets for the PICs, in three modeling years: 2025, 2030, and 2035. The algorithm considers existing conditions on the PIC grids, including peak demand, minimum demand, load shapes, existing generation, and RE targets, but does not involve economic optimization. Instead, the analysis focuses on optimizing the technical relationship between VRE and storage, to achieve predefined RE targets while minimizing curtailment.

Figure 3. Spreadsheet-based Algorithm

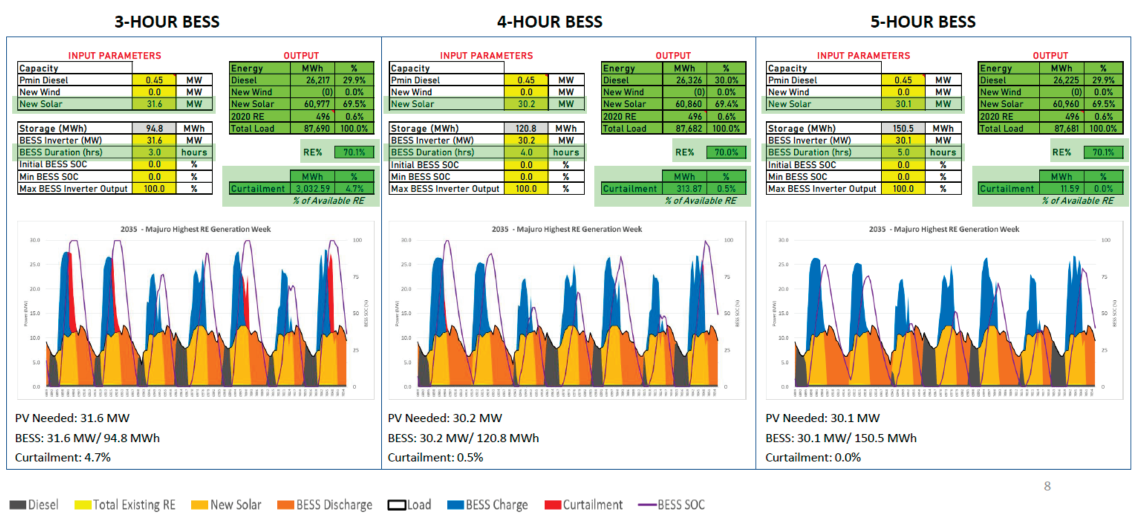


Table 4 provides peak demand of the PIC grids in 2020 and 2030, together with the national RE targets used in the algorithm, and the range of BESS requirements in 2030.

Table 4. Market Characteristics and Indicative PICs BESS Sizing

Country	Island Grid	2020 Peak Demand (MW)	2020 RE Penetration (%)	2030 RE Penetration Target (%)	Est. BESS Needed by 2030 BESS (MW / MWh) Duration (H)	
					Case 1	Case 2
FSM	Chuuk	3.0	5.1	50.0	5.0 / 15.0 (3H)	3.8 / 3.8 (1H)
	Kosrae	1.3	3.2		2.2 / 6.6 (3H)	2.0 / 4.0 (2H)
	Pohnpei	6.2	4.1		9.2 / 18.4 (2H)	6.4 / 6.4 (1H)

Country	Island Grid	2020 Peak Demand (MW)	2020 RE Penetration (%)	2030 RE Penetration Target (%)	Est. BESS Needed by 2030 BESS (MW / MWh) Duration (H)	
					Case 1	Case 2
	Yap	1.9	19.5		2.2 / 6.6 (3H)	1.8 / 1.8 (1H)
RMI	Ebeye	2.0	-	50.0	5.2 / 15.6 (3H)	3.4 / 3.4 (1H)
	Majuro	9.4	0.8		20.0 / 40.0 (2H)	13.4 / 13.4 (1H)
Tuvalu	Funafuti	1.4	15.7	50.0	2.1 / 8.4 (4H)	2.0 / 2.0 (1H)
Fiji	Viti Levu	180.2	64.2	85.0	213 / 426 (2H)	180 / 360 (2H)
Kiribati	Tarawa	5.6	6.8	50.0	7.9 / 15.8 (2H)	7.8 / 7.8 (1H)
Nauru	Nauru	5.8	7.7	50.0	9.3 / 18.6 (2H)	10.0 / 10.0 (1H)
Palau	Koror	11.5	2.0	50.0	27.1 / 54.2 (2H)	23.0 / 23.0 (1H)
Samoa	Upolu	30.0	44.4	80.0	51 / 255 (5H)	42 / 126 (4H)
Solomon Islands	Guadalcanal	15.9	1.7	50.0	37.5 / 75.0 (2H)	37.6 / 37.6 (1H)
Tonga	Tongatapu	11.5	11.8	50.0	19.4 / 38.8 (2H)	14.6 / 14.6 (1H)
Vanuatu	Efate	13.2	14.7	50.0	13.8 / 27.6 (2H)	9.0 / 9.0 (1H)

Donor interventions that would support increased use of BESS - itself supportive of higher VRE penetration in the region – are summarized below.

1. Improve policy. Examples include the following: require utilities to evaluate use of BESS to offset diesel use; develop BESS incentives policies; and develop policies encouraging private sector participation in the power sector.
2. Improve legal / regulatory frameworks. Currently, IPPs/PPPs are not specifically allowed by law in five of the PICs[7]. Donor work on improving the legal framework in any given PIC should be realistic about which framework improvements are politically possible, whether private investment/PPPs could plausibly be achievable in that market based on factors such as market size and market risk, and whether the benefits of enabling certain PPP structures are worth the costs. The report provides specific recommendations for each PIC.
3. Provide technical studies. Donors can offer engineering/economic studies to identify specific BESS needs in the near-term and to quantify the BESS value-added to utilities. These studies probably should be in the form of detailed grid expansion plans incorporating BESS, VRE and renewables. The BESS components in these studies should be detailed enough to be potentially included as the technical specifications in a procurement.
4. Conduct a market sounding exercise, to ascertain the degree of interest of renewable and BESS developers, rental companies, BESS vendors, and lenders to invest time and potentially money in PICs' BESS opportunities. The market sounding should solicit participants' views on what enabling conditions are most important (ideally, in specific markets) in the region, any lessons learned from activities in the region, and which types of structures and procurement approaches would be of most interest or most challenging.

[7] This report takes the position that the Lease/Rental structure is a PPP arrangement, when arrangements are sufficiently long term (5 years or more). It is believed that this structure is allowed by convention, if not expressly by law, in all PICs, as it is a standard utility arrangement.

5. Provide BESS IPP/PPP structuring studies that would develop the details of a PPP structure and prepare a draft procurement package for a given jurisdiction and one or more BESS projects.
6. Provide transaction support for specific procurements, under which the consultant would assist in taking a project through an entire procurement process. Transaction support could also be packaged with the structuring studies above, as an optional second phase of work.
7. Develop credit enhancement mechanisms with donor support and sovereign government participation to address off-taker credit risk and facilitate IPP projects.
8. Prepare outline template procurement packages and legal agreements (e.g., PPAs, etc.) matching the different PPP structures identified in this report. Since the documents would need to apply across multiple jurisdictions, local lawyers would be needed in specific jurisdictions to finalize the documents, likely with international legal support.
9. Provide capacity building, addressing technical aspects of integrating and operating BESS, and as appropriate, competitive procurement processes, PPP and IPP structuring, project finance basics (to understand the needs of IPPs/PPPs), and PPP monitoring and management.

Task 2 requires developing a regional strategy for BESS procurement and PPP structuring. There is no "one structure fits all" approach to supporting private investment in BESS in the PICs. Nonetheless, there are important regional commonalities, particularly across different groupings of PICs, that suggest a regional approach to the objectives could be effective, as outlined below.

Many of the interventions summarized above could be pursued efficiently as regional technical assistances (TAs). For instance, the market sounding would make most sense on a regional basis. The policy and legal framework support could build on donor outreach to specific PICs as to their interest in receiving such TA support; then, the work itself could cover all PICs requesting the support, using a single consultant team providing international legal / regulatory / commercial / technical expertise, supplemented by local firms in each market.

The more detailed technical studies, probably best packaged with detailed legal / regulatory / economic / structuring studies, could be split into several lots covering different groupings of PICs. For instance, one lot could cover the set of PICs where BESS mini grid concessions would appear to have advantages, another could cover PICs where there are prospects for VRE + BESS IPPs and Standalone BESS IPPs; and groupings reflecting travel challenges to the PICs could make sense as well. Statements of work for the technical / economic / structuring TAs might naturally also include capacity building. Work on legal templates for each PPP structure could build off the initial studies mentioned above.

Financing and credit support would appear to be best organized on a regional and program-specific basis. For instance, VRE + BESS and Standalone BESS IPPs would benefit from stapled debt + credit support packages; Lease/Rental structures would benefit from stapled credit support packages as well. A regional program offering capital grants and possibly concessional debt and/or first loss facilities, under a donor-led BESS Mini Grid Concession platform, could help immensely in advancing this structure and hence electrification of outlying islands in the PICs.

Finally, it would be important to build any regional approach with the support and engagement of pre-existing regional institutions, especially the Pacific Power Association, and potentially the University of the South Pacific (USP), based in Suva, Fiji.

1. INTRODUCTION

All Pacific Island Countries (PICs) have adopted policies to dramatically increase the share of renewables in the energy mix. Wind and solar are planned to account for the bulk of new generating capacity in regional power system expansion plans, with Battery Energy Storage Systems (BESS) ensuring system stability and power availability in the face of high variable renewable energy (VRE) penetration. Considering that VRE and BESS are capital intensive by comparison to conventional generating solutions, whereas most of the PICs' utilities cannot afford significant outlays, it is appropriate to consider mobilization of private capital for BESS investments through Public Private Partnerships (PPPs). The World Bank, with financial support from the Public-Private Infrastructure Advisory Facility, and in consultation with the Pacific Power Association, commissioned the present report to assess policy-related, technical, and commercial aspects of BESS integration in the PICs, with a focus on potential PPP structures appropriate to the PICs.

The PICs comprise eleven nations: Fiji, Kiribati, Republic of Marshall Islands (RMI), Federated States of Micronesia (FSM), Nauru, Palau, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. The PICs range in size from Nauru, with only 21 square km of land area, to the Solomon Islands, with a land area of over 28,000 square km; populations, in most cases spread over multiple islands, range from just over ten thousand people (Tuvalu and Nauru) to about 900 thousand (Fiji). Per capita GDP is lowest in Kiribati (USD 1,636) and highest in Palau (USD 15,673). Table 5 presents a summary of PICs.

Table 5: Summary of PICs

Country	Islands Count	Inhabited Islands Count	Capital	Land Area	Sea Area	Population (2021)	Population Density (2021)	GDP per Capita (2021)
				km^2	km^2 000s	000s	People per km^2	USD
FSM	607	65	Palikir	701	2,980	106	151	3,830
RMI	34	24	Majuro	181	2,131	55	303	4,337
Tuvalu	9	9	Funafuti	26	900	11	356	4,223
Fiji	330	110	Suva	18,272	1,290	898	49	6,152
Kiribati	33	21	South Tarawa	811	3,550	121	149	1,636
Nauru	1	1	Yaren	21	320	12	592	11,666
Palau	340	9	Ngerulmud	444	629	18	39	15,673
Samoa	9	4	Apia	2,935	120	200	71	4,384
Solomon Islands	1,000+	300+	Honiara	28,370	1,340	728	26	2,295
Tonga	169	36	Nuku'alofa	650	700	100	138	5,081
Vanuatu	83	65	Port Vila	12,190	680	301	25	3,223

Source: Compiled by Delphos

Electric power sector policy and regulations are summarized in Table 6. As can be seen, while all PICs have electricity policies and undertake sectoral planning, and all PICs have renewable energy (RE) targets, other relevant market details vary widely. In terms of market structure, except for Vanuatu, all countries/states feature state-owned vertically integrated utilities, some of them including IPPs. Vanuatu follows the utility concession model. Markets with experience with IPPs include Fiji, Palau, Samoa, Solomon Islands, Tonga, and Vanuatu; not surprisingly, all these markets also have an IPP/PPP framework or policy.

Table 6: PIC Energy Sector Policy and Regulatory Summary[8]

Country	Planning and Coordination		Electricity Sector				Renewable Energy			
	Act / Legislation	Policy or Roadmap	Act / Legislation	Independent Regulator	PPP/IPP Framework	IPP Experience	Act / Legislation	Feed-in-Tariff	Net-metering Policy	RE Targets
FSM	×	✓	✓	×	✓*	×	×	✓	✓*	✓
RMI	×	✓	×	×	×	×	×	×	×	✓
Tuvalu	×	✓	✓	×	×	×	×	×	×	✓
Fiji	×	✓	✓	✓	✓	✓	×	✓	×	✓
Kiribati	×	✓	✓	×	×	×	×	×	×	✓
Nauru	×	✓	✓	×	×	×	×	✓	×	✓
Palau	✓	✓	✓	×	✓	✓**	×	✓	✓	✓
Samoa	×	✓	✓	✓	✓	✓	×	✓	×	✓
Solomon Islands	×	✓	✓	×	✓	✓	×	×	×	✓
Tonga	×	✓	✓	✓	✓	✓	✓	✓	✓***	✓
Vanuatu	×	✓	✓	✓	✓****	✓	×	✓	✓****	✓

Source: Compiled by Delphos

** Policy exists at sub-national level.*
*** In May 2022, Parliament rejected a government guarantee arrangement for what would be the first successful IPP; it is doubtful the project can proceed without the guarantee arrangement. A previous IPP failed to proceed because its government guarantee arrangement also was rejected by Parliament.*
**** Tonga has a gross, not net, metering policy.*
***** There is no real IPP framework, the market being organized around vertically integrated private concessions. However, the concession framework constitutes a PPP framework. Outside of concession areas, private parties can sell and buy power, and in this sense, IPPs are permitted; but there are few regulatory details and little demand outside concession areas. The net-metering policy exists for one of the two concession areas.*

The PICs have embarked on a structural shift toward renewable energy and many PICs are targeting as much as 100% renewables for their generation mix, alongside increased access to electricity and more resilient power supply infrastructure. Table 7 summarizes renewable energy penetration targets for PICs.

[8] An International Finance Corporation (IFC) report consulted for the present report lists IPPs as present in RMI, FSM, Palau, and Kiribati, in addition to the countries listed in the table above as having IPPs. (See "Powering the Pacific: A guide to investing in renewable electricity generation in the Pacific". IFC/Economic Consulting Associates, 2021. page 22). Our research indicates that none of the projects listed in the IFC report for these countries, the largest of which is 600 kW, is an IPP. Some of the projects involved Engineering, Procurement and Construction contracts, but that by itself does not indicate an IPP. One project in FSM is what we call a "quasi IPP", as it is involves a PPA but is owned by a state-owned entity. In Palau, an IPP not listed in the IFC report is nearing approval and may proceed.

Table 7: Pacific Island Countries' Renewable Energy Targets[9]

Country	2020 Actual	2025 Target	2030 Target
FSM	6%	60%	70%
RMI	1%	50%	70%
Tuvalu	14%	100%	100%
Fiji	64%	90%	100%
Kiribati	5%	33%	
Nauru	7%	50%	50%
Palau	2%	45%	
Samoa	40%	100%	100%
Solomon Islands	2%	65%	100%
Tonga	12%	50%	70%
Vanuatu	13%	83%	100%

Source: Compiled by Delphos

The remainder of this report is organized as follows:

- Section 2 (Methodology) presents (i) the approach to PPP options assessment for each PIC and (ii) the approach to the technical assessment for each PIC.
- Section 3 (Country Analysis) documents, for each PIC, the existing regulatory, institutional, and physical market conditions; then provides a technical analysis of the potential role that BESS could play; and finally, recommends appropriate PPP structures for BESS.
- Section 4 (Regional Strategy on Auction Arrangement) develops an approach the World Bank could support to facilitate and advance BESS PPP projects in the PICs region.
- Annex: Technical Assessment, containing the detailed technical report prepared by HNEI.

Section 2 of the report focuses on PPP options rather than the public sector financing model prevalent in PICs. Public sector support in the energy sector will continue to be critically important in the PICs, whether through government subsidies or grant financing through development partners. Public financing support is necessary due to the weak financial health of most utilities in the PICs, high capital costs of BESS, and poor economies of scale. The PPP options explored in this report seek to augment the available public finance budgets from governments and development partners with private capital, and thereby accelerate the deployment of BESS and VRE projects in the PICs. As the initial tranches of projects aid the transition away from diesel generation, public finances directly benefit from reduced fuel costs. Another key factor in the context of the PICs is the importance of private sector technical expertise on optimizing BESS operations and management, which can be harnessed more effectively under PPP structures.

A separate report produced for the World Bank under the same engagement develops details BESS development roadmaps for three specific countries: FSM, RMI, and Tuvalu.

[9] Compiled by Delphos from each country's most recent NDC update. For FSM, the 2020 value reflects a demand-weighted average of data as follows for the year: Kosrae (3%), Yap (18%), Chuuk (5%), and Pohnpei (4%). For RMI, 2030 values are estimated based on the RMI Electricity Roadmap (2018), which the country's 2020 NDC update references; the document is not specific about renewable energy shares for 2030 (a target of 90% renewables for mini-grids is also mentioned for 2025 in the document). For Kiribati, the 2020 value is an estimate based on limited data and 2025 values are demand-weighted averages for Kiritimati, South Tarawa, and Outer Islands. For Kiribati's targets, the value given reflects a rough demand-weighted average of values in the NDC that are broken out by island groups as follows: 23% renewable energy generation by 2025 in South Tarawa; and 40% renewable energy generation in Kiritimati and Outer Islands by 2025.

2. METHODOLOGY

This section first presents the report's approach to identifying the PPP options that could be appropriate for a given market, then describes the approach used for the technical assessment of each market.

2.1 APPROACH TO PPP OPTIONS ASSESSMENT

Two acronyms – IPPs and PPPs – are used throughout this report and require discussion. An Independent Power Producer (IPP) project is a power project that is developed, constructed, operated, and owned by an entity distinct from the off-taker for the project, with sales to the off-taker occurring under a Power Purchase Agreement (PPA). Typically, IPPs are considered to be undertaken by private companies, though state-owned enterprises also sometimes claim to undertake IPPs (including some discussed in this report).[10]

The World Bank's PPP Knowledge Lab defines a PPP as: "A long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility, and remuneration is linked to performance." This definition is adequate for purposes of this report, though, as the PPP Knowledge Lab explains, there is no universally accepted definition of PPP, with terminology differing by country and by sector.

Bearing in mind that PPPs evolved first in the electric power sector in the form of IPP projects selling to state-owned utilities, the report uses electric power sector contractual terminology. With the dual aims of avoiding a lengthy taxonomy of PPPs and their nomenclature across sectors while also attempting to minimize confusion for non-power sector practitioners, several key points are highlighted below.

1. In the power sector, IPPs are the main PPP type, of which there are several sub-types. Other power sector PPP types include mini grid concessions and dispatchable demand-side resources. Brief descriptions follow, below. Structures near the top of the list are generally more complicated than structures near the bottom of the list.
    a. IPP: Build, Own, Operate (BOO). The private party designs, finances, builds, owns, and operates the project.
    b. IPP: Build, Operate, Transfer (BOT). This is the same as BOO, but at the end of the contract term, the project is transferred to the off-taker. BOT projects are known in some jurisdictions as "BOOT" (with the initial O standing for "own", making it consistent with BOO).[11] To be clear, within the power sector, BOT and BOOT are the same thing, it not being possible to transfer an asset one does not own in the first place.
    c. IPP: Tolling Contract. The private party designs, finances, builds, owns, and operates the project. The off-taker directs dispatch of the plant, and provides fuel to the plant (rather

[10] It is assumed for purposes of this report that IPPs involve private investment; IPPs involving investment by state-owned enterprises are identified as "quasi IPPs".

[11] Some sources also define a BOT as not involving the ownership function (in keeping with the acronym), though this usage, and this structure for that matter, is very rare in the power sector. In such usage, it is operational responsibility, not ownership, that is transferred. (It would be more accurate to say private operational responsibility just ends).

than the private party taking the fuel procurement and pricing risk). Tolling Contracts can be BOT or BOO.

d. IPP: Rental or lease. The private party designs, finances (almost always on balance sheet), builds, owns, and operates (usually) the project. At the end of the lease term, the off-taker will have the option to buy the facility. Typically, rental / lease arrangements involve relatively portable and modular technologies, such as diesel gensets, and recently, BESS. For small projects (< 10 MW), arrangements generally will involve provision of the equipment only, with the off-taker operating and maintaining the facility.

e. Mini grid concession. The private party designs, finances, builds, operates, and transfers (sometimes) a mini grid in a defined service territory. The concession can also be granted for pre-existing mini grids, typically packaged with an investment plan.

f. Dispatchable Behind-the-Meter (BTM) Resource. Many power markets (especially restructured ones) allow registered commercial and industrial customers (C&I) to disconnect from the grid when directed by the utility, for a fee. These arrangements allow the utility to "dispatch" those customers' demand, as it were, resulting in the same net amount of new supply on the grid as if a generator were dispatched with the same capacity as the demand that was disconnected. Typically, such arrangements do not allow for actual power dispatch onto the grid by a backup generator.[12] BESS technology, however, is flexible enough to allow for dispatch of power and ancillary services onto the grid from behind-the-meter settings, creating the potential to achieve a similar technical outcome as from on-grid BESS facilities.

g. Net metering is a variation on the Dispatchable BTM Resource. Net metering programs typically are renewables-specific (usually for solar PV) and therefore the energy is not dispatchable. Programs are usually limited to domestic customers.[13] While some may argue that a net metering program (or BTM Resource program) is not a PPP project, these programs can meet the standard conditions for PPPs, especially at the level of the program rather than at the level of individual projects. In the case of the PICs, a net metering program (some of the PICs already have such programs) combined with BESS could result in substantial BESS capacity with minimal capital invested by the utility. It is possible to imagine similar electric vehicle-to-grid programs in the region as well.

2. The terms BOO, BOOT and BOT are used as well in other sectors, with significantly different meanings. The "ABD Public-Private Partnership Handbook" (2008) asserts that, for BOTs, ownership is public, whereas it is private for BOOs. With respect to BOTs in the power sector, this is wrong; both BOTs and BOOs involve private ownership. The ADB document also states that a BOO requires a concession; in the power sector, both BOTs and BOOs can (but are not required to) involve concession agreements[14], depending on the nature of the project (large hydro projects often require concessions providing access to a public natural resource for use by the IPP) and the jurisdiction. (Note that the ADB document credits the United States Federal

[12] Generally, backup generators are not grid code compliant in terms of controls.

[13] The Massachusetts (USA) net metering program is unusual, in that it allows production from any technology, for residential, commercial, and industrial tariff customers, and up to 2 MW for private customers. See link.

[14] The legal meaning of the term "concession" varies by jurisdiction, such that in some jurisdictions, a PPA may contain concession-like features without being termed a concession agreement or arrangement.

Highway Administration for the underlying chart used in the ADB report; indeed, the chart is consistent with usage in the transport sector).[15]

3. Some sources, including the World Bank's PPP Knowledge Lab, take the position that rental / lease arrangements are not PPPs because they do not involve sufficient risk transfer to the private party. This is not necessarily true in the power sector. Larger rental projects can involve PPAs that are nearly as complex as those for full-blown project-financed IPPs and involving essentially the same risk allocation for a given setting. While it is true that small rental projects may involve less operational risk transfer to the private party, we would suggest this is because it is not economic to do so as a function of project size rather than PPP structure.[16] A related issue is that rental / lease arrangements may have terms of only a few years, whereas the PPP definition provided at the beginning of this section requires that PPP projects be "long term" (though other definitions do not). We note that terms for the rental / lease structure used in the present report for BESS projects would be expected to be 5 – 10 years.

The main reasons to undertake PPPs include mobilizing private capital, thereby reducing fiscal constraints; bringing in private sector technical expertise; increasing efficiency by harnessing the private sector's profit-maximizing incentives; transferring project delivery and operations risks to the private sector; and catalyzing broader sectoral reform by reallocating roles to align incentives and improve accountability. In the context of BESS PPPs in the PICs, the first two reasons listed are considered the most important.

Table 8 summarizes features of PICs relevant to BESS and PPPs.

Table 8: PICs Characteristics and BESS / PPP Relevance

Characteristics of PICs and their Power Systems	Pros	Cons
Small and remote island systems	▪ BESS is modular technology that can easily be sized up or down ▪ Can provide resilience	▪ Remoteness makes it expensive to deliver equipment, conduct maintenance ▪ Challenging weather (heat/ humidity/ salinity/ hurricanes) lead to safety risks ▪ Difficult to achieve economies of scale ▪ High transaction costs for smaller projects
Dependence on expensive diesel generation	▪ Favorable economics for fuel substitution for BESS + VRE	▪ BESS does not add new net energy supply by itself
Weak grid infrastructure	▪ BESS can deliver grid support services	▪ Lack of advanced monitoring and controls to maximize BESS benefits
Abundant solar resources and ambitious renewable energy targets	▪ Clear value delivered by shifting solar generation to evening hours or smoothening intra-day	▪ As above, BESS does not add new net energy supply by itself. As VRE penetration increases, other dispatchable sources of energy become

[15] A source consulted for the present report ("Assessment of battery storage IPP/PPP schemes for the Pacific utilities". Ricardo Energy & Environment/World Bank, October 2019) uses the ADB source and its terminology (page 2) and then attempts to distinguish between BOT and BOOT structures (page 30 – these are the same thing in the power sector) and uses the term "Design-Build-Operate (DBO)" (rarely used in the power sector).

[16] Operating and maintaining a power plant requires in-person presence near the power plant, which would be expensive for the lessor of small units/plants that can be operated/maintained by the renter/lessee, which will likely already have appropriately trained maintenance staff.

	variability in solar generation output	increasing important for security of supply
Full vertical integration at all utilities, with little PPP/IPP legislation	▪ Centralized planning and procurement of grid expansion to optimize BESS deployment with capacity and grid expansion	▪ Very little financial or technical capacity at most utilities to support BESS projects ▪ Lack of regulatory or technical framework in many PICs to undertake BESS PPPs

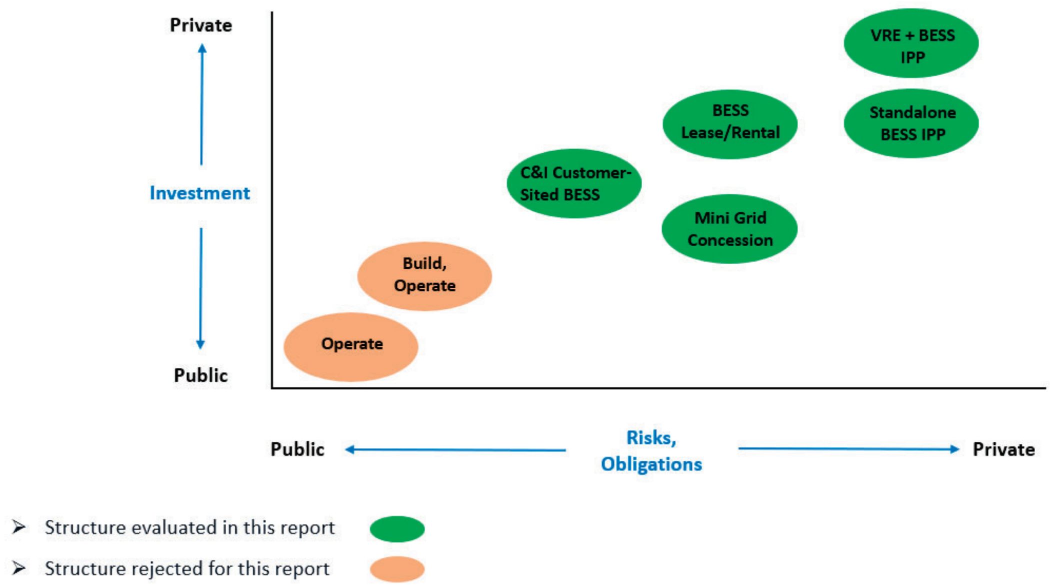
PPPs are complex. A set of PPP-enabling conditions are required to undertake PPPs. Table 9 describes the main categories of enabling conditions. The larger and more complicated the PPP project, the more important each enabling condition becomes.

Table 9: PPP Enabling Conditions

Enabling Condition	Description	Why Required	Notes
Legal / Regulatory Clarity	The type of PPP being considered must be allowed by law.	Investors, especially project lenders, need certainty on legal / regulatory matters.	The importance of this requirement is highest for debt on project-financed PPPs, lowest on shorter-term small projects without project-finance debt.
Acceptable Credit	Investors must be comfortable with the off-taker's ability to pay over the life of the project.	Poor credit increases the cost of equity and debt; and, lenders may require credit enhancements to lend at all.	The off-taker credit that prospective project lenders confront must be reasonable; otherwise, debt guarantees and/or other credit enhancements will be necessary.
Project Scale	Projects below a certain value will attract little developer and investor interest.	There are two related reasons. First, the costs of due diligence and documentation of PPPs is high and mostly fixed, hurting the economics of small projects. Second, developers and lenders often have minimum project sizes they will not even consider.	Development bank grants to cover due diligence and project preparation / negotiation can address the first issue, but such grants tend to not be offered indefinitely in a given jurisdiction. Minimum investment thresholds vary by the type of PPP, with longer term and more complex structures involving the highest thresholds.
Institutional Capacity	Government and sectoral entities (e.g., utilities) need the ability to formulate, procure, negotiate, and manage PPPs.	The first "P" in PPP needs to know what it is doing; otherwise, at best, the second "P" will extract unreasonable terms, and at worst (and more likely), the PPP project will not proceed at all.	The first PPP in a jurisdiction/sector is the hardest and can benefit from development bank support, which would typically include PPP capacity building. In addition, it may be necessary to create new and dedicated institutions with appropriate on-going funding, ensuring adequate on-going institutional capacity.
Capital market and developer interest	Project developers and investors tend to have regional and sometimes country-specific mandates.	It can be difficult to attract attention for projects in remote jurisdictions, resulting in less competitive PPP tenders.	The PPP strategy for a given jurisdiction and sector should sound the developer and capital markets for interest in the types of projects they envision.

A variety of potential PPP structures were considered for this report as being potentially appropriate for BESS projects in the PICs, as depicted in Figure 4. The chart locates PPP structures on two axes based on the degree of private investment relative to public investment and on the degree of risks and obligations borne by the public versus private parties.

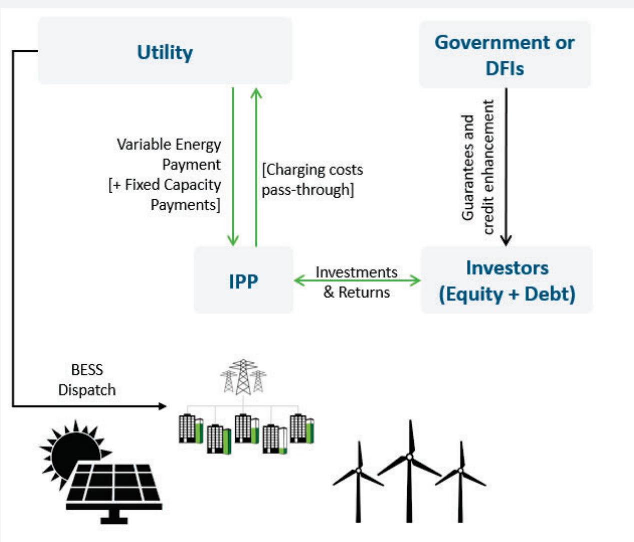
Figure 4: PPP Structures (Evaluated and Rejected)



Source: Delphos

Two structures – "Operate and Build" and "Operate", were rejected for purposes of this report. These structures - not always considered PPPs in any case - do not involve private capital financing for the

VRE + BESS IPP is a standard IPP structure, where the BESS is used to firm the variable dispatch of the VRE generator (wind or solar PV). PPAs can be BOT or BOO.



Responsibilities

- Public – [concept], [design], [tender – procurement, award, negotiations], contract management, performance monitoring, payments, [guarantees]
- Private - [concept], [design], financing, construction, operations, maintenance

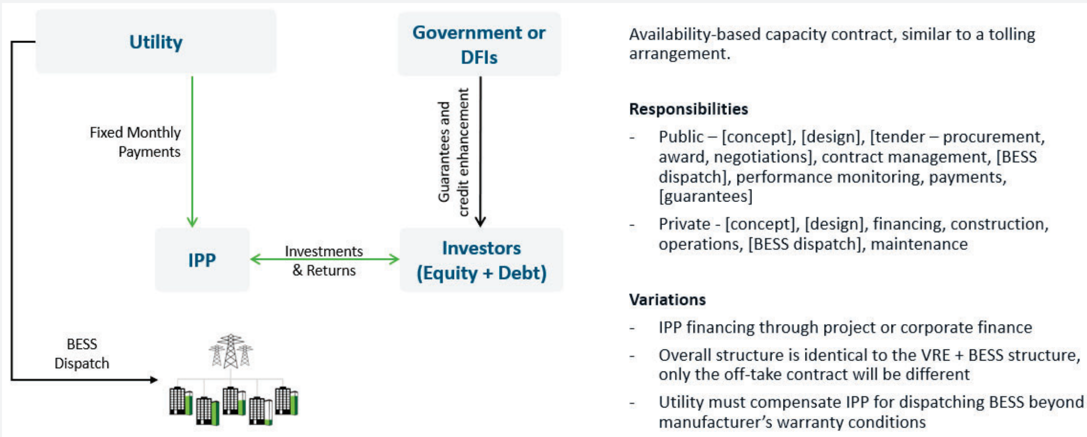
Variations

- Financing through project or corporate finance
- IPP or equity investors could also be the developers or equipment vendors/manufacturers (PV panels, BESS) or construction companies
- BESS dispatch assumed to be based on signals from the utility, which dispatches BESS for energy and/or ancillary services as needed
- Other contractual arrangements may exist: e.g., BESS that is only used to firm up the VRE output, in which case utility would have limited dispatch authority over the BESS

Source: Delphos

term of the project, and on this basis fail to meet a key need identified for undertaking BESS PPPs in the PICs: mobilizing private financing. The structures depicted in green, which were evaluated in this report, are discussed in more detail in the callouts. Brackets in the figures indicate optional items.

Standalone BESS IPP would be like any other IPP (could be BOT or BOO), except that the PPA must address charging of the BESS. In the PICs, we would envision a Tolling Contract version of this structure, where the utility manages both charging and discharging of the BESS facility.

