YSPSC PROJECT CONCEPT

POWER SYSTEM RESILIENCY INVESTMENT PLAN

1.Brief description of the project concept:

1.1 Corporate priorities

According to its mission statement, “the Yap State Public Service Corporation (YSPSC) is to provide reliable water and electricity services adequate to meet the needs of the people of Yap at a minimum price possible.”

1.2 Proposed interventions

Improve the ability of YSPSC infrastructures to maintain its electricity service during and after extreme weather events in the context of climate change. Protect YSPSC assets from potential damages in such circumstances and avoid consequent major financial losses that will dramatically increase the cost of the services for its customers.

1.3 Ongoing operations

Due to the isolation and remoteness of its operation, YSPSC uses simple generation facilities – Diesel power plant (N-2) coupled with Solar/Wind generation and a mainly radial grid structure (aerial 13.8kV or 4.16kV RUS standard), plus atolls aerial mini-grids to supply 90% of the people of the State on the main islands and most of the outer-islands. This choice has been proven successful until now (SAIDI SAIFI: https://www.dropbox.com/s/6466sa0v1u694xd/YSPSC%20SAIDI%20%26%20SAIFI.xlsx?dl=0), except for the years when major cyclones hit the region.

1.4 Lessons and evidence from analytical work

Catastrophic damage to the grid happened on Yap in 2004 with Typhoon Sudal, and on Ulithi in 2015 with Typhoon Maysak. Operations were severely impacted.

Sudal knocked down the power distribution network for the entire Yap main island. The duration of the power outage was 21 days impacting all customers: Residential, Government & Commercial. Maysak destroyed solar PV plants and a diesel plant in Ulithi, and knocked down the aerial distribution network in Falalop (one of the islands in

Ulithi atoll). The duration of the power outage was 4 weeks, impacting all types of customers.

Rebuilding efforts were supported by international assistance from FEMA and USAID/IOM respectively. The financial amounts to recover to the state before the extreme weather events were:

For Yap, USD$3 Millions
For Ulithi, USD$1 Million

The prolonged disruption of electricity to businesses, government offices, medical centers, and homes, resulting from typhoon damage to the energy infrastructure, can leave behind long lasting and severe consequences for the people (health, education, migration…) and the economy of these islands (industries, businesses, tourism).

1.5 International good practices

Worldwide, in regions regularly impacted by cyclones, utilities and governments have invested in resilient power infrastructures, resulting in economic and social benefits in the short and long term. Examples of standard good practices are:

Guam – USA: Grid reinforcement – aerial & underground lines – transmission and distribution lines reinforced with concrete and metallic poles specifically sized for the local environment conditions / wind loads, i.e. high risk of Category 4 and Category 5 typhoons.

Guadeloupe – (Caribbean) - France – Installed mesh underground network of 1565 kms of 20kV underground lines, and 66 kms of 20kV submarine lines.

La Reunion (Indian Ocean) – France – Installed 1082 kms aerial HV lines and 2138 kms underground HV lines.

Northern Queensland – Australia – Outback and Torres Strait Islands – All Isolated Diesel Power Plants with generators individually enclosed in concrete block engine rooms (for both environmental noise and cyclonic weather protections), themselves protected within the power plant building (metallic structure).

1.6 General Description of Proposed Resiliency Investments:

1.6.1 Distribution side – Yap and its Outer Islands

i/ Distribution redundancy and resiliency for key areas (Airport, Colonia, Hospital, all Water Plant Facilities) on the 4 feeders on Yap main islands by going from radial topology to mesh network with mixed underground / aerial loops & new underground links.

ii/ Conversion from aerial 4.16kV mini-grids on Ulithi and Woleai to 100% underground (HV & LV). Ulithi is in the path of Category 5 typhoons and Woleai is extremely remote.

iii/ Reinforcement of the 4 aerial feeders on Yap main islands –
With concrete poles (similar to Guam Power Authority for the same voltage level) or (Vanuatu Sarakata Hydro plant to Luganville HV lines with guyed concrete poles built by JICA).

1.6.2 Generation side – Yap Main Island

Enclose the 2 main high-speed diesel generators in new individual concrete engine rooms (Two) while repairing any deficiencies on existing Yap power plant metallic structure (roof and walls). Reinforcing the power plant control room building, especially the roof (double waterproofing against heavy rains and Category 5 cyclonic wind load).

2. Specific pathway to achieve resiliency in energy infrastructure against natural disasters:

2.1. Underground for Yap Main Island

Investment in new generation underground cables for public power distribution network (12/20 kV) with anti-termite resistant sheath, copper conductor, grounding conductor and **re-enforced burying resistance** ensured with an extruded polyethylene protection. This type of cables is already used by YSPSC in its wind farm facilities and has been directly buried without necessitating conducts nor bedding, except for areas of road and bridge crossing.

