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Cover Page Photograph - "Engineers Workshop in Palau"

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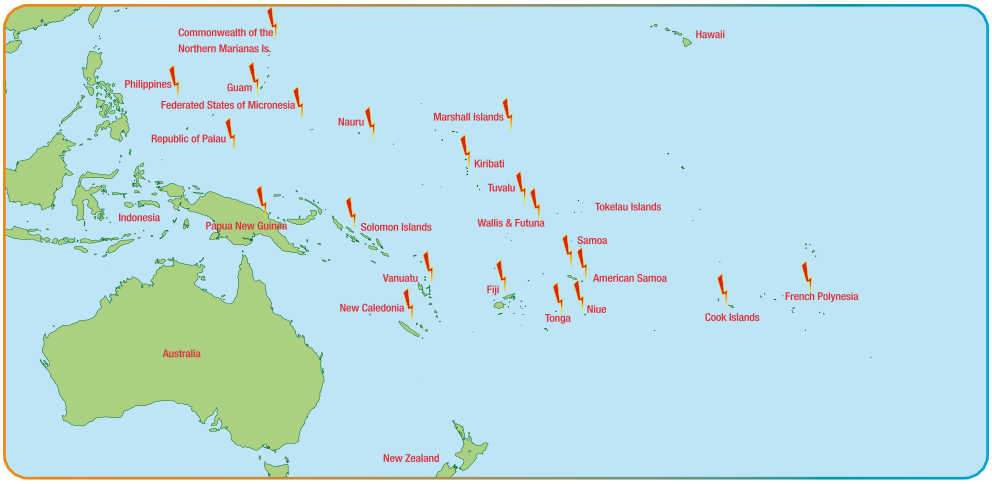

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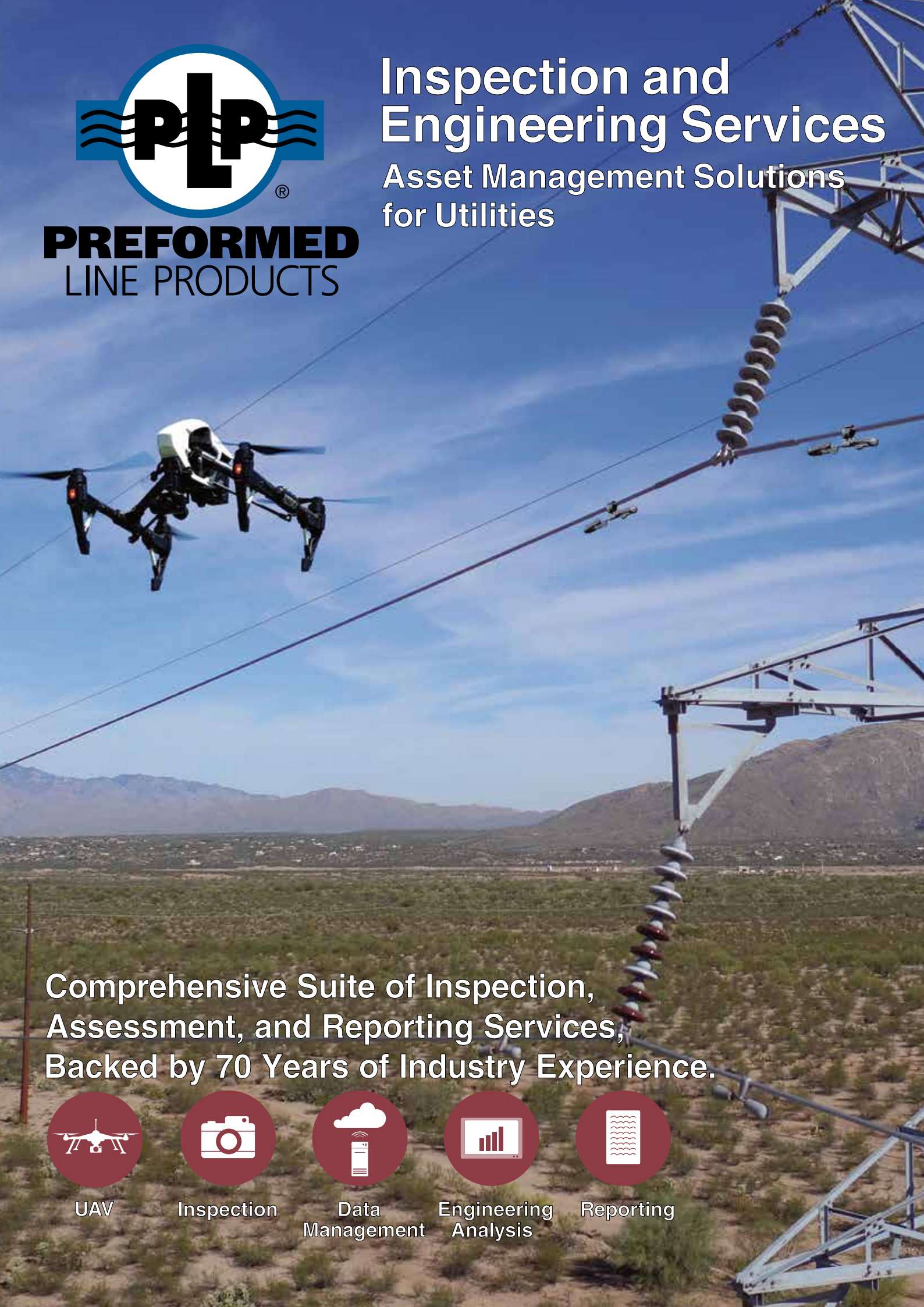

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Editor's Note

Andrew D. Daka
Executive Director

Greetings from Suva.

As we usher out 2019 and get ourselves ready to welcome 2020, it is probably a good time to reflect on the year, our achievements and plans for the upcoming year.

The year 2019 has been a busy one for the Association with the implementation of the Sustainable Energy Industry Development Project (SEIDP fully underway). Furthermore, a number of capacity building activities were held during the course of the year.

The latest round of the COP meetings, COP25, has just been held in Madrid, Spain from 2 - 13 December. The outcomes if one takes it from the mainstream press, has not been the outcome that the developing countries had expected. There is a push back from developed nations on agreeing to the outcomes of the IPCC report on keeping to less than the 1.5 o C temperature rise. This then means Pacific Islands countries will have to continue to do their bit in addressing climate change. For the electricity industry in the Pacific, accelerating the deployment of more renewable energy in the generation mix and improved energy efficiency is where we can contribute to addressing climate change.

The Pacific Power Association has taken this on board through it Sustainable Energy Industry Development Project (SEIDP). PPA has worked in collaboration with other development partners such as IRENA, PICREE, Word Bank, IFC to facilitate capacity building workshops centered on Power Purchase Agreements.

The Association recognizes that the private sector will play a very important role in the electricity generation sector. The private sector can take up much of the investment required to increase renewable energy contribution. For the utilities to be able to do that successfully, its personnel will need to have the knowledge to engage with the private sector through Power Purchase Agreements.

It is also encouraging to know that development partners working in the region are working to address some of the obstacles to private sector investment in the region. One such case is the Asian Development Bank's Pacific Renewable Energy Program. This initiative uses development partner grants from donors to attract private sector investors to power projects in the Pacific instead of governments providing a guarantee,

In this issue of the magazine you can read a number of the paper presented at the Association's 28th Annual Conference in Rarotonga, Cook Islands.

We also welcome Protech Power International Pty Ltd, based in Queensland, Australia, which has recently joined the Association as an Allied Member.

Wishing all the readers a Merry Christmas and Prosperous New Year 2020.

OTEC, The Key Catalyst for Energy Transition

Julien Blanc, Pierre Guerin, Mathieu Labaisse, Jeroen Mostert
Bardot Ocean, La Ciotat, France

ABSTRACT
Ocean Thermal Energy Conversion is a well-known technology in the Pacific area. The two fully working installations are located in Hawaii and Kumeijima. But Pacific islands are still waiting for a sound concept to foster the commercial deployment of this promising technology.

Already known as a baseload renewable energy with no impact on freshwater resources, OTEC can be a key utility infrastructure for climate change mitigation and adaptation.

In fact, OTEC can:

- Deliver a high share of renewable electricity into the grid at an agreed cost, hence reducing GHG emissions and oil price increase dependency
- Deliver electricity to produce potable water, hence fighting increasing water scarcity linked with climate change
- Deliver electricity to foster electric mobility, particularly relevant on Pacific islands due to the size of the land
- Be combined with a SWAC system to provide air-conditioning to large cooling consumer

As our case study shows, in a 10,000 people island, 2MW OTEC capacity could:

- Send 44.7MWh renewable energy to the grid, supplying 82% of renewable electricity to the existing demand
- Use excess generated electricity to produce an average of 663m3 drinking water per day
- Or use excess generated electricity to replace 24,000 km driven by diesel car or 130,000 by oil-based motorcycle
- Provide a cooling power of 500kWc by decreasing OTEC electric power by 10kWe

Therefore, OTEC can be the key catalyst for energy transition in Pacific Islands.

OTEC TECHNOLOGY IN A NUTSHELL

OTEC technology basic principle is to use ocean water temperature gradient between surface and depth to run an organic Rankine cycle, as shown below.