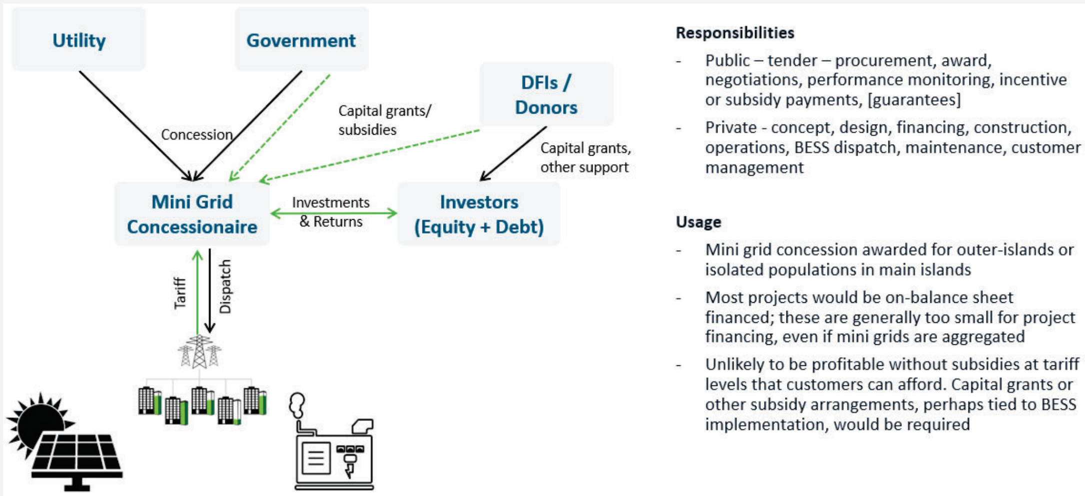


Source: Delphos

BESS Lease / Rental projects would be like rental of diesel-fired gensets, familiar to utilities around the world. In this case, the BESS supplier also would be expected to provide trainings covering integration of BESS on the system, plus operation and maintenance of the BESS facility.

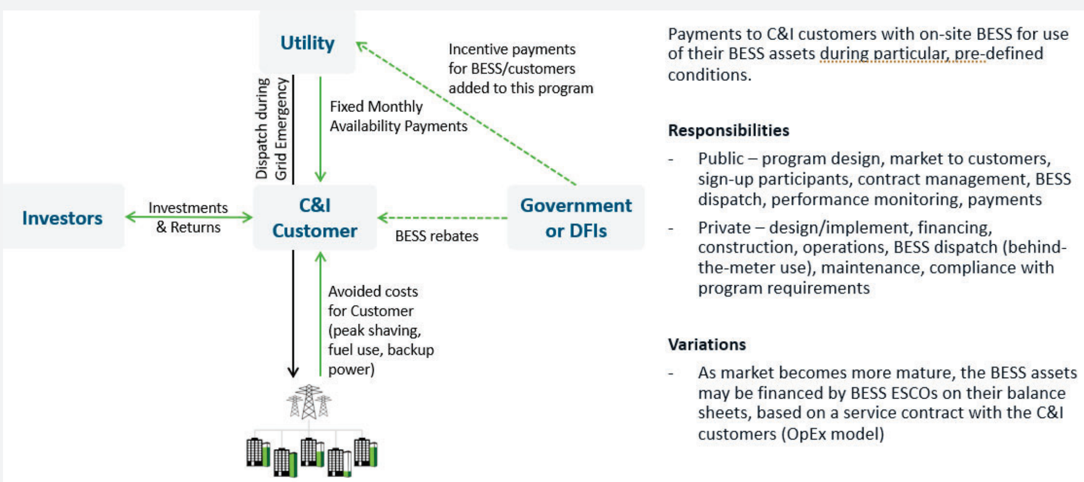
Source: Delphos

Mini Grid Concession projects would be expected to involve the concessionaire receiving the right to supply an outlying island (in most cases, already being provided service by the incumbent utility). The concessionaire would commit to providing a specified level of service. An upfront grant and/or tariff subsidy would likely be required for financial sustainability of these projects.



Source: Delphos

C&I Customer-sited BESS involve C&I customers installing BESS at their own facilities, providing backup power supply to the customer and grid support services to the utility. Considering that BESS is an expensive backup generating technology, the C&I customer would require incentives, potentially including availability payments and rebates for purchase of the BESS.

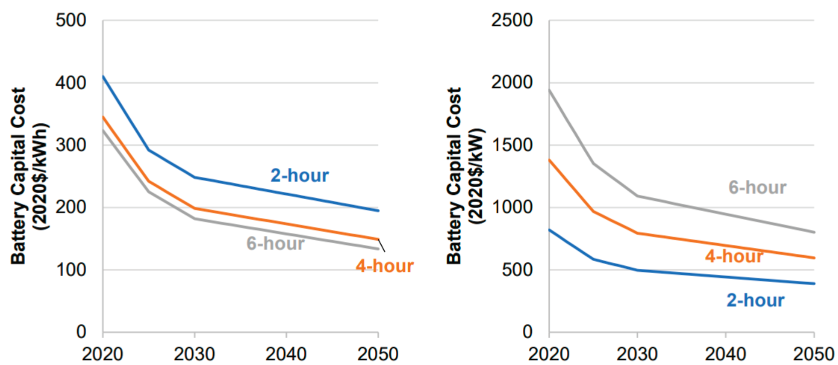


Source: Delphos

Numerous factors are involved in assessing the technical and commercial appropriateness of specific BESS PPP structures in specific PICs, and their individual islands. Figure 6, at the bottom of the next page, highlights three macro-level considerations, as discussed below.

1. The costs of structuring a given type of PPP project are largely independent of project size. With structuring costs for standalone, project-financed, PPP projects ranging upwards of USD 2-3 million, inclusive of legal, technical, and financial advisors for the sponsor, lender, and utility, small projects confront higher cost structures than larger projects. A related challenge for small projects is that most commercial lenders are not interested in issuing long-term loans below about USD 5 million. In short, even assuming regulatory structures are already in place, it is not generally economic to undertake project-financed PPPs with a value of less than USD 5 - 7 million. Simpler PPP structures could be economic at lower cost thresholds.
2. BESS costs are declining rapidly. NREL forecasts that capital costs for 2 - 6 hour BESS will fall about 40% by 2030, with much of the decline in the next few years. These projected cost reductions necessitate consideration of BESS deployment and PPP structuring alternatives that could allow PICs to lock in lower BESS costs later, rather than frontloading BESS investment. The team concluded, however, that delaying BESS deployment is unlikely to yield net benefits, considering that the projected rate of cost reductions slows significantly within the next several years, and that delayed deployment would also delay cost savings from diesel displacement.

Figure 5. Projection of BESS Capital Cost



Source: "Cost Projections for Utility-Scale Battery Storage: 2021 Update", NREL. 2021.

3. The technical difficulty and cost of raising renewables penetration increases at the higher end of the range, particularly when there is heavy VRE penetration, and especially as penetration rises into the 70% - 100% range. Challenges include the need to maintain sufficient firm capacity to ensure supply during prolonged adverse weather for VRE and the need for some amount of synchronous generation for grid forming.

Figure 6: Key Macro Considerations in Assessing BESS PPPs in PICs

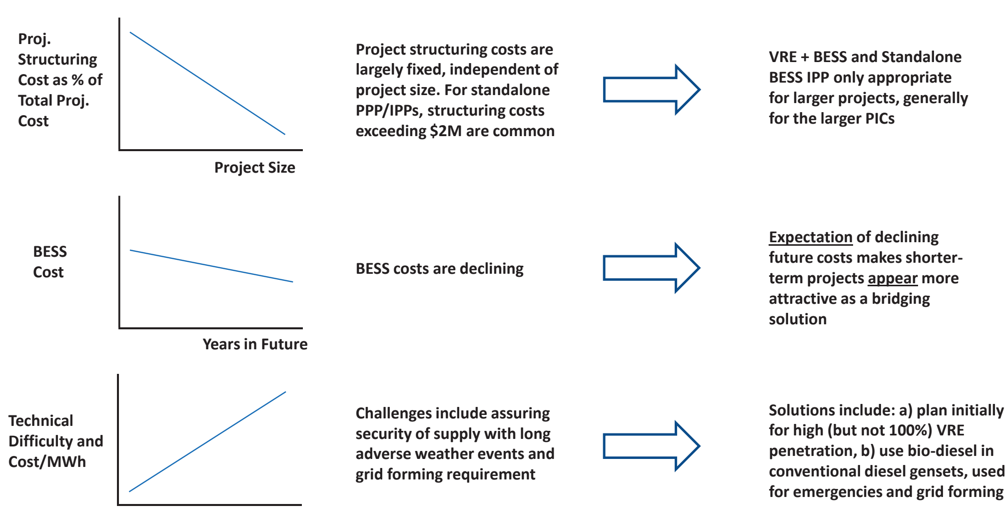


Figure 7, below, provides additional information about the structures evaluated for each of the PICs in this report. While most of the figure is self-explanatory, the column on the right, titled "Relevance for PICs by Island Size" bears additional explanation. The column assesses each evaluated PPP structure for its relevance and potential for islands based on their size in terms of electricity demand. Thus, for instance, we conclude that Standalone BESS PPPs are unlikely to make sense for small islands such as Funufuti (Tuvalu), Kosrae, Yap and Chuuk (FSM), and Ebeye (RMI), simply as a function of their size (all have peak demand below about 3 MW) and before looking at other enabling conditions. By contrast, we conclude there is high potential for micro-grid concessions on small islands as a class, again, before looking at other enabling conditions.

Figure 7: Summary of Evaluated PPP Structures

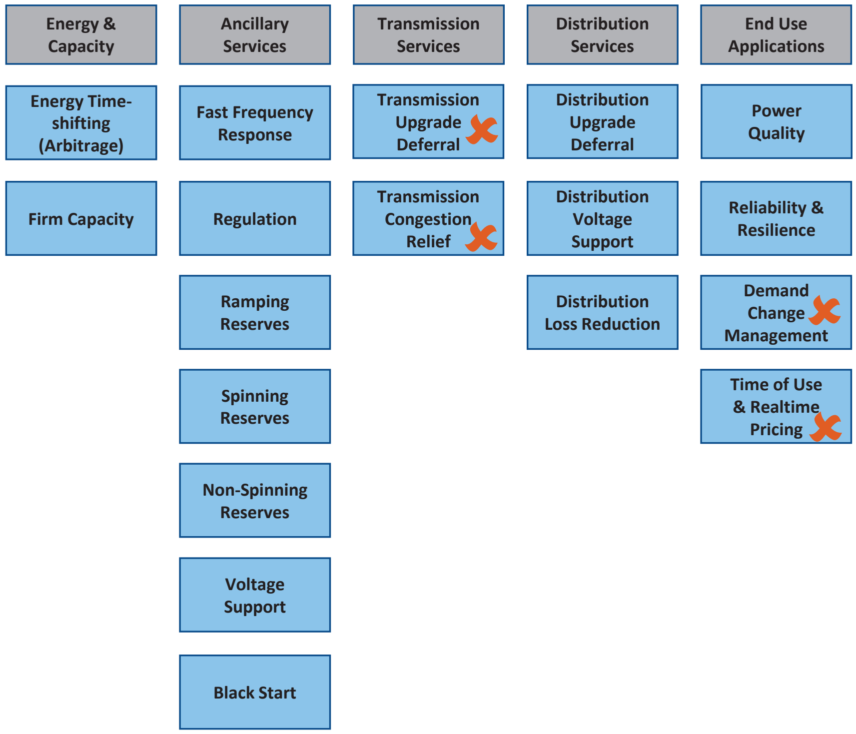
Project Structure	Project Length	Policy / Regulatory Requirements	Institutional Capacity Needed	Sources of Capital	PPP Rationale	Relevance for PICs by Island Size
VRE + BESS IPP	20 + years	PPP/IPP enabling legislation and regulatory authority; updated grid code (with VRE and BESS treatment) or detailed technical treatment in PPA/contract	Very High	Typically, project-financed non-recourse long-term debt and equity	Achieve project scale; more private sector partners (VRE developers) familiar with BESS; VRE firming + BESS stability benefits; long-term contract matching asset life	Small: Medium Medium: High Large: High
BESS Lease/Rental	5 – 10 years	Existing practice in many PICs and around the world is that rentals are not questioned even if not explicitly permitted	Low	On-balance sheet	Flexible solution without long-term obligation but option to extend	Small: Medium Medium: High Large: High
Standalone BESS IPP	20 + years	PPP/IPP enabling legislation and regulatory authority; updated grid code (BESS treatment) or highly detailed technical treatment in PPA/contract	Very High	Typically, project-financed non-recourse long-term debt and equity	Higher flexibility for system operator compared to VRE + BESS; long-term contract matching economically useful life of assets; easy to site	Small: Low Medium: Low Large: Medium
Mini Grid Concession	5 + years for exclusivity	PPP/IPP/private mini grid enabling legislation and regulatory authority	High	Usually on-balance sheet; medium term concession debt possible; capital grant usually required	Add BESS to other mini grid assets for improved VRE integration & power quality on isolated islands; gain expertise of mini grid operators; leverage concessional capital dedicated to mini grids and last-mile electrification	Small: High Medium: Medium Large: Medium
C&I Customer-Sited BESS	10 – 20 years	Must be permitted by electricity law; programs encouraging this approach require development of complementary utility arrangements	Medium	On-balance sheet; likely requires a subsidy	Retain valuable C&I customers by enabling them to earn additional revenue from their BESS assets	Small: Medium Medium: High Large: High

2.2 APPROACH TO TECHNICAL ASSESSMENT

2.2.1 BESS USE CASES

BESS may be categorized depending on the purpose and perspective of the underlying analysis. One of the commonly used approaches for classifying BESS focuses on usage applications. As shown in Figure 8, BESS use cases for PICs generally fall into three categories: (i) energy and capacity; (ii) ancillary services; and (iii) distribution services. For larger, more "conventional" grids, BESS use cases sometimes include transmission services, while several end-use applications may apply in some PICs.

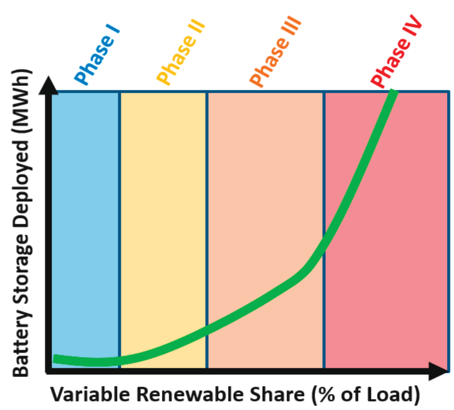
Figure 8: BESS Use Cases for PICs



2.2.2 PHASES OF BESS DEPLOYMENT

For isolated island systems such as those found in the PICs, optimized sizing (i.e., capacity and energy) tends to be a function of the degree of VRE (i.e., solar and wind) penetration. As illustrated in Figure 9, as VRE penetration increases, the need for energy storage increases, but not on a linear basis. As discussed in turn below, the degrees of VRE penetration can generally be grouped into four phases: (i) grid services and renewable enablement; (ii) capacity deferral and/or fossil retirement; (iii) energy shifting and curtailment mitigation; and (iv) long duration energy shifting for deep decarbonization.

Figure 9: Four Phases of BESS Deployment on Island Power Systems



Phase I: As shown in Figure 9, Phase I of BESS deployment for island systems generally applies to grids with 0-20% of their energy provided by VRE resources. At such low VRE penetrations, the grid can typically accommodate variability and there is no need for renewables to be shifted. However, because frequency stability poses a major challenge for island power systems, such systems tend to have a much higher reserve requirement (typically 20% or more of load) than larger power systems.

As a result, the use in Phase I of high-power, low-energy, BESS serving as reserve assets is often most economic. Specifically, a BESS installed in Phase I with sizing of roughly 10-20% of peak load and less than one hour of storage can provide cost-effective spinning and regulation reserves that improve grid stability and reliability, while also reducing fuel consumption (from reduced spinning reserves) even without incremental renewable generation. At its core, a Phase I BESS installation may be characterized as preparing or enabling the electric system for more VRE resources.

Phase II: Phase II of BESS deployment for island systems generally applies to grids with 20-30% of their energy provided by VRE resources. As VRE penetration increases into the 15-20% range, island systems begin to experience VRE resource saturation. In Phase II, longer duration battery storage can be used to "clip" short peak demand periods, thereby reducing the need for peaking capacity to serve load. Like Phase I, the typical BESS capacity for Phase II is roughly 10-20% of peak demand; however, the optimal duration of the storage increases from one hour to up to roughly four hours.

In systems with high load growth, the ability to clip short peak demand periods provides the economic benefit of deferring the installation of new peaking capacity. In addition, as renewable energy increases, the ability of the batteries to provide short-term firm capacity enables some of the older, less efficient thermal units to run less, making them candidates for retirement. However, in order to address increasing levels of renewable energy in future phases, on high VRE islands, a significant amount of firm capacity should be retained in order to cover multi-day low wind and solar events.

Phase III: Phase III of BESS deployment for island systems generally applies to grids with 30-70% of their energy provided by VRE resources. Once VRE penetration reaches 30% of annual energy, there are likely to occur hours when instantaneous VRE penetration reaches 60-80% of load. Saturation during these higher renewable periods renders renewable curtailment an increasing concern and diminishes the value of additional renewables.

Four-hour batteries pair well with solar energy due to the diurnal cycle. In Phase III, BESS projects with sizing between 40-100% of peak load and roughly four hours of duration can be utilized to cost-effectively shift energy from high renewable periods to higher net-load periods. In addition to reducing curtailment, Phase III BESS deployments can provide additional benefits including grid services and firm capacity.

Of note, Phase III BESS deployments should only be pursued after other "lower hanging fruit" for system flexibility (e.g., operating practices, thermal unit adjustments, load flexibility) have been addressed, as the level of investment in storage during Phase III grows increasingly significant. Maximizing the benefits of less capital-intensive measures before committing to large investments in batteries mitigates the risk of over-investing in storage that would not otherwise be needed. However, for smaller systems (e.g., less than 10 MW), a "one and done" Phase III BESS deployment that simultaneously provides the benefits of Phases I, II and III may be more cost-effective than a sequential BESS rollout.

Phase IV: At very high levels of VRE penetration, energy shifting requires longer durations. Phase IV of BESS deployment for island systems generally applies to grids with 70-90% of their energy provided by solar VRE resources. However, unlike diurnal solar resources, because wind generation tends to occur over multiple days and then slow for multiple days, the VRE threshold for reaching Phase IV is lower for wind-centric systems than solar-centric systems.

In Phase IV, long-duration storage becomes necessary to cover multi-day low VRE events or seasonal disparity in VRE resources. Weeks with very high VRE levels have nowhere to discharge; and weeks with sustained low VRE levels have no resources from which to charge. As a result, optimal BESS sizing in Phase IV significantly increases to 100-200% of peak load, with eight or more-hour duration.

One of the challenges posed in Phase IV is that current lithium-ion battery storage is likely not economic for such a high storage need. Certain PIC countries have access to more "firm" sources of renewable energy that may be able to serve as a substitute for diesel generation at very high VRE penetrations. For example, Fiji and Samoa have substantial portions of hydropower in their resource mix. Other potential candidates for firm renewable generation in the PICs include biomass, biodiesel, and geothermal resources; however, these resources are not available in all locations. Table 10 summarizes the planned RE deployments/potential for the various PIC countries.

Table 10: Planned Renewable Energy Deployment/ potential in PICs

Country	Main Grids	BESS	Solar	Wind	Hydro	Geothermal	Biomass
Tuvalu	Funufuti (TEC)	✓	✓	✓			
FSM	Kosrai (KUA)	✓	✓				
	Yap (YSPSC)	✓	✓				
	Chuuk (CPUC)	✓	✓				
	Pohnpei (PUC)	✓	✓				
RMI	Ebeye (KAJUR)	✓	✓	✓			
	Majuro (MEC)	✓	✓	✓			
	Outer Islands	✓	✓	✓			
Kiribati	South Tarawa	✓	✓	✓			
	Kiritimati (PUB)	✓	✓	✓			✓
	Outer Islands	✓	✓	✓			
Nauru	NUC	✓	✓				
Tonga	TPL	✓	✓	✓			
Palau	PPUC	✓	✓				
Vanuatu	UNELCO		✓	✓	✓		✓
Solomons	SP	✓	✓	✓	✓	✓	
Somoa	EPC	✓	✓	✓	✓		✓
Fiji	EFL		✓	✓	✓		✓

Source: Data compiled from "Powering the Pacific" (2021 - IFC) and "Battery Energy Storage System (BESS) Development in Pacific Island Countries (PICs)" (2021 - Coalition for Our Common Future, Korean Green Growth Institute, and World Bank).

Provided that a suitable energy storage resource is available for Phase IV, an island grid can likely achieve an annual RE penetration of 85-90%. While reaching 100% renewable energy via VRE + storage is technically possible, it is often not cost-effective given the current state of technology. As a result, the last 10-15% of generation is often better served by other, non-variable renewables until new storage technologies are developed. In addition, although grid-forming inverter technology is advancing quickly, currently there are limitations to running a 100% full inverter-based island system while maintaining grid stability.[17]

Practically speaking, countries with 100% RE targets may wish to re-examine them – or seek alternative means of achieving them – with an increased focus on reducing carbon emissions. Climate change (which is primarily driven by carbon emissions) has come to the forefront of global environmental focus and poses disproportionate threats for small island countries such as the PICs. While very high levels of RE penetration can be cost-effectively achieved in most instances, marginal costs increase exponentially as RE penetration nears 100% due to the tremendous (but rarely used) capital investments that are required to ride through multi-day/week low VRE events. The reality is

[17] See Footnote 135 for an explanation of grid forming.

that manufacturing all the equipment necessary to achieve the last slivers of a 100% RE target may likely result in greater carbon emissions than the small amount of fuel that would occasionally need to be burned to ride through long-duration low VRE events with thermal generation.

In that regard, the island grids covered in this report already have a substantial amount of operating diesel generation capacity, which could be used to cover multi-day low VRE events. Although not a renewable resource, diesel fuel is essentially a form of energy storage – and much cheaper than other storage alternatives that would be required to achieve 100% RE. Notwithstanding the desire to achieve 100% RE, consideration should also be given to the possibility that the premature retirement of existing diesel units (which are already paid for) could pose risks for isolated island grids that lack an adequate source of firm renewable energy.

2.2.3 SPREADSHEET-BASED ALGORITHM

Based in part on the BESS rollout considerations discussed above, HNEI created a spreadsheet-based algorithm to identify combinations of renewable energy resources and energy storage capable of meeting various RE targets for the PICs. The algorithm considers existing conditions on the PIC grids, including peak demand, minimum demand, load shapes, existing generation, and RE targets. It should be noted, however, that notwithstanding the quantitative analyses conducted in connection with this report, the algorithm used here does not consider many of the common inputs to traditional planning studies (e.g., information related to financial and economic optimizations). Instead, this work is focused on optimizing the technical relationship between renewable generation and storage, in order to achieve predefined renewable energy targets while minimizing curtailment.

Considering that many of the PICs have fallen behind in achieving their RE targets, the team created targets for the years 2025, 2030 and 2035, based on the targets but with updated and more realistic timeframes. With respect to types of future renewable resource additions, the team considered two types of scenarios: (i) cases where 100% of the incremental renewable energy is from solar photovoltaics ("PV"); and (ii) cases where 50% of the incremental renewable energy is from solar PV, and the other 50% is from wind. Using only VRE resources in the analysis lends a degree of conservatism, as the alternative use of less-intermittent renewable energy resources (e.g., hydro, biodiesel, biomass, geothermal) reduces the required sizing of energy storage systems.

Energy consumption growth of 2% per year was assumed. This rate is applied to the grid's peak demand, minimum demand, and energy.

As noted above, electric systems in the PICs vary greatly in size. Different sized grids have different constraints and needs, and therefore need to be modeled differently. As a result, the main PIC grids were modeled in five different groups, based on peak demand:

1. Grids between 1 and 3 MW (i.e., Kosrae, Tuvalu, Ebeye, Yap and Weno);
2. Grids between 5 and 7 MW (i.e., Tarawa, Pohnpei and Nauru);
3. Grids between 9 and 16 MW (i.e., Majuro, Tongatapu, Koror, Efate, and Guadalcanal);
4. Upolu, with a 2020 peak demand of 30.0 MW; and
5. Viti Levu, with a 2020 peak demand of 180.2 MW.

Additional details regarding the modeling methodology and results for the PICs are provided in Annex: Technical Assessment) to this Report.

2.2.4 ADDITIONAL CONSIDERATIONS

Notwithstanding the different sizes of the various PIC grids, the results of the analyses performed consistently reflect the reality that as VRE penetration increases, so does the need to capture that energy during periods of low demand and shift it to periods of high demand, to avoid curtailment (which is tantamount to a cost). In turn, the more the storage that is incorporated into an electric system, the more the energy that can be captured – and with less VRE generation capacity, which can further reduce costs. Therefore, from an economic standpoint, striking the appropriate balance between the sizing of VRE generation and energy storage will be a function of the cost inputs for each, as well as the cost of electricity from the incumbent utility.

Another important consideration in the PPP procurement context is the sizing of specific projects. For example, the PV and storage needs of a small grid might be met by a single co-located project, while the needs of a larger grid may justify multiple projects in multiple locations. While there is no single "right answer" to the question of discrete project sizing, there are multiple factors that should be taken into account when making such a determination, including economies of scale, reliability and geographic diversity.

Economies of scale are cost advantages reaped by increasing production and lowering marginal costs as fixed costs are spread over greater output. All other things being constant, a single large project will yield a lower per-unit cost than multiple small projects. Especially for smaller islands, this means that a single co-located PV/BESS project may be more cost-effective than multiple smaller projects.

However, reliability also needs to be taken into account. In this regard, consideration should be given to mitigating risks related to "single points of failure." Currently, the largest contingency event on most PIC grids is failure of the largest generating unit. For example, the largest generator on Yap is 1.65 MW. It stands to reason, therefore, that relying on a single system larger than 1.65 MW could likely increase risk to the grid, while relying on multiple systems with equal aggregate capacity would likely mitigate risk to the grid. This is not to say that the size of an overall "project" on Yap should not exceed 1.65 MW; rather, no "single point of failure" (e.g., component) of a project should exceed 1.65 MW, to maintain a level of reliability that is at least commensurate with the existing electric system.

Geographic diversity should also be considered in determining ideal project size. Regarding resiliency, siting projects in different locations mitigates risks associated with local events such as accidents or natural disasters. In addition, although somewhat mitigated by energy storage, locating VREs in different locations helps to smooth the intermittency of the resources (e.g., due to cloud cover).

In addition, as detailed in Annex 5. to this Report, a multitude of recently-published guidelines, codes and standards for BESS integration have been published and are available to help streamline the process of safely and effectively deploying BESSs for various applications throughout the world. The available publications consider BESS from a variety of perspectives: from high-level overviews (e.g., International Electrotechnical Commission (IEC) International Standard 62933 on *Electrical Energy Storage Systems* (IEC 62933)), to distribution-level interconnections for inverter-based distributed energy resources (e.g., IEEE 1547-2018), to hazard mitigation (e.g., National Fire Protection Association Standard 855 for the *Installation of Stationary Energy Storage Systems* (NFPA 855)), to permitting (e.g., the 2020 New York Battery Energy Storage System Guidebook (NYBESSG)), to system integration, design and permitting (e.g., Australian/New Zealand Standard (AS/NZS) 5139 on *Electrical installations – Safety of battery systems for use with power conversion equipment*). In addition to the modeling discussions above, conformance with relevant standards should be considered in the development of a BESS procurement roadmap for the PICs.

3. COUNTRY ANALYSIS

For each of the 11 PICs, this section presents information and analysis in the following categories:

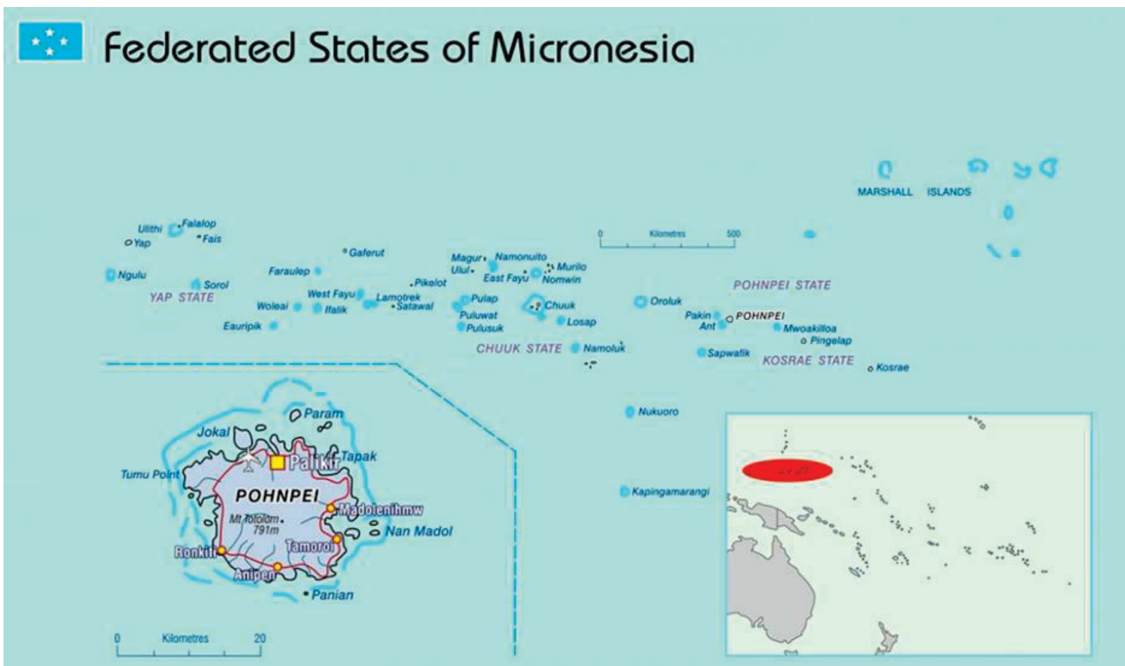
1. a country overview, providing basic geographic, demographic and economic information;
2. a “Market, Policy, and Regulatory Assessment”; and,
3. a “Technical Assessment”.

Each of the Technical Assessments for a given island contains three tables: one providing assumptions and two providing results. For the first PIC discussed below, FSM, the tables are complemented by text that explains the tables. To avoid undue repetition, similar text was omitted for other PICs. Annex (Technical Assessment) may be consulted for additional detail in this area and other technical areas.

3.2 FEDERATED STATES OF MICRONESIA

The Federated States of Micronesia comprises a group of islands and atolls with a total land area of 701 square km dispersed across an ocean area of 2,980 thousand square km. FSM lies to the north of Papua New Guinea and shares maritime borders with the RMI, Guam, and Palau. [18]

Figure 10: Map of Federated States of Micronesia



Source: Pacific Community

As shown in Figure 10, FSM’s 607 islands, of which 65 are inhabited, are grouped into four semi-autonomous states: Chuuk, Kosrae, Pohnpei, and Yap. FSM is politically organized as a federation that

[18] Pacific Community and GIZ. “Strategy 2030: A Blueprint for NDC Implementation in Pacific Island Countries”, 2021. link

gives significant autonomy to the states to manage domestic affairs through their own executive and legislative bodies.

As of 2021, FSM had a population of about 106,000 and a per capita GDP of USD 3,830. Most of the population is engaged in subsistence farming and fishing, except in the urban centers, where government employment and a small commercial sector drive economic activity. Fees from fishery licenses account for nearly half the domestic budget.

Pohnpei is the largest island and includes Palikir - the national capital. Palikir's population is about 5,000; the largest city Weno, located on Chuuk, has a population of about 14,000. Chuuk and Pohnpei are significantly larger in terms of population than the other two states.

Chuuk State is the most populous of the four states (roughly 50,000 population) and is made up of five island groups: Faichuuk, Northern Namoneas, Southern Namoneas, Mortlock Islands and Northwest Islands. The state has 120 square km land area and covers around 200 villages on 48 inhabited islands. Chuuk Lagoon is where most of the population lives. Weno Island, the state capital, is the largest city. Average population density for the state is 400 people per square km. A summary of Chuuk State's main islands is shown in Table 11.

Table 11: Chuuk State Island Groups

Region	Population (000)	Main islands (population in 000)
Faichuuk	11.3	Tol (4.6), Udot (1.7), Paata (1.1), Romanum (0.8), Wonei (0.6)
Northern Namoneas	14.6	Weno (14), Fono (0.4), Piis-Penau (0.4)
Southern Namoneas	10.2	Tonoas (3.5), Fefan (3.5), Uman (2.5), Tsis (0.4)
Mortlock Islands	5.7	Moch (0.9), Lukunor (0.8), Satawan (0.7), Etal (0.7)
Nortwest Islands	6.8	Pulusuk (1.1), Pulap (1.1), Nomwin (0.7), Tamatam (0.5)

Source: Compiled by Delphos

Pohnpei State is the second most populous state (37,000 population). The State has a land area of 370 square km, and a population density of 97 per square km. More than 95% of the state's population lives on Pohnpei Proper Island. Only five of the outer islands are inhibited: Mwoakilloa, Pingelap, Sapwuahfik, Nukuorom Kapingamarangi; the population on these islands is less than 400 on each.

Kosrae State has a land area of 110 square km and a population of about 6,500. The state has a population density of 150 people per square km, and comprises the Kosrae Islands and nearby small islands, the largest of which Lelu Island is inhabited by 1,500 people.

Yap State has a land are of about 120 square km and a population of about 11,500. The state consists of Yap main Islands (Rumung, Maap, Gagil-Tamil and Yap Proper) and 134 smaller islands. Around 60% of the population lives on Yap Main Islands. Ten of the outer islands are inhabited, of which Wolei has the largest population of around 1,000. Other outer islands such as Ulithi, Ifalik and Satawal have populations of around 600-800, while others such as Fais, Faraulep, Elato and Eauripik have populations of less than 200.

3.2.1 Market, Policy, and Regulatory Assessment

Institutional Framework: The Energy Division of the Department of Resources and Development oversees the energy sector and is responsible for policy formulation, research on renewable energy potential, and coordination with state governments as well as regional and international counterparts.

Chuuk Public Utility Corporation (CPUC), Kosrae Utilities Authority (KUA), Pohnpei Utilities Corporation (PUC), and Yap State Public Service Corporation (YSPSC) – the state-level public utilities – are responsible for electricity services along with water and wastewater services. The utilities are autonomous and report to their respective state governors. There is no independent regulator, and the electricity tariff is regulated by the utilities themselves.

Vital Group is a state-owned enterprise (SOE) consisting of Vital FSM Corporation (which operates in all four of the FSM states) and its affiliate Vital Energy Inc., which has operations in Nauru and Guam. It operates fuel storage and wholesale fuel distribution facilities. The Vital Group owns conventional power plants that provide spinning reserve and peak power to the state utilities and is installing renewable energy solutions at its fuel terminal facilities to reduce power bills and carbon emissions.