YSPSC distribution crew will do the trenching, lay the HV cables, perform all cables joints and terminations. This will keep the cost down and give YSPSC a sense of ownership of the new underground network, and increase its technical capacity. It will also acquaint YSPSC's technical staff with a visual familiarity of the actual layout of the underground network, which will be useful in buttressing their interpretation of the underground network's as-built drawings after project completion.

Trenching equipment, soil compactor, road asphalt repair equipment will be purchased and operated by YSPSC in collaboration with the Yap Public Works Department. Normally, trenches will be opened along the road shoulder outside the asphalted area, with minimal asphalt crossings at certain road junctions. The underground links will run directly from the Diesel Power Plant to the Airport, the Hospital, and the Gagil-Tomil Water Authority plant, the Southern Yap Water Authority plant, and the YSPSC water plants, with pad-mounted transformers and pad-mounted switchgear inserted along the way. In the Colonia area, the Radio Station, the Fuel Farm, the Police Station, the Administration and Legislature Buildings, YCA complex and the Hospital will be directly connected to this underground network. The Airport, the Aircraft Rescue & Firefighting Complex, and the Weather Station will also be directly fed by the new underground feeder. FSM Telecom will also be given redundancy via short distance aerial link to the underground cable.

Switching and reclosing equipment will be installed in strategic locations (open & tie points) within the 4 primary feeders to transform the radial grid into the new loop / mesh system. They will be both operated manually on site and remotely from the power plant control room through the existing substation supervision software (Enervista Viewpoint Monitoring). Communication links will be by buried fiber optic cables (preferably) or GSM (extreme ends of the network).

2.2. Underground for Outer Islands

For the outer-islands of Falalop, Ulithi, and Falalop, Woleai, investment in new underground 4.16kV mini-grids, and new buried secondary (LV) lines up to each customer service points. This has already been done on the outer islands of Mogmog, Asor, Fadray, Fais and Satawal.

2.3. Hardening Primary Aerial Grid on Yap Main Island

The primary aerial grid on Yap main island currently use mainly wooden poles, except for a few sections that have prestressed spun concrete poles based on Guam Power Authority Specifications E-035. YSPSC seeks to complete the resiliency of the primary overhead grid by replacing all remaining wooden poles with the same type of concrete poles.

YSPSC distribution crew will install them as it is the sole experienced powerline contractor on island. This will bring the cost of the project down while at the same time give them a sense of ownership of the assets.

Two additional modern line trucks will be purchased to renew and complete the existing fleet of vehicles for construction, operation and maintenance of the grid. Bucket trucks are the most practical option for accessing the overhead powerlines (the traditional way of climbing poles can become unsafe and difficult with concrete poles).

3. Specific outputs, intermediate and desired outcomes:

The continuity of service will be significantly improved in normal weather conditions as incidents on the aerial network will not lead to long outages, since affected customers can be routed to the redundant line prior to repairing the fault. Within the mesh areas, following troubleshooting and fast switching operations on the loops, repair works on the network will not have to delay or interrupt power restoration to customers.

During extreme weather conditions, essential public services are able to be continuously supplied electricity through the underground links not impacted by the cyclonic winds. In 2019, 70% of SAIDI for unplanned interruptions were due to the vulnerability of the aerial grid to strong winds and heavy rain. The distribution network, when partially underground, will reduce the risk of disturbance and damage from tree falls, vegetation growth, animal contacts, and severe weather events. The quality of

power supply will be able to be maintained with considerably less risk of such disturbances as:

1. Transients
2. Interruptions: Instantaneous, Momentary, Temporary & Sustained.
3. Sag / Undervoltage
4. Swell / Overvoltage
5. Waveform distortion
6. Voltage fluctuations

Enclosure of diesel generators within individual concrete rooms within the powerhouse will enhance protection of the generators against typhoons, and ensure continuity of power production during and immediately after extreme weather events.

4. Priorities and Approximated Costs:

4.1. Priorities

Ideally, YSPSC will have the financing support to undertake all the investments under one project. However, if funding were to require YSPSC to prioritize these investments, it would give first priority to building distribution resiliency and redundancy for critical infrastructures on Yap main island and distribution resiliency for Falalop, Ulithi, and Falalop, Woleai; second priority to resiliency for the powerhouse on Yap main island; and third priority for the reinforcement of the primary overhead powerlines on Yap main island. This prioritization is based on what has been most impacted in the last 20 years by strong wind conditions. But it must be noted that, while the powerhouse on Yap main island has not been damaged by a typhoon since its completion in the 1970s, the island will be without power for a prolonged period should the powerhouse be damaged and rendered inoperable by a typhoon.