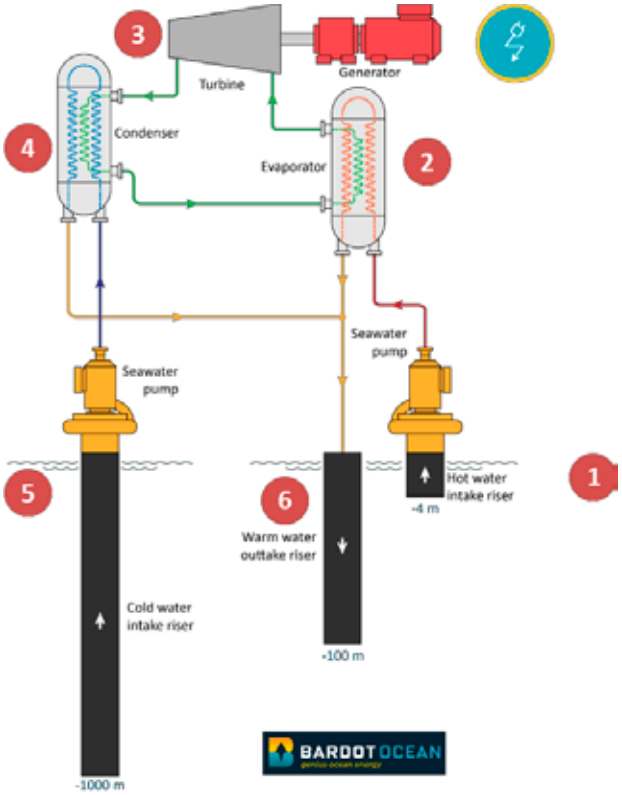


Figure 1: OTEC technical principle

- Hot surface water (>25°C) is pumped to the process through a HDPE pipe.
- Its heat content is used to vaporize a working fluid (typically NH3, R134a or R1234yf) through evaporators.
- The vapor is expanded in an ORC turbine to produce electricity.
- The low pressure vapor exhausted by the turbine is then condensed in the condensers by a flow of deep ocean cold water (5-7°C) pumped in a HDPE pipe.
- Hot and cold water from the heat exchangers (evaporators and condensers) are then mixed and released back into the ocean without any

change in chemical and biological content.

Based on this principle, OTEC can provide the grid with **baseload 24/7 predictable renewable electricity.**

As OTEC efficiency relies directly to the temperature gradient (the higher the temperature difference, the more efficient is the OTEC – and the lower the electricity cost), OTEC is perfectly suited for Pacific islands as the following map shows:

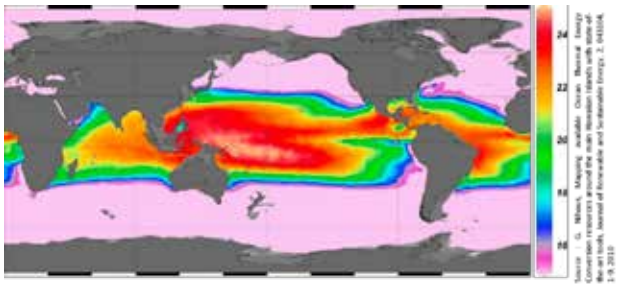


Figure 2: Worldwide average ocean temperature differences (between 20 m and 1,000 m water depths)

On top of this carbon free renewable electricity generation, deep ocean water can be used for many other purposes:

- **Cooling:** After the heat exchanger, ocean water is still cold and can be used to refresh buildings or to increase cooling efficiency
- **Drinking water:** Conventional reverse osmosis can be used to desalinate pumped back sea water
- **Agriculture / irrigation:** After the heat exchanger, ocean water is still cold and can be used to foster natural condensation, providing fresh water for irrigation.
- **Aquaculture:** The absence of pathogens in deep ocean makes the water particularly well suited for the culture of sensitive and valuable species.
- **Cosmetics:** Mineral-rich deep water can be used in cosmetics and are alleged to better moisturize skins and increase collagen production compared to regular cosmetics.
- **Bottled water:** Bottled deep-ocean water is getting more and more popular, with several brands expanding on Asian and North American markets.
- **Thalasso and Spa:** Using pristine and mineral-rich water from the ocean's depths can increase spa and hotel occupancy and rates.

Figure 3: Deep ocean water valorisation

OTEC AND RENEWABLE ELECTRICITY SHARE CASE STUDY DEFINITION

To study how an OTEC system could contribute to the climate change strategy of Pacific islands, we defined a hypothetic island with the following characteristics:

- Inhabitants: 10,000 people
- Electricity average production: 5 kWh/capita/day, in line with an average of the Pacific islands

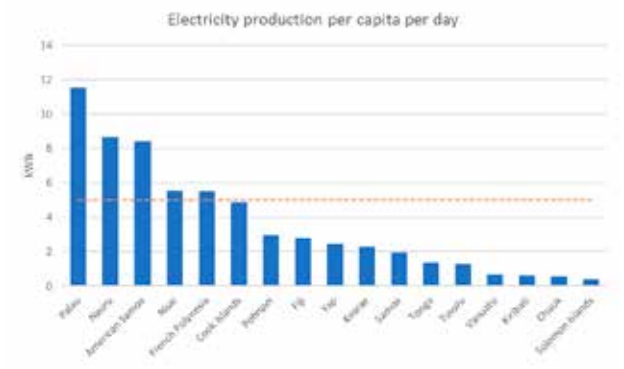


Figure 4: Selected average electricity consumption

- Electricity annual peak: 4.2MW

We then considered two typical electricity load curves, for weekdays, and for week-end days:

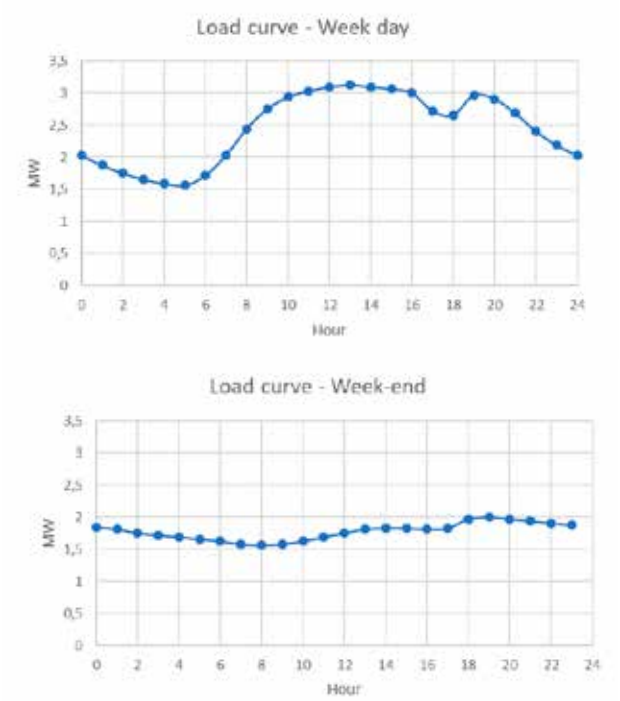


Figure 5: Load curves hypothesis

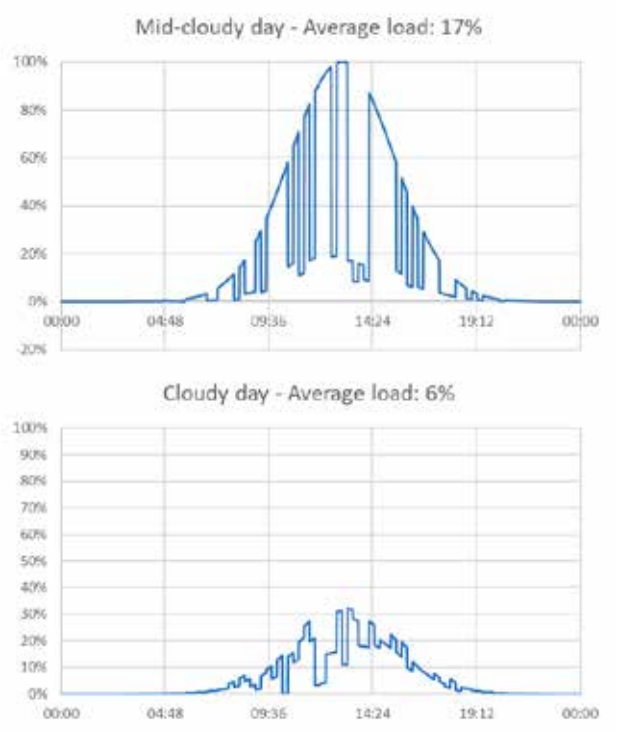
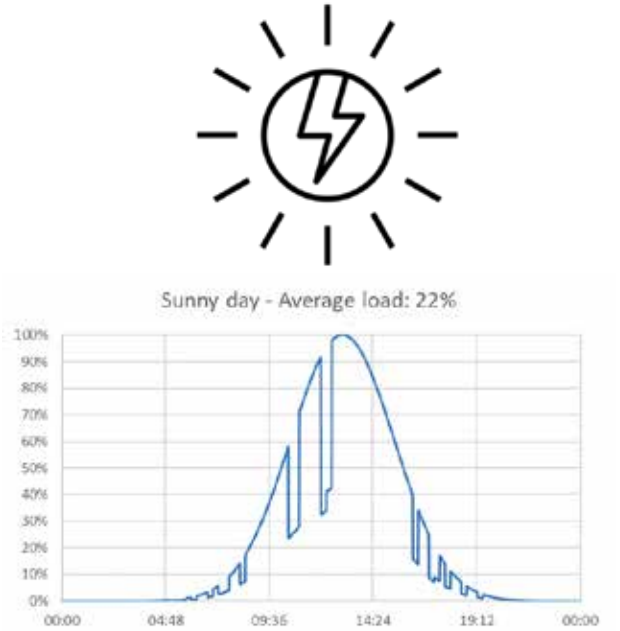


Figure 6: Solar electricity production curves

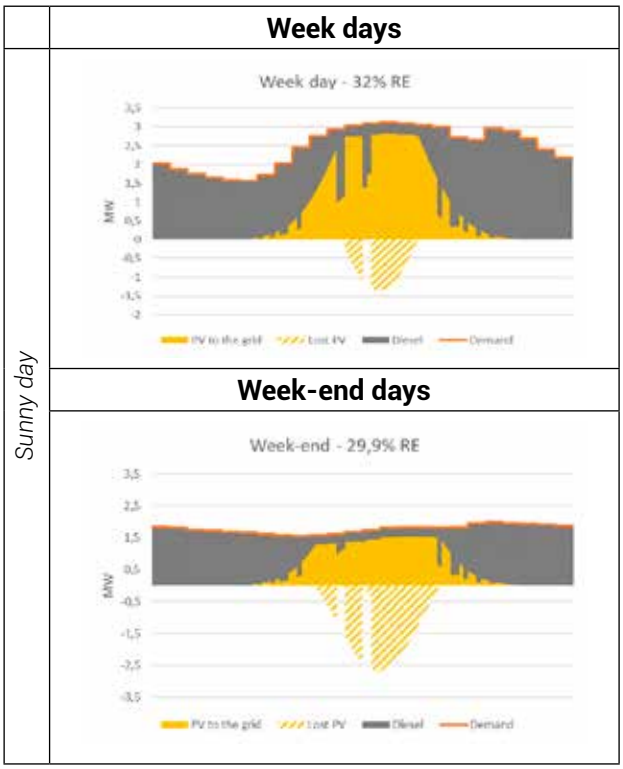
SOLAR ELECTRICITY AND RENEWABLE ELECTRICITY PENETRATION

First of all, we studied the solar electricity (photovoltaic panels) integration into the grid.