Utility Services: The utilities primarily serve the largest islands of each state, with smaller systems on the outer islands. The utilities provide basic electrification (lighting) on the outer islands and for isolated communities by installing and maintaining Solar Home Systems (SHS) at households and community buildings.[19] Electrification rates are high except in Chuuk, where electrification was only 27% in 2018, as there are a larger number of inhabited outer islands (with higher population) where CPUC does not operate any electricity grid. Residential customers on Chuuk and Kosrae are all on prepaid meters; PUC and YPSC are also installing prepaid meters for their residential customers.[20]

CPUC operates a main grid on Weno Island, where electrification is nearly 100%. Micro-grids are planned (e.g., in Udot and Satowan) or under construction (e.g., in Tonoas, Fefen and Uman) on several outer islands. A diesel-BESS hybrid microgrid on Tonoas, being developed by the Vital Group, is expected to eventually include a biomass generator.

KUA serves customers on the Kosrae Island and its grid reaches all parts of the island except the Walung village, where KUA has installed and maintains SHSs. The KUA grid also serves the Lelu Island.

PUC's grid serves customers on Pohnpei Proper Island. The Vital Group has been operating a 2 MW diesel plant on Pohnpei as a quasi-IPP project.[21] Outer Island municipalities in Pohnpei state – Mokil, Pingelap, Sapwuahfik, and Kapingamarangi – all have small populations (less than 500) and are served by PUC through SHSs under a "fee-for-service" model.

YSPSC operates its main grid on the Yap Main Islands which are home to 70% of the state's population. The utility also operates Mini Grids on seven islands: three diesel-solar hybrid Mini Grids and four solar micro-grids. YSPSC also installs and operates standalone solar systems at households and community buildings on ten outer islands.

The four public utilities have their unique characteristics but also share common challenges, including a need for institutional strengthening and reform. None generates sufficient revenue to cover its full costs; tariffs are generally sufficient to cover current operating costs but not capital replacement.

Table 12: FSM Utility Services by Main and Outer Grids

Utility	Main Grid Capacity	Outer Islands Capacity
CPUC	Weno: 9.9 MW	Tonoas: 3.85 MW diesel
KUA	Kosrae: 4.9 MW	SHSs only
PUC	Pohnpei: 10.3 MW	SHSs only

[19] World Bank. "Sustainable Energy Development and Access Project", 2018. link (Page 8)

[20] Asian Development Bank. "Renewable Energy Development Project: Sector Assessment - Energy". link

[21] Asian Development Bank. "Sector Assessment (Summary): Energy". link The project is deemed a quasi-IPP project because the owner is an SOE, rather than a private sector entity. This plant is sometimes referred to as an IPP, in the sense that it is not owned by the public utilities, and sells power under a PPA, but it is important to understand that this is not a privately-owned IPP and does not indicate FSM's legal and regulatory framework accommodates such projects.

YPSC	Yap Islands: 5.2 MW	Falalop: 40 kW [+ 90 kW] diesel, 63 kWp solar Mogmog: 35 kW diesel, 48 kWp solar Woleai: 52 kW diesel, 41 kWp solar Asor: 20 kWp solar Satwak: 15 kWp solar Fadray: 28 kWp solar Fair: 15 kWp solar; 19 kWp solar

Source: Compiled from World Bank reports for main grids, and websites for CPUC and YSPSC.

Market Size: PUC is the largest utility, in terms of both installed capacity (10.3 MW) and total energy generation (44,200 MWh). Most of FSM's grids rely on diesel-fired generation; renewable energy generation projects include a small hydro plant in Pohnpei, a wind plant in Yap, and distributed solar PV plants and micro-grids operated by all utilities.

Table 13: FSM - Capacity (kW) by Fuel Type

State	Diesel	Solar	Wind	Hydro	Total
Chuuk	9,712	265			9,977
Kosrae	4,875	527			5,402
Pohnpei	8,600	980		725	10,305
Yap	4,130	240	825		5,195
Total	27,317	2,012	825	725	30,879

Source: Pacific Power Association. "Assessment of Variable Renewable Energy Grid Integration and Evaluation of SCADA and EMS system design in the Pacific Island Countries", 2019. link

The Vital Group is the only entity involved in electricity generation/transmission/distribution in FSM besides the four public utilities.

Quasi IPP on Tonoas Island: The Vital Group is a state-owned enterprise consisting of Vital FSM Corporation (which operates in all four of the FSM states) and its affiliate Vital Energy Inc., which has operations as well in Nauru and Guam. It operates fuel storage and wholesale distribution facilities.

Vital is developing an Integrated Coconut Processing Facility on Tonoas Island. The CPUC signed a PPA with Vital to supply electricity to the local community. The project includes a 3.85 MW diesel power plant, a 800 kW solar PV element and a 640 kWh BESS, as well as a biomass generator to be added later. Similar systems are planned on Fefen and Uman islands.[22,23]

FSM's Energy Master Plan suggests that the quasi-IPP approach may have been used as a substitute for utility borrowing. Although Vital's projects are not traditional competitively procured IPPs, this model has the potential to facilitate private sector participation in BESS development; and, whether private investment is involved or not, this approach also devolves project risks from the utility to other entities. Although Vital is an SOE in FSM, similar models have been used elsewhere in PICs (e.g., Fiji) to simultaneously support a vital industry and expand power supply.

Energy Policy and Electricity Regulations: FSM is a federation that gives significant autonomy to the states to manage domestic affairs through their own executive and legislative bodies. Therefore, implementing energy policy objectives is complex and requires coordination between national and state governments. The national energy policy provides direction to the state governments which

[22] Vital Group. "Frequently Asked Questions". link

[23] Pacific Power Association. "27th PPA Conference Hybrid Case Studies", 2018. link

oversee the state-level public utilities, but state governments rely on the national government and the network of international development partners to implement energy projects.

The "Energy Policy of 2012" focuses on reducing dependence on imported energy by increasing the share of renewable energy as well as through energy conservation and energy efficiency standards (including energy loss reductions). The policy aims to increase private sector participation in investment, ownership, and management in the electricity sector through PPPs.[24]

To achieve the goals of the 2012 energy policy, the Government of FSM commissioned the "Energy Master Plans" in 2018. The Master Plans include technical, financing, and project implementation plans for energy sector development over a twenty-year period extending from 2018 to 2037. The Master Plans include high-level generation capacity and grid expansion plans for the four states to achieve national renewable energy targets – 44% of electricity from renewable energy by 2020, 63% by 2027, and 84% by 2037.[25]

Net Metering in Pohnpei State: Grid-connected Solar System[26]: The electricity supply to Vital Group's fuel terminal in Pohnpei, connected to the PUC grid, was unreliable and critical loads such as fuel pumps need highly reliable supply. The fuel pumps have heavy starting current draw that presented challenges in starting pumps from a battery or solar PV system. The annual cost of power at the terminal was around USD 38,000.

To improve power supply, reliability, and reduce the cost of energy, Vital installed a grid-tied hybrid energy solution comprising a 40-kW rooftop solar PV system, 40 kWh BESS and a 35 kVA coconut oil and diesel generator. The system can operate in three modes: (i) grid connected mode, (ii) standalone mode, and (iii) UPS mode. The solar PV system cost around USD 220,000 and is generating around 52.9 MWh annually. Besides improving power supply reliability, the system is helping Vital save around USD 21,290 annually on electricity bills. The project operates under the net metering regulations.

A net-metering regulation was adopted by Pohnpei State in 2012. However, it is unclear whether the PUC can manage the tariffs and charges implied by the law because the law was not developed through consultations with the utility.[27] This has led to challenges in implementing net-metering projects since clarity is lacking on the permitting and approval process, though there has been at least one successful net metering project (see callout above). PUC's net-metering pamphlet advertising the initiative highlights the fact that customers do not need BESS to participate since the grid would essentially function as the customer's storage for excess energy from their systems.[28]

Electricity generation contributes around 42% of FSM's GHG emissions. It's National Determined Contributions (NDC) aim to reduce 28% GHG emissions by 2025 compared to 2000 levels. With

[24] Department of Resources and Development (Government of Federated States of Micronesia). "Energy Policy Volume I & II", 2012. link

[25] Department of Resources and Development, "Energy Master Plans for the Federated States of Micronesia", 2018. link

[26] Pacific Power Association. "27th PPA Conference Hybrid case Studies". link (This project is called a "quasi IPP" because Vital Group is an SOE, whereas IPPs are generally considered to be undertaken by private companies.)

[27] Asian Development Bank. "Federated States of Micronesia: Strengthening the Energy Sector Regulatory Framework", 2021. link (Page 4)

[28] Pohnpei Utilities Corporation. "FSM Net Metering Initiative". link

financial and technical support from international community, FSM aims to achieve an additional 7% reduction over the same period.[29]

Development partners are very active in FSM's energy sector. Key activities are presented in Table 14.

Table 14: FSM - Development Partners Activities

Development Partner	Project	Key Activities Financed
World Bank	Sustainable Energy Development and Access Project (2019 – ongoing)	2 MW solar PV system in Weno. 1 MWh BESS and energy management system to reduce renewable energy curtailment in Kosrae. 830 kW high-speed genset facility in the existing diesel power plant in Yap. Construction of microgrids in Udot and Satawan. SHS installation in off-grid areas. Capacity building.
European Union	Sustainable Energy and Accompanying Measures (2021 – 2025)	Capacity building. Policy/regulatory review. Promote renewable energy systems in remote areas. Explore jointly implementing/co-funding grid-connected renewable energy IPPs.
Japan International Cooperation Agency	Project for Introduction of Hybrid Power Generation System in the Pacific Island Countries (2017-2022)	Preparing operational manual for hybrid power generation systems. Preparing O&M manual and future O&M plan and budget. Training program for hybrid power systems.
Asian Development Bank	Pacific Renewable Energy Investment Facility (2017-2024)	Financing smaller renewable energy projects (Renewable Energy Development Project – 2.96 MW solar + 0.8 MWh BESS; Solar Plus Project – 5 MW solar + 4 MWh BESS; Renewable Energy Development Project Phase 2 – 9 MW hydro)
Asian Development Bank	Capacity Building and Sector Reform for Renewable Energy Investments in the Pacific (2017-2022)	Technical assistance on utilities' operations and performance; policy, regulatory and governance arrangements; preparing sustainable investment programs and financing plans.
Asian Development Bank	Renewable Energy Development Project (2020-2024)	Financial assiatance of USD 15.5 million for activities including:[30] Kosrae: 1.15 MW solar PV plant; mini-grid in Walung village wih 60 kW solar, 30kW/160 kW BESS and 30 kW diesel generator. Yap: 300 kW solar PV rooftop plant at Sport Centre; 1.95 MW solar PV plant with 800 kW/800kWh BESS.
New Zealand Ministry of Foreign Affairs & Trade	Four Year Plan – 2021	Technical assistance in development work and funding for investment in renewable energy.

Source: Compiled by Delphos.

Private Sector Participation and Investments

FSM has no participation of the private sector in electricity generation. The diesel generators operated by Vital Energy Group to supply power to PUC are the only electricity supply assets not owned by the four public utilities in FSM. The utilities even operate the standalone solar systems at community buildings (e.g., schools) and households at isolated communities.

[29] Government of FSM. "Federated States of Micronesia Intended Nationally Determined Contribution", 2016. link

[30] Asian Development Bank. "Renewable Energy Development Project", 2021. link

The regulatory framework is inadequate to facilitate private sector participation across all FSM states, including through PPP structures.[31] Currently, only Pohnpei explicitly incorporates IPPs into the state law whereas IPPs are implicitly allowed in Chuuk.[32] Due to the autonomy of state governments and the state-level Utility Boards in overseeing the electricity sector, it is likely that future IPP/PPP frameworks or other policies will need to be developed for each state separately.

Factors hindering private investments and Foreign Direct Investment (FDI) in FSM include: (i) prohibitions on foreign ownership of land and businesses; (ii) the need to navigate regulations and licensing at both state and national levels; (iii) high legal risks vis-à-vis contract enforcement, protection of minority (foreign) investors' rights, and bankruptcy settlement; (iv) weak enabling infrastructure, including health and education systems; and (v) high costs of imported goods and various business services.[33]

3.2.2 TECHNICAL ASSESSMENT

Chuuk State: Chuuk State has a low electrification rate of 27% and CPUC has an electric grid only on Weno Island that serves FSM's largest city - Weno. The Weno grid serves around 2,100 customers, including 61 large commercial and government customers.[34] The grid operates at 60 Hz and comprises a 13.8 kV distribution network with five feeders. Table 15 summarizes CPUC's Weno grid.

Table 15: CPUC's Weno Grid Summary

Parameter	Unit	Value
Peak Demand	MW	2.97
Conventional Generating Capacity	MW	7.9
Energy Demand	MWh	16,894
Renewable Energy Penetration	%	5.1

Source: HNEI

Modelling results, based on the assumptions discussed in Section 2.2.3, for the potential system configurations with incremental solar PV and BESS to meet RE targets of 30%, 50% and 70% are discussed below.

Weno grid can achieve 30% RE penetration with addition of a modest amount of solar PV and BESS. A 1-hour BESS with 2.6 MW new solar PV capacity achieves 30% RE penetration, but the system is likely to see 11.6% curtailment of the RE generation. Increasing BESS to a 2-hour storage reduces the requirement of new solar PV capacity to 2.4 MW for the 30% RE penetration target. The extra storage capacity can reduce RE curtailment to 5.9%. Increasing BESS size beyond 3-hours storage does not suggest any significant gains in curtailment reduction or lowering new solar PV capacity requirements.

Achieving 50% RE penetration will require a larger BESS capacity. Increasing BESS capacity from 2-hours to 3-hours reduces curtailment from 22.7% to 8.7% and reduces requirement of new solar PV capacity from 5.9 MW to 5.0 MW. A further increase in the battery size from 3-hours to 4-hours reduces curtailment to 3.2%, and the new solar PV capacity requirement to 4.7 MW. Increasing the

[31] European Commission. "Action Document for Sustainable Energy and Accompanying Measures in the Federated States of Micronesia", 2019. link

[32] Department of Resources and Development, "Energy Master Plans for the Federated States of Micronesia", 2018. link

[33] US State Department. "2021 Investment Climate Statements: Micronesia", 2021 link

[34] Chuuk Public Utility Corporation. "Current Tariffs and Change Process", 2022. link

battery size beyond 4-hours results in diminishing decreases in curtailment, and only a slight reduction in new solar PV capacity requirement.

For Weno to achieve 70% RE penetration, a larger 5-hour BESS may be needed. In this case, increasing the battery size from 4-hours to 5-hours reduces curtailment from 10.9% to 7.1% and reduces the new solar PV capacity requirement from 8.1 MW to 7.8 MW. A summary of new solar capacity and BESS requirements for CPUC's Weno grid is shown in Table 16.

Table 16: Weno Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	2.6	2.6 / 2.6	11.6	9.3	9.3 / 9.3	51.3	NA	NA	NA
2 Hours	2.4	2.4 / 4.8	5.5	5.9	5.9 / 11.8	22.7	11.7	11.7 / 23.4	38.3
3 Hours	2.4	2.4 / 7.2	2.9	5.0	5.0 / 15.0	8.7	9.0	9.0 / 27.0	19.4
4 Hours	2.3	2.3 / 9.2	1.1	4.7	4.7 / 18.8	3.2	8.1	8.1 / 32.4	10.9
5 Hours	2.3	2.3 / 11.5	0.3	4.6	4.6 / 23.0	1.4	7.8	7.8 / 39.0	7.1

Source: HNEI

Comparing the purely incremental solar case with the 50/50 solar and wind case suggests significantly less curtailment for RE penetration levels of 30% and 50%, thereby mitigating the need for longer duration batteries. However, when the RE level is increased to 70%, larger-sized BESS, with 4- and 5-hours storage, provide diminished ability to reduce curtailment due to the relatively longer duration of wind events when compared to the diurnal solar cycle. At 70% RE, even with a 5-hour BESS, a substantial curtailment of 19.9% is expected in the week with the highest RE generation. A summary of the potential system configurations with equal portions of incremental PV and wind, and a BESS to meet RE targets of 30%, 50% and 70% on Weno is shown in Table 17.

Table 17: Weno Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.9 / 0.9	1.8 / 1.8	2.0	1.9 / 1.9	3.8 / 3.8	8.2	NA	NA	NA
2 Hours	0.9 / 0.9	1.8 / 3.6	0.8	1.9 / 1.9	3.8 / 7.6	4.8	3.8 / 3.8	7.6 / 15.2	26.9
3 Hours	0.9 / 0.9	1.8 / 5.4	0.3	1.8 / 1.8	3.6 / 10.8	2.4	3.7 / 3.7	7.4 / 22.2	24.1
4 Hours	0.9 / 0.9	1.8 / 7.2	0.2	1.8 / 1.8	3.6 / 14.4	1.8	3.6 / 3.6	7.2 / 28.8	21.8
5 Hours	0.9 / 0.9	1.8 / 9.0	0.1	1.8 / 1.8	3.6 / 18.0	1.4	3.5 / 3.5	7.0 / 35.0	19.9

Source: HNEI

Kosrae State: Kosrae State has an electrification rate of over 95%. The KUA grid serves 1,800 customers in all regions of Kosrae Island, where the majority of the population lives, except the Walung village which is served by solar lighting systems installed and maintained by the KUA. The KUA grid operates at 60 Hz and comprises a 13.8 kV distribution network with three feeders. A summary of the KUA's Kosrae grid is presented in Table 18.

Table 18: KUA's Kosrae Grid Summary

Parameter	Unit	Value
Peak Demand	MW	1.29
Conventional Generating Capacity	MW	4.9
Energy Demand	MWh	6,927
Renewable Energy Penetration	%	3.2

Source: HNEI

The BESS requirement for the KUA grid on the Kosrae Island are summarized in Table 19 and Table 20.

Table 19: Kosrae Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	1.2	1.2 / 1.2	11.0	3.7	3.7 / 3.7	45.9	NA	NA	NA
2 Hours	1.1	1.1 / 2.2	5.3	2.5	2.5 / 5.0	18.7	4.8	4.8 / 9.6	34.4
3 Hours	1.1	1.1 / 3.3	2.4	2.2	2.2 / 6.6	7.2	3.8	3.8 / 11.4	16.3
4 Hours	1.1	1.1 / 4.4	0.9	2.1	2.1 / 8.4	2.6	3.5	3.5 / 14.0	9.3
5 Hours	1.1	1.1 / 5.5	0.3	2.1	2.1 / 10.5	1.3	3.4	3.4 / 17.0	6.1

Source: HNEI

Table 20: Kosrae Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.5 / 0.5	1.0 / 1.0	3.2	1.0 / 1.0	2.0 / 2.0	10.2	NA	NA	NA
2 Hours	0.5 / 0.5	1.0 / 2.0	1.6	1.0 / 1.0	2.0 / 4.0	6.9	1.9 / 1.9	3.8 / 7.6	26.3
3 Hours	0.5 / 0.5	1.0 / 3.0	0.8	1.0 / 1.0	2.0 / 6.0	5.2	1.8 / 1.8	3.6 / 10.8	22.4
4 Hours	0.5 / 0.5	1.0 / 4.0	0.5	0.9 / 0.9	1.8 / 7.2	2.5	1.8 / 1.8	3.6 / 14.4	21.5
5 Hours	0.5 / 0.5	1.0 / 5.0	0.3	0.9 / 0.9	1.8 / 9.0	1.9	1.7 / 1.7	3.4 / 17.0	18.3

Source: HNEI

Pohnpei State: Pohnpei State has an electrification rate of over 95%. PUC has a power grid on the Pohnpei Proper Island, where more than 90% of the state's population lives. The Pohnpei Proper Island grid serves around 7,350 customers, operates at 60 Hz and comprises a 13.8 kV distribution network with three feeders. A summary of the KUA's Kosrae grid is presented in Table 21.

Table 21: PUC's Pohnpei Proper Grid Summary

Parameter	Unit	Value
Peak Demand	MW	6.2
Conventional Generating Capacity	MW	8.6
Energy Demand	MWh	37,482
Renewable Energy Penetration	%	4.1

Source: HNEI

The BESS requirement for the PUC's grid on Pohnpei Proper Island are summarized in Table 22 and Table 23.

Table 22: Pohnpei Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	4.4	4.4 / 4.4	0.8	11.8	11.8 / 11.8	26.9	NA	NA	NA
2 Hours	4.4	4.4 / 8.8	0.0	9.2	9.2 / 18.4	6.3	19.7	19.7 / 39.4	30.6
3 Hours	NA	NA	NA	8.8	8.8 / 26.4	1.8	15.4	15.4 / 46.2	10.9
4 Hours	NA	NA	NA	8.7	8.7 / 34.8	0.4	14.1	14.1 / 56.4	2.6
5 Hours	NA	NA	NA	8.7	8.7 / 43.5	0.0	13.8	13.8 / 69.0	0.8

Source: HNEI

Table 23: Pohnpei Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
No BESS	1.7 / 1.7	No BESS	0.0	3.3 / 3.3	No BESS	3.8	6.4 / 6.4	No BESS	21.6
1 Hour	NA	NA	NA	3.2 / 3.2	6.4 / 6.4	1.0	6.4 / 6.4	12.8 / 12.8	8.5
2 Hours	NA	NA	NA	3.2 / 3.2	6.4 / 12.8	0.2	5.3 / 5.3	10.6 / 21.2	4.3
3 Hours	NA	NA	NA	3.2 / 3.2	6.4 / 19.2	0.0	5.2 / 5.2	10.4 / 31.2	2.9
4 Hours	NA	NA	NA	NA	NA	NA	5.2 / 5.2	10.4 / 41.6	2.5
5 Hours	NA	NA	NA	NA	NA	NA	5.2 / 5.2	10.4 / 52.0	2.2

Source: HNEI

Yap State: Yap State has an electrification rate of over 87%. The Yap Main Island is home to over 70% of the state's population. Electricity on the Yap Main Island is supplied by YSPSC's grid, and the outer islands are served by diesel generators and stand-alone solar systems. The Yap Main Island grid serves 2,900 customers, operates at 60 Hz and comprises a 13.8 kV distribution network. A summary is presented in Table 24.

Table 24: YSPSC's Yap Main Island Grid Summary

Parameter	Unit	Value
Peak Demand	MW	1.9
Conventional Generating Capacity	MW	4.1
Energy Demand	MWh	10,646
Renewable Energy Penetration	%	19.5

Source: HNEI

Table 25 and Table 26 summarize BESS requirement for the YSPSC's grid on the Yap Main Island.

Table 25: Yap Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.7	0.7 / 0.7	3.0	3.3	3.3 / 3.3	37.5	NA	NA	NA
2 Hours	0.7	0.7 / 1.4	1.4	2.4	2.4 / 4.8	14.3	5.8	5.8 / 11.6	35.7
3 Hours	0.7	0.7 / 2.1	0.5	2.2	2.2 / 6.6	5.4	4.5	4.5 / 13.5	16.7
4 Hours	0.7	0.7 / 2.8	0.2	2.1	2.1 / 8.4	1.9	4.1	4.1 / 16.4	8.3
5 Hours	0.7	0.7 / 3.5	0.1	2.1	2.1 / 10.5	0.6	3.9	3.9 / 19.5	5.1

Source: HNEI

Table 26: Yap Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.4 / 0.4	0.8 / 0.8	1.2	0.9 / 0.9	1.8 / 1.8	8.3	NA	NA	NA
2 Hours	0.4 / 0.4	0.8 / 1.6	0.6	0.9 / 0.9	1.8 / 3.6	5.3	2.0 / 2.0	4.0 / 8.0	28.4
3 Hours	0.4 / 0.4	0.8 / 2.4	0.2	0.9 / 0.9	1.8 / 5.4	3.9	1.9 / 1.9	3.8 / 11.4	24.8
4 Hours	0.4 / 0.4	0.8 / 3.2	0.1	0.8 / 0.8	1.6 / 6.4	1.7	1.9 / 1.9	3.8 / 15.2	24.0
5 Hours	0.4 / 0.4	0.8 / 4.0	0.0	0.8 / 0.8	1.6 / 8.0	1.2	1.8 / 1.8	3.6 / 18.0	21.0

Source: HNEI

3.2.3 RECOMMENDATION

Table 27: PPP Structures Recommendations for FSM

System	PPP Structure	Rationale	Policy Recommendations
Chuuk, Kosrae, Pohnpei, Yap – Main Grids	C&I Customer Sited BESS	Vital Group's diesel plant in Pohnpei and mini-grid project in Chuuk (Tonoas) are templates to build on. Near-term projects should focus on encouraging C&I customers like Vital Group to install BESS (standalone or as part of solar or diesel hybrids) to meet their own energy needs and also export to the grid.	Create formal mechanism across all four states for C&I customers to offer self-built plants for partial export to grid. Fully fledged IPP enabling frameworks are not necessary. Add federal incentives for BESS deployment.
	BESS Lease/Rental	To expand BESS deployment beyond the suitable sites of C&I customers, which are likely to be limited, adopt the BESS lease/rental model.	For other identified BESS needs, conduct simplified public tender for BESS rental projects. Projects for tenders

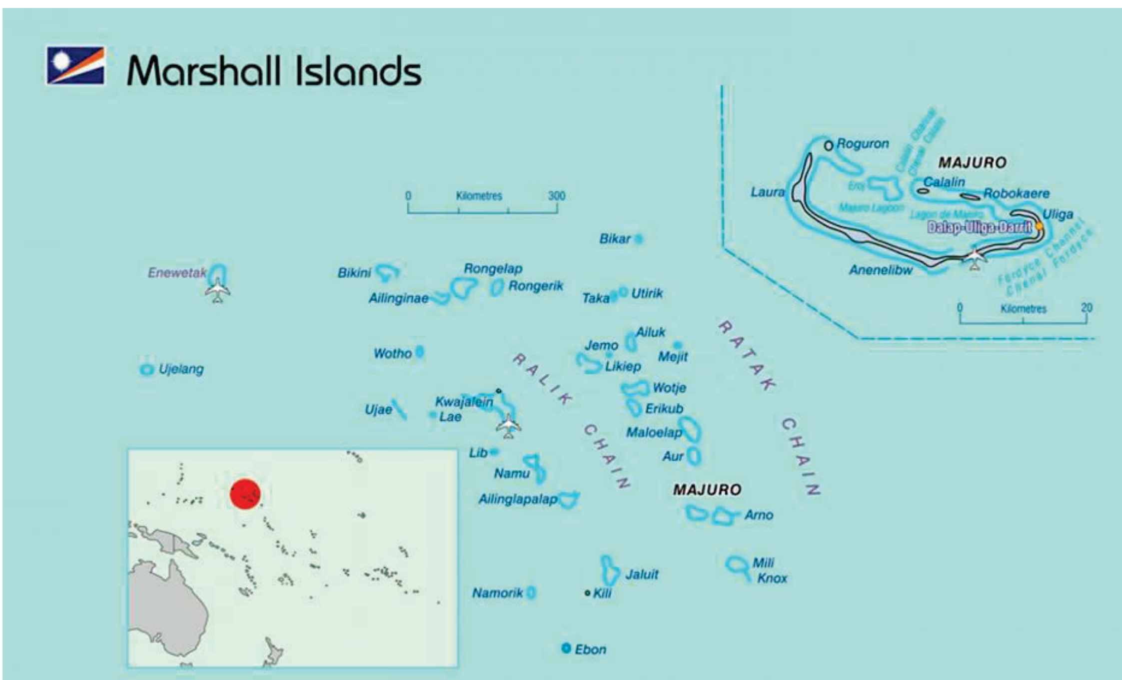
			should be conducted in aggregate.
Chuuk, Kosrae, Yap – Outer Islands	Mini Grid Concession	Take the existing practice of using Mini Grids for electrification and allow private-sector third parties to do this for a fee.	For identified islands for Mini Grid development, conduct a simplified public tender for Mini Grid operations.
Pohnpei – Outer Islands	BESS Lease/Rental	Project deployments are likely to be standalone systems (SHSs or at community facilities). The utilities can adopt a BESS Lease/Rental model to add BESS to the existing standalone systems at community facilities.	Conduct simplified BESS rental tenders, in aggregate with projects on main grids and possibly other countries.

Source: Delphos

3.3 REPUBLIC OF MARSHALL ISLANDS

The Republic of Marshall Islands (RMI) consists of 29 atolls and five isolated islands (of which 24 are inhabited), and numerous small islets. The country covers an area of over 2,131 thousand square km but has just 181 square km in land area. RMI shares maritime borders with FSM, Nauru, Kiribati, and Wake Islands (USA). As of 2021, RMI had a population of 55,000 of which about 28,000 live in Majuro, the country's capital, and about 11,000 live in Ebeye on the Kwajalein Island). RMI has a population density of about 303 persons per square km, and a per capita GDP of USD 4,337.

Figure 11: Map of Federated States of Micronesia



Source: Pacific Community

The Government of Marshall Islands is the country's largest employer; the economy is heavily reliant on payments made by the USA under the Compact of Free Association. The private sector is relatively small, consisting of commercial fishing, retail services, copra production, and tourism. The fishing sector remains the main source of export revenue, followed by copra products.[35]

3.3.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Energy Planning Division of the Ministry of Resources and Development is responsible for national energy planning and coordination, as well as the national energy policy framework.

The state-owned utilities, Marshalls Energy Company (MEC) and Kwajalein Atoll Joint Utility Resources (KAJUR), are responsible for electricity services. KAJUR operates as a subsidiary of MEC and in addition to the electricity services also provides water and sanitation services on Ebeye. The utilities' operations and management are overseen by the Combined Utilities Board, a body appointed and directed by the Cabinet.[36] MEC is also responsible for diesel fuel import, storage, and bunkering, and rural photovoltaic (PV) programs.

RMI does not have an independent energy regulator and there are no licensed private generators.[37]

Utility Services: The electrification rate in RMI approaches 100%. MEC supplies 50% of the population from its grid on Majuro; and 16% using off-grid solar home systems (SHSs) and three mini-grid systems on the islands of Wotje, Jaluit, and Rongrong. KAJUR supplies the remaining 34% of the population through its grid network on Ebeye. Table 28 summarizes the operations of the two utilities.

Table 28: RMI Utility Services

Utility	Main Grid Capacity	Outer Islands Capacity
MEC	Majuro: 18.0 MW	Wotje: 550 kW Jaluit: 600 kW Rongrong: 120 kW
KAJUR	Ebeye: 5.1 MW	N/A

Source: Compiled by Delphos from World Bank reports.

The electricity tariff is not cost recovering. The government supports MEC by exempting it from taxes on fuel imports as well as cash support to supply fuel and power to Ebeye, Wotje, and Jaluit. The government also provides financial support of around USD 0.8 million to MEC annually to supply fuel and power to Wotje and Jaluit atolls through the National Energy Support Fund, and about USD 2-2.5 million for KAJUR.[38]

Market Size: MEC and KAJUR operate a generation capacity of around 24.4 MW. MEC operates a 1 MW solar PV plant on its Majuro grid (Table 29). Around 97% of RMI's electricity mix is from diesel generation, with solar PV accounting for the remaining 3%. There are approximately 3,000 standalone SHS and some small grid-connected solar systems in Majuro, including a 600 kW MASDAR system near the airport, a 209 kW system on the hospital roof funded by the Japan International Cooperation

[35] World Bank Group. "Project Appraisal Document for the Marshall Islands Maritime Investment Project", 2019. link

[36] World Bank. "Project Appraisal Document for Sustainable Energy Development Project", 2017. link (Page 15)

[37] Asian Development Bank. "Sector Assessment (Summary): Energy", 2019. link

[38] World Bank. "Project Appraisal Document for Sustainable Energy Development Project", 2017. link

Agency (JICA), a 111 kW system at the College of Marshall Islands, a 55 kW system at the University of South Pacific Campus.[39]

Table 29: RMI - Capacity (kW) by Fuel Type

Utility	Grid	Diesel	Solar	Total
MEC	Majuro	17,000	1,000	18,000
MEC	Other	1,270	0	1,270
KAJUR	Ebeye	5,144	0	5,144
Total		23,414	1,000	24,414

Source: Compiled by Delphos from various World Bank reports.

Energy Policy and Electricity Regulations: RMI's key energy policy document is the "National Energy Policy and Energy Action Plan" from 2016, which provides guidance for the planning, financing, and advancing the energy sector through a "whole of sector" development approach. The policy objectives include reducing dependence on imported fossil fuels, expanding access to modern energy services, and improving reliability, affordability, and sustainability of energy supply. The policy emphasizes use of BESS, including the development of a management and financial system that allows recovery of O&M and battery replacement costs and environmentally sound disposal of batteries.[40]

RMI has set a target of 100% renewable electricity generation by 2050 and has committed to reducing GHG emissions by 32% below 2010 levels by 2025, 45% by 2030, and to have net zero emissions by 2050.[41] [42] The same is reflected in the country's NDC. To achieve this ambitious target, the Government of RMI developed the "Marshall Islands Electricity Roadmap" in 2018 with assistance from the New Zealand Ministry of Foreign Affairs and Trade. The roadmap provides a strategic framework for reducing GHG emissions from the power sector by accelerating the deployment of proven and cost-effective renewable energy technologies as well as enabling technologies like BESS. The roadmap envisions significant additions of wind generation capacity, BESS capacity, and transmission and distribution infrastructure in the near-term (2022 to 2025) for both Majuro and Ebeye.[43]

Some relevant engagements in the sector by development partners are summarized in Table 30.

Table 30: RMI - Development Partners Activities

Development Partner	Project	Key Activities Financed
World Bank	Sustainable Energy Development Project (2019 – ongoing)	Technical assistance to evaluate potential renewable energy and BESS solutions, including on Ebeye and outer islands near Majuro. Finance the design, supply, installation, and operational support for solar PV, BESS, and grid management equipment in Majuro. Finance gensets for MEC and KAJUR´s power plants in Majuro and Ebeye to help accommodate the planned grid solar capacity, and to improve fuel efficiency and system reliability. Supporting design and implementation of loss reduction program for KAJUR.

[39] World Bank. "Project Appraisal Document for Sustainable Energy Development Project (P160910)", 2017. link

[40] Republic of the Marshall Islands. "National Energy Policy and Energy Action Plan", 2016. link

[41] US Department of Energy. "Marshall Islands: Energy Snapshot", 2020. link

[42] Government of Marshall Islands. "Marshall Islands Electricity Roadmap", 2018. link

[43] Ibid.

Asian Development Bank	Pacific Renewable Energy Investment Facility (2017-2024)	Financing smaller renewable energy projects (Solar Plus Project – 2 MW solar + 1 MWh BESS)

Source: Compiled by Delphos.