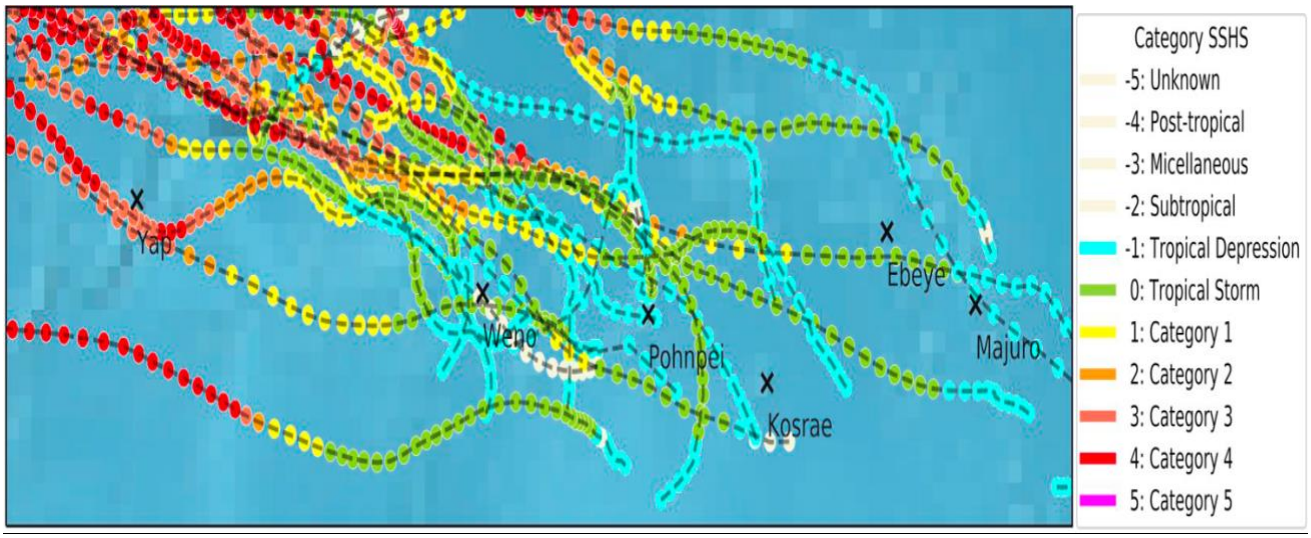
The tables below are extreme weather data contained in a report produced by Vortex for a World Bank technical assistance assessment of extreme weather and climatic risks in the Federated States of Micronesia and the Republic of the Marshall Islands:[1]

[1] Report in draft form at time of issuance of this Investment Plan.

Table A Recorded Storm/Typhoon Occurrences in Micronesia

Island	Number of storms	Number of Super Typhoons (Category >= 3)
Yap	290	18
Weno	195	5
Pohnpei	143	3
Kosrae	84	2
Ebeye	81	1
Majuro	62	0

Table B Historical Typhoon Paths



4.2. Approximated Costs

The total approximated cost of the investment plan is USD$8,736,604. Below is the cost breakdown:

First Priority	
A/ Distribution Redundancy & Resiliency for Critical Infrastructures for Yap main island	**USD**
New Underground Links/Loops for Yap Main Island Grid	
Airport feeder cable	434,609
Colonia feeder cable	372,810
Northern feeder cable	797,344
Optical Fiber cable plus grounding cable	230,000
2 Reclosers type NOVA 15kV 3-Phase with form 6 Electronic Control	20,000
Extension of Substation RMU2 w Two GAE 1250/630 Circuit Breakers for underground feeders	50,000
11 Vista SD Underground Distribution Switchgear 413 (4-ways)	599,500
5 Loop feed padmounted transformers (with 6 universal HV bushing wells)	75,000
100 HV junctions and termination kits	100,000
Trenching Equipment & Compactors	357,699
Sand, Concrete & Conduits	192,767
	3,229,729
Engineering (using YSPSC engineer - 3 travel)	20,000
Labor (YSPSC Distribution crew to implement with hiring of extra local labor)	322,973
Contingency @5%	178,635
	3,751,337
B/ Distribution Resiliency for Outer/Remote Islands	
Conversion from aerial 4.16kV mini-grids on Ulithi and Woleai to 100% underground (HV & LV)	770,000
Engineering & Local Labor (using YSPSC engineer, distribution crew, and extra local labor)	50,000
	820,000
Contingency @5%	41,000
	861,000
Second Priority	
C/ Generators & control room protection for Yap main island power plant	1,000,000
Engineering & Consultancy @15%	150,000
Contingency @5%	57,500
	1,207,500
Third Priority	
D/ Reinforcement of the 4 aerial feeders on Yap main island	
443 Concrete poles, 45 ft. long, Class B (guyed)	2,152,980
Wire - Crossarms - Hardware	612,893
	2,765,873
Labor (YSPSC to use own distribution crew)	0
Enginering (using YSPSC engineer - 2 travel)	12,000
Contingency @5%	138,894
	2,916,767
	8,736,604