We took a yearly average load factor of 19%, and considered three typical days: sunny, mid-cloudy and cloudy.



We considered a solar capacity equal to the annual peak of the grid, hence 4.2MW. The generated solar electricity leads to a yearly average of 29% renewable electricity.



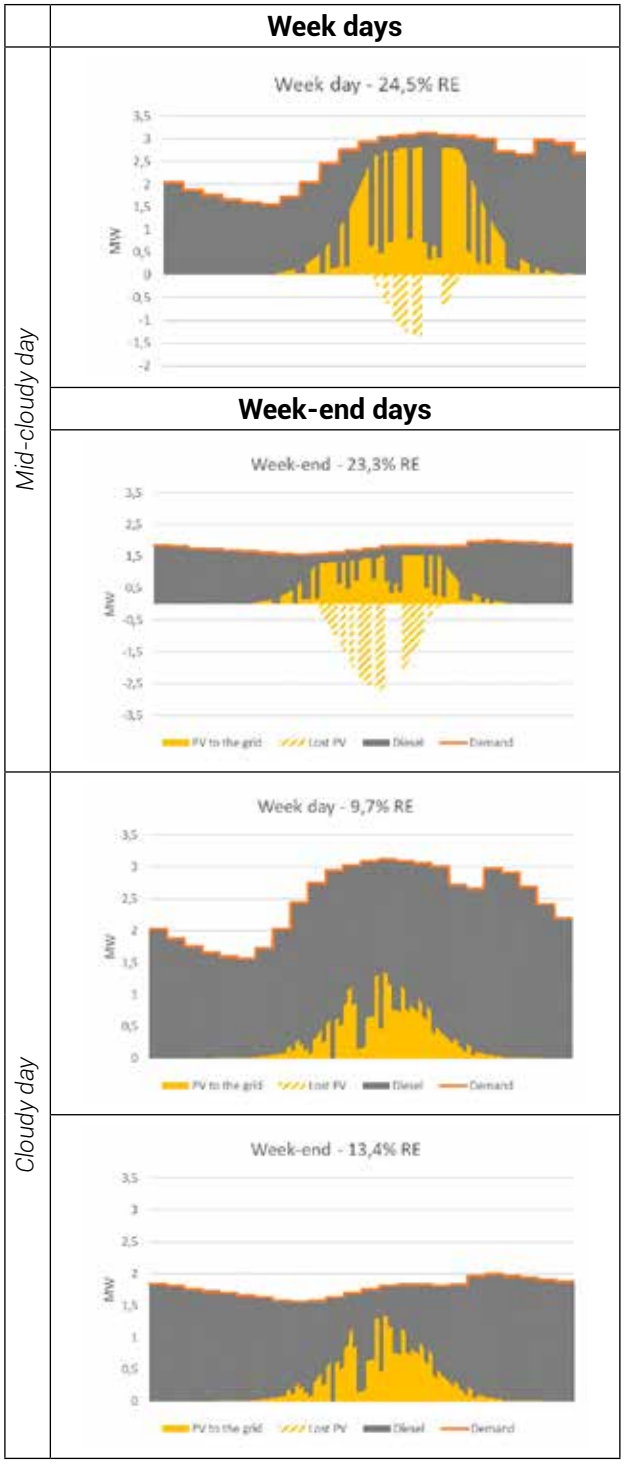


Figure 7: Grid balance with 4.2MWp solar capacity

Given the relatively high solar capacity considered, a share of the generated electricity cannot be injected to the grid, especially during week-end days, when the demand is lower. This non-revenue electricity represents 13% of the total photovoltaic production.

In fact, if during weekdays the demand rises in line with the PV production capacity, the base demand remains too high to enable a large renewable penetration rate using only solar electricity. Increasing solar capacity goes along with an increase in renewable electricity share, but with diminishing returns.

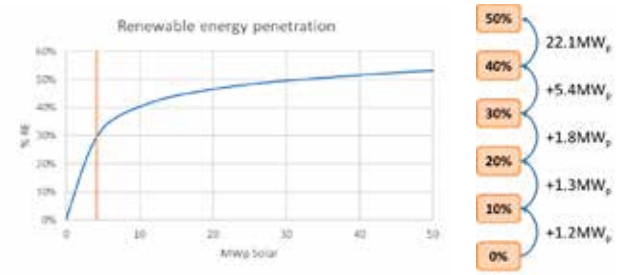


Figure 8: Renewable electricity share as a function of solar capacity

And without any storage system, installing high solar capacity will inevitably lead to high share of PV production that cannot be sent to the grid, hence higher electricity production costs.

Share of RE	Solar capacity	Share of PV production lost
10%	1.2MWp	0%
20%	2.5MWp	2%
30%	4.3MWp	14%
40%	9.7MWp	49%
50%	31.8MWp	81%

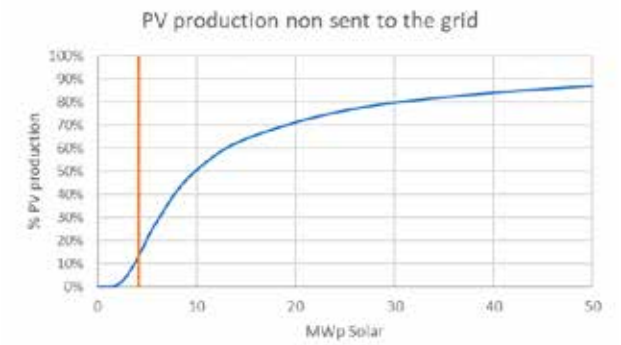


Figure 9: Share of solar electricity non sent to the grid as a function of solar capacity

OTEC ELECTRICITY AND RENEWABLE ELECTRICITY PENETRATION

On the contrary, baseload OTEC can yield high renewable electricity penetration at low capacity, without losing to much of the production.

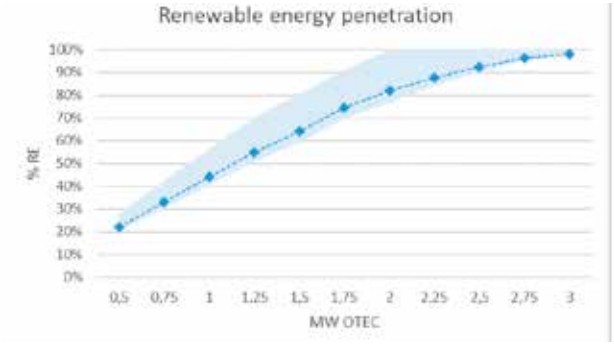


Figure 10: Renewable electricity share as a function of OTEC capacity

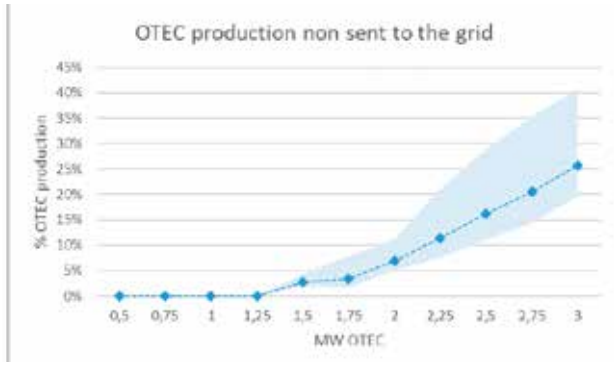


Figure 11: Share of OTEC electricity non sent to the grid as a function of OTEC capacity

Roughly adding 0,25MW leads to 10% more renewable electricity in the mix, while you can reach 82% of renewable electricity with only 2MW OTEC capacity.

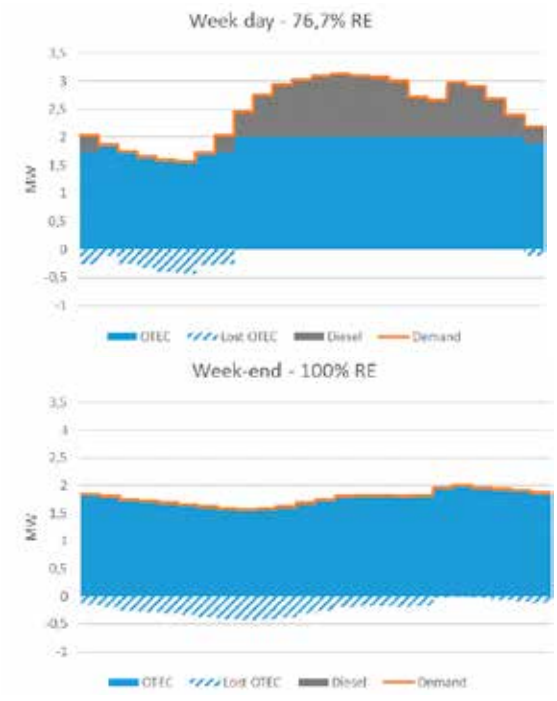


Figure 12: Grid balance with 2MW OTEC capacity

OTEC AND WATER

Pacific islands are also facing, to some extent, **water stress**, worsened by upcoming **climate change** (change of rainfall patterns, sea level rise leading to aquifer saline intrusion, etc.).