Private Sector Participation and Investments: RMI has no participation of the private sector in the power sector in terms of asset investment, ownership, and operations. There is no net-metering framework in place because the SHSs are installed and operated by the public utilities.[44]

The factors hindering private investments and FDI in RMI include (i) laws preventing non-Marshallese from purchasing land; (ii) lack of public land in the country, requiring businesses/utilities to lease land from private landowners; (iii) high climate risks due to very low elevation above sea level; (iv) weak enabling environment; and (v) high costs of doing business due to remoteness.[45]

3.3.2 TECHNICAL ASSESSMENT

Majuro: Majuro Island has an electrification of almost 100%. The island is served by MEC's grid that comprises of 13.8 kV, 4.2 kV and low voltage distribution network operating at 60 Hz. A summary of the MEC's Majuro grid is presented in Table 31.

Table 31: MEC's Majuro Grid Summary

Parameter	Unit	Value
Peak Demand	MW	9.4
Conventional Generating Capacity	MW	17.0
Energy Demand	MWh	65,141
Renewable Energy Penetration	%	0.8

Source: HNEI

The BESS requirement for the MEC grid on Majuro Island is summarized in Table 32 and Table 33.

Table 32: Majuro Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	10.5	10.5 / 10.5	0.0	24.5	24.5 / 24.5	20.8	NA	NA	NA
2 Hours	NA	NA	NA	20.0	20.0 / 40.0	3.0	38.0	38.0 / 76.0	20.6
3 Hours	NA	NA	NA	19.5	19.5 / 58.5	0.1	32.0	32.0 / 96.0	5.0
4 Hours	NA	NA	NA	19.5	19.5 / 78.0	0.0	30.5	30.5 / 122.0	0.6
5 Hours	NA	NA	NA	NA	NA	NA	30.5	30.5 / 152.5	0.0

Source: HNEI

Table 33: Majuro Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	3.6 / 3.6	7.2 / 7.2	0.0	6.7 / 6.7	13.4 / 13.4	0.1	11.8 / 11.8	23.6 / 23.6	12.2
2 Hours	NA	NA	NA	6.7 / 6.7	13.4 / 26.8	0.0	11.4 / 11.4	22.8 / 45.6	9.1
3 Hours	NA	NA	NA	NA	NA	NA	11.1 / 11.1	22.2 / 66.6	7.0
4 Hours	NA	NA	NA	NA	NA	NA	11.0 / 11.0	22.0 / 88.0	6.1
5 Hours	NA	NA	NA	NA	NA	NA	11.0 / 11.0	22.0 / 110.0	5.8

Source: HNEI

[44] US Department of Energy. "Marshall Islands: Energy Snapshot", 2020. link

[45] US State Department. "2021 Investment Climate Statements: Marshall Islands", 2021.

Ebeye: Ebeye Island has an electrification rate of almost 100%. The island is served by the KAJUR grid (13.8 kV and a low voltage distribution network). Table 34 summarizes KAJUR's Ebeye grid.

Table 34: KAJUR's Ebeye Grid Summary

Parameter	Unit	Value
Peak Demand	MW	1.4
Conventional Generating Capacity	MW	6.3
Energy Demand	MWh	16,425
Renewable Energy Penetration	%	0

Source: HNEI

The BESS requirement for the KAJUR grid on Ebeye Island is summarized in Table 35 and Table 36.

Table 35: Ebeye Results – 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	2.7	2.7 / 2.7	2.2	8.6	8.9 / 8.9	44.3	NA	NA	NA
2 Hours	2.6	2.6 / 5.2	0.1	5.6	5.6 / 11.2	14.1	11.2	11.2 / 22.4	34.0
3 Hours	2.6	2.6 / 7.8	0.0	4.9	4.9 / 14.7	2.1	8.5	8.5 / 25.5	12.5
4 Hours	NA	NA	NA	4.8	4.8 / 19.2	0.1	7.6	7.6 / 30.4	2.6
5 Hours	NA	NA	NA	3.8	3.8 / 19.0	0.0	7.5	7.5 / 37.5	0.9

Source: HNEI

Table 36: Ebeye Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.9 / 0.9	1.8 / 1.8	0.1	1.6 / 1.6	3.2 / 3.2	1.5	NA	NA	NA
2 Hours	0.9 / 0.9	1.8 / 3.6	0.0	1.6 / 1.6	3.2 / 6.4	0.3	2.8 / 2.8	5.6 / 11.2	14.7
3 Hours	NA	NA	NA	1.6 / 1.6	3.2 / 9.6	0.1	2.8 / 2.8	5.6 / 16.8	14.0
4 Hours	NA	NA	NA	1.6 / 1.6	3.2 / 12.8	0.0	2.7 / 2.7	5.4 / 21.6	11.5
5 Hours	NA	NA	NA	NA	NA	NA	2.3 / 2.3	4.6 / 23.0	11.2

Source: HNEI

3.3.3 RECOMMENDATION

Table 37: PPP Structures Recommendations for RMI

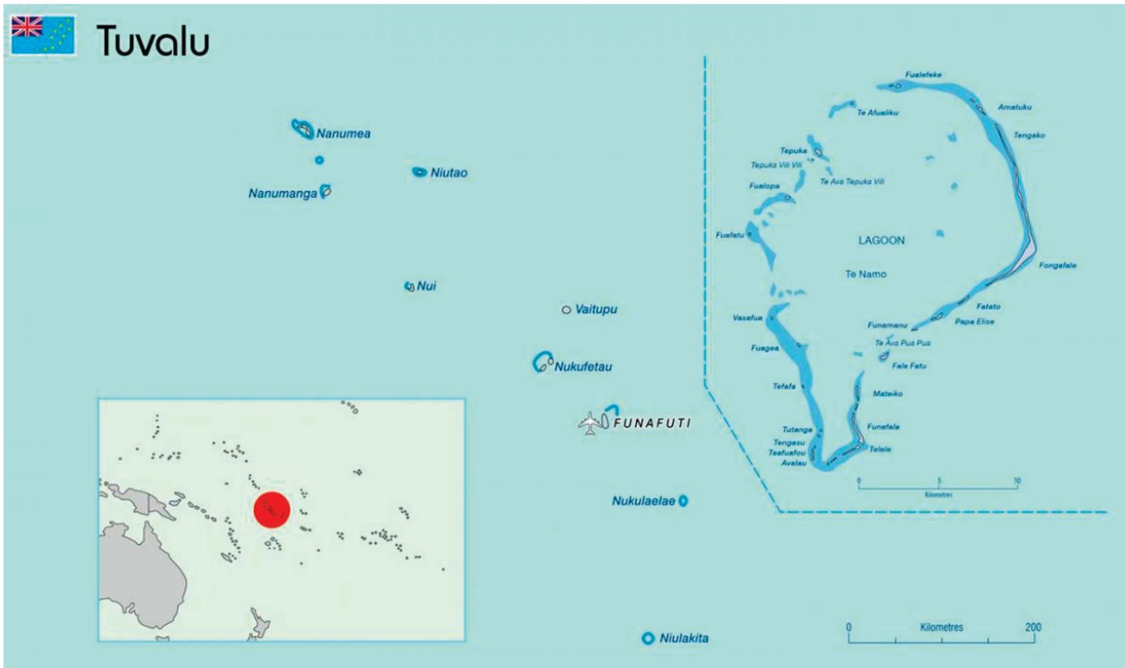
System	PPP Structure	Rationale	Policy Recommendations
Majuro, Ebeye – Main Grids	BESS Lease/Rental VRE + BESS IPP	The main grids have aging diesel generators and very low renewable energy capacity, requiring the addition of both BESS and VRE capacity in the near term to meet policy objectives. Adding some BESS capacity on new VRE projects would help smooth VRE generation. BESS rentals are likely to be effective solutions for MEC to meet short time reliability needs to avoid full replacement of diesel capacity.	Fully fledged IPP enabling frameworks are not necessary. Adopt informal IPP structures, similar to what exists in FSM with Vital Group. To be clear, these structures would not necessarily involve private capital, focusing instead on an SOE's investment. Offer incentives to add BESS capacity on VRE projects.
Majuro – Outer Islands	Mini Grid Concession	Similar to the existing diesel Mini Grids, allow private-sector third parties to build and operate solar-diesel-BESS hybrid Mini Grids for a fee.	For islands identified for Mini Grid development, conduct a simplified public tender for Mini Grid operations.

Source: Delphos

3.4 TUVALU

Tuvalu consists of six coral atolls and three islands in the central South Pacific; Funafuti Atoll is the capital and includes Fongfale, the largest island and town where the administrative buildings are located. The country covers an area of nearly 900 thousand square km but has just 26 square km of land area. As of 2021, Tuvalu's population was about 11,000; half of which lives in Fongfale. The country's population density is around 356 persons per square km, and per capita GDP is USD 4,223.

Figure 12: Map of Tuvalu



Source: Pacific Community

Tuvalu's economy depends on foreign aid, license fees from foreign fishing vehicles, and remittances. Economic activities in the country are mostly public-sector based.[46] The country does not have a central bank and its currency, the Tuvaluan Dollar, is pegged at a 1:1 parity with the Australian Dollar.[47]

3.4.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Department of Energy within the Ministry of Public Utilities and Infrastructures manages the energy sector. The Tuvalu Electricity Corporation (TEC), an SOE, is responsible for enforcing the Electricity Act and regulations, setting standards, and examining and registering electricians.[48] There is no competition in Tuvalu's power generation and distribution and TEC has exclusive rights to generate and supply electricity on all islands.[49] The electricity sector does not have an independent regulator.[50]

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[46] World Bank. "The World Bank Data", 2019. link

[47] World Bank. "Project Appraisal Document for an Energy Sector Development Project", 2014. link

[48] Asian Development Bank. "Sector Assessment (Summary): Energy", 2019. link (Page 1)

[49] Commonwealth Governance. "Tuvalu Country Profile".

[50] Global Environment Facility. "Facilitation of the Achievement of Sustainable National Energy targets of Tuvalu", 2021. link

Utility Services: TEC operates a main grid on Fongfale along with smaller power systems on three outer islands: Nukulaelae, Nukufetau, and Nui. The three outer islands have solar-battery-diesel hybrid systems, implemented with assistance from the European Union and the Government of New Zealand.[51]

Table 38: TEC Utility Services

Utility	Main Grid Capacity	Outer Islands Capacity
TEC	Funafuti: 2.1 MW	Nukulaelae: 135 kW hybrid microgrid Nukufetau: 217 kW hybrid microgrid Nui: 207 kW hybrid microgrid

Source: Asian Development Bank. "Pacific Renewable Energy Investment Facility; Tuvalu: Increasing Access to Renewable Energy Project", 2019. link

Market Size: Tuvalu has achieved full electrification and there are no significant power outages. Funafuti accounts for over 85% of electricity supply and consumption. In 2019, TEC's Fongfale system had a peak load of 1.3 MW and installed capacity of about 2.5 MW – three 600 kW diesel generators and a 735 kWp solar PV capacity.[52] Solar's share of electricity generation is about 15%.

Table 39: Tuvalu - Capacity (kW) by Fuel Type

Utility	Grid	Diesel	Solar	BESS (kWh)	Total
TEC	Fongfale	1,800	350		2,150
TEC	Nukulaelae	90	45	576	135
TEC	Nukufetau	130	87	1,008	217
TEC	Nui	130	77	864	207
Total		2,150	759	2,448	2,709

Source: Compiled by Delphos from World Bank and ADB reports.

Energy Policy and Electricity Regulations: The "National Energy Policy of 2009" emphasizes affordability and sustainability and provides the basis for high-level guidance for the power sector. Tuvalu's NDC aim to achieve zero emissions from electricity generation by 2025 and reducing GHG emissions from energy sector by 60% below 2010 level by 2025.[53]

The "Master Plan for Renewable Energy and Energy Efficiency of 2012" aimed to achieve 100% renewable energy by 2020 and a 30% increase in energy efficiency. The Master Plan (i) recognizes BESS as an important resource; (ii) identifies conversion of existing diesel generation to run on biodiesel as a path to firm renewable capacity; and (iii) suggests that a mix of wind and solar generation could potentially minimize the level of BESS and use of generation from diesel or biodiesel fuels. The target date for achieving 100% renewable energy was subsequently extended to 2025.[54]

The ADB, in 2019, funded a technical assistance project to develop a roadmap to 100% renewable energy by 2025 on Funafuti, which estimates that 7.6 MW of solar and 3 MW/14 MWh BESS was required to accomplish this target.[55]

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[51] Asian Development Bank. "Pacific Renewable Energy Investment Facility; Tuvalu: Increasing Access to Renewable Energy Project", 2019. link

[52] Asian Development Bank. "Pacific Renewable Energy Investment Facility; Tuvalu: Increasing Access to Renewable Energy Project", 2019. link

[53] Government of Tuvalu. "Intended Nationally Determined Contributions", 2015. link

[54] Tuvalu Electricity Corporation. "Enetise Tutumau 2012-2020: Master Plan for Renewable Electricity and Energy Efficiency in Tuvalu", 2013. link

[55] Entura. "Tuvalu – Funafuti Road Map", 2019. link

Tuvalu's NDC aims to achieve zero GHG emission from electricity sector by 2025.[56]

Development partner engagement in Tuvalu is summarized in Table 40.

Table 40: Tuvalu - Development Partners Activities

Development Partner	Project	Key Activities Financed
World Bank	Energy Sector Development Project (2015 – 2022)	Invest in the design, supply, and building of a 750 kW solar PV facility with a 2 MWh BESS. The contract for the solar PV facility was awarded to Infratec Ltd., a New Zealand based contractor, in September 2019 but has been delayed due to COVID-19.[57,58]
Asian Development Bank	Preparing Clean and Renewable Energy Investments in the Pacific	Technical assistance to assess potential for floating solar projects. Due diligence to prepare three floating solar projects for approval in 2022–2023. Tuvalu Increasing Access to Renewable Energy Project (Phase 2) ~ 1–2 MW of floating and rooftop photovoltaic system + BESS.[59]
Asian Development Bank	Pacific Renewable Energy Investment Facility: Increasing Access to Renewable Energy Project	Financial assistance of USD 6.5 million for solar PV projets on outer islands: Nui (101 kW), Nukufetau (78 kW) and Nukulaelae (45 kW); and 500 kW solar PV and a 1 MW/2 MWh BESS on Funafuti island.[60]
New Zealand Ministry of Foreign Affairs & Trade	Bilateral support	Financing support to add solar PV and BESS on the diesel Mini Grids in outer islands to reduce diesel usage.

Source: Compiled by Delphos.

Private Sector Participation and Investments: There is no private sector participation in project development, investment, or operations in Tuvalu's power sector.

3.4.2 TECHNICAL ASSESSMENT

Funafuti: The TEC grid on Funafuti Island on the Fongfale atoll operates at 50 Hz and comprises a 11-kV distribution network with three feeders. Table 41 summarizes TEC's Funafati grid.

Table 41: TEC's Funafati Grid Summary

Parameter	Unit	Value
Peak Demand	MW	1.42
Conventional Generating Capacity	MW	1.8
Energy Demand	MWh	9,649
Renewable Energy Penetration	%	15.7

Source: HNEI

[56] Government of Tuvalu. "Intended Nationally Determined Contributions", 2015. link

[57] World Bank. "Energy Sector Development Project (P144573)". link

[58] World Bank. "Energy Sector Development Project". link

[59] Asian Development Bank. "Preparing Floating Solar Plus Projects under the Pacific Renewable Energy Investment Facility", 2020. link

[60] Asian Development Bank. "Pacific Renewable Energy Investment Facility Tuvalu: Increasing Access to Renewable Energy Project", 2019. link

The BESS requirement for the TEC grid on the Funafuti Island is summarized in Table 42 and Table 43.

Table 42: Funafati Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.9	0.9 / 0.9	8.9	4.5	4.2 / 4.2	54.7	N.A.	N.A.	N.A.
2 Hours	0.9	0.9 / 1.8	3.4	2.8	2.8 / 5.6	27.2	6.1	6.1 / 12.2	42.4
3 Hours	0.8	0.8 / 2.4	1.3	2.3	2.3 / 6.9	10.7	4.6	4.6 / 13.8	22.7
4 Hours	0.8	0.8 / 3.2	0.5	2.1	2.1 / 8.4	3.0	3.9	3.9 / 15.6	9.2
5 Hours	0.8	0.8 / 4.0	0.1	2.1	2.1 / 10.5	0.7	3.7	3.7 / 18.5	3.9

Source: HNEI

Table 43: Funafati Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	0.4 / 0.4	0.8 / 0.8	1.9	1.0 / 1.0	2.0 / 2.0	8.9	NA	NA	NA
2 Hours	0.4 / 0.4	0.8 / 1.6	0.6	1.0 / 1.0	2.0 / 4.0	3.7	1.8 / 1.8	3.6 / 7.2	14.5
3 Hours	0.4 / 0.4	0.8 / 2.4	0.2	0.9 / 0.9	1.8 / 5.4	0.9	1.7 / 1.7	3.4 / 10.2	9.5
4 Hours	0.4 / 0.4	0.8 / 3.2	0.0	0.9 / 0.9	1.8 / 7.2	0.2	1.7 / 1.7	3.4 / 13.6	7.9
5 Hours	NA	NA	NA	0.9 / 0.9	1.8 / 9.0	0.0	1.7 / 1.7	3.4 / 17.0	6.6

Source: HNEI

3.4.3 RECOMMENDATION

Table 44: PPP Structures Recommendations for Tuvalu

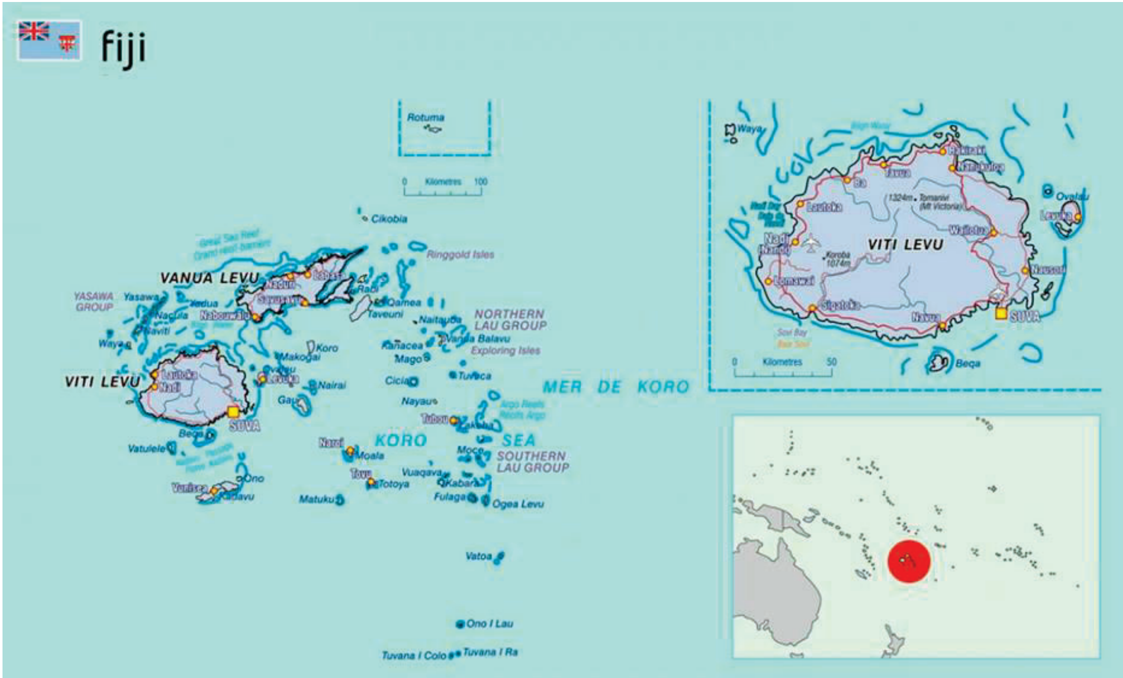
System	PPP Structure	Rationale	Policy Recommendations
Funafuti	BESS Lease/Rental	Due to the small size of the grid, BESS rentals are likely to be the most effective solutions for TEC to mobilize private sector capital to deploy BESS. Current renewable energy and BESS projects are funded by development partners so VRE + BESS IPP structures are not likely in the near term.	Create plan for partial replacement/substitution of current diesel generators with BESS before conducting procurements for rentals.

Source: Delphos

3.5 FIJI

Fiji is the largest country by population (898,000 in 2021) among the eleven PICs assessed in this report and second largest by land area (18,272 square km). Fiji comprises about 330 islands, of which one third are inhabited, spread across 1,290 thousand square km of sea area. Most of the population is concentrated on two main islands: Viti Levu (75% of the population) and Vanua Levu (20% of the population). Suva, the national capital, is located on Viti Levu Island. Fiji has a population density of about 49 persons per square km and a per capita GDP of USD 6,152.

Figure 13: Map of Fiji



Source: Pacific Community

Fiji has a more advanced economy compared to other PICs. Along with its larger land mass, Fiji is also endowed with a greater variety of natural resources – forests, minerals (bauxite, copper, and gold), fisheries, seascape, and pristine beaches. Commercial activity in Fiji includes sugarcane production and sugar milling, garment manufacture, and tourism. Fiji also serves as the regional hub for transportation, business, and telecommunications.[61]

3.5.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The institutional and policy framework in Fiji is complex, with overlapping jurisdictions. The Department of Energy, which is under the Ministry of Infrastructure and Meteorological Services, develops and implements government policies on renewable energy and rural electrification. It implements rural electrification by subsidizing Energy Fiji Limited to build mini-grids.[62]

Energy Fiji Limited (EFL), previously known as the Fiji Electricity Authority, is a public utility that has been corporatized and is planned to be registered on the South Pacific Stock Exchange by 2022. It is responsible for generation, transmission, distribution, and sale of electricity on Viti Levu, Vanua Levu, Ovalau and Tavenui. EFL also carries out some regulatory functions on an interim basis (including approving and licensing suppliers) until its responsibilities are fully transitioned to the Fijian Competition and Consumer Commission (FCCC). FCCC is an independent statutory body intended to serve regulatory functions in the electricity, telecommunications, maritime, and airport sectors.

Utility Services: Fiji has achieved near-universal electrification. EFL's main grid is on Viti Levu Island. On Vanua Levu Island, it operates two separate grids – Labasa and Savusavu. There are two further

[61] World Bank. "Project Appraisal Document for Fiji Carbon Fund Emission Reduction Program (P163484)", 2020. link

[62] Fiji Department of Energy. "About Us". link

smaller grids on Ovalau (near Viti Levu) and Taveuni (near Vanua Levu). While majority of its generation is based on hydropower, thermal power plants generate over one third of the country's electricity. In 2020, EFL generated around 976 MWh (57% hydropower, 36% thermal accounted from 57.2%. IPPs accounted for 6.9% of the total generation.[63] EFL has over 205,000 customers, including many added under rural electrification programs funded by the government.

Market Size: The main grid on Viti Levu Island accounts for over 90% of both peak demand and available generation capacity in Fiji. The larger hydro plants, the 9.9 MW Butoni Wind Farm, and three of the four operational IPP plants are all on Viti Levu. The IPPs are all biomass plants that export surplus generation to the grid – Fiji Sugar Corporation, Tropik Wood Industries, and Nabou Green Energy (a joint-venture between Tropik Wood Industries and Korean investors).

Additional IPP projects are also underway. Sunergise is developing a 5 MW Qeleloa solar plant as an IPP, after initially pursuing the project as a joint-venture with EFL.[64] EFL has also signed a partnership agreement with the International Finance Corporation to add at least 15 MW solar PV capacity on the grid through private sector partners.[65] EFL has also signed PPAs with Hydro VL for three hydro projects totaling 32 MW on Viti Levu Island, proposed as an unsolicited bid by the IPP.

Table 45: Fiji – Demand and Supply (kW)

Utility	Grid	Peak Demand	Installed Thermal	Available Thermal	Installed Renewable	Available Renewable	Total Available Capacity
EFL	Viti Levu	180,220	144,560	118,200	146,500	123,930	242,130
EFL	Vanua Levu – Labasa	8,100	16,300	12,200	-	-	12,200
EFL	Vanua Levu – Savusavu	2,490	6,200	4,000	800	800	4,800
EFL	Ovalau	1,800	3,050	2,480	-	-	2,480
EFL	Taveuni	460	2,000	1,600	700	700	2,300
Total		193,070	172,110	138,480	148,000	125,430	263,910

Source: EFL. Presentation at Pacific Power Association Virtual Conference, August 2021.

Energy Policy and Electricity Regulations: The "National Energy Policy 2013-2020" provides policy goals for the electricity sector including (i) increasing private sector in renewable energy sector; (ii) establishing IPP framework; and (iii) establishing cost-effective tariff mechanism for retail electricity prices. The policy had not been approved by the Cabinet as of 2021 but many of the strategies are already being implemented.[66]

In 2017, Fiji's Parliament approved a new Electricity Act, introducing changes to the electricity sector including (i) divesture of EFL to private investors, (ii) devolution of regulatory functions from EFL to an independent regulator, and (iii) transition to a "Single Buyer" model with competitively procured IPPs, with EFL retaining its monopoly on its grid and retail service.[67]

[63] Energy Fiji Limited. "Annual Report 2020". link

[64] International Finance Corporation. "Powering the Pacific." November 2021. Pg. 66.

[65] International Finance Corporation. "EFL and IFC sign agreement for Pacific's largest solar project". Press Release.

[66] Government of Fiji. "Fiji National Energy Policy 2013-2020 (Final Draft), 2013". link

[67] Government of Fiji. "Electricity Act 2017", 2017. link

The FCCC, responsible for retail electricity tariff setting, issued its tariff methodology in September 2019.[68] The tariff methodology is expected to help EFL's financial viability and support the IPP sector by lowering counterparty credit risk. The key provisions of the tariff methodology include calculating revenue requirement based on the building blocks methodology, reviewing tariffs every four years, annual tariff adjustments for fuel and IPP costs. The tariff methodology suggests a tariff structure with three types of charges (i) service charge (FJD/ month), (ii) demand charge (FJD/ kVA), and (iii) energy charge (FJD/ kWh).[69]

Fiji's NDC aim to achieve 100% renewable electricity generation (grid-connected) by 2030.[70]

Private Sector Participation and Investments: There are two potential issues in the current regulatory framework that limit private sector participation in Fiji's power sector. Section 16 of the new Electricity Act grants EFL the right of first refusal to match the price of self-supply or eliminate self-supply for an entity with its own generation, which creates significant risks for private investors. The Grid Code requires generation facilities greater than 250 kW to have ramping capability, which renewable resources like solar PV, wind, and run-of-river hydro do not have. Thus, this requirement creates a barrier for IPPs but may facilitate the addition of BESS technologies to planned VRE projects.

IPP in Fiji: 5 MW Qeleloa Solar Farm: The 5 MW Qeleloa Solar Farm IPP on Viti Levu Island, being developed by Viti Renewables Pte Ltd. (joint venture between EFL's subsidiary Fiji Renewables Ltd. and Sunergise Fiji Pte Ltd.), has signed a PPA with EFL. The project was scheduled to be constructed and commissioned by Q2-2022, but delays are expected due to the Covid-19 pandemic.

Sources: EFL & Viti Renewables Pvt. Ltd.

3.5.2 TECHNICAL ASSESSMENT

Viti Levu: EFL's grid on Viti Levu Island operates at 50 Hz, with the highest voltage lines operating at 132 kV. A summary of the EFL's grid on Viti Levu Island is presented in Table 46. The Viti Levu grid includes biomass generators, and storage hydropower plants, which are more dispatchable than run-of-river hydropower plants. The presence of these technologies on the grid could reduce the BESS requirements to meet the aggressive RE targets.

Table 46: EFL's Viti Levu Grid Summary

Parameter	Unit	Value
Peak Demand	MW	180.2
Conventional Generating Capacity	MW	316.0
Energy Demand	MWh	627,180
Renewable Energy Penetration	%	64.2

Source: HNEI

The BESS requirement for the EFL's Viti Levu grid is summarized in Table 47 and Table 48.

[68] Fijian Competition & Consumer Commission. "Electricity Tariff Methodology", 2019. link

[69] Fijian Competition and Consumer Commission. "Electricity Tariff Methodology", 2019. link

[70] Government of Fiji. "Fiji's Updated Nationally Determined Contribution", 2020. link

Table 47: Viti Levu Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	97.5	97.5 / 97.5	0.5	250.0	250.0 / 250.0	20.7	NA	NA	NA
2 Hours	97.0	97.0 / 194.0	0.1	213.0	213.0 / 416.0	6.4	NA	NA	NA
3 Hours	97.0	97.0 / 291.0	0.0	206.0	206.0 / 618.0	3.5	NA	NA	NA
4 Hours	NA	NA	NA	203.0	203.0 / 812.0	2.4	389.0	389.0 / 1,556.0	18.1
5 Hours	NA	NA	NA	202.0	202.0 / 1,010.0	1.8	376.0	376.0 / 1,880.0	15.2
6 Hours	NA	NA	NA	201.0	201.0 / 1,206.0	1.4	367.0	367.0 / 2,202.0	13.2
7 Hours	NA	NA	NA	NA	NA	NA	361.0	361.0 / 2,527.0	11.7
8 Hours	NA	NA	NA	NA	NA	NA	356.0	356.0 / 2,848.0	10.5
9 Hours	NA	NA	NA	NA	NA	NA	351.0	351.0 / 3,159.0	9.3

Source: HNEI

Table 48: Viti Levu Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	42.0 / 42.0	84.0 / 84.0	2.8	92.0 / 92.0	184.0 / 184.0	10.5	NA	NA	NA
2 Hours	41.0 / 41.0	82.0 / 164.0	0.7	90.0 / 90.0	180.0 / 360.0	8.1	NA	N.A.	NA
3 Hours	40.5 / 40.5	81.0 / 243.0	0.1	88.0 / 88.0	176.0 / 528.0	6.4	NA	N.A.	NA
4 Hours	40.5 / 40.5	81.0 / 324.0	0.0	87.0 / 87.0	174.0 / 696.0	5.5	178.0 / 178.0	356.0 / 1,424.0	25.7
5 Hours	NA	NA	NA	87.0 / 87.0	174.0 / 870.0	4.9	173.0 / 173.0	346.0 / 1,730.0	23.5
6 Hours	NA	NA	NA	86.0 / 86.0	172.0 / 1,032.0	4.2	169.0 / 169.0	338.0 / 2,028.0	21.8
7 Hours	NA	NA	NA	NA	NA	NA	166.0 / 166.0	332.0 / 2,324.0	20.5
8 Hours	NA	NA	NA	NA	NA	NA	164.0 / 164.0	328.0 / 2,624.0	19.4
9 Hours	NA	NA	NA	NA	NA	NA	162.0 / 162.0	324.0 / 2,916.0	18.4

Source: HNEI

3.5.3 RECOMMENDATION

Table 49: PPP Structures Recommendations for Fiji

System	PPP Structure	Rationale	Policy Recommendations
Viti Levu	VRE+BESS IPP C&I Customer Sited BESS BESS Lease/Rental Standalone BESS IPP	There are plans to add VRE IPPs – including a 15 MW solar PV project in partnership with IFC. Adding BESS to these projects would help these projects comply with grid code requirements. Current IPPs have on-site biomass plants that deliver surplus power to the grid. BESS projects can fit similar models, providing more flexibility to both EFL and the IPPs. Fuel costs of thermal plants is a big issue, which BESS rentals can help reduce in the short-term. By charging from off-peak hydro generation and discharging during peak demand, standaone BESS could further improve the flexibility of the power system. BESS can also provide transmission level grid support services in parts of the island where the grid density is low. If the BESS rental provides value, Viti Levu is large enough for standalone	Assess and modify the IPP framework, as necessary, to ensure that VRE+BESS or Standalone BESS IPPs can deliver the products/benefits sought. BESS as non-wires solutions should be part of the technology-agnostic options considered for grid services. Identify locations on the grid where BESS projects can benefit the grid and solicit BESS rentals.

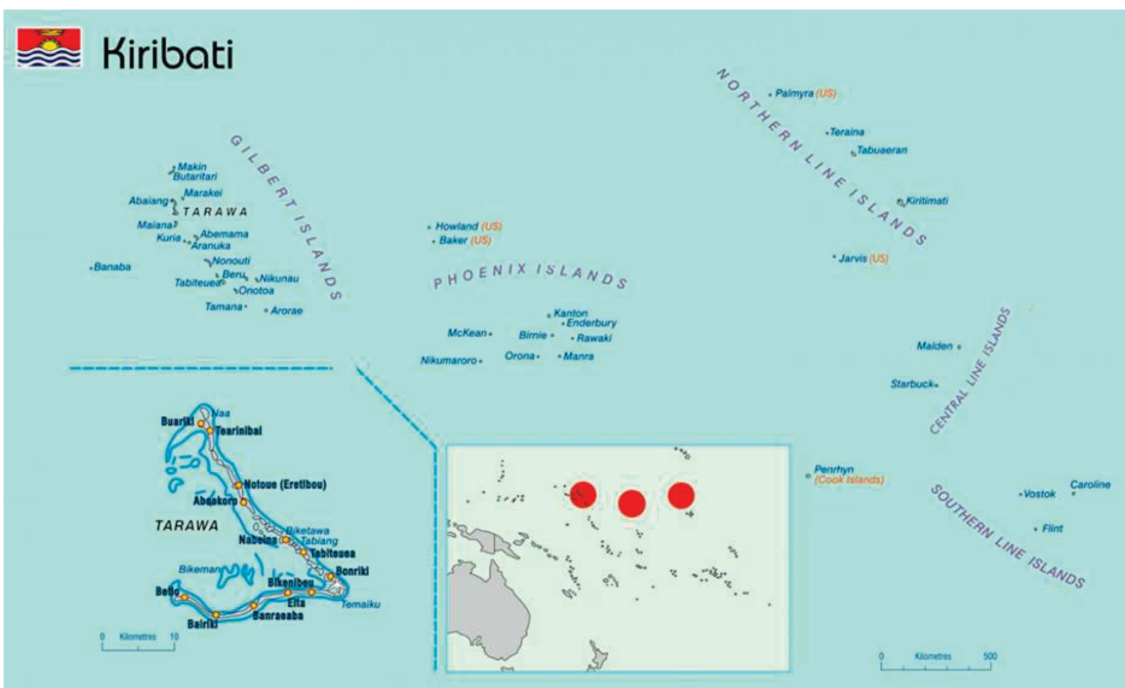
		BESS IPPs, which would deliver BESS rental benefits at lower costs.	
Vanua Levu – Lavasa	VRE+BESS IPP C&I Customer Sited BESS BESS Lease/Rental	Add BESS component to solar project being developed with IFC support. Add BESS to existing IPPs with on-site biomass plants. Reducing reliance on thermal plants as more renewable capacity is added.	Offer additional incentives (e.g., improved PPA) for adding BESS to planned VRE projects or on-site biomass IPPs.
Vanua Levu – Savusavu	BESS Lease/Rental	Reducing reliance on thermal plants particularly during dry season. Add flexibility to existing run-of-river hydro with BESS.	
Other	BESS Lease/Rental	Reducing reliance on thermal plants for grid support.	