The electricity generated by OTEC that cannot be sent to the grid can be used to **desalinate water** and produce drinking water, hence **reducing island vulnerability**.

A **2MW OTEC** excess electricity generation can be used to **produce drinking water in line with Pacific islands average water consumption**.

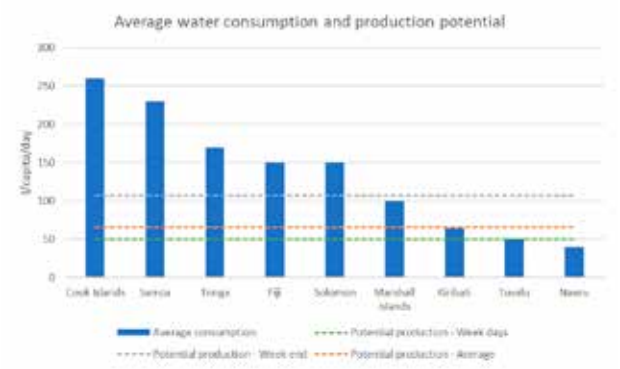


Figure 13: Average water consumption and average water production potential

Such a system would benefit from interesting synergies:

- We need really high sea water flows in a OTEC system to produce electricity (24,000m3/hour for the 2MW system) far beyond islands water needs.
  - This means there's no need for an additional pumping infrastructure
- Brine will be highly diluted in the outtake pipe
  - This means no environmental impact

	Week days	Week-end	Average
Electricity non sent to the grid (MWh/day)	2.49	5.36	3.31
DW production (l/capita/day)	50	107	66
Hot sea water need (% OTEC hot water)	0.17%	0.37%	0.23%
Brine rejected (% OTEC rejected water)	0.06%	0.23%	0.08%

OTEC AND MOBILITY

As excess renewable electricity production occurs mainly at night, when demand is low, this electricity can be used to charge electric vehicles.

Using the same demand/production curves, we assessed the energetic potential for electric mobility, considering two illustrative figures:

- The kilometres that can be driven using the excess electricity;
- The amount of diesel that would be needed to drive these kilometres.

Both were evaluated for cars and for motorcycles, and the results are shown in the table below.

		Week days	Week-end	Average
Electricity non sent to the grid	MWh/day	2.49	5.36	**3.31**
Electric car	eq liters	891	1,914	**1,183**
	km/capita/day	1.78	3.83	**2.37**
Electric motorcycle	eq liters	1,746	3,752	**2,319**
	km/capita/day	9.70	20.84	**12.88**

This will even more reduce the island oil dependency, decreasing greenhouse gases emissions linked with mobility.

OTEC AND AIR-CONDITIONING

SWAC IN A NUTSHELL

SWAC (Sea Water Air Conditioning) uses cold deep ocean water to provide cooling to centralised air-conditioning systems.

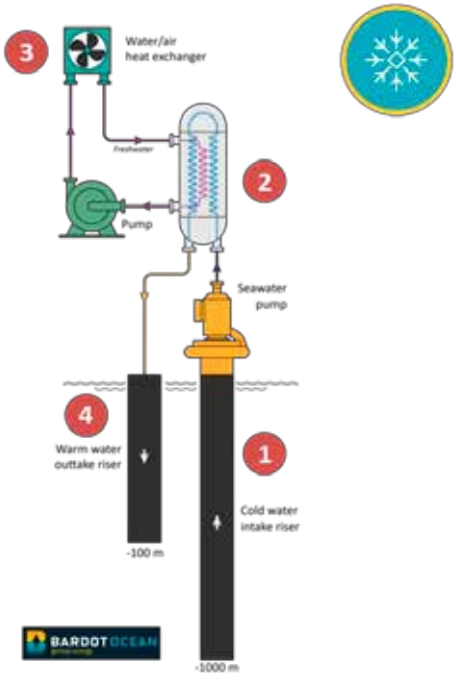


Figure 14: SWAC technical principal

- Cold deep water (**5-7°C**) is pumped to the process through a HDPE pipe.
- Its cooling content is transferred to the chilled water loop through heat exchangers.
- The chilled water loop provides cooling to the connected buildings through water/air heat exchangers.
- The heated-up sea water (11-12°C) is then released back into the ocean **without any change in its chemical and biological content.**

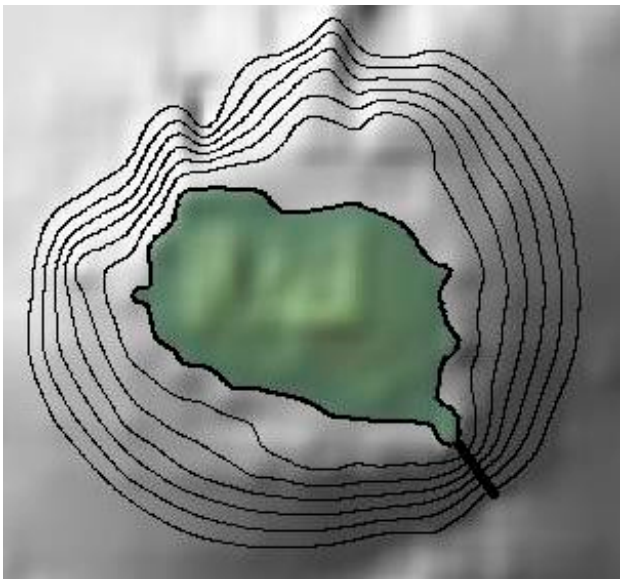
No refrigerant is needed in the process.

Some components can be mutualised with an OTEC system: water intake, water outtake and seawater pumps.

CASE STUDY DEFINITION

We studied the impact of a diversion of the OTEC cold water to provide air-conditioning through a SWAC system. To do so, we designed a realistic case study, located in Rarotonga (Cook Islands). The main characteristics of the system are the following:

Location: south-east of the island

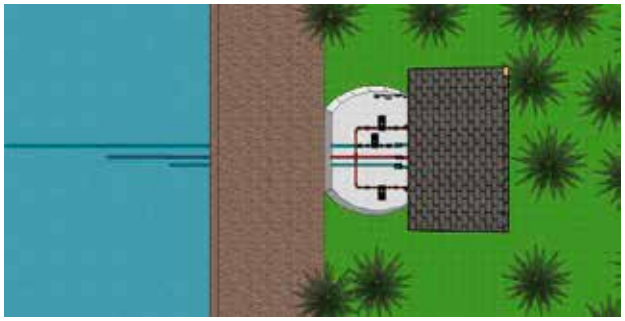


Main characteristics:

Cold seawater T°	3.8°C
Hot seawater average T°	25.8°C
Gross generated power	2,000 kW
Net generated power	1,200 kW

Typical layout:

Typical layout:

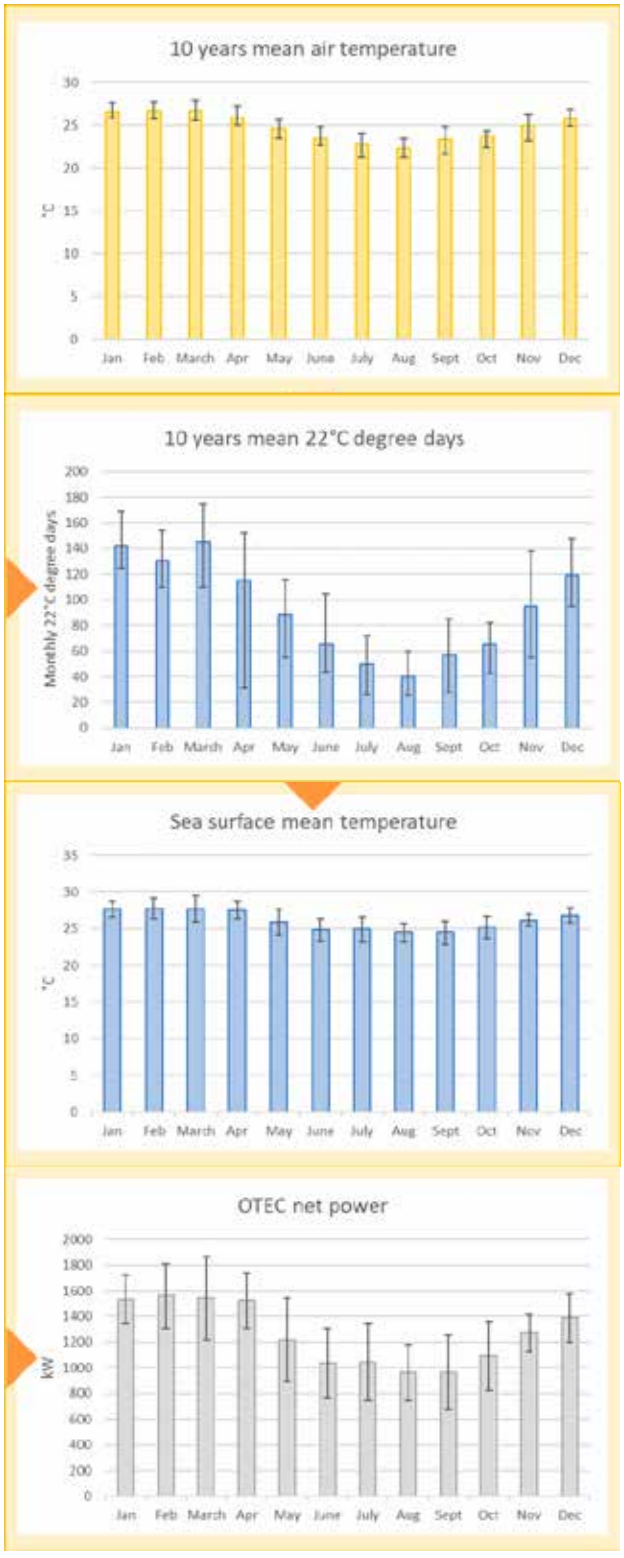


Due to the site characteristics and the expected power, the pipelines properties are:

Cold seawater intake pipe	OD	1,800 mm
	SDR	17
	Length	3,000 m
	Number	1
	Flow rate	10,900 m3/h
Hot seawater intake pipe	OD	1,800 mm
	SDR	22
	Length	50 m
	Number	1
	Flow rate	15,000 m3/h
Mixed seawater outtake pipe	ID	2,003 mm
	Length	500 m
	Number	1
	Flow rate	25,900 m3/h

Cooling demand, air temperature, sea surface temperature and OTEC efficiency are tightly linked: cooling demand is at its maximum when OTEC power also is.

The following graphs are based on the selected site climate:



RESULTS

Although it will decrease OTEC power, this combined system will have a better energy efficiency than a standalone OTEC and regular chillers to provide cooling.

The direct impact can be read on the following graph:

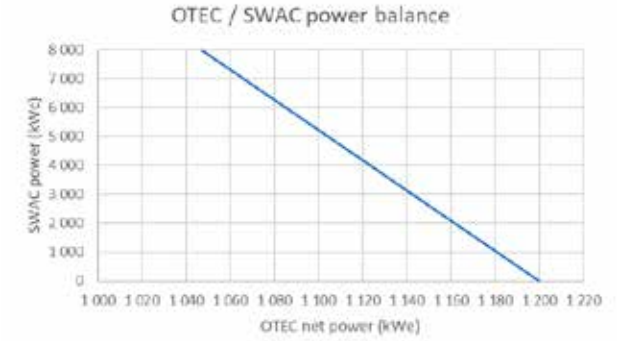


Figure 15: OTEC / SWAC power balance

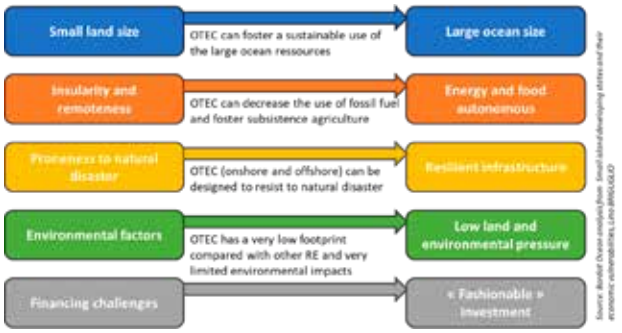
Providing a cooling power of 500kWc will decrease OTEC electric power by 10kWe.

The overall impacts can be read on the following table:

Diverted cold water flow (m³/hour)	Cooling production (kWh$_c$/hour)	OTEC loss in production (kWh$_e$/h)	Electricity savings from unused chillers (kWh$_e$/hour)	Electricity balance (kWh$_e$/hour)
50	286	-6	95	90
100	571	-11	190	179
150	857	-16	286	269
200	1142	-22	381	359
250	1428	-27	476	449

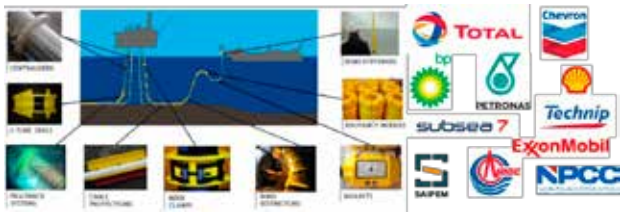
CONCLUSION

OTEC, combined with desalination, electric mobility or air-conditioning, can really help islands to overcome their vulnerability factors.



ABOUT BARDOT OCEAN

Bardot Group has a 14 years successful track record in oil & gas offshore projects, developing subsea solutions for more than 60M€ revenues.



In 2015 Bardot successfully delivered 6 Deep Sea Water Intake Riser to SAIPEM/TOTAL to improve KAOMBO FPSOs process.

Bardot has invested in SWAC and OTEC technology, developing its own OTEC Lab, one of the few in the world.

Since then, Bardot Ocean has the experience, the skills and the will to become the leading technology provider and project developer for OTEC and SWAC.

In 2019, Bardot Ocean has been awarded its first SWAC project to provide air conditioning to a large hospital in the Indian Ocean. SWAC capacity will be 6.6MWc (1,900RT) for an expected benefit of 90% electricity savings. Bardot Ocean will provide project finance, EPCI and operation and

maintenance for 20 years with a cooling purchase agreement.

Figure 16: SWAC project layout

We can work either as a technology provider or as an IPP, throughout the value chain, to transform OTEC potential into practical reality in the Pacific.

Microgrids and Hybrid Power Generation

ComAp Limited

WHAT IS A MICROGRID?
A microgrid is a small-scale power grid that can operate independently (island mode) of the mains (or macrogrid), as well as in conjunction with the grid (grid mode) to supply backup or supplementary power. Any small-scale, localized power station that has its own generation and storage resources and definable boundaries can be considered a microgrid – such as any power station on any island throughout the Pacific Islands.

WHY IT BECOMES SUCH A HOT TOPIC?
Microgrids are becoming increasingly popular because of the rapid rise in power demand due to population and industrial growth. In many locations, the current mains grid system is unable to cope with the increase in power demands, so business, governments and even some individuals have begun to resort to generating their own power, to ensure reliability, but also to gain more control over rapidly rising electricity prices.

Islands, such as the Pacific Islands are also becoming increasingly interesting in microgrids because of the above increasing demands, but also because the difficulty of obtaining electricity from the main island, (or mainland) electricity grid system.

The increase in the price of diesel, and the assosciated costs of diesel transportation to isolated island communities, has also let to the development of local microgrids in to Hybrid PV/Diesel Microgrid Systems.

WHAT IS A HYBRID SYSTEM?
Remote places such as islands or mines are often located outside of the national electricity grid reach and therefore, have to use their own microgrids to generate electricity. Usually these microgrids rely heavily on diesel gensets. When the diesel system is combined with a renewable source of energy (such as solar panels, wind turbines or hydro power) it's a hybrid system, bringing the reliability of diesel power generation along with the environmental benefits and the cost savings of the renewable source. A hybrid system can operate with one diesel generator or many, depending on the amount of electricity required.

WHY THE PV-DIESEL COMBINATION IS SO POPULAR?
The PV-Diesel Hybrid combination is popular because of the ease of integration between the two, and the relatively low cost of the photovoltaic panels and ancillary equipment. The weather in the Pacific, with its high levels of sunny days, also contributes to the efficiency and reliability of the PV/Diesel Hybrid system. Integration with Wind Turbines is also possible within a Hybrid system, but the initial costs (and therefore return on investment times), on a cluster of wind turbines is much, much higher.

WHAT ARE THE BENEFITS?
The main benefits of a Hybrid system are the reduction in power generation costs, and the increase in system reliability, as well as the environmental benefits found from using a renewable source of energy.

WHY USE THE COMAP HYBRID SYSTEM?
With hybrid systems two goals are always crucial - save fuel and keep the system reliability. Thanks to its advanced functions designed specifically for hybrid systems ComAp controllers can maximize the amount of energy from renewables while not endangering the system stability.

ComAp system continuously monitors data from all sources of energy, including solar, wind, hydro, batteries and gen-sets. ComAp controllers are suitable for multiple gen-set applications and can also directly control the output of Solar, Wind & Battery Storage Systems.

ComAp also has a cloud forecasting system which increases the efficiency of any PV-Diesel hybrid power generation installation. The forecasting system uses a camera to continuously monitor the cloud cover over the photovoltaic installation. The cloud forecasting system uses an algorithm to predict overall solar irradiation that is above the PV cells. The algorithm uses overhead cloud cover, background radiation and other factors to predict the solar output and ensure the maximum utilization of the PV system before the gen-set starts. This system allows for the maximum input from the PV system, whilst also reducing the use of the diesel gen-set – resulting in a reduction of wear on the engine and saving in diesel consumption.

Why Are Energy Management and Battery Energy Storage Systems Critical To Delivering Renewable Energy In The South Pacific?

PowerSmart NZ Limited

Over the last decade the world has seen a massive development and investment in renewable energy centred around solar electricity and large-scale batteries. At the same time the South Pacific has been at the forefront from the effects of global warming, due to rising sea levels and thus a need to reduce the carbon emissions is very real. Ironically though most South Pacific countries have historically generated almost all their electricity by using diesel generators.

Global warming, carbon emissions and the cost of diesel has led most South Pacific countries to start investing in renewable energy and introducing renewable energy targets.

To answer the question of why Energy Management (EMS) and Battery Energy Storage Systems (BESS) are critical to delivering renewable energy we are going to look at Niue.

In 2015 the Government of Niue released its Strategic Energy Roadmap which states a target of having 80% of electricity produced by renewables by 2025. In 2019 Vector PowerSmart commissioned an EMS, BESS and large solar farm for the island of Niue in partnership with the Government of Niue and The New Zealand Aid Programme.

Start Point for the Renewable Energy Project
To fully comprehend the project, it is important to understand what Niue had before the project commenced.