Source: Delphos

3.6 KIRIBATI

Kiribati is a nation with a population of about 121,000 in the central Pacific Ocean comprising 33 coral atolls and islands (21 inhabited) spanning an area of 3,550 thousand square km of ocean (stretching 2,900 km east to west) with a land area of about 811 square km. There are three island groups: Gilbert, Phoenix, and Line Islands. 90% of the population resides on the Gilbert Islands, of which approximately half live on the capital island of South Tarawa. The majority of the remaining population lives on the Kiritimati Islands, which are part of the Line Islands (Figure 14). Kiribati has a population density of 149 per square km and a per capita GDP of 1,636 (lowest amongst PIC's covered in this report).

Figure 14: Map of Kiribati



Source: Pacific Community

Kiribati's primary commercial income comes from fishing and coconut products. Much national income is sourced from abroad, including from sale of fishing licenses, development assistance, remittances and tourism. The country is among the most vulnerable to climate change.[71]

3.6.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Energy Planning Unit under the Ministry of Infrastructure and Sustainable Energy is responsible for coordinating and implementing energy policies. The government-owned Public Utility Board (PUB) is responsible for generating and supplying electricity to grid-connected customers in South Tarawa. The Kiribati Solar Energy Company, an SOE, provides electricity to outer islands through SHS and solar maneaba (community meeting halls) systems.[72,73]

Energy Policy and Regulations: The "Kiribati Integrated Energy Roadmap (2017-2025)" presents institutional, policy, regulatory, technical, financial, and capacity building actions that will enable the Government of Kiribati to achieve its energy objectives including, as summarized below:[74]

- Tarawa: 45% reduction in fossil fuel use by 2025. 23% of this goal is to be achieved through deployment of renewable energy and 22% through improvements in energy efficiency.
- Kiritimati: 60% reduction in fossil fuels by 2025. 40% is to be achieved through deployment of renewable energy and 20% through improvements in energy efficiency.
- Outer Islands: 60% reduction in fossil fuel use in all rural public infrastructure, including Southern Kiribati Hospital and ice plants, (40% through deployment of renewable energy and 20% through improvements in energy efficiency) by 2025.
- Rural public and private institutions (e.g., boarding schools, private amenities, and households) to meet of 100% electricity demand with renewable energy by 2025.

The Roadmap suggests that the addition of new renewable energy capacity should take into account properly sized BESS projects placed in various locations on the network. The use cases identified for BESS include supporting system stability, improving the fuel efficiency of diesel generators, frequency support, and allowing for the turn off diesel generators for periods on sunny days.

Table 50: Kiribati – Development Partners Activities

Development Partner	Project	Key Activities Financed
Asian Development Bank	Preparing Clean and Renewable Energy Investments in the Pacific	Due diligence support to prepare three floating solar projects for approval in 2022–2023 under the PREIF (see callout below). The proposed Kiribati South Tarawa Renewable Energy Project (Phase 2) would install 5 MW of floating and ground-mounted solar photovoltaic, a BESS and other grid infrastructure.

Source: Compiled by Delphos

Kiribati is receiving technical and financial assistance from the Government of Korea on ocean thermal energy conversion (OTEC). Kiribati is planning to deploy a 1 MW OTEC plant off the coast of South

[71] World Bank. "Implementation completion and results report for Kiribati Grid Connected Solar Photovoltaic Project (P121878)", 2019.

[72] Commonwealth Governance. "Utilities in Kiribati". link

[73] International Solar Alliance. "Country Profile: Republic of Kiribati". link

[74] IRENA. "Kiribati Integrated Energy Roadmap: 2017-2025", 2017. link

Tarawa in cooperation with the Korea Research Institute of Ships and Ocean Engineering. Activities of other development partners in Kiribati is summarized in Table 50.

Pacific Renewable Energy Investment Facility (PREIF): The PREIF is a USD 750 million investment facility (USD 200 million financing from ADB, USD 500 million from co-financing sources and USD 50 million from PIC governments) designed to finance a series of renewable energy projects in the PICs. The PREIF is designed to help PICs rapidly move away from their fossil fuel dependent energy pathway towards a low-carbon and climate-resilient pathway with the additional aim of increasing electricity access.

The PREIF, by grouping smaller projects into a single facility, aims to reduce preparatory activities for individual project approval, thus improving the efficiency of donor support to deploy a larger volume of small-scale projects. As of September 2020, USD 141 million of investment had been approved for 8 projects and 19 projects were in pipeline for approval.

3.6.2 TECHNICAL ASSESSMENT

Tarawa: The Table below summarizes PUB's 11 kV (50 Hz) grid on Tarawa.

Table 51: PUB's Tarawa Grid Summary

Parameter	Unit	Value
Peak Demand	MW	5.6
Conventional Generating Capacity	MW	18.0
Energy Demand	MWh	32,993
Renewable Energy Penetration	%	6.8

Source: HNEI

The BESS requirement for PUB's grid in Tarawa is summarized in Table 52 and Table 53.

Table 52: Tarawa Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	3.7	3.7 / 3.7	2.2	10.1	10.1 / 10.1	27.2	NA	NA	NA
2 Hours	3.6	3.6 / 7.2	0.2	7.9	7.9 / 15.8	7.2	17.1	17.1 / 34.2	30.8
3 Hours	3.6	3.6 / 10.8	0.0	7.6	7.6 / 22.8	3.0	13.3	13.3 / 39.9	10.9
4 Hours	NA	NA	NA	7.4	7.4 / 29.6	0.7	12.2	12.2 / 48.8	3.0
5 Hours	NA	NA	NA	7.3	7.3 / 36.5	0.0	12.0	12.0 / 60.0	1.1

Source: HNEI

Table 53: Tarawa Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	1.9 / 1.9	3.8 / 3.8	0.3	3.9 / 3.9	7.8 / 7.8	3.5	7.3 / 7.3	14.6 / 14.6	17.4
2 Hours	1.8 / 1.8	3.6 / 7.2	0.0	3.8 / 3.8	7.6 / 15.2	1.4	6.7 / 6.7	13.4 / 26.8	10.0
3 Hours	NA	NA	NA	3.8 / 3.8	7.6 / 22.8	0.7	6.5 / 6.5	13.0 / 39.0	7.5
4 Hours	NA	NA	NA	3.8 / 3.8	7.6 / 30.4	0.4	6.4 / 6.4	12.8 / 51.2	6.1
5 Hours	NA	NA	NA	3.7 / 3.7	7.4 / 37.0	0.2	6.4 / 6.4	12.8 / 64.0	5.4

Source: HNEI

3.6.3 RECOMMENDATION

Table 54: PPP Structures Recommendations for Kiribati

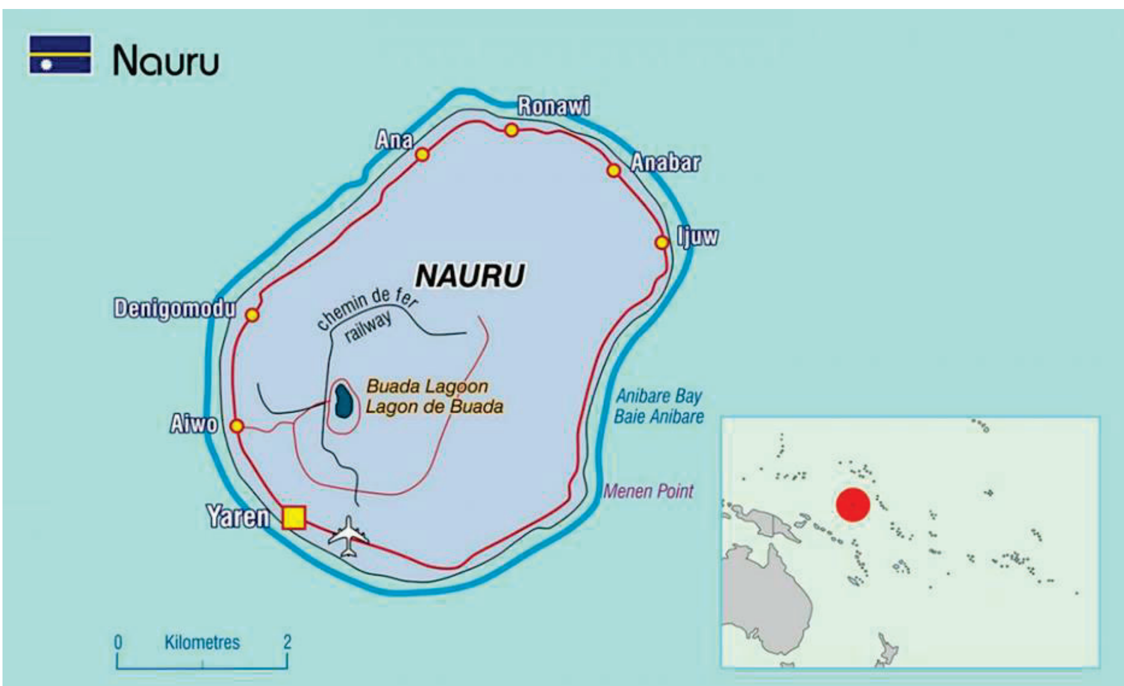
System	PPP Structure	Rationale	Policy Recommendations
Tarawa	BESS Lease/Rental	ADB's South Tarawa Renewable Energy Project is supporting the development of solar PV and BESS projects through grant financing. Due to poor creditworthiness of PUB and small size of the system, similar projects under the VRE+IPP model is not recommended. However, PUB can continue to add BESS capacity under a lease/rental model after initial capacity building under the ADB project.	Add additional solar PV capacity with the support of development partners and move to BESS lease/rental model to complement solar PV generation with BESS.

Source: Delphos

3.7 NAURU

Nauru, one of the smallest countries in the world, is an isolated, coral capped island with 21 square km of land area, located in the central Pacific Ocean. The country has population of about 12,000. Yaren, the capital city, is the largest town. Nauru has a population density of around 592 persons per square km and a per capita GDP of USD 11,666.

Figure 15: Map of Nauru



Source: Pacific Community

Nauru's economy used to be based on phosphate mining. With primary phosphate reserves exhausted by the end of the 2010s, Nauru has diversified its sources of income to sale of fishing rights, and revenue from the Regional Processing Centre (off-shore Australian immigration detention facility). The country is highly dependent on foreign aid from Australia and New Zealand.

3.7.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Ministry of Finance provides the national budget for energy; procures and sets prices for fuel; and oversees the implementation of the National Sustainable Development Strategy (2005–2025). The Planning and Aid Division of the Ministry of Finance manages the finance flows from development partners, which are crucial for capital investment in the energy sector. The Department of Commerce, Industry and Energy carries out policy and planning functions. Nauru Utilities Corporation (NUC), an SOE, owns and operates the power generation and distribution systems.[75] Nauru is 100% electrified.

Energy Policy and Regulations: The "National Sustainable Development Strategy 2005–2025" outlines Nauru's vision for reliable, affordable, secure, and sustainable energy to meet the socio-economic development and sets the goal of meeting 50% of Nauru's energy needs through renewable energy by 2020. The strategy was reviewed in 2018, and an updated version is currently undergoing government approval.[76,77]

The "National Energy Policy Framework of 2009" identified renewables as one of the seven strategic areas to achieve socio-economic development through reliable, affordable, and sustainable energy.[78]

The "Nauru Energy Road Map (2014–2020)" builds on the development agendas outlined in the National Sustainable Development Strategy (2005-2025 and the National Energy Framework of 2009. It aims to provide reliable electricity, with 50% coming from renewable energy sources.[79]

Nauru's NDC aim to achieve 50% renewable energy penetration.[80]

Development partner engagement in Nauru is summarized in Table 55.

Table 55: Nauru – Development Partners Activities

Development Partner	Project	Key Activities Financed
Asian Development Bank	Preparing Clean and Renewable Energy Investments in the Pacific	Finance for (i) 6 MW solar project with a 2.5 MW / 5 MWh BESS, (ii) 2 MW solar project with a 1 MWh BESS, and (iii) 3 MW solar project with 6 MWh BESS..

Source: Delphos

3.7.2 TECHNICAL ASSESSMENT

The NUC grid operates at 50 Hz, with a 11 kV distribution network. A summary of NUC's grid is presented in Table 56.

[75] Asian Development Bank. "Sector Assessment (Summary): Energy". link

[76] Government of Nauru. "National Sustainable Development Strategy 2005-2025". link

[77] Asian Development Bank. "Sector Assessment (Summary): Energy". link

[78] Government of Nauru. "Energy Policy Framework", 2009. link

[79] Asian Development Bank. "Sector Assessment (Summary): Energy". link

[80] Government of Nauru. "Updated Nationally Determined Contribution", 2021. link

Table 56: NUC's Grid Summary

Parameter	Unit	Value
Peak demand	MW	5.75
Conventional generating capacity	MW	17.9
Energy demand	MWh	39,151
Renewable energy penetration	%	7.7

Source: HNEI

The BESS requirement for the NUC grid in Nauru is summarized in Table 57 and Table 58.

Table 57: Nauru Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	4.2	4.2 / 4.2	0.6	12.0	11.5 / 11.5	28.2	NA	NA	NA
2 Hours	4.1	4.1 / 8.2	0.0	9.3	9.3 / 18.6	7.4	20.3	20.3 / 40.6	31.0
3 Hours	NA	NA	NA	8.9	8.9 / 26.7	2.2	15.8	15.8 / 47.4	11.5
4 Hours	NA	NA	NA	8.7	8.7 / 34.8	0.3	14.4	14.5 / 58.0	2.9
5 Hours	NA	NA	NA	8.7	8.7 / 43.5	0.0	14.1	14.1 / 71.5	0.6

Source: HNEI

Table 58: Nauru Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	2.3 / 2.3	4.6 / 4.6	0.1	5.0 / 5.0	10.0 / 10.0	3.8	9.7 / 9.7	19.4 / 19.4	19.2
2 Hours	2.3 / 2.3	4.6 / 9.2	0.0	4.9 / 4.9	9.8 / 19.6	1.6	8.7 / 8.7	17.4 / 34.8	10.0
3 Hours	2.2 / 2.2	4.4 / 13.2	0.0	4.9 / 4.9	9.8 / 29.4	1.0	8.5 / 8.5	17.0 / 51.0	7.5
4 Hours	NA	NA	NA	4.9 / 4.9	9.8 / 39.2	0.6	8.4 / 8.4	16.8 / 67.2	6.3
5 Hours	NA	NA	NA	4.9 / 4.9	9.8 / 49.0	0.5	8.3 / 8.3	16.6 / 83.0	5.5

Source: HNEI

3.7.3 RECOMMENDATION

Table 59: PPP Structures Recommendations for Nauru

System	PPP Structure	Rationale	Policy Recommendations
Nauru	BESS Lease/Rental	Currently, 6 MW solar PV with 2.5 MW / 5 MWh BESS is being developed with $22 million in grants from ADB and the government. Add additional BESS capacity under lease/rental model going forward.	Add additional solar PV capacity with the support of development partners and move to BESS lease/rental model to complement solar PV generation with BESS.

Source: Delphos

3.8 PALAU

Palau comprises 340 islands (nine of which are inhabited) spread across 629 thousand square km of sea area. Palau has a land area of 444 square km and a population of about 18,000. 80% of population lives in Koror and Airai States. The capital of Palau is Ngerulmud, located on Babeldoab - the largest island. Palau has a population density of 39 per square km and a per capita GDP of USD 15,673 (highest amongst PICs covered in this report).

Figure 16: Map of Palau

Source: Pacific Community

Palau's economy consists primarily of tourism, subsistence agriculture and fishing. Government is the largest employer, and the economy is reliant on financial assistance from the USA.

3.8.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Palau Energy Administration (PEA) under the Ministry of Public Infrastructure, Industries and Commerce, is the central coordinating agency for the energy sector. PEA's main duties include developing and updating the National Energy Policy, setting energy efficiency programs and benchmarks, developing guidelines to review electricity tariffs, promulgating regulations related to the Energy Act and reporting on energy–related climate change information.[81]

The Palau Public Utilities Corporation (PPUC), an SOE, is responsible for managing and operating electrical power, water, and wastewater systems in Palau.

Energy Policy and Regulations: The "National Energy Policy of 2010" provides a unified and integrated energy sector management framework. The policy set a target of achieving a minimum of 20% of electricity generation through renewable energy by 2020.[82]

In 2016, Palau became the second PIC in over two decades to sign a National Energy Act into law. The law established the PEA as the primary entity within the government on all energy-related matters.[83]

[81] European Union. "Action Document for Support to Energy Efficiency in Palau", 2018. link

[82] Government of Palau. "Republic of Palau National Energy Policy", 2010. link

[83] Pacific Regional Data Repository for Sustainable Energy for All. "Pacific Islands Report", 2016. link

The "Net-Metering Act of 2012" permits PPUC customers to install renewable energy systems for self-consumption and supplying the excess electricity to the PPUC grid. The Act allows PPUC consumers to install solar and wind plants with following restrictions:[84]

- up to 5 kW systems for residential customers; and
- up to maximum demand at site for commercial and industrial consumers.[85]

Palau's NDC target 22% energy sector emissions reduction below 2005 level by 2025 and aims to achieve 45% renewable energy penetration by 2025.[86]

The Palau Energy Act of 2016 provides the basis for a standardized system for the licensing of IPP renewable energy projects.[87] PEA's "Regulations for the Development of Renewable Energy Facility by IPPs (2019)" provides a licensing framework for IPPs to set up generating stations and sell electricity to PPUC under a PPA.

Development partner engagement in Palau is summarized in Table 60.

Table 60: Palau - Development Partners Activities

Development Partner	Project	Key Activities Financed
Asian Development Bank	Palau Renewable Energy Project (proposed) Palau Solar Independent Power Producer Project (proposed) Palau Public Utilities Corporation Reform	Technical assistance to prepare a least-cost generation expansion plan and identifying generation projects for investments.
The Government of Australia	Australian Infrastructure Financing Facility (AIFF) for the Pacific	USD 18 million loan and USD 4 million grant to Solar Pacific Pristine Power Inc for a 15MWp solar PV plant with 10MW / 12.9MWh BESS.

Source: Delphos

Private Sector Participation and Investments: The Government of Palau has prioritized private sector involvement in the renewable energy generation sector. The Energy Act was amended in 2016 and regulation for licensing of IPPs was issued in 2019, but PPUC's poor credit and related challenges may deter IPPs and other sectoral PPPs, as illustrated by the two recently proposed investments discussed below.

Under a negotiated arrangement, Engie Electric Power Systems signed a PPA with PPUC to invest up to USD 80 million to build and operate a 35 MW solar plant with 45 MWh BESS (with options to expand the system) and sell electricity to PPUC at USD 0.2/kWh for 30-years. The deal involved a sovereign guarantee backing PPUC's contractual obligations. In 2018, the PPA was cancelled by Palau's Senate Committee, which did not accept the guarantee and sought a lower tariff due to falling solar prices.[88]

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[84] Pacific Islands Legal Information Institute. "Palau Net Metering Act of 2009", 2011. link

[85] Note: Consumers can install larger systems with approval from PPUC.

[86] Government of Palau. "Intended Nationally Determined Contribution", 2015. link

[87] Office of the President of Republic of Palau. "Executive Order No. 403", 2017. link

[88] Island Times. "Senator's junk resolution endorsing PPA implementation", 2018. link; and a Facebook post, 2018. link.

in 2021, Solar Pacific Energy Corporation (SPEC), won an IPP bid to build and operate a 20 MW solar plant and sell power to PPUC for a 25-year period. The PPA for the project was approved by both PPUC and PEA in 2021. SPEC required a Government Support Agreement (GSA) to sign the PPA. The GSA, claimed by some to amount to a "light" sovereign guarantee, includes an escrow account of USD 3 million that the Government would help PPUC to establish. However, in May 2022, the Senate voted against approval of a key part of the arrangement - waiver of sovereign immunity - without which, it is expected the project will not close on financing.[89] [90]

3.8.2 TECHNICAL ASSESSMENT

The PPUC's Koror-Babeldaob grid operates at 60 Hz and comprises a 13.8 kV distribution network. A summary of the PPUC's Koro-Babeldaob grid is presented in Table 61.

Table 61: PPUC's Koro-Babeldaob Grid Summary

Parameter	Unit	Value
Peak demand	MW	11.5
Conventional generating capacity	MW	13.9
Energy demand	MWh	82,239
Renewable energy penetration	%	2.0

Source: HNEI

The BESS requirement for PPUC's grid on Koror-Babeldaob is summarized in Table 62 and Table 63.

Table 62: Koror-Babeldaob Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	13.3	13.3 / 13.3	0.0	34.2	34.2 / 34.2	26.5	NA	NA	NA
2 Hours	NA	NA	NA	27.1	27.1 / 54.2	7.3	51.9	51.9 / 103.8	24.3
3 Hours	NA	NA	NA	25.5	25.5 / 76.5	1.2	43.2	43.2 / 129.6	8.9
4 Hours	NA	NA	NA	25.2	25.2 / 100.8	0.0	40.2	40.2 / 160.8	2.2
5 Hours	NA	NA	NA	NA	NA	NA	39.6	39.6 / 198.0	0.8

Source: HNEI

Table 63: Koror-Babeldaob Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	6.0 / 6.0	12.0 / 12.0	0.0	11.5 / 11.5	23.0 / 23.0	2.1	21.7 / 21.7	43.4 / 43.4	18.8
2 Hours	NA	NA	NA	11.4 / 11.4	22.8 / 45.6	0.7	20.1 / 20.1	40.2 / 80.4	12.5
3 Hours	NA	NA	NA	11.3 / 11.3	22.6 / 67.8	0.2	19.7 / 19.7	39.4 / 118.2	10.6
4 Hours	NA	NA	NA	11.3 / 11.3	22.6 / 90.4	0.0	19.4 / 19.4	38.8 / 155.2	9.3
5 Hours	NA	NA	NA	NA	NA	NA	19.2 / 19.2	38.4 / 192.0	8.3

Source: HNEI

3.8.3 RECOMMENDATION

Table 64: PPP Structures Recommendations for Palau

System	PPP Structure	Rationale	Policy Recommendations
Babeldaob	VRE+BESS IPP	Develop projects similar to the planned projects with ADB and AIFF support,	Allow IPPs to propose unsolicited projects if they have

[89] Island Times. "Senate rejects resolution giving gov't support to IPP", 2022. link

[90] Island Times. "OEK's support for solar power purchase agreement sought", 2022. link

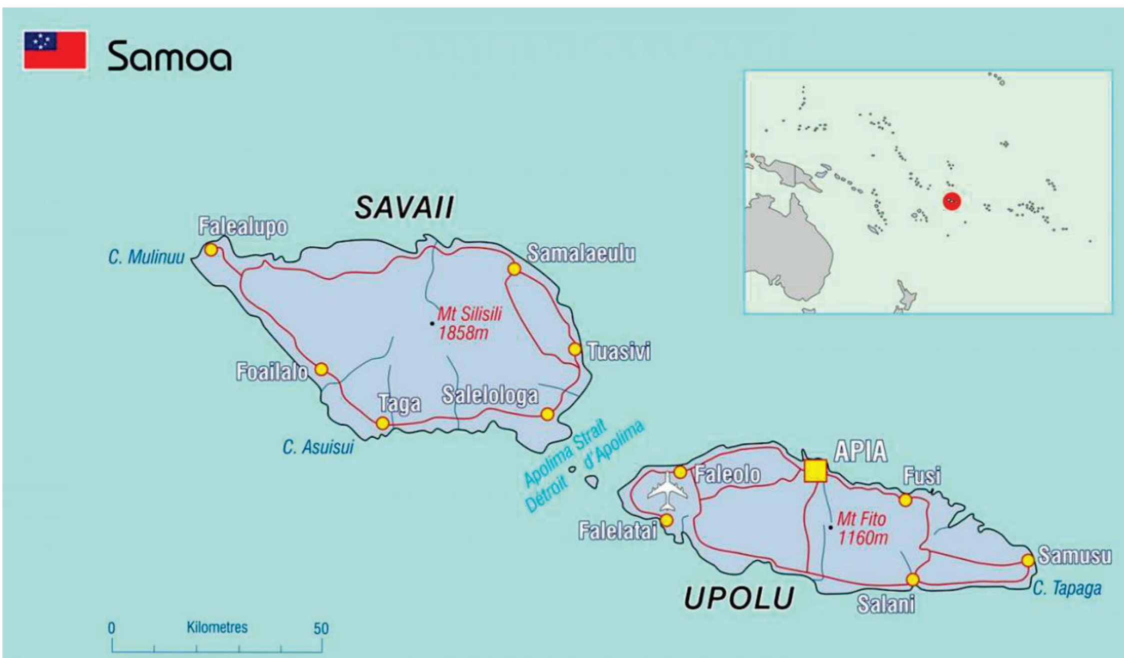
		once government guarantee issue is addressed	demonstrated access to funds on balance sheet or through facilities like AIFF.
	Standalone BESS IPP	Leverage existing IPP framework and interest in IPP projects (including with BESS) from international developers and investors, once government guarantee issue is addressed.	Address challenge of poor credit: the "light" guarantee proposed by the SPEC project, if accepted by Parliament, may be generally bankable.

Source: Delphos

3.9 SAMOA

Samoa is made up of nine volcanic islands, four of which are inhabited. The country has a land area of about 2,935 square km that spreads across 120,000 thousand square km of sea area. Samoa has a population of around 200,000, 77% of which lives on Upolu Island and 22% on the Savai'I Island. Manono and Apolima are other major population centers in outer islands. Samoa has a population density if 71 persons per square km and a per capita GDP of USD 4,384.

Figure 17: Map of Samoa



Source: Pacific Community

Samoa's economy is largely dependent on agricultural exports and development aid. Agriculture employs two-thirds of the labor force and accounts for around 10% of exports, mostly coconut and fish.

3.9.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Ministry of Finance, through its Energy Division, is responsible for the energy sector strategy.

The Electric Power Corporation (EPC), an SOE, is the national electric utility. Electricity generated by IPPs is sold to EPC. EPC operates eight hydro plants (one in Savaii and seven in Upolu), solar farms at

Apolima Island, Tuanaimato, Vaitele, Tanugamanono and Salelologa Savaii, a wind farm at Vailoa Aleipata, and diesel power plants at Fiaga Upolu and Salelologa Savaii.[91]

The independent Office of the Regulator sets power tariffs, and issues licenses to power producers and suppliers other than EPC.[92]

Energy Policy and Regulations: The "Electricity Act of 2010" began restructuring of the electricity sector, particularly in the area of electricity generation, where IPPs are now allowed to generate electricity through renewable energy sources.

The "Energy Sector Plan (2017-2022)" provides a comprehensive strategy for the energy sector.[93] Samoa's NDC aim to reduce 30% GHG emissions from the energy sector by 2030 compared to 2007 levels. The NDC also aim to achieve 100% renewable electricity generation by 2025.[94]

Development partner engagement in Samoa is summarized in Table 65.

Table 65: Samoa - Development Partners Activities

Development Partner	Project	Key Activities Financed
Asian Development Bank	Pacific Renewable Energy Investment Facility	Finance smart grid project with a 1 MWh BESS.

Source: Delphos

Private Sector Participation and Investments: Most IPPs in Samoa have been able to access local financial institutions in financing large-scale renewable IPP projects.[95] Samoa's renewable IPPs are shown in Table 66.

Table 66: IPPs in Samoa (as of March 2018)

Location	Owner	Capacity
Faleolo Airport, Upolu	Sun Pacific Energy	2.07 MW solar
Faleolo Airport, Upolu	Sun Pacific Energy	1.50 MW solar
Faleolo Airport, Upolu	Green Power Samoa	3.50 MW solar
Faleolo Airport, Upolu	Solar for Samoa	2.81 MW solar
Race Course, Upolu	Green Power Samoa	2.55 MW solar
Race Course, Upolu	Solar for Samoa	1.50 MW solar
Afiamalu, Upolu	Shanghai E Power	10 MW wind + 10 MW pumped storage hydro (planned)
Location TBD, Savai'i	IPP	4.00 (planned)

Source: Pacific Power Association (link)

[91] Electric Power Corporation. "History of EPC". link

[92] Asian Development Bank. "Sector Overview". link

[93] Energy Policy Coordination and Management Division, Ministry of Finance, Government of Samoa. "Samoa Energy Sector Plan 2017-2022", 2017. link

[94] Government of Samoa. "Samoa's Second Nationally Determined Contribution", 2021. link

[95] United Nations Development Programme. "Improving the Performance and Reliability of RE Power System in Samoa (IMPRESS)", 2017. link

3.9.2 TECHNICAL ASSESSMENT

Upolu Island, home to 77% of Samoa's population, is served by EPC's grid operating at 50 Hz and comprises a 33 kV distribution network. The grid has two BESSs that are used for regulation and reserves for VRE: (i) a 2,000 kW/ 3,500 kWh BESS; and (ii) a 6,000 kW/ 10,200 kWh BESS. The grid has run-of-river hydropower stations that provide grid support, that could reduce the amount of BESS required to meet higher RE penetration.[96] A summary of EPC's Upolu grid is presented in Table 67.

Table 67: EPC's Upolu Grid Summary

Parameter	Unit	Value
Peak Demand	MW	30.0
Conventional Generating Capacity	MW	45.0
Energy Demand	MWh	192,410
Renewable Energy Penetration	%	44.4

Source: HNEI

The BESS requirement for the EPC grid on the Upolu Island is summarized in Table 68 and Table 69.

Table 68: Upolu Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	31.5	31.5 / 31.5	36.5	NA	NA	NA	NA	NA	NA
2 Hours	24.0	24.0 / 48.0	17.3	80.0	80.0 / 160.0	39.6	NA	NA	NA
3 Hours	22.0	22.0 / 66.0	8.7	61.0	61.0 / 183.0	21.1	NA	NA	NA
4 Hours	21.0	21.0 / 84.0	4.0	54.0	54.0 / 216.0	10.6	91.0	91.0 / 364.0	20.8
5 Hours	20.5	20.5 / 102.5	1.7	51.0	51.0 / 255.0	5.8	87.0	87.0 / 435.0	17.1
6 Hours	20.0	20.0 / 120.0	0.6	50.0	50.0 / 300.0	4.0	84.0	84.0 / 504.0	14.3
7 Hours	NA	NA	NA	NA	NA	NA	82.0	82.0 / 574.0	12.3
8 Hours	NA	NA	NA	NA	NA	NA	81.0	81.0 / 648.0	10.9
9 Hours	NA	NA	NA	NA	NA	NA	79.5	79.5 / 715.5	9.4

Source: HNEI

Table 69: Upolu Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	9.0 / 9.0	18.0 / 18.0	7.0	25.5 / 25.5	50.0 / 50.0	23.3	NA	NA	NA
2 Hours	8.5 / 8.5	17.0 / 34.0	2.7	22.0 / 22.0	44.0 / 88.0	11.8	NA	NA	NA
3 Hours	8.5 / 8.5	17.0 / 51.0	0.9	21.0 / 21.0	42.0 / 126.0	7.2	NA	NA	NA
4 Hours	8.1 / 8.1	16.2 / 64.8	0.2	20.5 / 20.5	41.0 / 164.0	5.0	36.0 / 36.0	72.0 / 288.0	21.6
5 Hours	NA	NA	NA	20.5 / 20.5	41.0 / 205.0	4.0	35.0 / 35.0	70.0 / 350.0	19.3
6 Hours	NA	NA	NA	20.0 / 20.0	40.0 / 240.0	2.8	34.0 / 34.0	68.0 / 408.0	17.1
7 Hours	NA	NA	NA	NA	NA	NA	33.0 / 33.0	66.0 / 462.0	14.9
8 Hours	NA	NA	NA	NA	NA	NA	32.0 / 32.0	64.0 / 512.0	12.7
9 Hours	NA	NA	NA	NA	NA	NA	31.5 / 31.5	63.0 / 567.0	11.4

Source: HNEI

[96] See BESS Development in PICs; see also Powering the Pacific.

3.9.3 RECOMMENDATION

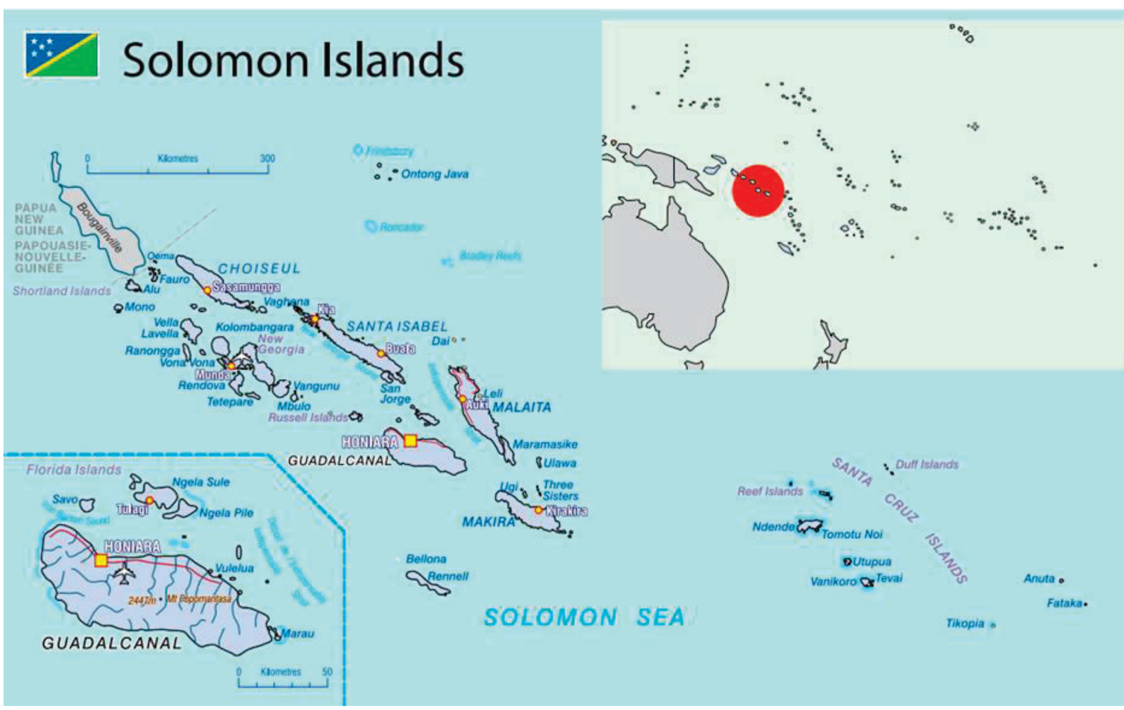
Table 70: PPP Structures Recommendations for Samoa

System	PPP Structure	Rationale	Policy Recommendations
Upolu	VRE+BESS IPP	Add BESS capacity to future planned VRE IPP projects.	Provide incentives to add BESS to VRE projects.
	BESS Lease/Rental	EPC has already installed BESS projects and a microgrid controller with the help of ADB, JICA, Government of Australia, and the Government of New Zealand to manage/regulate the operations of its plants and IPP solar plants. For future projects, procure through lease/rental models to utilize private sector capital and latest expertise.	
	Standalone BESS IPP	Samoa has grid-scale BESS projects installed (at the site of an existing diesel plant) with the support of donors to manage ancillary services. As costs of BESS decrease, a Standalone BESS IPP model may become viable.	