There were four key areas for consideration:

- Existing solar generation
- Existing diesel generators
- Electricity control centre
- Solar electricity curtailment

Niue has a central power station that houses 4 x 500kVA generators and is the control centre for Niue's electricity supply and the centre of their electricity network. Their network uses mainly underground cabling and is split into two 11kV networks servicing the north and the south of the island.

Additionally, there are 8 different existing locations where solar arrays are situated around the island. These were built between 2009 and 2018 by multiple companies and ranging in size from 20kW through to 200kW.

Before the start of the project, solar on the island was having mixed results, as one of the main issues with Niue's electricity grid was balancing the electricity produced by the various solar arrays and that produced by the diesel generators with demands from the electricity grid. This balancing act was very difficult and resulted in the curtailing of solar generation to try and maintain grid stability. As a result, not all the solar electricity produced was able to be used.

'What we observed on some of our site visits was the 200kW solar farm at the power station being turned on and off to try and balance the loads between solar electricity and electricity generated by the diesel generators'.

What was done?
To help Niue move toward its goal of 80% renewable electricity by 2025, a large part of the project was to install more solar. This was done by installing 600kW of solar near the hospital in a central part of Niue. The solar array was installed well inland on high ground to avoid any potential damage from cyclones in the future

As identified at the beginning of the project, the curtailment of solar generation was hampering Niue's drive to achieve 80% renewable electricity generation. One key component that was missing from Niue's electricity grid was a BESS.

The BESS is key to any sustainable solution using renewables such as wind or solar as they provide instantaneous electricity to the grid. Lithium Ion batteries are perfect for this as they are designed for rapid recharge and discharge. To this end, Vector PowerSmart installed 3.15MWh of batteries at the PowerStation in Niue to work alongside the solar from around the island and with the existing generators.

With diesel generators, solar and BESS, Niue now has three different energy sources that need to be balanced to provide stable electricity to the network.

To do this Vector PowerSmart's EMS is the key component to the success of the project. The EMS balances the energy flows between the solar, diesel generators and the batteries.

The EMS:

- Controls when diesel generators need to be turned on or off
- Assesses what electricity is being produced by the solar and when to use this directly or store it
- Assesses how much electricity is stored in the batteries and what actions need to be taken

Essentially it is the central brain talking with the original diesel generators, original and new solar arrays and the BESS. Making sure that Niue has electricity.

As an example, if a cloud passes over the island, it will cause a temporary decrease in generation by the solar, the BESS will instantaneously increase its output resulting in stable electricity supply. This in turn means the generators can run at a more constant load and solar is not needing to be curtailed to meet these variations in generation.

Results:
Through the addition of an EMS, BESS and more solar to the network Niue can often operate without any diesel generators running for up to 10 hours at a time - on average the generators are switched off for 5-7 hours per day. As a result, Niue is well on its way to meeting its renewable energy targets with a significant amount of Niue's electricity now coming from renewables.

Case Study: Yap Renewal Energy Development Project, a Pacific Island Success Story

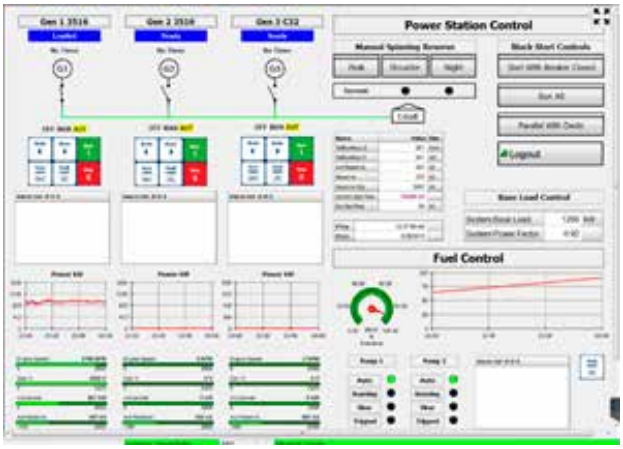
Istvan Ponsot & Théo Dumanchin
Vergnet SA

Abstract
The Yap Renewal Energy Development Project (YREDP) coordinated by Yap State has allowed a decisive leap toward the Island's objective of producing 50% of its energy needs from renewables by 2030.
YREDP combines 508 kWp PV installed by YSPSC at multiple locations, a 825 kW cyclone-resistant wind farm and 4 550kW of high speed diesel generators, all dispatched by a single island-wide integration system: Hybrid Wizard by VERGNET.
This case study proposes an overview of YREDP performance through actual operating data demonstrating that high renewable energy share can be achieved by proper design and optimization of complementary renewable energy sources, without compromising the grid stability and safety.

Focus on the Yap assets

1. Diesel power plant

The 4550 kW diesel power plant consists of 3 CATERPILLAR high speed generators: two generators of unit power equal to 1860 kW and one generator of 830 kW. The plant runs with automated and real-time control in order to manage the high-speed generators at their optimum levels of operation (spinning reserve) and ensure the good penetration of the renewable energies. The power plant is linked to the wind farm by optic fiber.



Automated and real-time high-speed diesel generators

2. PV power plants

The PV power plants consists of a 508,5 kWp total capacity located on 6 different sites, by Yap State Power Corporation:

- PEC: 200 kWp
- Sports Complex: 194.5 kWp
- ECE: 50 kWp
- Public Works: 26 kWp
- Public Safety: 25 kWp
- Water treatment: 13 kWp

All the solar PV sites communicate each other by radio connection.

Solar PV rooftop installed in the Sports Complex

3. Wind farm

The wind farm is composed of three VERGNET GEV MP-C turbines specifically designed for remote islands and with the following features: 32 m rotor diameter, 275 kW rated power, 55 m hub height.
The collapsible design of the GEV MP-C provides unmatched resistance to cyclones. Once secured on the ground, the whole GEV MP-C turbine can resist wind speeds up to 72 m/s at 10 m above ground, averaged over 1mn, i.e. a class 5 cyclone.

With 500 units installed worldwide, this turbine model has the largest track record in the industry of medium power collapsible design.

The three wind turbines secured on the ground

Impressive performance due to an effective hybrid solution

After 20 months of operation, the Yap grid is showing impressive performance levels, with average penetrations reaching up to 38% over periods of several months and occurrences of instantaneous penetration above 60%, without the use of storage.

To achieve such results, VERGNET has deployed its patented hybrid technology, Hybrid Wizard in order to optimizes the assets available on the YSPSC grid, by maximizing the complementarity of Wind and Solar PV and combining them in real-time with a nimble set of new high-speed diesels.

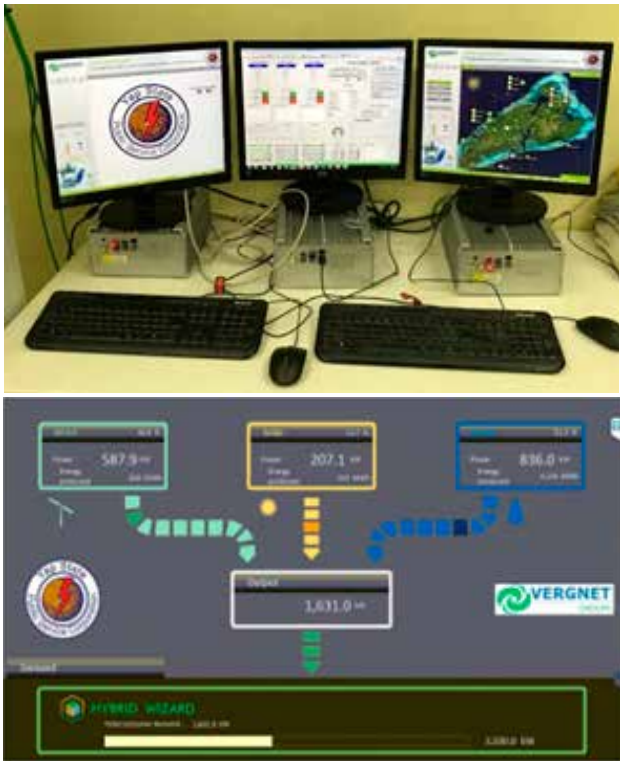
The Hybrid Wizard controller is able to send real-time instructions to the diesel, PV and wind power plants via their respective SCADA interface.

The instructions will command the plants in order to switch on/off the plants, define power setting (active and reactive), manage the renewable energy plants curtailment and ensure keeping a correct running state of the diesel power plant.

Architecture of the Hybrid Wizard deployed in Yap

Hybrid Wizard ensures to the YSPSC grid the following key points:

- Stability and safety of the grid by maintaining both voltage and frequency parameters within their required operating ranges;
- Optimization of the real-time renewable energy penetration rate in order to maximize the integration of the renewables in the generation mix;
- Real-time spinning reserve by maintaining a reserve of power instantly available, in case of quick loss of renewable energy production (cloud, drop of wind speed, unscheduled failure, etc.);
- Control the key parameters of the grid to ensure a power quality management (voltage, frequency, current, flickers coefficient, harmonics percentage);
- Avoidance of black-outs event at high Renewable Energy levels.