Source: Delphos

3.10 SOLOMON ISLANDS

Figure 18: Map of Solomon Islands



Source: Pacific Community

Solomon Islands is an archipelago of around 1,000 islands (300+ of which are inhabited), with a land area of 28,370 square km spread across 1,340 thousand square km in the South Pacific Ocean. The country has population of around 728,000 which is concentrated on six major islands: Guadalcanal, Malaita, Makira, Santa Isabel, Choiseul, and New Georgia. Honiara, located on Guadalcanal Island, is the capital city. Solomon Islands has a population density of around 26 persons per square km (lowest amongst PICs covered in this report) and a per capita GDP of USD 2,295.

3.10.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: The Ministry for Mines, Energy and Rural Electrification is responsible for legal and regulatory development, institutional strengthening, and supervision of the vertically integrated, state-owned utility, the Solomon Islands Electricity Authority (SIEA), operating under the name Solomon Power (SP). The ministry directs SP's policy and direction and is responsible for regulating SP's tariff. The Energy Division within the ministry is responsible for setting energy policy and encouraging rural electrification.

SP is the main electricity generator and supplier. It holds a few regulatory functions such as for issuing generation licenses and advises the government on policy matters. The SP operates in Honiara (the capital city situated on the island of Guadalcanal) and 11 outstations, namely Gizo, Noro, Auki, Munda, Bualam Malu'u, Tulagi, Kirakira, Lata, Seghe and Taro; and has over 21,000 customers.[97]

IPP in Solomon Islands: Tina Hydropower Project[98]: SP's least-cost expansion plan recommended construction of the Tina River Hydropower Plant supported by the expansion of solar power generation. The 15 MW project is being developed under a build-operate-own-transfer scheme.

A special project company (SPC) will enter into a 34-year PPA with the project developers, and through a government guarantee agreement, the Government of Solomon Islands will guarantee SP's payment obligations to project developers.

Energy Policy and Regulations: The "Solomon Islands National Energy Policy (2014)" aims to achieve 100% household electrification in urban areas and 35% in rural areas by 2020 and increase the use of renewable energy sources for power generation to 79% by 2030. To support clean energy development for sustainable rural development, Solomon Islands exempts imported solar power equipment from import duty and goods tax.[99] Other relevant legislations related to the electricity sector in the Solomon Islands include:

1. The Electricity Act of 1969 created SIEA and gave it exclusive rights for power generation in Honiara and provincial centers. The Act was later amended to allow private generation of less than 50 kW for certain purposes without the need for an SIEA license. This allowed rural villages to generate their own electricity without government approval.[100]
2. The Provincial Government Act of 1981 allows provincial governments to provide electrical services within their jurisdiction.[101]

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[97] Solomon Islands Electricity Authority. "Annual Report, 2019", 2020. link

[98] Asian Development Bank. "Proposed Loan and Grant Solomon Islands: Tina River Hydropower Project", 2019. link

[99] Ministry of Mines, Energy and Rural Electrification (Government of Solomon Islands). "Solomon Islands National Energy Policy", 2014. link

[100] Government of Solomon Islands. "Electricity Act", 1969 and amended time to time. link

[101] Government of Solomon Islands. "Provincial Government Act", 1981. link

The government of Solomon Islands has indicated a preference for private sector involvement, but private sector participation has been minimal. Electricity tariffs are regulated, but there is no provision for feed-in tariffs to encourage investment by IPPs. There are also no preferential grid access rights for renewable energy, and no provision for net metering for rooftop solar.

Solomon Islands' NDC targets for the energy sector include increasing access to electricity in rural households to 35% by 2025, rolling out solar-diesel hybrid and battery storage plants by SIEA in large communities, and improving energy efficiency and conservation by regulating imports of electrical appliances by 2035.[102] The Renewable Energy Roadmap for Honiara aims to achieve 100% renewable energy by 2030 and 100% accessibility by 2050.[103]

Solomon Islands does not have a net-metering policy.[104]

Development partner engagement in Solomon Islands is summarized in Table 71.

Table 71: Solomon Islands - Development Partners Activities

Development Partner	Project	Key Activities Financed
World Bank	Electricity Access and Renewable Energy Expansion Project	Finance supply, installation, and initial maintenance of new hybrid mini-grids in Central Province, Choiseul, Guadalcanal, Isabel, Makira, Renbel, Temotu, and Western Province. Design, supply, installation, and commissioning of 1 MW solar power plant at Henderson.
Asian Development Bank	Preparing Clean and Renewable Energy Investments in the Pacific	Finance for (i) 3.6 MW solar and 10 Mh BESS for rural electrification, and (ii) 2 MW solar project wth 0.5 MWh BESS.

Source: Compiled by Delphos.

3.10.2 TECHNICAL ASSESSMENT

A summary of the SP's Guadalcanal grid is presented in Table 72.

Table 72: SP's Guadalcanal Grid Summary

Parameter	Unit	Value
Peak demand	MW	15.9
Conventional generating capacity	MW	67.0
Energy demand	MWh	98,950
Renewable energy penetration	%	1.7

Source: HNEI

Table 73 and Table 74 summarize BESS requirement for the SP's grid on Guadalcanal Island.

[102] Ministry of Environment, Climate Change, Disaster Management and Meteorology (Government of Solomon Islands). "Solomon Islands 2021 Nationally Determined Contribution", 2021. link

[103] Ministry of Environment, Climate Change, Disaster Management and Meteorology (Government of Solomon Islands). "Solomon Islands 2021 Nationally Determined Contribution", 2021. link

[104] Ministry of Mines, Energy and Rural Electrification (Government of Solomon Islands). "Data Collection Survey on the Promotion of Renewable Energy in Solomon Islands", 2019. link

Table 73: Guadalcanal Results – 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	19.1	19.1 / 19.1	1.4	44.8	44.8 / 44.8	20.8	NA	NA	NA
2 Hours	18.9	18.9 / 37.8	0.1	37.5	37.5 / 75.0	5.4	65.1	65.1 / 130.2	14.8
3 Hours	18.9	18.9 / 56.7	0.0	36.0	36.0 / 108.0	1.3	59.0	59.0 / 177.0	4.3
4 Hours	NA	NA	NA	35.6	35.6 / 142.4	0.3	56.7	56.7 / 226.8	2.3
5 Hours	NA	NA	NA	35.6	35.6 / 178.0	0.1	56.1	56.1 / 282.5	1.2

Source: HNEI

Table 74: Guadalcanal Results – 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	9.3 / 9.3	18.6 / 18.6	0.1	18.8 / 18.8	37.6 / 37.6	6.5	36.0 / 36.0	72.0 / 72.0	24.0
2 Hours	9.3 / 9.3	18.6 / 37.2	0.0	18.0 / 18.0	36.0 / 72.0	2.4	31.9 / 31.9	63.8 / 127.6	14.2
3 Hours	NA	NA	NA	17.8 / 17.8	35.6 / 106.8	1.2	30.8 / 30.8	61.6 / 184.8	11.1
4 Hours	NA	NA	NA	17.7 / 17.7	35.4 / 141.6	0.7	30.3 / 30.3	60.6 / 242.4	9.6
5 Hours	NA	NA	NA	17.6 / 17.6	35.2 / 176.0	0.4	30.0 / 30.0	60.0 / 300.0	8.7

Source: HNEI

3.10.3 RECOMMENDATION

Table 75: PPP Structures Recommendations for Solomon Islands

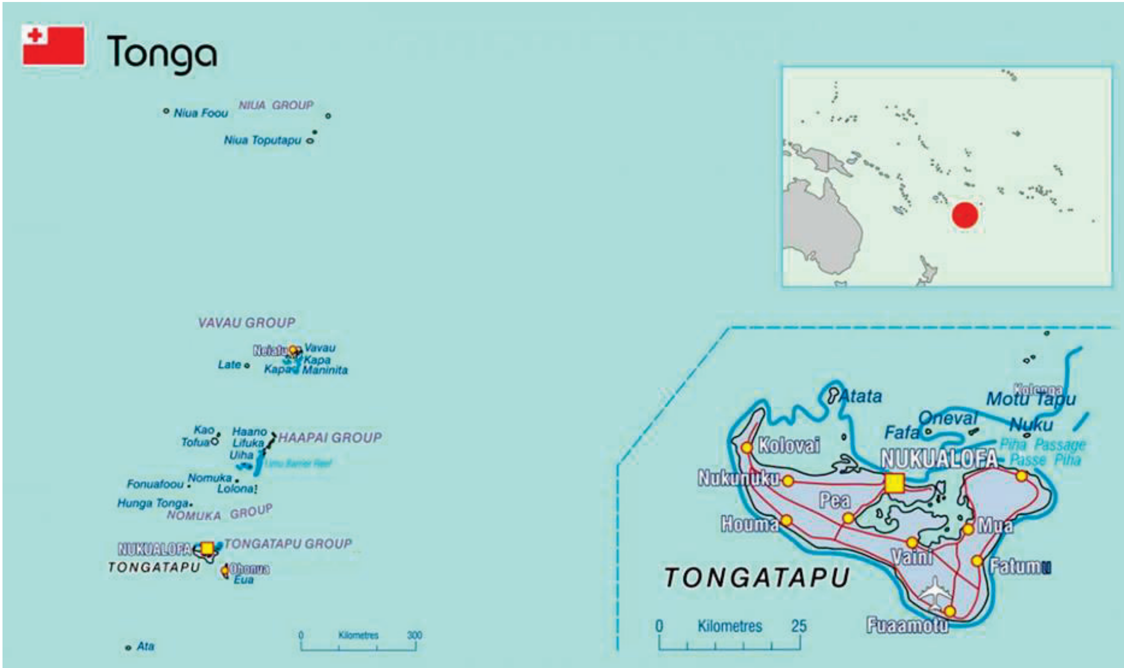
System	PPP Structure	Rationale	Policy Recommendations
Guadalcanal	VRE+BESS IPP BESS Lease/Rental	Add BESS capacity to future planned VRE IPP projects to lower reliance on diesel generation. Add flexibility to planned run-of-river hydro plants with BESS capacity procured under lease/rental model.	Provide incentives to add BESS to VRE projects. Identify suitable locations on the grid for BESS projects and solicit rental/lease projects.
Other	Mini Grid Concession	Rural areas lack electricity or are dependent on own gen-sets, which can be supplemented by solar PV and BESS.	For sites identified for mini-grids/microgrids, conduct tenders to bring in private investors/operators.

Source: Delphos

3.11 TONGA

Tonga is a kingdom of 169 islands organized into five island groups: Eua, Ha'apai, Niuas, Tongatapu, and Vava'u. Thirty-six of the islands have permanent settlements, and more than 75% of the country's total population of 100,000 lives on Tongatapu, the main island and the location of the capital, Nuku'alofa. The country covers around 700,000 thousand square km of ocean areas but has just 650 square km of land area. Tonga has a population density of 138 persons per square km and a per capita GDP of USD 5,081.

Figure 19: Map of Tonga



Source: Pacific Community

Tonga's economy is largely based on agriculture (coconut, vanilla beans and bananas are the main cash crops) and relies heavily on remittances from population that lives abroad. All land is essentially owned by the monarch, with large estates given to nobles. Manufacturing sector consists of handicrafts and a handful of small-scale industries. Tourism sector is relatively underdeveloped.

3.11.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: Overall responsibility for electricity sector policy and planning is shared by the Prime Minister's Office and the Ministry of Finance and National Planning (MFNP). The MFNP's policy and planning division helps other government entities formulate outcomes and outputs at operational levels, and monitors progress on strategic policy objectives. The MFNP is also Tonga Power Limited's (TPL) contractual partner in the concession agreement that governs the state-owned, vertically integrated power utility's operations.[105]

TPL is solely responsible for providing grid-connected electricity services in Tonga. TPL is a vertically integrated public enterprise wholly owned by the government and under the oversight of the Ministry of Public Enterprises and the government cabinet. It has concessions to operate four independent grids: the largest, which is on the main island of Tongatapu, and three smaller grids on the main islands of the 'Eua, Ha'apai, and Vava`u island groups (Table 76). TPL generates, distributes, and retails electricity, and provides O&M services.[106]

[105] Asian Development Bank. "Sector Assessment (Summary): Energy". link

[106] Asian Development Bank. "Sector Assessment (Summary): Energy". link

BESS in Tonga: TPL is constructing several on-grid wind and solar projects. To minimize the grid impact of VRE, TPL is installing two BESS: (i) 7.2 MW/3.8 MWh BESS at Popua Power Station on Tongatapu for grid stability, and (ii) 6 MW/21 MWh BESS at Villa for load shifting. The project is being financed through ADB's Tonga Renewable Energy Project with co-funding from GCF and DFAT.[107]

The Energy Department of the Ministry of Meteorology, Energy, Information, Disaster Management, Climate Change, and Communications is responsible for off-grid — that is, non-TPL grid — rural electrification planning and has not had a role in formulating policies or strategic plans for grid-based electricity supply.[108]

The Renewable Energy Authority is responsible for the development of renewable energy sector in Tonga. It develops regulations and establishing standards for renewable energy equipment and the production, storage, and distribution of renewable energy.

The Tonga Electricity Commission is responsible for regulating tariff on TPL's concession areas. It is also responsible for the licensing of electricians and establishing standards for electrical safety.

Table 76: TPL's power grids

System	Tongatapu	Vavaú	Éua	Haápai
Peak Demand (MW)	10.4	1.2	0.4	0.5
Diesel Installed Capacity (MW)	14.3	1.9	0.8	0.7
RE Capacity (MW)	5.7	0.4	0.2	0.6
Electricity Generation (MWh)	61,000	6,500	1,500	1,800

Source: Tonga Power Limited. "About Us". link

Energy Policy and Regulations: The "Gross-Metering Policy for the Connection of Small Distributed Generation of 2012" allows TPL customers to produce electricity for the own use and supply the excess electricity to the TPL grid. A customer's electricity purchase from TPL is charged at TPL's published rates. Conversely, TPL purchases electricity from gross-metered generation at its lower "export tariff". The key provisions of the Act are as follows:[109]

1. Maximum total capacity of gross-metered projects is 800 kW, to ensure grid stability. Sub-limits are: educational institutions (150 kW); religious institutions (350 kW); commercial (250 kW); and residential (50 kW).
2. Gross-metered connections are classified into three categories: (i) Up to 4 kW_p, (ii) 4-160 kW_p, and (iii) > 160 kW_p.
3. Systems above 4 kW_p need to have three-phase connections, while systems larger than 160 kW_p are dealt through a power purchase agreement.

In 2020, Tonga submitted its NDCs with the goal of reducing GHG emissions form the combustion of fossil fuels in energy sector by 13% by 2030 compared to 2006. The government aims to achieve this by implementing measures (i) 70% electricity generation from renewable energy sources by 2030 through combination of solar, wind and battery storage; (ii) adopting minimum energy performance

[107] TPL. "Battery Energy Storage System". link

[108] Asian Development Bank. "Sector Assessment (Summary): Energy". link

[109] Tonga Power Limited. "Tonga Power Limited Gross Metering Policy for the Connection of Small Distributed Generation", 2012. link

standards; and (iii) limiting growth in grid-connected residential electricity end-use to 1% per year on average for the period 2021-2030 by adopting minimum energy performance standards for appliances, lighting, and electrical equipment.[110]

Tonga's NDC aim to achieve 13% reduction in energy sector GHG emissions by 2030 compared to 2006 while transitioning to 70% renewable electricity by 2030.[111]

IPP in Tonga: 6 MW Solar PV Plant: Sunergise New Zealand Ltd. signed a PPA with TPL in 2019 to finance, build, and operate a 6 MW solar PV plant and sell electricity to the TPL. The project, covering three sites on Tongatapu, does not have a BESS component. The project was expected to begin operations in 2020 but was delayed due to Covid-19 pandemic. The solar PV plant is expected to meet 15% of Tonga's electricity demand and reduce electricity costs. TPL is also working on setting up other IPPs including a 4.5 MW wind project at Niutoua.

Source: TPL

Development partner engagement in Tonga is summarized in Table 77.

Table 77: Tonga – Development Partners Activities

Development Partner	Project	Key Activities Financed
Asian Development Bank	6 MW Hihifo Solar Power Project (Proposed)	Sunergise New Zealand and TPL have requested financial assistance to finance three solar projects with aggregate capacity of 6 MW.
Asian Development Bank	Preparing Clean and Renewable Energy Investments in the Pacific (Proposed)	Transactional technical assistance for 5 MW Tonga floating solar project. Additional financial support may be requested by the Government of Tonga.
Asian Development Bank	Renewable Energy Project	Financial assistance of USD 53.2 million for activities including the following: Tongatapu: 5.1 MW/2.5 MWh BESS for grid stability and 5.0 MW/17.4 MWh BESS for load-shifting. Eua and Vava'u: grid connected 650 kW solar PV plant coupled with a 1.3 MW/1,4 MWh BESS. Outer islands (O'ua, Tungua, Kotu, Mo'unga'one, and Niuafo'ou): hybrid renewable energy mini-grids consisting 501 kW solar PV plant and a 4.3 MWh BESS.[112]

Source: Compiled by Delphos.

3.11.2 TECHNICAL ASSESSMENT

The Tongatapu Island is served by TPL's grid operating at 50 Hz and comprises a 11 kV distribution network. The grid has two 500 kW BESSs – one located at the power station and another at Vaini. A summary of TPL's Tongatapu grid is presented in Table 18.

[110] Kingdom of Tonga. "Tonga Second Nationally Determined Contribution)", 2020. link

[111] Government of Tonga. "Tonga's Second Nationally Determined Contribution", 2020. link

[112] Asian Development Bank. "Pacific Renewable Energy Investment Facility: Renewable Energy Project", 2019. link

Table 78: TPL's Tongatapu Grid Summary

Parameter	Unit	Value
Peak Demand	MW	11.5
Conventional Generating Capacity	MW	23.0
Energy Demand	MWh	76,016
Renewable Energy Penetration	%	11.8

Source: HNEI

The BESS requirement for TPL's grid on the Tongatapu Island is summarized in Table 79 and Table 80.

Table 79: Tongatapu Results – 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	7.6	7.6 / 7.6	0.1	26.0	26.0 / 26.0	32.7	NA	NA	NA
2 Hours	NA	NA	NA	19.4	19.4 / 38.8	9.6	42.1	42.1 / 84.2	30.3
3 Hours	NA	NA	NA	17.9	17.9 / 53.7	2.2	33.3	33.3 / 99.9	11.7
4 Hours	NA	NA	NA	17.6	17.6 / 70.4	0.3	30.4	30.4 / 121.6	3.3
5 Hours	NA	NA	NA	17.5	17.5 / 87.5	0.0	29.7	29.7 / 148.5	1.0

Source: HNEI

Table 80: Tongatapu Results – 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	3.1 / 3.1	6.2 / 6.2	0.0	7.3 / 7.3	14.6 / 14.6	2.1	14.2 / 14.2	28.4 / 28.4	16.1
2 Hours	NA	NA	NA	7.2 / 7.2	14.4 / 28.8	0.4	13.2 / 13.2	26.4 / 52.8	9.9
3 Hours	NA	NA	NA	7.1 / 7.1	14.2 / 42.6	0.0	12.8 / 12.8	25.6 / 76.8	7.2
4 Hours	NA	NA	NA	NA	NA	NA	12.6 / 12.6	25.2 / 100.8	5.8
5 Hours	NA	NA	NA	NA	NA	NA	12.5 / 12.5	25.0 / 125.0	4.8

Source: HNEI

3.11.3 RECOMMENDATION

Table 81: PPP Structures Recommendations for Tonga

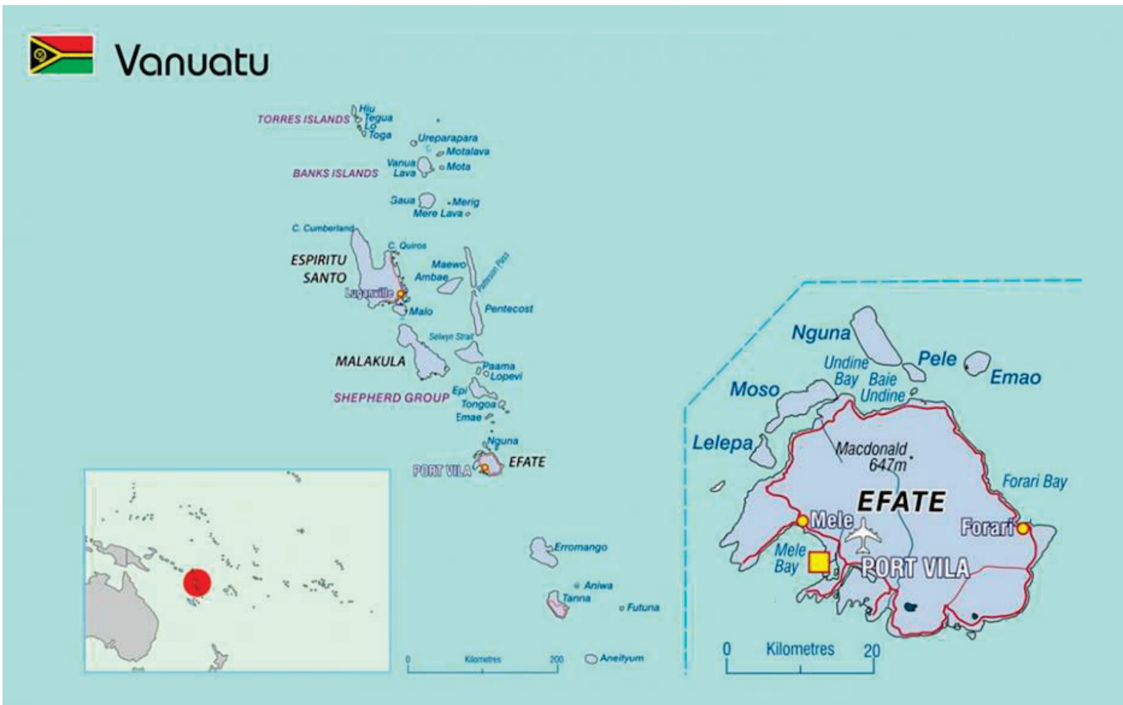
System	PPP Structure	Rationale	Policy Recommendations
Tongatapu	BESS Lease/Rental	After initial ADB-funded projects and capacity building, add additional BESS capacity under lease/rental model going forward with grant funding prioritized for adding renewable generation capacity.	Conduct tenders for BESS lease/rental projects in parallel with VRE projects built with development partner support.
	Standalone BESS IPP	As there is already IPP activity in VRE generation projects and TPL has experience with BESS projects, Standalone BESS IPP projects may be viable in the longer term if BESS costs decline. Some grant or concessional funding support may still be necessary	
Other	Mini Grid Concession	Small outer islands are suitable for Mini Grids concessions to serve electrification targets.	Conduct tenders to bring in private investors/operators for Mini Grids.

Source: Delphos

3.12 VANUATU

Vanuatu is an archipelago of 83 islands, 80% of which are inhabited. The country has a population of around 301,000, 75% of which live in rural areas. 20% of the population lives on two islands – Efate and Espiritu Santo. Port Vila, the national capital, is located on Efate Island. Vanuatu has 12,190 square km of land area and stretches over 680,000 thousand square km of sea area. The country has a population of 25 persons per square km (lowest amongst PICs covered in this report) and a per capita GDP of USD 3,223.

Figure 20: Map of Vanuatu



Source: Pacific Community

Vanuatu's economy is agriculture based, with 80% of the population engaged in agricultural activities that range from subsistence farming to smallholder farming of coconuts and cash crops. The country is a tax haven and around 2,000 registered institutions offer a wide range of offshore banking, investment, legal, accounting, insurance, and trust company services.

3.12.1 MARKET, POLICY, AND REGULATORY ASSESSMENT

Institutional Framework: Grid-connected electricity is supplied by private entities through concession agreements granting electricity supply exclusivity. Union Electrique de Vanuatu Limited (UNELCO) is a privately held company, owned by Engie (51 percent) and the Vanuatu National Provident Fund (49 percent). UNELCO is responsible for electricity generation and supply for Efate. Vanuatu Utilities and Infrastructure Limited (VUI) is a subsidiary of the American construction company, Pernix Group Inc. VUI has the concession for Espiritu Santo Island. It provides both water and electricity supply services. The Espiritu Santo concession area is divided into two separate areas, Luganville and Port Olry. The Luganville system is many times larger than the Port Olry system and benefits from economies of scale and hydropower generation.

The Utilities Regulatory Authority (URA), established in 2008, is the independent regulator for both water and electricity services. URA's regulatory powers are not well-established. UNELCO has challenged several of URA's regulations in court, some of which have been successful, and others not. These challenges have placed significant financial and resource burdens on the URA. The URA and the government are drafting an amendment to the Electricity Act that it is hoped will resolve uncertainties around the legality of the URA's regulatory responsibilities.

The Department of Energy (DoE) under the Ministry of Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management, is responsible for managing the government's electricity generation assets. The Supply of Electricity (Districts) Act allows the government to supply electricity outside the concession areas. The DoE is responsible for rural electrification.

Utility Services: UNELCO's Efate concession agreement covers the capital, Port Vila, and most of the island's coastline. Port Vila and the Efate grid is by far the largest grid and supplies over 80 percent of the country's total generated electricity. Electricity is mostly generated using diesel along with a small amount of coconut oil, with some RE in the form of solar PV and wind power. UNELCO has been investing in further RE capacity, and recently installed additional solar capacity.

From 2000 through 2020, UNELCO also had an electricity concession covering the islands of Tanna and Malekula. The Government of Vanuatu is temporarily administering the system until a new concession is tendered.

VUI has been operating the Espiritu Santo concession area since 2011. The Espiritu Santo area consists of two main load centers: Luganville and Port Olry. It is the only area in Vanuatu where most of the electricity generated comes from RE sources, with about 1.2 MW of installed hydropower capacity. The Port Olry system has only 300 customers with a peak load of 40 kilowatts (kW) and is supplied by diesel generators. Luganville customers are cross-subsidizing customers in Port Olry.

Energy Policy and Electricity Regulations: Vanuatu's NDC aim to achieve 100% electrification in off-grid areas and 100% renewable electricity generation by 2030.[113]

The "Electricity Supply Act of 1972", as amended in 2010, allows the Minister of Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management to issue exclusive electricity supply concessions.[114] The Act also allows anyone to generate electricity for self-consumption. The Act allows entities other than concession holders to generate and supply electricity outside the concession areas.[115] The Act appears to prevent a third-party on-site distributed generator from selling power to the owner of the premises, as affirmed by the recent experience with Iririki Resort in Port Vila (see callout below).

> **Distributed Generation for Self-use in Vanuatu: Iririki Resort and Spa Solar Minigrid:** Iririki Island Resort and Spa is a 5-star luxury resort in the South Pacific. In 2017, the resort installed a 783-kW solar minigrid with a 2 MWh BESS. The minigrid is isolated from UNELCO's grid and reduces overall operating expenses.

[113] Government of Republic of Vanuatu. "Vanuatu's First Nationally Determined Contribution (Updated Submission 2020)", 2021. link

[114] Government of Vanuatu. "Electricity Supply Act, 1972", 1972. link

[115] Government of Vanuatu. "Electricity Supply Act Amendment of 2010", 2010. link

UNELCO disputed the minigrid on grounds that some of Iririki's apartments were owned by Iririki's customers and not by Iririki. Therefore, Iririki was effectively selling electricity within UNELCO's concession area. The eventual solution to this dispute was for Irikiri to supply its apartments with power from its micro-grid, and for the other accommodation to be supplied by UNELCO.

Source: Solomon Star, Sunergise Group & IFC

The Utilities Regulatory Authorities Act of 2007 established the URA as the independent regulator responsible for regulating the electricity and water sector with functions and powers to (i) act in a policy advisory role for the government; (ii) inform the public of matters relating to utilities; (iii) issue safety and reliability standards; (iv) regulate prices; (v) help consumers to resolve grievances; and (vi) uphold the legislation laid out both in the Act and in the Electricity Supply Act. The Act allows the URA to determine maximum prices but does not define how the URA should do this.[116] UNELCO has successfully disputed URA's ability to enforce regulated prices on several occasions.[117]

The "National Energy Roadmap (2016-2030)" ("NERM 2016") identifies five priorities for the energy sector: access, petroleum supply, affordability, energy security and climate change. It set out objectives, targets, and actions to achieve these priorities and contribute to NERM's overall vision. The NERM 2016 focuses on five priorities: accessible energy, affordable energy, secure and reliable energy, sustainable energy, and green growth. Objectives of the NERM 2016 relevant to this assignment include:[118]

1. Increase RE generation and grid expansion through utility-scale RE development in Efate and mini/microgrid development for rural electrification. Concession holders are required to expand their grids to communities that are close to existing grid infrastructure. The added demand is to be met through increased RE development.
2. Improve the regulatory and legislative framework for PPP and IPPs through effective policy and risk sharing frameworks. This should increase the URA's power to enforce regulation.

The "Net-metering Rules of 2014" allow UNELCO's customers on Efate Island to install solar systems primarily for self-consumption. The key provisions are:[119]

1. Maximum total capacity limit of 500 kW for net-metered projects; with the following limits by customer categories:
    a. 50-70 domestic customers with aggregate maximum capacity of 320 kW.
    b. 10 commercial customers with aggregate maximum capacity of 120 kW.
    c. 3 high voltage customers with aggregate maximum capacity of 60 kW.
2. Maximum allowed system size is 19.8 kWp and larger installations may be considered on a case-by-basis.
3. Limit of 4 installations per local loop or transformer.

[116] Government of Vanuatu. "Utilities Regulatory Authority of 2007", 2007. link

[117] Government of Vanuatu. "UNELCO vs Utilities Regulatory Authority", 2018. link

[118] Government of Vanuatu. "Updated Vanuatu National Energy Roadmap 2016-2030", 2016. link

[119] Vanuatu Utilities Regulatory Authority. "Final Decision and Commission Order in the matter of investigating and implementing feed-in-tariffs and net-metering program for renewable energy in Port Vila", 2014. link (Page 6)

Development partner engagement in Tonga is summarized in Table 82.

Table 82: Vanuatu – Development Partners Activities

Development Partner	Project	Key Activities Financed
World Bank	Rural Electrification Project Stage 2	Finance SHS and micro-grids for 37 public institutions and 8,400 households benefitting around 42,000 people and construction of 5 mini grids which are that will provide electricity service to approximately 550 rural households (around 2,750 people.
Asian Development Bank	Pacific Renewable Energy Investment Facility	Finance for 1 MW solar and 2 MWh BESS for rural renewable energy program.

Source: Compiled by Delphos

3.12.2 TECHNICAL ASSESSMENT

The Efate Island is served by UNELCO's grid operates at 50 Hz and comprises a 11 kV distribution grid, A summary of the KUA's Kosrae grid is presented in Table 83.

Table 83: UNELCO's Efate Grid Summary

Parameter	Unit	Value
Peak Demand	MW	13.2
Conventional Generating Capacity	MW	34.8
Energy Demand	MWh	59,736
Renewable Energy Penetration	%	14.7

Source: HNEI

Table 84 and Table 85 summarize BESS requirement for the UNELCO's grid on the Efate Island.

Table 84: Efate Island Results - 100% Incremental Solar

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV	BESS	Curtailment	New PV	BESS	Curtailment	New PV	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	5.2	5.2 / 5.2	0.0	16.6	16.6 / 16.6	21.5	NA	NA	NA
2 Hours	NA	NA	NA	13.8	13.8 / 27.6	5.9	30.5	30.5 / 61.0	26.8
3 Hours	NA	NA	NA	13.2	13.2 / 39.6	1.6	25.0	25.0 / 75.0	10.6
4 Hours	NA	NA	NA	13.0	13.0 / 52.0	0.2	23.3	23.3 / 93.2	4.0
5 Hours	NA	NA	NA	NA	NA	NA	22.9	22.9 / 114.5	2.4

Source: HNEI

Table 85: Efate Island Results - 50/50 Incremental Solar and Wind

BESS Hours	30% RE by 2025			50% RE by 2030			70% RE by 2035		
	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment	New PV/Wind	BESS	Curtailment
	MW	MW/MWh	(%)	MW	MW/MWh	(%)	MW	MW/MWh	(%)
1 Hour	1.8 / 1.8	3.6 / 3.6	0.0	4.5 / 4.5	9.0 / 9.0	0.9	8.9 / 8.9	17.8 / 17.8	14.1
2 Hours	NA	NA	NA	4.5 / 4.5	9.0 / 18.0	0.2	8.5 / 8.5	17.0 / 34.0	10.0
3 Hours	NA	NA	NA	4.5 / 4.5	9.0 / 27.0	0.1	8.3 / 8.3	16.6 / 49.8	8.2
4 Hours	NA	NA	NA	NA	NA	NA	8.2 / 8.2	16.4 / 65.6	7.2
5 Hours	NA	NA	NA	NA	NA	NA	8.2 / 8.2	16.4 / 82.0	6.6

Source: HNEI

3.12.3 RECOMMENDATION

Table 86: PPP Structures Recommendations for Vanuatu

System	PPP Structure	Rationale	Policy Recommendations
Efate	C&I Customer Sited BESS BESS Lease/Rental	BESS added by customers similar to Iririki Resort can benefit them (backup power, diesel use reduction) and UNELCO. Procure BESS capacity through lease/rental models to complement new VRE capacity added.	Assess and modify the Electricity Act so that customers can use on-site resources (including BESS and generators) to supply power to the grid.
Espiritu Santu	BESS Lease/Rental	Procure BESS capacity through lease/rental models to add flexibility to hydro resource or offset diesel generator use for peaking capacity.	
Other	Mini Grid Concession	Small outer islands are suitable for Mini Grids concessions to serve electrification targets.	Conduct tenders to bring in private investors/operators for Mini Grids.

Source: Delphos

4. REGIONAL STRATEGY ON PPP (AUCTION) ARRANGEMENTS

The analyses conducted in the previous sections identified the PPP structures most relevant for BESS projects in the PICs based on an assessment of their power systems (including at the sub-national level), existing policy and regulatory frameworks, and practical realities of implementing projects in the PICs given their geographic remoteness and small scale. Table 87 summarizes the Team's recommendations on BESS PPP options.