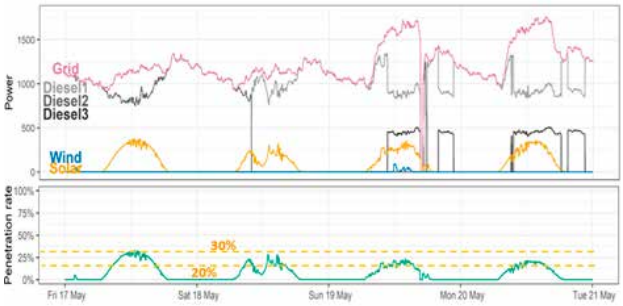
Hybrid Wizard control room in Yap

YREDP real-life operating data analysis

Based on the analysis of the real-life operating data taken from the YREDP hybrid plant, the following features can be highlighted:

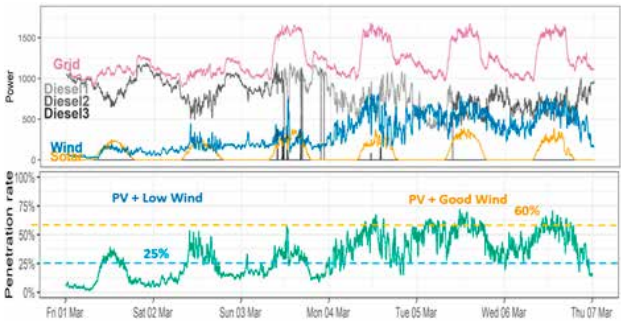
Analysis 1: Solar PV + Very Low Wind
The graph below shows in purple the YREDP grid

power profile over a 4-day period between May 17th 2019 and May 21st 2019, with sunny and very low wind conditions.
With the wind almost absent, the RE power contribution comes mainly from the solar PV plants. Under such conditions, it appears that additional solar PV capacity could be added, as renewable energy generation only peaks between 20% and 30% penetration rate during the daylight.



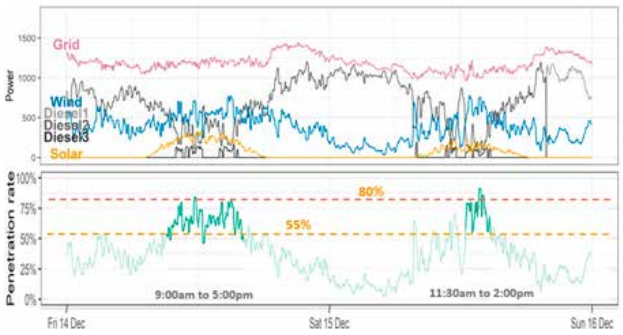
YREDP grid power profile and Renewable Energy penetration rate with very low wind

Analysis 2: Solar PV + Wind
The graph below shows the YREDP grid power profile over a 6-day period taken from March 1st 2019 to March 7th 2019, with a sunny weather and a gradually increasing wind pattern.
When the trade winds pick up an average RE penetration rate of around 50% is achieved and peaks above 60% are reached. These meteorological conditions illustrate the highly effective complementary of both wind and solar resources into the YREDP power.



YREDP power profile and Renewable Energy penetration rate with both low and high wind

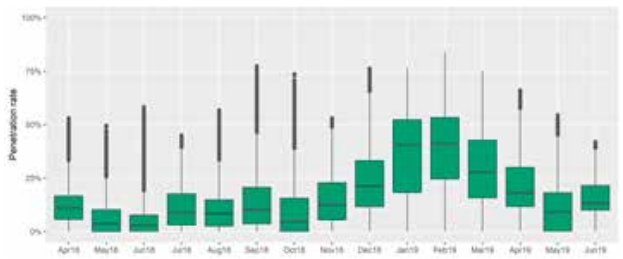
Analysis 3: Pushing the limit of RE Penetration
With excellent solar and wind conditions, the Hybrid Wizard controller can maximize the renewable energy penetration rate without compromising the grid's stability and safety. Using the example over a 2-day period from December 14th 2019 to December 16th 2019, the graph below shows average penetration above 60% with peaks up to 80% that can be reached during a few hours, without the use of battery storage. The level of performance can be achieved in Yap thanks to a very tight management of the grid parameters by Hybrid Wizard, which can also rely on the flexibility of the renewed high-speed generator sets. The fast variations of the diesel curves prove that the diesel generators are indeed actively solicited to ensure good spinning reserve.



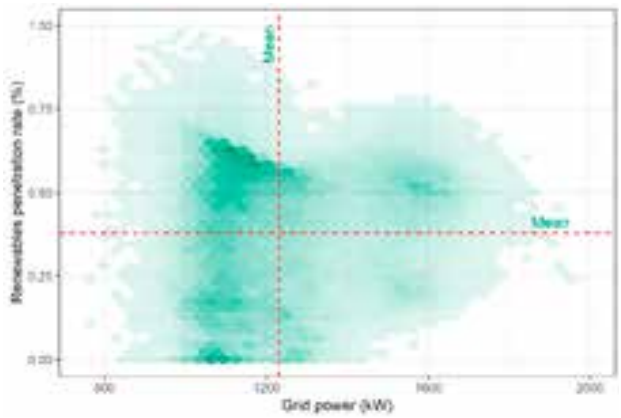
YREDP power profile and Renewable Energy penetration rate with high wind

Issues occurred during the YREDP operation
Since the YREDP commissioning in February 2018, only 2 occurrences of default in the hybrid system have appeared due to the same root cause: occurrence of a reverse power on the gensets during periods of low consumption (week-end) and high RE production.
The problem has been solved by adjusting a software setting and enabling dynamic regulation limit windows.
Since the setting has been corrected into the Hybrid Wizard controller, no blackout occurred due to the RE production which proves the robustness and the reliability of the hybrid system.

Actual performances of the system
Since commissioning, the YREDP system has been performing beyond the initial objectives. An average of 38% of RE production has even been reached over a 2-month period from January 2019 to February 2019, with peaks up to 80%.



Distribution of RE penetration rate from April 2018 to June 2019



Yap RE penetration heat map over 2-month period from January 2019 to February 2019

Conclusion: Towards 100% Renewable Energy with battery storage

The YREDP system has demonstrated its robustness and its reliability on an island system with specific grid conditions such as those found in Yap Island.

In order to reach 50% penetration and beyond, the grid can still integrate additional Wind and Solar PV capacity.

The introduction of Battery Storage will also become necessary to reach even higher RE shares, in order to maintain a high and stable level of RE production as well as to reduce solicitations on the high-speed diesel generators currently used to maintain sufficient Dynamic Spinning Reserve into the system.

Test Instruments for the Maintenance of Electrical Power Systems

MEGGER TORKEL900

Battery Load/Discharge Tester:

- Discharge testing for full insight into battery capacity
- Enhanced safety features including spark free connection and emergency safety fuse
- Ability to test the battery without disconnecting it from the system
- High discharge capacity shortens the test time
- A complete stand-alone discharge test system
- Optional individual cell monitoring

MEGGER SVERKER900

Manual Relay and Substation Test System

- Versatile toolbox for substation 3-phase testing
- Three currents and four voltages
- Stand-alone functionality
- Rugged and reliable for field use
- Generation of 900 V and 105 A in single phase mode
- Secondary and primary testing

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Consultancy on Renewable Energy and Energy Efficiency Guidelines, Competency Standards and Training delivered by GSES

Sandip Ravi Kumar
Pacific Technical Officer - Global Sustainable Energy Solutions

Global Sustainable Energy Solutions (GSES) is one of the leading companies in Australia in the fields of renewable energy engineering, training and consultancy. GSES also acts as the secretariat for Sustainable Energy Industry Association of Pacific Islands (SEIAPI).

Within Component 2 (Provision of Technical Services) of the World Bank funded Sustainable Energy Industry Development Project (SEIDP) for Pacific Power Association (the Project Implementation Agency) guidelines and competency standards being developed for renewable energy and energy efficiency for the Pacific Island countries. Furthermore, guideline workshops were conducted in 2018, continuing in 2019 and will be completed in 2020.

Caption: Participants of SEIDP 2019 Guideline Workshops in Port Moresby that was facilitated by Mr Geoff Stapleton

Renewable Energy and Energy Efficiency Guidelines
To date, the project has updated/developed the following industry guidelines:

- Grid-Connected PV Systems – System Design Guidelines
- Grid-Connected PV Systems – System Installation Guidelines
- Grid-Connected PV Systems – Operations and Maintenance Guidelines
- Off Grid PV Power Systems – System Design Guidelines
- Off Grid PV Power Systems – System Installation Guidelines
- Utility-Scale Grid Energy Storage Guidelines
- Solar Water Pumping: Selection and Installation Guidelines
- Energy Efficiency – Residential and Small Commercial Applications Guidelines
- Hybrid Power Systems (PV and Fuelled Generator) – System Design and Installation Guidelines
- Solar Water Heaters – Selection and Installation Guidelines
- SCADA System Guidelines

There will be 5 more guidelines developed as part of the project.

To access these guidelines and for any further information on the guidelines, please visit: http://www.seiapi.com/

Competency Standards
So far, the following competency standards which are more accurately known as unit standards by the Pacific Register of Qualifications and Standards (PRQS), have been created and have also passed the accreditation process:

- Designer of Grid Connected PV Systems
- Installer of Grid Connected PV Systems
- Designer of Off Grid PV Power Systems – DC Load SHS
- Designer of Off Grid PV Power Systems – Stand-alone Solar Systems
- Designer of Off Grid PV Power Systems – Hybrid Power Systems
- Installer of Off Grid PV Power Systems – DC Load SHS
- Installer of Off Grid PV Power Systems – Stand-alone Solar Systems
- Installer of Off Grid PV Power Systems – Hybrid Power Systems
- Maintainer of Off Grid PV Power Systems – DC Load SHS
- Maintainer of Off Grid PV Power Systems – Stand-alone Solar Systems
- Maintainer of Off Grid PV Power Systems – Hybrid Power Systems
- Operator and Maintainer of Grid Connected PV Systems
- Selection and Installation of Solar Water Pumping Systems
- Designer and Installer of Solar Water Heaters

These unit standards in the form of skill sets could be utilised by any training centre in the Pacific and can be easily framed into certificate and diploma courses on renewable energy.

There will be 6 more competency standards developed as part of the project.

For further information on the competency standards, please visit: http://www.seiapi.com/

Guideline Workshops

The guideline workshops have been very successful in bringing people from private industry, utility, government and trainers together to discuss technical issues. This interaction was beneficial to those who attended. The verbal feedback during the workshops was that they were benefitting from more time being spent on doing written exercises.