Table 87: Summary of Recommended PPP Structures by PICs' Major Grids

	VRE + BESS IPP	Standalone BESS IPP	BESS Lease/Rental	Mini Grid Concession	C&I Customer-Sited BESS
Federated States of Micronesia			All four main grids as well as outer islands in Pohnpei	Outer islands in Chuuk, Kosrae, and Yap	All four main grids
Republic of Marshall Islands	Both main grids		Both main grids	Outer islands in Majuro	
Tuvalu			Funafuti and outer islands		
Fiji	Viti Levu and Vanua Levu (Lavasa)	Viti Levu	All systems		Viti Levu and Vanua Levu (Lavasa)
Kiribati			Tarawa		
Nauru			Nauru		
Palau	Babeldaob	Babeldaob			
Samoa	Upolu	Upolu	Upolu		
Solomon Islands	Guadalcanal		Guadalcanal	Other islands	
Tonga		Tongatapu	Tongatapu	Other islands	
Vanuatu			Efate and Espiritu Santu	Other islands	Efate

This section focuses on highlighting the most relevant structural, economic/financial, and technical features of each PPP type, and how those items could be addressed in competitive procurement documents, including the underlying contracts and other arrangements. The subsequent sub-sections provide guidance on procurement considerations for each PPP structure, followed by a discussion of how a regional strategy for auction arrangements may be implemented given the Team's recommendations, geographic groupings, and the need for scale.

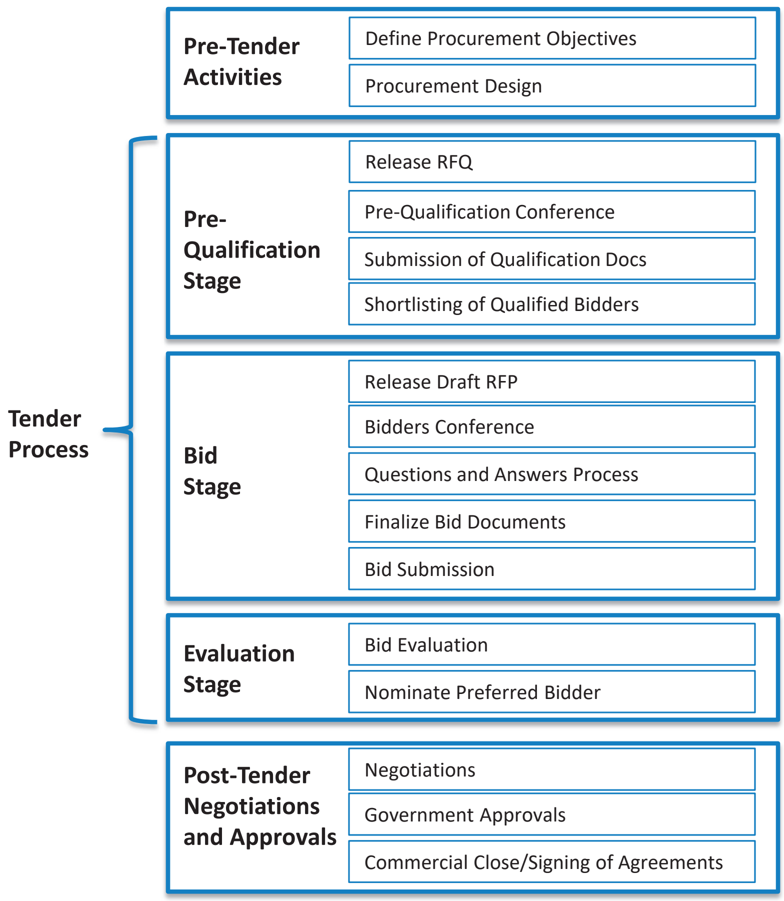
Procurement under all PPP structures discussed here entails several concepts, which are introduced below to streamline the sub-sections with specific guidance on procurement for each PPP structure.

Procurement Process: There are two basic procurement modes: competitive tendering and negotiation of unsolicited proposals. Reflecting the statement of work for this engagement, the focus of the analysis is on the former mode, though unsolicited proposals are discussed briefly as well.

The topic of "how to procure" through a competitive process requires addressing a range of activities starting from preparation of tender documents to running the tender to signing of project agreements.

The following figure shows typical activities during the competitive procurement of a power project, including pre-tender, tender, and post-tender phases. This depiction would apply, in a generic sense, to all the PPP structures evaluated for this report, though somewhat different approaches might be more appropriate in some cases for some of the PPP structures. For instance, Micro-grid Concession procurement arrangements might be organized around project proponents competing to qualify to receive capital grants, with little or no emphasis on the price offer. C&I Customer-sited BESS, meanwhile, would be expected in most cases to not involve procurement by the utility at all, but rather qualification by C&I customers to receive fees/rebates for installation of BESS facilities, under a formal utility incentive program.

Figure 21. Procurement Activities



Tenders usually are "single stage" or "two stage". The figure depicts a standard two stage[120], two envelope, sealed bid tender. These concepts are discussed below.

- **Single stage or two stage:** In single stage tendering, the tender is released with all relevant information provided at the point of issue. Two stage tendering involves an initial pre-qualification stage, facilitating early collaboration between the procuring entity and bidders, followed by a second stage to select the winning bidder using selection criteria outlined in the

[120] In a single stage process, there is no prequalification stage.

first stage.[121] Single stage tendering is more efficient when the project is well-defined, all key information that bidders require to submit a realistic bid is available, and the market is familiar with the jurisdiction, technology, and procuring entity.

Two stage tendering enables the procuring entity to obtain input at the prequalification stage from bidders to ensure greater certainty on structuring, project design, and costs. Additional advantages of two stage bidding include that the qualification stage affords the opportunity to identify truly qualified bidders, avoiding the problem of "surprise bids" from low quality bidders; the qualification stage provides feedback on market interest early in the lengthy process of developing bid documents, so that, if interest is low, the RFQ can be improved and re-issued, whereas in a single stage process, one may not learn until bids are due that the process is a failure; and, two stage processes increase bidder confidence, encouraging them to bid, because shortlisted bidders have a known minimum chance of winning against other shortlisted bidders, rather than facing high uncertainty about the total number of bidders (as is the case in a single stage process).

Choosing a Single Stage or a Two Stage Process

- A single stage process works best for smaller, simpler, and well-defined projects in jurisdictions where bidders have experience.
- Two stage process benefits:
  - Input from bidders improves bid document quality.
  - Identify truly qualified bidders at the qualification stage.
  - Qualification stage provides early indication of market interest.
  - Increases chance of successful process; shortlisted bidders are more confident in their chances.
  - Two stage processes may be appropriate for initial BESS projects in PICs, given newness of technology, potential lack of bidder interest, and lack of procurement experience.

- **Two envelopes, sealed bid.** In this type of tender process, bidders submit two sealed envelopes. "Envelope One" contains the administrative, technical, and funding proposal, while "Envelope Two" contains the financial offer. Envelope Two is only opened for bidders with a passing score on the Envelope One evaluation. This type of process is discussed in more detail later in this section.

Pre-Tender Activities: Key activities in the pre-tender phase relate to designing the tender process and preparation of tender documents, including drafts of key project agreements. It is recommended to use standard forms of key agreements where possible, including the power purchase agreement (if applicable), government support agreement (if applicable), and draft direct agreements, among others. Use of standardized forms of agreements reduces transaction costs (time and money) by avoiding the need to completely re-draft agreements for every tender.

To be clear, for PICs projects, we envision two stages of standardization. The first stage, expected to benefit from donor support, would develop generic standardized forms of agreement for each of the recommended project structures (e.g., BESS + IPP, Standalone BESS, etc.). In the second stage, these

[121] Final, detailed, selection criteria, including scoring methodology for each and every component, do not need to be presented in the qualification stage, though they do need to be presented in outline form.

forms of agreement would need to be aligned with local law, and local market structure, during preparation of initial tenders. It should be straightforward to replicate documents for later tenders.

Tender Process: There are typically three distinct stages to an IPP (or more generally, a PPP) tender process (as identified in the figure above). In the pre-qualification stage, submissions are invited – through issuance of a request for qualifications (RFQ)[122] – from parties potentially interested in bidding for the project. The objective of the pre-qualification stage is to create a shortlist of bidders that meet minimum technical and financial requirements.

Pre-qualification criteria must be provided in the RFQ, which would cover technical and financial parameters relevant to implementing the project. Typically, submissions should include at least bidders' corporate profile, financial information (parent company information, if necessary), information on potential partners and/or contractors, relevant experience, and other administrative requirements.

During the bid stage, shortlisted bidders are invited in a request for proposals (RFP) to submit technical and financial proposals. The RFP would include instructions to bidders on the bid process, studies relating to the project (if any), drafts of key project agreements, and other relevant documents (described in more detail in an ensuing subsection, "Bid Documents Contents"). The bid stage involves the procuring entity taking the following steps: (i) release the draft RFP for review and comment by bidders; (ii) hold one or more a bidders' conferences to provide clarifications and address any concerns of bidders; (iii) respond to questions from bidders; (iv) issue the final RFP (tender documents); and (v) receive technical and financial proposals based on the prescribed format, location, and deadline.

The importance of releasing the draft RFP before finalizing the same is worth highlighting. Draft RFPs are released to shortlisted bidders to give them an opportunity to address a variety of concerns including contractual terms that that could be deal-breakers, details that make the project unfeasible, technical specification features that may increase the cost of the project, evaluation criteria that may be unfair or unreasonable, etc. Typically, the concerns are submitted in a confidential manner by bidders and the procuring authority is at liberty to address the concerns as it deems fit; questions (stripped of identifying information) and answers are provided to all bidders.

Two critical aspects relevant during the bid stage are: (i) specification of proposal contents and format; and (ii) setting of the specific criteria for evaluation of proposals. Information on these aspects would be specified in the tender documents.

As mentioned earlier, the figure above depicts a standard two-envelope, sealed bid process, in which "Envelope One" normally contains the administrative[123], technical, and funding proposal, while "Envelope Two" contains the financial offer. Evaluation criteria should mirror the contents of the two envelopes, addressing: (i) administrative, technical, and funding criteria; and (ii) financial criteria. *Administrative criteria* include items such as corporate documentation, documentation of good business standing, parent-subsidiary relationships, mandatory affirmations, and so on. *Technical criteria* address the technical specifications relating to the facility to be constructed, in terms of construction and operations phases (for instance, plant and equipment standards for construction phase and rated capacity and rated efficiency during operations phase), experience of personnel and contractors demonstrating ability to implement the project, and corporate capability with project

[122] Other terms for the same stage in the process include "request for expressions of interest", "call for expressions of interest", and "request for information".

[123] Depending on the level of detail required and bidder vetting in the qualification stage, it may or may not be necessary to document administrative items at the bid stage.

development and implementation. *Funding criteria* are used to evaluate the bidder's financial resources to fund the project with equity and debt and might include documentation of an adequate balance sheet and creditworthiness of the bidder or its parent company, an indicative financing plan (potentially with lender letters of interest), and previous experience with the financing of similar projects. The *financial criteria* often are based on a single metric in the form of levelized cost of electricity (LCOE) offered by the bidder.[124]

During the evaluation stage, the procuring authority evaluates proposals received from bidders against the criteria established in the tender documents. After receiving the proposals, the procuring authority should open Envelope One and evaluate compliance with the administrative, technical, and funding criteria. Proposals of bidders meeting the criteria are considered as compliant. Often, evaluation criteria feature a mix of pass/fail scoring and scored components. Thus, the Envelope One evaluation might comprise a pass/fail evaluation of administrative requirements, with failing bids rejected at that point, followed by scoring of technical and funding components, subject to a minimum qualifying score. Once the Envelope One evaluation is complete, the unopened Envelope Two submissions of rejected bids are returned to those bidders, and the financial offers of remaining, compliant, bidders are opened for evaluation. The financial offer in Envelope Two, normally in the form of LCOE[125], which would be ranked from lowest to the highest, and the bidder with the lowest bid is nominated as the "preferred bidder".

For BESS projects in the PICs, it may make sense for at least initial projects, to rank bids based on a weighted total score based on technical and financial scores. This would allow consideration to be given to the capacity building program offered, and any innovative or important technical considerations that were not specifically addressed in the technical specifications. Such an approach is generally discouraged for power projects, but the newness of BESS technology, its fast-evolving nature, and the uniqueness of PICs' grids, argue for flexibility in this regard. If a weighted score is used, the financial offer should be weighted heavily (e.g., 80% - 95%); at the end of the day, these are power projects designed to deliver specific services, not architectural designs for say, a parliament building, where design details may be considered highly important.

Post-Tender Negotiations: After the preferred bidder is nominated, the procuring authority and the preferred bidder begin negotiations to finalize and sign the project agreements, often referred to as "commercial close". A guiding principle is to minimize post-tender negotiations of project agreements.

Publishing draft project agreements during the bid stage gives all bidders a chance to review and provide comments on the project agreements, thereby addressing concerns or limitations with the draft project agreements. Key terms of projects agreements should be in agreed form when the final RFP is issued, which ensures a level playing field for all bidders, avoids aggressive bidding with an intention to renegotiate upon selection, and reduces transaction costs after the selection of the

[124] Calculation of the LCOE involves dividing the NPV of total project costs over project's life by the NPV of total generation over that period. It is akin to an average cost of electricity over the project's life.

[125] For some procurements, it may be acceptable to simply specify the starting tariff, provided that the projects being proposed by bidders would be expected to be fundamentally similar and would all be subject to the same tariff indexation provisions.

preferred bidder. It is therefore imperative that the procurement authority does not entertain material[126] changes to the project agreements with the preferred bidder.

Timelines: The tendering process must have clearly defined and realistic timelines for each step. The timelines should be sufficient for bidders to properly review documents and submit informed bids. While delays occur and are indeed expected by all participants in the procurement process, indicating an overly aggressive timeline in an RFQ and/or RFP is more likely to deter bidders than to speed up the overall process, as it suggests a lack of experience on the part of the procuring entity. A realistic timeline for a utility scale IPP / PPP competitive tender process, starting when the procuring entity retains transaction advisory support (expected to be necessary in nearly all PICs for initial BESS-related procurements) to commercial close is two to three years.

Unsolicited Proposals: Unsolicited proposals allow the private sector to identify and generate ideas for infrastructure projects, particularly when public agencies have limited capacity to do so. However, bilaterally negotiated contracts resulting from unsolicited proposals can have drawbacks, including that they: (i) often do not adequately assess the fiscal risks to the procuring entity associated with the project; (ii) lack transparency, often resulting in allegations of corruption, undermining the legitimacy of the procuring authority and the project; (iii) may result in higher costs due to the absence of competition; and (iv) burden the public agency's limited capacity by diverting attention to evaluations of, and negotiations on, unsolicited proposals.

Balancing the benefits and drawbacks discussed above, we recommend that the procurement authority be permitted to accept unsolicited proposals only under a narrow set of circumstances, such as that the project has demonstrably unique benefits or attributes that would be impractical or impossible to obtain *via* a competitive procurement process. For further guidance on unsolicited proposals, see the World Bank Group's detailed guidelines for managing unsolicited proposals in infrastructure projects, that are also applicable to power projects.[127]

Bid Documents Contents: The bid documents should contain an explanation of the purpose of the procurement, the entities involved, timelines, project description, services sought from the bidder for the project, and instructions to the bidder including selection award criteria. VRE + BESS IPP and Standalone BESS IPP projects are likely to entail more detail due to the complexity of IPP transactions. Minigrid Concession projects at the larger end of the size range for minigrids may involve considerable detail as well, reflecting the broader scope of operating a mini-grid; smaller projects, on the other hand, might involve relatively little detail, with bidders[128] themselves expected to document their own understanding of the opportunity. Some of the main categories of bid documents are discussed below.

Project Description: The project may have well-defined specifications if it has been studied in detail, in terms of type (technology), size, location, and use cases (for BESS). Some procurements are for

[126] There is, nonetheless, a need for reasonableness as to materiality. For instance, Direct Agreements are generally only negotiated post bid, and lenders usually have their own strong preferences on form and content of these agreements. While the bid documents may and generally should contain draft forms of these agreements, the procuring entity should be aware of market expectations in this regard. It also may be necessary in some cases to materially shift a specific risk allocation, as lender due diligence reveals new issues. In these situations, it is important to assess factors such as how important the issue is to financial close, whether information was reasonably available to the bidder pre-bid and whether a material shift in the provision has a meaningful expected impact on the tariff.

[127] World Bank Group, "Policy Guidelines for Managing Unsolicited Proposals in Infrastructure Projects", August 2018, available at https://ppp.worldbank.org/public-private-partnership/library/policy-guidelines-managing-unsolicited-proposals-infrastructure-projects.

[128] As noted earlier, mini-grid concession arrangements might be organized around awarding of capital grants to qualifying proponents, rather than involving a competitive tender awarded based on a cost or price evaluation.

specific amounts of capacity and expected energy in a region, leaving it to bidders to identify sites and propose specific technologies and other details. Other procurements are much more specific in these respects. In the context of the PICs and BESS, in order to encourage bidder participation, it is recommended that detailed studies and analyses documenting project details should be prepared before commencing procurement (or at least before commencing Stage 2 of a two stage process). There may be some flexibility, such as with respect to the exact configuration and combination of generators and BESS in a mini-grid; the size, location, and technologies (other than BESS) for a customer-sited BESS project; or, size of BESS in a lease/rental procurement if the bidders' products come in pre-set sizes.

Except for C&I Customer-sited BESS projects, the project site is a critical detail for PICs BESS projects. Studies conducted prior to procurement of the other types of projects will have evaluated the suitability of the site in terms of site conditions, access, and grid connection. Mini-grid Concession projects would also include details on the island as well as location of customers and different generators. Even for C&I Customer-sited BESS projects, given the context of the PICs, the reality in the near-term is that the likely locations for such projects are known ahead of time, though the program incentivizing such projects would not provide this information.

Bidders will also benefit greatly from additional details on the project and site (especially if bidders are informed that they can rely on these detail) including:

i. topographical drawings and photos of the site;
ii. geo-technical and environmental studies as well as atmospheric data for the site; and,
iii. drawings of the project, network model, single-line diagrams, etcetera.

While not bid documents *per se*, bidders should be afforded the opportunity to visit the site, and if they wish, perform non-destructive testing on the site and any related facilities.

Legal Documents: The central legal document for power projects is the PPA, containing a description of the project, the services to be procured, and agreed terms. Other legal documents that are frequently included in the bid documents package include (as appropriate): documentation of site control (even if the site is provided by the procuring entity or the government); the grid code; government support or guarantee agreement; stapled financing and credit support package[129]; form of direct agreement; legal opinions from the relevant legal authority as to the legality of the proposed transaction; and, the project's technical specifications (if not contained as an annex to the PPA).

For most cases, the nature of services sought would be generally similar: finance, construct, and operate the project to provide energy/capacity/ancillary services. In some cases, concessional debt or grants may already be identified and earmarked. Mini-grid developers/operators may have to factor in the integration of existing assets owned by customers or the utility on an island.

For a C&I Customer-sited BESS project, the utility would only procure energy/capacity/ancillary services for a fixed term. Customers could supply contracted services using an existing asset or committing to build an asset to deliver those services. In the latter case, the customer would then conduct its own procurement to construct and operate the project.

The critical details lie in the technical and commercial terms for services to be provided. On the technical side, these could include obligations regarding equipment and software (technology, asset

[129] A stapled financing package is one that is offered to the winning bidder, often by development finance institutions, and attached (or "stapled") to the bid documents. The stapled package might include credit enhancement mechanisms such as a government guarantee (offered in conjunction with the lender package), first-loss facilities, and partial risk or loan guarantees.

life, vendors, warranties/guarantees); project completion timelines; the utility's obligations to construct interconnection facilities; minimum performance requirements; and decommissioning. For BESS, obligations on technology and minimum performance requirements must be detailed and cover specific technical parameters such as battery chemistry; ratings on power, energy, duration, ramp rates, and operational life (years or number of cycles); operational configuration requirements; maximum average degradation of rated power and energy from expected cycling; minimum round-trip efficiency; monitoring and communication controls; and measures for safety against fires and flooding risks.

The commercial terms of service mainly focus on the tariff: the tariff price components, escalation, and term. However, there are other terms that impact project bankability, such as curtailment rights for the project and utility; BESS charge/discharge rights, conditions, and dispatch protocol; minimum/maximum number of cycles per month/year; penalties for construction delays; penalties for under-performance or unavailability; and treatment of force majeure events. Other key issues addressed in the PPA are dispute resolution and a contract termination framework.

Bidder Instructions: Bidders are usually instructed to submit their responses in a standardized form to facilitate comparison of submissions. It is recommended to provide templates for required bidder submissions. Instructions guide bidders as to what detailed supporting information they need to include in their bid, which may include:

i. organization of the entities involved in the bid;
ii. parent company information and a support letter if the bidder is representing parent company financial or other support;
iii. documentation of corporate good standing;
iv. documentation of the bidder's representatives and their legal authority to represent their company in the bid;
v. detailed CVs of key staff;
vi. evidence of technical qualifications;
vii. evidence of financial qualifications and wherewithal, often including audited financial statements for the past three years and letters of interest from banks;
viii. a financing plan referencing the sources of equity and debt that have been documented, including a sources and used of funds;[130]
ix. OEM warranties;
x. insurances quotes (especially All Risk, with appropriate minimum coverages)
xi. health and safety protocols and records on similar projects;
xii. a technical proposal encompassing design, vendor quotes (for key equipment), construction plan, network diagram of the BESS system and SCADA points list (including a plan to integrate BESS with existing communication network), and a detailed Gannt chart schedule;
xiii. manuals and operation guides for all major equipment and systems;
xiv. a plan to provide training to utility and other stakeholders on the BESS component, potentially covering hardware, software, operations and maintenance, and emergency response procedures; and,

[130] Bidders often object to providing a sources and uses of funds on the ground that it may allow the procuring entity to back into a likely financial bid range, and using this information, potentially seek to unfairly exclude some bidders by failing them on technical grounds. It is indeed true that an accurate sources and uses of funds, together with information in lender letters of interest, can be used to develop a likely financial bid range (but not necessarily a very narrow range). The importance of being able to assess whether a bidder has a credible financing plan usually outweighs bidder concerns in these areas. It is also noted that bid evaluation design, including the constitution of a qualified and diverse evaluation committee, can help allay bidder concerns in this area.

xv. end of life disposal and recycling plan.

Key Commercial and Financial Issues: There are several items in this category, as discussed below.

PPA term: The PPA duration must be sufficient to cover the investors' capital and operating costs for the BESS structure in question. For BESS rental/lease projects, where rental companies can retrieve and re-rent or sell equipment at the end of the PPA term, rental terms would be expected to be in the range of five to ten years, somewhat longer than would normally be the case for diesel rentals. BESS + Solar IPP and Standalone BESS IPP structures would be expected to involve terms of 15 to 30 years, reflecting the expected lifespan of the technologies. BOT structures could involve shorter terms but BOO structures would need to be as long as possible, since project owners would have no realistic expectation in the PICs to be able to sell power once the contract ended to anyone else besides the original off-taker. Mini-grid concessions often involve relatively short terms, with options to extend if performance conditions are met. Five to fifteen years may be appropriate. C&I arrangements might involve annual to multi-year contracts, with the ability for the C&I provider to re-enlist in the program for as long as the program exists.

Off-taker credit and credit enhancements: The creditworthiness of the off-taker is a key bankability consideration for any project. Investors must be confident that the off-taker is financially strong enough to make payments and that they can repatriate their income if the source of investment is offshore. For longer term contracts, particularly for project financed transactions, the credit-worthiness of the off-taker represents a significant risk to the project. In the best case, weaker credit results in more expensive terms of financing, and therefore, higher bid prices; in the more likely case for most of the PICs, poor off-taker credit will lead to no bids at all or projects that fail to close on financing, unless credit enhancements are offered. The off-taker credit risks are likely so high for most utilities in the PICs that procurements for larger[131] IPP projects with long-term PPAs would not receive any bids without credit enhancement mechanisms. Therefore, depending on the credit risk profile of the off-taker, the tender process must also clarify what credit enhancement mechanisms are available.

Backing of seller's obligations: The procuring entity must be confident that the winning bidder can deliver the project on time and can stand behind any obligations for the duration of the contract. In this respect, typically, the PPA will specify payments by the seller under the PPA for failure to deliver the project on time, failure to deliver the required MW or performance, or for environmental mismanagement. Bidders generally will be required to post bid security (to avoid spurious bids) and operational security (to protect against the IPP's potential failure to meet obligations) in the form of guarantees from a creditworthy sponsor or parent company, bonds, letter of credit, or cash collateral.

Dispute resolution and termination provisions: The PPA must specify how disputes are handled. In developing markets, dispute resolution usually is handled as follows: a party takes a position on an issue in writing; the other party disputes that position; one or the other party gives notice of the existence of a dispute; the parties meet to try to resolve the dispute amicably; failing that, and only for disputes of a technical nature, the parties appoint a technical expert, who issues an opinion on the matter, which may or may not be binding; if a party challenges the opinion or for other reasons the dispute has not been settled, the dispute moves to binding international arbitration.

It is this last stage that is of most interest to investors and especially lenders to a project. The fundamental reason why the parties might agree to binding international arbitration is that it is

[131] Lenders may be able to accept lower quality off-taker credit for projects that are small in relation to the off-taker's balance sheet; and local or regional lenders (who could potentially get comfortable with higher off-taker risk than international commercial lenders), may be able to finance smaller projects without credit enhancements.

recognized that the private parties (equity and debt) may not receive fair treatment in a national court; this is particularly true when foreign investors are involved and the projects are perceived as large and important in the national market (common for power projects). Having recourse to binding arbitration gives investors comfort that they will receive a fair ruling. The next issue is how to enforce the ruling. Often, the state-owned utility counterparty has poor credit and may not be able to meet the financial obligations of an adverse ruling. This is why government guarantees or similar credit enhancing arrangements typically are required in challenging project finance settings: that is, the government will itself commit to pay under adverse rulings when the off-taker cannot pay. The problem, however, is that a ruling in a binding arbitration case does not, by itself, provide legal compulsion to the government to honor its guarantee. Consequently, lenders generally also require a waiver of sovereign immunity, allowing lenders to pursue the sovereign's assets in other jurisdictions if the government does not honor its guarantee.

In short, acceptable dispute resolution provisions and accompanying government guarantees (if applicable), and the related waiver of sovereign immunity, are of paramount importance to project bankability. Unfortunately for prospective project-financed PPP projects, these provisions often become intensely politicized, since guarantees and the waiver of sovereign immunity often require a cabinet level or parliamentary decision be taken. In many cases, good projects with reasonable requirements in these areas succumb to politically driven opposition.[132]

Key Technical Issues: There are several items in this category, as discussed below.

Technical specifications: BESS use cases for PICs generally fall into one or more of three categories: (1) energy and capacity; (2) ancillary services; and (3) distribution services. In some of the PICs, there may be behind-the-meter BESS use cases as well, focused on power reliability and quality. The required functionalities of a BESS for a particular grid will be affected by the level of VRE penetration on that system. For example, systems with very low VRE penetration can benefit from relatively short-duration batteries that provide cost-effective "spinning" and regulation reserves to improve grid stability and reliability, while also reducing fuel consumption. However, as VRE penetration increases, the need for longer-duration storage increases exponentially, and eventually (at very high VRE penetrations), result in unacceptably high incremental cost.

In this regard, it is important for the technical specifications of a BESS procurement to be flexible. Overly-specific technical requirements may deter vendors from bidding into the procurement – especially for relatively small projects on remote islands. In addition, particularly given the rapid pace of technological advancements in this area, technical requirements that are too specific may preclude consideration of new technologies that are technically superior to and/or more cost-effective than existing technologies. Moreover, since many of the PIC grids currently have very low VRE penetrations, the technical requirements of the grids themselves are likely to change significantly with the introduction of substantial levels of VRE resources.

Technical qualifications: The commercial deployment of BESS technologies is a relatively recent development, which to date, has been concentrated in electric grids that are more sophisticated than those found in the PICs. Indeed, the lack of BESS installations in the PICs is likely an indication that there is a limited number of vendors with extensive experience implementing BESSs on remote small island systems. However, a lack of experience on small islands *per se* should not in and of itself preclude a vendor from being considered.

[132] See discussion of recent IPPs in Palau, in Section 3.8.

Instead, the evaluation of a vendor's technical qualifications for BESS installations in the PICs should focus on the vendor's experience with small off-grid power systems such as mini-grids or microgrids, which are or can be isolated from larger electric grids. There are ample vendors with such experience. For example, as of 2020, there were over 5,000 installed mini-grids in Sub-Saharan Africa, Asia, and small island nations.[133] Similarly, the size of the global microgrid market surpassed USD 500 million in 2021, and is expected to continue growing.[134] Although there should be no shortage of vendors with mini-grid/microgrid experience, attracting them to the small PIC markets may pose a challenge unless projects on multiple small islands can be aggregated to add project scale.

Inverter-based technology: The transition to inverter-dominant, renewable power grids is driving new developments in power converter controls technology. Most installed inverter-based resources today interface to the grid through inverters that operate under a "grid following" control approach, which requires that the "grid" already be present.[135] In contrast, "grid forming" technology refers to an inverter control paradigm in which the inverters synthesize a voltage phasor to achieve the desired current and power flow, which enables the inverters to essentially provide the synchronizing source that forms the grid itself. As a result of increasing penetration of inverter-based technologies (e.g., solar PV, wind, batteries), many vendors are now offering and have installed grid-forming inverters for small-scale hybrid systems. Although grid-forming inverter technology is advancing quickly, currently it is difficult to run a 100% inverter-based system while maintaining grid stability.

Grid-forming inverters have capabilities beyond those of non-grid-forming inverters. For grids that are expected to achieve high VRE penetration in the near- to mid-term planning horizon, grid-forming inverters may be supportive of system reliability and resiliency (e.g., by providing black-start capability). However, expressly requiring the use of grid-forming inverters as part of a BESS procurement may add unnecessary costs for a technology that is still evolving. The application of grid forming inverters in the context of a grid with numerous other generating resources (either inverter-based or synchronous) may require detailed technical analysis to ensure effective operation and avoid adverse control interactions. Thus, overly specific technical requirements could deter bids, preclude more cost-effective alternatives, and result in premature investments that are not needed at this time.

Key BESS parameters: Notwithstanding the recommendation to avoid overly specific technology requirements, there are several specific parameters that should be required in a BESS procurement package including, at a minimum, energy capacity, power rating, roundtrip efficiency and expected service life. Additional requirements may include system response time/ramp rate, auxiliary power consumption, self-discharge rate, voltage range, frequency range, ride through requirements, volt-watt function, frequency-watt function, volt-var function and limiting of overvoltage contribution. Key parameters addressing hazard mitigation and safety should also be included.

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[133] *Sustainable Energy for All*, "State of the Global Mini-grids Market Report 2020, Trends of renewable energy hybrid mini-grids in Sub-Saharan Africa, Asia and island nations".

[134] *Market Watch,* "Emerging Trends in Microgrid Market 2022".

[135] The term "grid" as used here is referring to electrical characteristics of the grid, specifically system inertia, not to the wires themselves. Inertia in power systems refers to the energy stored in large rotating generators and some industrial motors, which gives them the tendency to remain rotating. Historically, inertia from conventional fossil, nuclear, and hydropower generators was abundant—and thus taken for granted in the planning and operations of the system. However, increasing penetration of inverter-based resources – e.g., wind, solar PV, and BESS – that do not inherently provide inertia may be characterized by low grid inertia due to the lack of frequency containment provided by synchronous generators.

4.1 VRE + BESS IPP

A VRE+BESS IPP in the PICs would be a standard IPP structure. The project would have a long-term PPA with the utility and deliver renewable energy from the VRE generators. The BESS component could be used to firm the variable dispatch of VRE generation, provide capacity or ancillary services, or store renewable energy generation from the VRE component to dispatch during peak demand (time shifting). The value of the BESS component can differ by different PIC grids and timelines (near-term vs. longer term).

A VRE + BESS IPP structure would be relevant for: (i) both main grids on RMI – Majuro and Ebeye; (ii) the Viti Levu grid and the Lavasa grid on Vanua Levu in Fiji; (iii) Badeldaob grid in Palau; (iv) Upolu grid in Samoa; and (v) Guadalcanal grid in Solomon Islands.

Technical Considerations: The VRE + BESS IPP structure has been identified as a potential PPP structure for one small grid with a peak demand between 1.42 MW (i.e., Ebeye); four medium sized grids with peak demand between 5 and 16 MW (i.e., Labasa, Babeldaob, Majuro and Guadalcanal); and two large grids with peak demands up to 180 MW (i.e., Upolu and Viti Levu).

One of the geographical features that distinguishes Ebeye from the other islands covered by this structure is its very low elevation above sea level. In this regard, suitable locations, prohibited locations, rooms and enclosures, and protection against environmental conditions for BESS are discussed in “Annex: Technical Assessment”. Given the potentially large investment in the BESS, consideration should be given to even more stringent requirements than those provided in “Annex: Technical Assessment”.

In FSM, the Department of Resources and Development issued an invitation for bids in May 2020 to supply and install various projects in two separate lots for Yap and Kosrae, which included a standalone BESS facility to be installed at the same location as an existing diesel plant in Yap.[136] Options for VRE + BESS IPPs should also evaluate adding BESS to existing power plants, especially VRE plants, to take advantage of interconnection and other facilities that are already in place.

All proposed projects should be required to meet the requirements of the International Electrotechnical Commission (IEC) International Standard 62933 on Electrical Energy Storage Systems. Projects connecting at the distribution level should be required to meet the requirements of the Institute of Electrical and Electronics Engineers (IEEE) Standard 1547-2018. With respect to Upolu and Viti Levu, projects connecting at the transmission level should be required to meet the requirements of IEEE 2800-2022.

Economic Considerations: Under this structure, the BESS component would be used predominantly - at least in the near term - to firm the variable dispatch of VRE generation and/or provide ancillary services as needed.

Ebeye has a peak demand of only 1.42 MW, and little or no VRE generation. As a result, there is no current need for energy shifting on Ebeye, making the island a good candidate for a small, high-power, low-energy (e.g., less than one hour) BESS to enable the grid to accommodate VRE resources in the future. However, given Ebeye’s target of 50% RE by 2025, consideration should be given to a longer

[136] Source: https://kosraepower.com/files/IFB-YSPSC-KUA-ADB-signed-May-4-2020.pdf. Note that this is not a Standalone BESS IPP; the RFP is simply for supply and installation of the facilities.

duration battery (e.g., four hours) to enable future capacity deferral, fossil retirement, energy shifting and curtailment mitigation.

Considering the small size of the Ebeye grid and expected BESS sizing, the incremental costs of a longer duration (four hours) BESS would be significant compared to the cost of the entire system. It may be prudent to initially add a small, high-power, low-energy BESS designed to enable the developer to expand the energy storage capacity of the BESS over time as system requirements change and BESS costs decrease.