In 2018, there were 17 workshops conducted in 12 countries. Over 400 different people attended at least one day of the 4-day workshops conducted in 12 countries. These workshops were aimed at creating awareness on the grid-connect PV system, Off-grid PV system, Operation and Maintenance of PV Systems and Energy storage related industry guidelines.

In 2019, in excess of 250 people have attended at least one workshop of the eight 4-day workshops conducted in 11 countries. This year the guideline workshops were aimed at presenting design exercises and answers to enable better understanding on design and application principles.

Caption: Participants of SEIDP 2019 Guideline Workshops Conducted in Solomon Islands

A table summary provides details of guideline workshops conducted in 2019.

Country	Venue	Starting Date	No. of Participants	Presenter
Fiji	Novotel Hotel, Suva	8th July	28	Dr Herb Wade
Vanuatu	Ministry of Climate Change Conference Room	15th July	24	Dr Herb Wade
Nauru	CRC Conference Room, Yaren	15th July	18	Mr Geoff Stapleton
Solomon Islands	Solomon Power's conference room	22nd July	25	Dr Herb Wade
Tonga	Tonga Power Head Office	30th July	17	Dr Herb Wade
Kiribati	Public Utilities Board (PUB) canteen	6th August	23	Dr Herb Wade
Port Moresby	PNG Power training centre	20th August	42	Mr Geoff Stapleton
Lae	PNG University of Technology	27th August	24	Mr Geoff Stapleton
Cook Islands	TAU Board Room	7th October	30	Mr Geoff Stapleton
Tuvalu	Lagoon Hotel	16th October	16	Mr Geoff Stapleton
Samoa	Elisa Hotel	18th November	30	Mr Geoff Stapleton

To-date the project has delivered:

- 26 workshops in 12 countries;
- Updated versions of 4 pre-existing guidelines and developed 7 new guidelines;
- Developed 14-unit standards with 12 of them accredited through EQAP that is registered on the PRQS.

In addition, the project resulted in two workshops being conducted in Cooks Islands that were funded by TAU.

The guideline workshops that will be conducted in 2020 include:

- Chuuk: Tuesday 28th April to Friday 1st May 2020.
- Pohnpei: Monday 4th to Thursday 7th May 2020.
- Kosrae: Tuesday 12th to Friday 15th May 2020.
- RMI: Tuesday 19th to Friday 22nd May 2020.
- Palau : Monday 10th to Thursday 13th February.
- Yap: Either Monday 17th to Thursday 20th Ferbruary (or starting 24th – to be finalised)

Dr Herb Wade will be conducting the workshops in Yap and Palau while Mr Geoff Stapleton will be conducting all the other workshops.

PNG Power Substation Engineers Undergo Electrical Earthing Training – "A Practical Guide to Earthing in PNG"

Justin Harris
General Manager - Power Protection Industries

A total of seventy two (72) PNG Power Substation engineers and officers underwent a two-day training for 'AC Substation Grounding' to equip themselves with the latest technologies and standards.

Among the participants where ten staff from PNG Power centres in Wewak, Lae, Alotau, Kokopo, Yonki, Goroka, Kundiawa, Mt Hagen.

According to training organiser and PNG Power Transmission Support Engineer, Brian Inamo, the training was basically done to upskill Power Substation Operators and Technical Officers with the new technologies and improved industrial standards of Earthing which is expected to provide a low resistance path from specific equipment parts to the ground/earth for safety purposes or for fault currents to flow through and dissipate without causing harm to the equipment, human and lives.

"It is a requirement in electrical installations to have not just an earthing but a very low resistive path to the earth and if this is not installed, lives and thousands of dollars' worth of investments, asset and property can be lost from electrical faults. Even in our network today, as we speak, some faults prevail in the system because of poor earthing system and cause our protection system to trip and disconnect continuity of supply/service to our clients which result in loss of business," said Mr. Inamo.

"Our participants in this training are qualified engineers and officers, however understanding the improved industrial standards and practices is something I believe we as an organization lack because technically, we don't have Earthing Standards or guides/procedures spelt out to help us. This training is compulsory for the organisation and its business as far as the industry is concerned to upskill and empower its employees appropriately and then the employees will be expected to give back the service required to the company."

Facilitating the training was Power Protection Industries General Manager, Justin Harris, who said that their organization is also one of PNG Power's suppliers from Australia. Prior to the training, Mr Harris worked closely with Brian in the last couple of months to come up with the Konedobu Substation Upgrade - Earthing Design and Bill of Materials which has arrived for installation.

"It is paramount that suppliers of products into PNG provide both product training and training on the latest standards. We plan to continue servicing our customers for a long time throughout the Pacific Islands and we feel strongly that is our responsibility to continue passing on the latest technologies and expose clients like PPL to our manufacturers to address any questions they have as well as suggestions from the industry experts to help PPL grow" Said Mr Harris.

For further information about how PPI can help your organisation, please contact sales@ppindustries.com.au or +61 (7) 4412 6888.

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Kiwi Companies Recognised for Sustainable Energy Projects"

Infratec & Sunergise

Two New Zealand sustainable energy companies, Infratec and Sunergise, have each won two sustainable energy awards in the past week for solar projects in the Pacific.

Infratec received an Energy Globe National Award on Wednesday night for its Cook Islands mini-grid project and Sunergise was presented with an Energy Globe National Award for its Fiji Rural Electrification Programme.

Both companies were also recognised last Friday with the SEANZ (Sustainable Electricity Association of NZ) Award for Best Grid Connected Renewable Energy System, for their joint venture project in Nauru.

Nauru is the smallest island nation in the world and largely relies on imported diesel fuel to provide electricity to its 11,000 inhabitants. The joint venture's 1.15 MW solar plant, commissioned last month, is part of a larger drive to reduce reliance on imported diesel and reduce greenhouse gas emissions. It is expected to provide 2112 MWh annually (6.6% of the annual energy consumption in Nauru), and to save 600,000L of diesel annually.

Infratec's Cook Islands project has delivered four solar plants, providing clean, reliable and affordable energy to almost 1,500 people - about 9% of the population - and meeting about 95% of the energy supply needs of four islands that were previously supplied solely by diesel generators.

Infratec Chief Executive Greg Visser said it was pleasing to see the benefits that the projects are delivering.

"These are the sorts of projects that we relish doing at Infratec and Sunergise, which are all about making people and the planet better off, and we are really delighted to have that work recognised in this way," Greg Visser said.

"Both projects are delivering significant ongoing environmental and community benefits through the reduction of reliance on diesel power and reduced greenhouse gas emissions."

The Sunergise Fiji Rural Electrification project is a 'pay-forward' funding solution to bring sustainable cost-effective energy to up to 500 communities. It was made possible with support from the Leonardo DiCaprio Foundation and the Fiji government.

Sunergise CEO, Paul Makumbe said: "The future is about forming new energy partnerships and implementing innovative solutions. We are excited to be bringing these kind of projects to New Zealand and the Pacific Islands."

Media Release: Kiwi Company to Help Tuvalu towards 100% Renewable Energy Goal

Infratec

New Zealand renewable energy company Infratec has won a $NZ8.4 million contract with the Tuvalu Electricity Corporation (TEC) that will help the tiny island nation of Tuvalu towards its goal of 100% renewable electricity.

Infratec will design, procure, build and commission a Solar PV (Photovoltaic) facility and battery energy storage system on Tuvalu's main atoll of Funafuti. Once completed, the project will be Tuvalu's largest solar and battery storage asset. It will also be a strong foundation for further planned development projects, with Tuvalu targeting 100% renewable power generation by 2025.

About 6,000 people (55-60% of Tuvalu's population) live on Funafuti. Currently about 85% of the atoll's electricity is generated by diesel, with some distributed solar supplementing that. The project, expected to be completed by November 2020, is expected to provide about 10% of the island's energy supply, saving about 360,000 litres of diesel each year.

The project will include 770 kW of Solar PV and at least 1 MWh of battery storage, as well as upgrades to the existing power station controls, which will allow further renewable generation to be added in the future. The system will be designed to minimise the effect of rising sea levels by elevating the equipment above known inundation levels.

Infratec Chief Executive Greg Visser says that alongside the environmental benefits, the project will bring economic and social benefits for local businesses and communities.

"Up to 30 people will be involved in the design and construction of the plant, and Infratec will employ people from the local community for the construction phase wherever possible. We will also provide ongoing training to TEC employees who will operate and manage the plant following commissioning."

Infratec has also committed to work with local communities to deliver a programme to help reduce the incidence of sexually transmitted infection and diseases, in particular HIV and Aids.

"We are delighted to be working on a project that will deliver such meaningful benefits, and that is helping Tuvalu towards its goal of being 100% renewable by 2025," Greg Visser said.

"This is the kind of work Infratec relishes doing — delivering innovative renewable energy solutions to create positive impacts for communities, businesses and the planet."

The contract is financed by a US$ 9.1 million grant received by the Government of Tuvalu from the International Development Association (The World Bank) and the Small Islands Development States DOCK Support Program Multi Donor Trust Fund, toward the cost of implementing the Tuvalu Energy Sector Development Project.

This project is Infratec's third in the island nation, with a rooftop solar and battery storage system project currently being completed for the Tuvalu Fisheries Department, and having previously delivered a New Zealand Ministry of Foreign Affairs and Trade contract to install a roof-top solar system on two of the Government of Tuvalu's buildings in Funafuti.

Welcome!

New Allied Members

One new Company has joined PPA as an Allied Member since our last PPA Magazine. The new member is:

PROTECH POWER INTERNATIONAL PTY LTD: Protech Power International Pty Ltd is based in Queensland, Australia. Their primary activity is HV/LV Engineering design and consulting. Their secondary activity is commissioning, repairs, testing and maintenance.

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