Like Ebeye, the medium-sized grids on Labasa, Babeldaob, Majuro and Guadalcanal have little or no VRE generation, making these islands good candidates for high-power, low-energy BESS to prepare these grids for renewable energy in the future, or longer duration BESS to enable future capacity deferral, fossil retirement, energy shifting and curtailment mitigation. In the case of Labasa, Fiji's goal of 100% RE by 2030 will require very long duration storage (e.g., exceeding eight hours) or other more cost-effective sources of firm renewable capacity.

The medium-sized grids are large enough with little VRE penetration that the BESS component of initial VRE + BESS IPP projects need not be designed to add energy storage capacity over time, as in Ebeye. Additional projects will have to be implemented over time to meet the RE generation needs and consequent BESS requirements for other benefits beyond firming the intermittent VRE dispatch.

The much larger grids on Upolu and Viti Levu have current RE penetrations of 44% and 64%, respectively, and both islands have future 100% RE goals. Tempered by relatively firm hydropower resources, four to six-hour BESSs would enable these systems to reach RE penetrations of 90-95%, respectively, while significantly mitigating future curtailment on these systems. However, reaching 100% RE on these islands will require long duration energy shifting (e.g., over 100 hours) unless other more cost-effective sources of firm renewable generation can be brought online. In addition, in the case of Viti Levu, Fiji's grid code requirement that generation facilities greater than 250 kW have ramping capability could improve the value proposition for VRE + BESS IPP projects.

Contracting and Financial Considerations: For projects where the BESS is used mainly to firm up VRE generation, the PPA can consist of just an energy component and be of a length typical for VRE + IPP projects: 15 to 25 years. The utility would have limited dispatch authority over the BESS. The IPP dispatches BESS to meet the power firming requirements as outlined in the PPA. For other BESS use-cases, the utility could dispatch the BESS for ancillary services.

The project developer may be the same entity as the EPC contractor and plant operator, or these two parties may be separate entities bound by contractual agreements. The EPC contractor should have established relationships with BESS manufacturers to ensure smooth implementation of projects. BESS manufactures can also advise the developer on operating the BESS component as part of their service package.

As part of the procurement process, bidders must receive information on the revenue contracts and submit details on their organizational or contractual relationships with entities that provide equipment supply, financing, construction, operations, and maintenance.

VRE + BESS IPP projects can be financed through either project finance (off-balance sheet) or corporate finance (on-balance sheet). Project financing can enable a broader spectrum of private sector participation – project developers, equity investors, EPC and O&M contractors, insurance – but adds to project costs due to structuring complexity. Bankable project financing also requires the off-taker to be creditworthy or backed by credit enhancements like guarantees, which also add costs.

Furthermore, the benefits and value of the BESS component, which is inherently difficult to precisely forecast, must nonetheless be packaged into a PPA that provides predictable revenue streams. Therefore, projects with larger BESS components will likely require some fixed capacity payments to ensure cost recovery.

It is likely that this structure would be implemented with balance sheet financing for projects on small- and medium-sized grids because they lack sufficient scale to justify the costs and complexity of project financed transactions. The provision of grants to offset some of the soft costs and BESS costs may be necessary help make VRE + BESS IPP projects financially viable.

Such financial support to the utilities already exists in several countries. In RMI, both the World Bank and ADB have supported or plan to support generation assets. The World Bank's support includes financing solar PV, BESS, and grid management equipment in Majuro as well as financing gensets in Majuro and Ebeye to help accommodate planned solar capacity. ADB's Solar Plus Project is evaluating hybrid solar PV + BESS project. The government of RMI also provides cash support to both utilities through the National Energy Support Fund to support capital cost recovery.

In Palau, two VRE IPPs, one with BESS, failed to close because guarantee arrangements were rejected by authorities.[137]

In Solomon Islands, the 15 MW Tina River Hydropower Project is being developed under a BOT model, with a PPA backed by a government guarantee.

Procurement Process: As detailed previously, the procurement process for this structure is likely to be the most intensive in terms of details and documents required for bankable projects. A two stage process is recommended.

For projects in RMI, Palau, and Solomon Islands, the procurement documents should include information on guarantees and financing support available from development partners or the government. The type and size of the credit enhancement and financing support should be determined as part of the feasibility studies for those projects or a broader initiative on developing a strategy for public financing support that improves on the *ad hoc* support that already exists.

Bidders should be able to demonstrate prior experience on three to five similar projects – similarly sized or larger IPPs. VRE experience is not required, but preferred (extra points could be awarded), since VRE technology is generally simpler to implement than other generating technologies. Similarly, BESS experience is not required, but preferred, since in a VRE + BESS configuration, the BESS component is easy to integrate. Also, note that the relevant experience in these areas is largely technical and largely at the EPC level; therefore, a developer without its own VRE and/or BESS experience should be able to document qualifications through its proposed EPC contractor, with an accompanying letter documenting the bidder's relationship with that EPC contractor. As discussed earlier, prior experience working in island grids in the Asia Pacific region should not be required (but could be preferred). What is relevant is experience in developing markets and ideally small grids.

Bidders must meet minimum financial qualifications tied to the size of the project and anticipated economic commitment. These may include, for a hypothetical 1 MW project: minimum net assets of the developer of at least USD 3 million; experience as the project sponsor in raising the equivalent of at least USD 10 million in total financing for previous projects; provide consolidated audited financial

[137] See Section 3.8.

statements for the past three years[138]; and demonstrate ability to post Letter of Credit or parent company guarantee or other security.

4.2 STANDALONE BESS IPP

The IPP structure could also be used to procure, finance, build, and operate a BESS-only project. The structure is like that of a VRE + BESS IPP, except that the PPA must address charging of the BESS. Although a Standalone BESS IPP would not provide renewable generation, it could help integrate more VRE on a grid by providing capacity and ancillary services to the utility.

In the context of PICs, the Team considers this structure to be relevant for the Viti Levu grid in Fiji, Palau (if problems finalizing guarantee arrangements can be resolved), Samoa, and Tonga.

Technical Considerations: Proposed Standalone BESS IPP projects should be required to meet the requirements of the IEC 62933. In addition, projects connecting at the distribution and transmission levels should be required to meet the requirements of the IEEE 1547-2018 and IEEE 2800-2022, respectively.

Standalone BESS IPP projects require a greater degree of technical capacity from the utility to fully capture the values of BESS. The sizing of the BESS component should be informed by the location on the grid where it is expected to be implemented and the specific benefits that it is expected to provide the utility. Compared to a VRE + BESS IPP, a Standalone BESS IPP project has a much smaller physical footprint, making it more suitable to be implemented in specific locations where the BESS can deliver the greatest benefit.

Economic Considerations: Although less common than VRE + BESS projects, Standalone BESS projects can be cost-effectively implemented, particularly on larger power systems such as Viti Levu's (which has a peak demand of 180 MW) where economies of scale can be realized. For example, if Viti Levu uses solar PV resources to increase its RE% to 85%, a 250 MW, one-hour BESS would reduce curtailment from 21% to 6%. However, as the RE% approaches 95% and beyond, the ability of the BESS to address curtailment will result in increasing marginal costs and diminishing returns.

Standalone BESS projects are currently expensive when compared to other generation technologies in purely $/kW or $/kWh terms. However, their costs must be evaluated against the value they provide prior to conducting the procurement: (i) RE goals (absorb higher levels of RE); (ii) utility economics (reduce RE curtailment - avoided costs of diesel use offset), optimize use of diesel generators (lower fuel costs), lower losses (avoided costs of generation); and (iii) value to customers (improved power quality and reliability).

The grid on Viti Levu island in Fiji already has storage hydro capacity as well as run of river hydro. But Standalone BESS IPP could be explored to add additional storage capability to optimize use of run of river hydro generation and diesel generation to lower fuel costs.

The relevance of Standalone BESS IPP projects will likely increase as renewable penetration increases at the expense of existing thermal generators. Future VRE power plants will be geographically limited to areas with the best resources, which may not coincide with current load centers and transmission

[138] Some jurisdictions, such as the US, do not require companies prepare audited financial statements, and smaller and privately held companies tend not do not do so. Requirements should be flexible in this respect, allowing alternative verification approaches where applicable.

infrastructure. Consequently, Standalone BESS IPP projects could increasingly provide significant grid support value to the utility.

Contracting and Financial Considerations: In the context of PICs, a tolling structure where the utility manages both charging and discharging of the BESS and makes fixed monthly payments to the IPP is likely to be the most viable contractual arrangement.

A fixed long-term contract could create some risk of PPA repricing if battery costs continue to fall rapidly, and initial projects are expensive compared to later vintage projects. A contract in which the fixed payments periodically step down could help mitigate this risk, though at the cost of higher initial fixed payments.

This structure is more likely to rely on on-balance sheet financing compared to VRE + BESS IPP structures, unless there is support from development partners. A PPA for a standalone BESS project that is high and stable enough (capacity payments) to be bankable and ensure sufficient returns is less likely to be appealing to utilities because of BESS capital costs.

Procurement Process: A two-stage procurement process is recommended for a Standalone BESS procurement. Overall, the procurement documents are expected to be like those in the VRE + BESS IPP structure, but without having to address the added technical complexity of multiple technologies. There would be greater emphasis on the technical parameters of the BESS, its operational capabilities, and training programs for the utility to maximize use of the BESS facility.

The technical qualification requirements are like those of VRE + BESS IPPs, except more focused on similarly sized or larger BESS projects, whether as standalone projects or projects co-located with VRE.

The financial qualification requirements also would be like those of VRE + BESS IPPs, with the amounts adjusted to reflect the total project costs.

4.3 BESS LEASE/RENTAL

This structure would replicate the utilities' practice of renting diesel-fired gensets but would be implemented as a short-term version of the Standalone BESS IPP. Unlike the IPP structure, this structure is more likely to feature used BESS facilities being redeployed.[139]

In the near-term, the Team views this structure as the most applicable in the following PICs: (i) all four main grids in FSM as well as outer islands in Kosrae and Pohnpei; (ii) both main grids in RMI; (iii) Funafuti grid in Tuvalu; (iv) all grids in Fiji; (v) Tarawa grid in Kiribati; (vi) Nauru; (vii) Upolu grid in Samoa; (viii) Guadalcanal grid in Solomon Islands; (ix) Tongatapu grid in Tonga; and (x) Efate and Espiritu Santu grids in Vanuatu.

Technical Considerations: The procured equipment must be sized according to the needs of the particular system into which it is integrated. For example, the existing power systems of Tuvalu, FSM, RMI, Kiribati, Nauru, Tonga, Vanuatu and the Solomons all have RE penetrations of less than 20%,[140] and therefore can be characterized as falling under Phase I of BESS deployment, in which high-power, low-energy BESS can provide cost-effective "spinning" and regulating reserves to prepare/enable those systems for more VRE resources. However, particularly for the Phase I systems with peak

[139] The RFP would need to specify whether used equipment (with an appropriate warrantee) would be acceptable.

[140] Palau also has a RE% of less than 20% but was not identified as a candidate for the BESS Lease/Rental structure.

demand less than 10 MW (i.e., Tuvalu, FSM, RMI, Kiribati and Nauru) consideration should be given to pursuing a larger “one and done” Phase III procurement that also enables capacity deferral/fossil generation retirement, as well as energy shifting and curtailment mitigation. Recall that the Lease/Rental structure will include a purchase option at the end of the rental term, such that the utility can expect to keep the equipment for its normal operating lifespan.

In contrast, the systems on Upolu and Viti Levu, which have RE penetration rates of 44% and 64% respectively, can be characterized as already falling under Phase III of BESS deployment, where the role of the BESS is focused on energy shifting and curtailment mitigation, and therefore requires longer-duration storage. Notwithstanding their utilization of relatively firm hydropower, these are also much larger systems, and therefore will require much higher capacity batteries than in the smaller systems that are still in Phase I.

BESS rental suppliers can also be required to provide training to the utility on optimally integrating and operating (dispatching) the BESS. Such training should also cover BESS hazards as discussed in “Annex: Technical Assessment”.

Proposed BESS Lease/Rental projects should be required to meet the requirements of the IEC 62933. In addition, projects connecting at the distribution and transmission levels should be required to meet the requirements of the IEEE 1547-2018 and IEEE 2800-2022, respectively.

Economic Considerations: Lease/Rental arrangements typically deliver value to the utility by (i) leveraging standardized terms for a “plug and play” approach to streamline the procurement process; and (ii) negating the need to commit to a long-term contract for an asset type that may not be fully understood by the utilities. The latter point also obviates the need for IPP/PPP enabling conditions and to a large extent, the need for major credit enhancements, since the lessor is exposed for a shorter term and can recover the equipment if needed (BESS is portable, solar PV arrays, wind turbines, and large power plants tend to be less easy to recover).

However, since the rented BESS asset may be required to deliver a wide variety of services depending on system size and VRE penetration, it is important to ensure that the standardized terms for a “plug and play” approach be flexible enough to cover different use cases of BESS or have multiple customized versions of standardized terms for each use case.

There are examples of financing support from development partner for standalone BESS projects in PICs. The procurement in FSM with ADB financing support to supply install, among other facilities, a BESS facility at an existing diesel generation plan in Yap. The World Bank’s Sustainable Energy Development and Access Project for FSM includes a 1 MWh BESS and energy management system to reduce curtailment in Kosrae. In Samoa, EPC has already installed BESS projects and a microgrid controller with the help of ADB, JICA, Government of Australia, and the Government of New Zealand to manage/regulate the operations of its plants and IPP solar plants. In Tonga, TPL is developing two standalone BESS projects with ADB financing for grid stability and load-shifting.

Such initiatives could be an opportunity for the BESS Lease/Rental structure. Support from development partners could be redirected towards additional VRE capacity as well as BESS lease/rental payments. In the short-term, this benefits the utility because the additional VRE capacity helps to lower fuel usage from diesel generators. The short-term BESS lease payments can also be lower (in aggregate) than overall capital costs of a new BESS facility.

Contracting and Financial Considerations: The contracting arrangements are likely to be based on a combination of fixed monthly rental fees and usage fees to cover BESS degradation. There may also be additional deployment and decommissioning costs to cover the costs of deploying and removing the asset.

In the context of PICs, the financial challenges are likely to be smallest in the BESS Lease/Rental structure, given the rental company faces lower risks, as a function of the shorter initial term for this structure, and the ability to retrieve the assets in the event of a dispute of failure to pay.

Procurement Process: Procurement for BESS Lease/Rental should be a streamlined process, like those already run by regional utilities for rental diesel gensets. There would need to be additional provisions related to the technical characteristics of BESS technology, and to the capacity building anticipated to be packaged with these rentals; there might also need to be modest additional credit support provisions to reflect the higher capital cost of this technology, longer lifespan, and longer rental term than normally is the case for diesel rentals.

Technical qualifications should focus on technical BESS experience without necessarily requiring BESS rental experience. Similarly, financial qualification requirements should focus on performance warranties/guarantees offered.

4.4 MINI-GRID CONCESSION

The Mini-grid Concession structure has been identified as a potential PPP structure for the outer islands of Chuuk, Yap, Majuro, Tuvalu, Tonga, Vanuatu and the Solomons. Under this structure, the concessionaire would receive the right to supply an outlying island (or islands) in exchange for committing to provide a specified level of service.

Technical Considerations: The outer islands that have been targeted for this PPP structure vary greatly in terms of existing electrical infrastructure. For example, Tuvalu already has solar-battery-diesel mini-grids; Majuro has diesel-powered mini-grids with plans to add solar and battery systems; Chuuk and Yap have SHS and diesel mini-grids, with plans to install more-mini grids; and many of the other islands have no electricity at all or rely on their own diesel gensets for power. Therefore, procurement for mini-grid concessions must be tailored for specific conditions in each outer island.

For mini-grids in isolated outer islands, the importance of robust enclosures will be magnified, as the mini-grid equipment will represent a single point of failure on which an entire island may rely for electricity. Adequate locking mechanisms and signage will also be important for the mini-grid equipment, not only to prevent tampering, but also for the safety of neighboring inhabitants. Moreover, in the case of atolls, care should be taken to install the equipment at an elevation that is not susceptible to seawater inundation in the event of a storm.

Economic Considerations: Mini-grid concessions are often granted for unserved or underserved areas. The concession would free the utility from the financial implications of serving low revenue, high-cost customers. Experienced mini-grid developers and operators may be able to design a more optimal solution for the outer islands. However, the concession documents must clarify how the utility’s existing assets in the concession area would be treated: purchase by the concessionaire at a regulated price or a free transfer to the concessionaire.

The main economic benefit of a mini-grid concession is to bring in capital so that each mini-grid can be optimally designed and operated by a specialized mini-grid operator with more suitable expertise than a utility that is stretched thin.

The project economics for mini-grid developers is driven by whether the approved tariff level for end customers and subsidies from development partners and government is sufficient to cover the capital and operating costs (including non-payment risk from micro-grid consumers). A large anchor customer is also helpful for project economics. On Chuuk state in FSM, Vital Group is developing a mini-grid to supply its coconut processing facility but also has a PPA with CPUC to supply electricity to the local community. Vital Group benefits from avoided bill payments to CPUC and reliability of power supply at the plant. The CPUC PPA provides greater revenue certainty and reduces non-payment risk relative to community members.

Contracting and Financial Considerations: The primary revenue source for mini-grid developers/operators is electricity sales. Typically, the existing tariff does not come close to covering existing costs for utility operated mini-grids, making subsidies from government or development partners necessary, typically in the form of capital grants.

The developer should be informed of the concession process and arrangement, the tariff or the tariff-setting process, and the terms and conditions of the available subsidies at the start of the procurement process. There could be flexibility to vary the exact level of subsidy payments based on the developer's demonstrated costs.

There is strong support from development partners for mini-grids. The FSM tender under ADB's FSM Renewable Energy Development Project includes a hybrid mini-grid for Walung Village in Kosrae. The World Bank is also support hybrid micro-grids with BESS in FSM (Udot and Satawan) through the Sustainable Energy Development and Access Project, and in Solomon Islands through the Electricity Access and Renewable Energy Expansion Project . The New Zealand government provides funding support to add solar PV and BESS to diesel micro-grids on outer islands in Tuvalu.

In a Mini-grid Concession model, similar support could catalyze the activity of private micro-grid developers that have the experience in deploying BESS as part of hybrid micro-grids and can mobilize some private capital, allowing public financing to go further.

Procurement Process: Detailed studies must first be conducted to determine which islands are suitable for the Mini-grid Concession model, their likely size and configuration, feasible tariff level, and the level of public financing support available. An initial general prequalification process to identify an approved list of bidders that would participate in subsequent tenders for specific projects.

The project documents would need to include more socio-economic data on the end-customers on the island, so that the bidders can assess the customers' electricity demand and ability to pay. This would help to determine end-customer tariff and subsidy levels.

Bidders must demonstrate prior experience in developing and operating mini grids, ideally with the type of generation assets envisioned: a combination of solar PV, diesel gensets, and BESS. Bidders must demonstrate relationships with BESS manufacturers – solar PV and BESS equipment manufacturers – as well as software providers that help to operate the mini-grid.

The financial qualifications for bidders should be greater than for the other PPP structures, relative to the size of the project in terms of total costs. Mini grids entail greater complexity and would also be the only source of electricity supply for its customers on the island. This calls for greater financial wherewithal to guarantee minimum level of operations and service.

Financing for mini-grid concessions is likely to be on balance sheet for the developer/operator.

4.5 C&I CUSTOMER-SITED BESS

This PPP structure seeks to utilize behind-the-meter BESS assets installed by C&I customers and give them additional incentives to do so with availability-based payments for allowing the utility to deploy the BESS for grid support services during pre-defined hours and conditions. The primary value of the BESS facility for the customer would come from back-up power supply to the customer. Payments from the utility for grid support services (if included in arrangements) would be an added incentive to facilitate BESS deployment.

This structure has been identified as a potential option for: (i) all four main grids in FSM; (ii) Viti Levu grid and the Lavasa grid on Vanua Levu in Fiji; and (iii) Efate grid in Vanuatu.

Technical Considerations: BESS projects under this structure that are grid-connected would connect at the distribution level and therefore should be required to meet the requirements of the IEEE 1547-2018.

The program to implement C&I Customer-sited BESS would be available to customers in the Commercial or Industrial tariff categories (or equivalent higher voltage service categories).

Depending on the expected profile of customers that are likely to participate in such a program, the utility should specify the minimum capacity and storage duration of BESS, other technical parameters of BESS, as well as applicable technologies and vendors. Additional communication equipment would also be required for the utility to be able to dispatch the BESS. It may also be prudent to have joint trainings on operating the customer-sited BESS between the customer, its BESS manufacturer and/or O&M contractor, and the utility.

Economic Considerations: Under this structure, C&I customers would install their own BESS to provide backup power to their facilities, increase behind-the-meter renewable energy utilization (with a corresponding decrease in energy purchase from the grid), and potentially provide grid support services to the utility in exchange for monetary compensation (should such utility instituted programs be available). Grid services can be leveraged to provide value to utility operations in several ways or "use cases," including but not limited to frequency regulation, regulating reserves, contingency reserves, and firm capacity.

For grid-connected arrangements, it is important to limit the utility's use of BESS to a pre-defined time or have an annual cap on the number of times it can charge/discharge the BESS. This is helpful for the customer to understand expected BESS degradation from the utility's use and also manage its own use of BESS around those hours. The utility can be required to make additional payments to the customer for dispatching the BESS beyond the established hours and cycling limits.

The availability payments to the customer should be based on the value to the utility rather than the needs of the customers to make the BESS project viable. Customers that can extract more value from the BESS in terms of backup power supply would generate greater returns from this structure and be incentivized to install larger BESS facilities.

There are a number of C&I customer-sited/owned BESS that have been implemented in Hawaii. For example, to address expected capacity shortfalls arising from the imminent retirement of fossil-fueled generators on Oahu and Maui, HECO (the local utility) recently launched a new "Battery Bonus" program in the summer of 2021, under which the utility provides cash incentives and bill credits to customers on Oahu and Maui who add behind-the-meter energy storage (a battery) to their existing or new rooftop solar systems, and commit to discharge their capacity to the grid for a two hour period between the hours of 6:00 to 8:30 p.m. The amount of committed capacity eligible for the program is capped at 50 MW on Oahu and 15 MW on Maui. Customers accepted in the program for the first 15 MW of committed capacity on Oahu and Maui receive $850 per kW. Customers who sign up for the next 15 MW and last 20 MW of committed capacity receive $750 and $500 per kW, respectively. In addition, customers receive a $5 per kW monthly peak capacity payment (in the form of a bill credit) for the ten-year duration of the program.[141]

Contracting and Financial Considerations: The C&I customer would finance, procure, and construct the BESS facility based on a combination of its own needs and the utility incentive payment program, which would have standardized terms and conditions. The payments from the utility may be received as bill credits (e.g., as is done in Hawaii).

The benefit of this structure is that it leverages the balance sheet of the C&I customer. The availability payments from the utility do not have to provide full capital cost recovery, since the C&I customer is expected to attribute value to having the BESS at its site, providing backup power and improved power quality. The C&I customer should have an O&M arrangement in place, with the BESS OEM or a separate service provider, to ensure smooth utilization of the asset.

Procurement Process: There are two related procurement processes in this structure: (i) the utility's procurement of services from customer-sited BESS facilities (for grid-connected projects); and (ii) the C&I customer's procurement to construct and operate the facility. In the near-term in PICs, a utility's procurement of ancillary services from C&I customers is likely to be through bilateral discussions; the customers are likely to already be considering adding BESS and other generation resources behind the meter, like solar PV or diesel gensets. In the medium- to long-term, when the penetration of behind-the-meter batteries is higher, utilities in the PICs may also be able to implement programs like the "Battery Bonus" program in Hawaii.

The procurement process of the C&I customer does not have to be as rigorous but must be aligned with the utility's technical requirements regarding the BESS facility.

The utility may impose technical qualifications on eligible customers in the form of minimum energy demand, as well as on the technical parameters of the BESS equipment and the qualifications of their O&M consultant.

The utility may restrict eligibility to C&I customers in good financial standing and without overdue utility bills.

4.6 REGIONAL STRATEGY

This section presents a regional strategy for increased BESS development in the PICs. Many of the recommendations themselves[142] also would be directly supportive of various other desirable objectives, such as increased VRE penetration and increased private sector participation in the electricity supply industry. The focus of the analysis is on (i) identifying the specific actions that the

[141] See: https://www.hawaiianelectric.com/products-and-services/customer-renewable-programs/rooftop-solar/battery-bonus.

[142] In other words, the recommendations would be directly supportive of these other objectives, as opposed to BESS facilities indirectly supporting these other objectives (which also generally is true).

donor community, including the World Bank Group, can take to encourage private investments in BESS in the region, and (ii) proposing regional approaches to pursue the specific actions identified.[143]

4.6.1 ACTIONS TO SUPPORT BESS

As presented in Section 2.1, Table 6, of this report, BESS PPPs in the region would require several enabling conditions to be met, including: legal / regulatory clarity, acceptable off-taker credit, project scale, institutional capacity, and capital market and developer interest. Donors can support the meeting of these enabling conditions, through actions such as those listed below.

1. Improve policy, providing direction to PIC governments and utilities on relevant planning activities and undertakings. The analysis for this report found that policies in the region are broadly supportive of BESS, to the extent that BESS assists the PICs' aggressive renewables penetration objectives. Some PICs' power sector policies or expansion plans/roadmaps mention BESS specifically and some mention encouragement or consideration of mechanisms for private investment in the electricity supply industry. In other countries, PPPs/IPPs are permitted under electricity laws. Specific mention of BESS in technical and commercial policies for the electric power industry should be encouraged, though it should be recognized that many PICs are extremely small and tend not to develop detailed policies or detailed laws and regulations; in this respect, improved policies are a supportive, rather than requisite, enabling condition in the region. Below are several examples of policy support.
    a. BESS technical policy: Require utilities to evaluate use of BESS to offset diesel use. This would be more relevant to islands with higher RE penetration – Yap (FSM), Viti Levu (Fiji), Upolu (Samoa), where BESS can optimize RE generation on the grid to displace diesel generation. The policy could also direct utilities to consider co-locating BESS projects with diesel plants, as was done for an FSM (Yap) tender for an ADB-funded project, and for Fiaga power station in Samoa. The policy potentially could encourage deployment of advanced distribution grid operations hardware and software controls with development partner support to be able to manage multiple smaller customer-sited BESS projects (C&I, EVs once penetration increases).
    b. BESS incentives policy: For PICs with utility-scale VRE projects already online, offer PPA adders to add BESS to their projects, e.g., in Palau and Samoa.
    c. Private sector participation policy: For PICs where private sector participation is not currently allowed, the policy could simply state that private sector participation is desirable and identify plausible areas for legal and regulatory changes. For PICs that already allow some private sector participation, the policy should encourage higher levels of such participation through PPP structures, identify any necessary legal / regulatory changes, and direct relevant authorities to enable such structures. For PICs where IPP structures are feasible, the policy should note the strategic benefits of achieving largescale private investment in renewables, and that credit enhancements including government guarantees and related measures might be necessary to secure such investments.
2. Improve legal / regulatory frameworks. Currently, IPPs/PPPs are not specifically allowed by law in Kiribati, RMI, Nauru and Tuvalu. In FSM, IPPs are not addressed at the federal level, and only one state's electricity law (Pohnpei's) expressly allows IPPs; it is not clear, however, that private IPPs

[143] One approach that was considered is organizing a regional BESS procurement. It was decided that such an undertaking would involve immense coordination challenges: how to coordinate the BESS need (MW, hours of storage, other technical capabilities), timing, scope (types of training), studies, and contracting structures (e.g., Standalone IPP or Mini Grid Concession), across multiple distinct markets, each with their own laws and regulations. Indeed, such an approach was found implausible even across any two PICs.

(rather than quasi IPPs owned by SOEs) are permitted in that state. At a practical level, the federal prohibition on foreign ownership of business and land constitutes a significant obstacle to increased private participation in the power sector in FSM. Donor work on improving legal frameworks should be realistic about what sorts of private investment/PPPs could plausibly be achievable in these markets, reflecting the detailed discussion of each PIC in Section 3. For instance, it is not realistic to pursue enabling Standalone BESS IPPs or VRE + BESS IPPs in Nauru and Tuvalu, based only on the small size of those markets. For FSM and RMI, it would be helpful to enable at a minimum the quasi IPP structure found on Pohnpei, and ideally, amend laws to allow foreign ownership of companies in the electric power industry. In Tuvalu, laws could be adopted/amended that would facilitate private investment in an aggregated mini grid covering service in outlying islands. Net metering laws or regulations facilitating the C&I BESS structure could be developed for some PICs.

3. Provide technical studies. Donors can offer (as they have been, in various PICs) engineering/economic studies to identify specific BESS needs in the near-term and to quantify the BESS value added to utilities. These studies probably should be in the form of detailed grid expansion plans incorporating BESS, VRE and renewables. The BESS components in these studies should be detailed enough to be potentially included as the technical specifications in a procurement, be it for the BESS itself or as a BESS PPP.
4. Conduct a market sounding exercise, to ascertain the degree of interest of renewable and BESS developers, rental companies, BESS vendors, and lenders (development banks, DFIs, regional and international commercial lenders) to invest time and potentially money in PICs' BESS opportunities. The market sounding should solicit participants' views on what enabling conditions are most important (ideally, in specific markets) in the region, any lessons learned from activities in the region, and which types of structures and procurement approaches would be of most interest or most challenging.
5. Provide BESS IPP/PPP structuring studies that would develop the details of a PPP structure and prepare a draft procurement package for a given jurisdiction and one or more BESS projects.
6. Provide transaction support for specific procurements, under which the consultant would assist in taking a project through an entire procurement process, start to finish. That is, the TA could begin with issuance of an RFQ and end upon commercial/financial close. Transaction support could also be packaged with the structuring studies above, as an optional second phase of work.
7. Develop credit enhancement mechanisms with donor support and sovereign government participation to address offtaker credit risk and facilitate IPP projects.
8. Prepare outline template procurement packages and legal agreements (e.g., PPAs, etc.) matching the different PPP structures identified in this report. Since the documents would need to apply across multiple jurisdictions, there would be a need for local lawyers in specific jurisdictions to finalize the documents, likely with international legal support. The templates, therefore, would provide guidance on requirements in the normal contractual areas, rather than the precise language. For the C&I BESS structure, the work would develop the program structure and simple agreements between the utility and participating C&I customers rather than a procurement package. For the BESS Mini Grids structure, the work would focus on developing a program under which mini grid developers would qualify to receive a capital grant and any other incentives for specific mini grids, as well as an associated milestone tracking and monitoring framework.
9. Provide capacity building, addressing technical aspects of integrating and operating BESS, and as appropriate, competitive procurement processes, PPP and IPP structuring, project finance basics (to understand the needs of IPPs/PPPs), and PPP monitoring and management.

4.6.2 REGIONAL APPROACH TO PROVIDE SUPPORTIVE ACTIONS

As detailed throughout this report, the PICs are small, widely dispersed, and feature varied legal and regulatory structures. In addition, power grids range considerably from extremely small to moderate utility sizes for some of the more populous PICs; some grids involve a mix of generating resources, including hydro, and others are essentially all diesel, with small amounts of VRE. In other words, there is no "one size fits all / one structure fits all" approach to supporting private investment in BESS in the PICs, through the actions identified in the previous section. Nonetheless, there are important regional commonalities, particularly across different groupings of PICs, that suggest a regional approach to the objectives could be effective, as outlined below.

Many of the actions presented in the previous section could be pursued efficiently as regional technical assistances (TAs). For instance, the market sounding would make most sense on a regional basis, as each national or sub-regional market sounding would essentially duplicate the task at the regional level. The policy and legal framework support (items 1 and 2 from the section above) could build on donor outreach to specific PICs as to their interest in receiving such TA support; then, the work itself could cover all PICs requesting the support, using a single consultant team providing international legal / regulatory / commercial / technical expertise, supplemented by local firms provided at cost in each market.[144] The commercial and technical expertise would be needed to craft the appropriate policies and regulations.

The more detailed technical studies mentioned in the previous section (item 3), probably best packaged with detailed legal/ regulatory / economic / structuring studies, could be split into several lots covering different groupings of PICs. For instance, one lot could cover the set of PICs where BESS mini grid concessions would appear to have advantages, another could cover PICs where there are prospects for VRE + BESS IPPs and Standalone BESS IPPs; and travel-related groupings could make sense as well, reflecting that it would be extremely time-consuming for a single group of consultants to visit more than a subset of widely dispersed and often poorly connected PICs. Statements of work for the technical / economic / structuring TAs might naturally also include capacity building.

Work on legal templates for each PPP structure could build off the initial studies mentioned above. At first face, it might seem to make more sense to create the templates at the start. The reasons why it would work better the other way around include that it will be very difficult to create generic structures potentially applicable in multiple jurisdictions without first learning the details of the specific structures that could work in a few specific jurisdictions; also, the nature of the templates work is largely desktop, and would not require travel to each relevant PIC, and so could be performed cost effectively by a separate team. In other words, what is envisioned is a set of targeted TAs to develop pilot projects, and then to build off those pilot projects to encourage broader regional uptake.

Financing and credit support would appear to be best organized on regional and program-specific basis. For instance, VRE + BESS and Standalone BESS IPPs would benefit from stapled debt + credit support packages; Rental / Lease IPP structures would benefit from stapled credit support packages as well. A regional program offering capital grants and possibly concessional debt and/or first loss facilities, under a donor-led BESS Mini Grid Concession platform, could help immensely in advancing this structure and hence electrification of outlying islands in the PICs.

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[144] Considering many of the PICs have extremely small legal communities, it will be unreasonable to expect international consultants to each separately identify local legal support in each PIC. Ideally, it would be possible for the donor to pre-qualify a set of potential firms in each PIC that would offer services at pre-set rates, subject to a cap.

Finally, it would be important to build any regional approach with the support and engagement of pre-existing regional institutions. One that should be central to any regional BESS program for the PICs (or indeed for any electric power sector work in the region) is the Pacific Power Association. The Association could advise on likely interest in different structures in the region, help scope initial TAs, provide data and guidance to consulting teams, and provide a venue for regional workshops and trainings. Another regional institution that could assist is the University of the South Pacific (USP), based in Suva, Fiji. The USP, with nearly 30,000 students total and branch campuses in many of the PICs, has an electrical engineering degree program, the leaders of which might be interested to be involved in regional BESS work. Also, involving nominated students and academics from the USP in some workshops and trainings might be an effective way to build the relevant human capacity that will be necessary as VRE and BESS penetration grow in the region.

5. ANNEX: TECHNICAL ASSESSMENT

The Technical Assessment is found on ensuing pages.

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