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Pacific Power Association, Suva Fiji Islands. The PPA is an inter-governmental agency and member of the Council of Regional Organisations in the Pacific (CROP) established to promote the direct cooperation of the Pacific Island Power Utilities in technical training, exchange of information, sharing of senior managment and engineering expertise and other activities of benefit to the members.

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Cover Page Photograph – The attendees at GSEP and PPA's workshop on grid interconnection of renewable energies in the Pacific Island.

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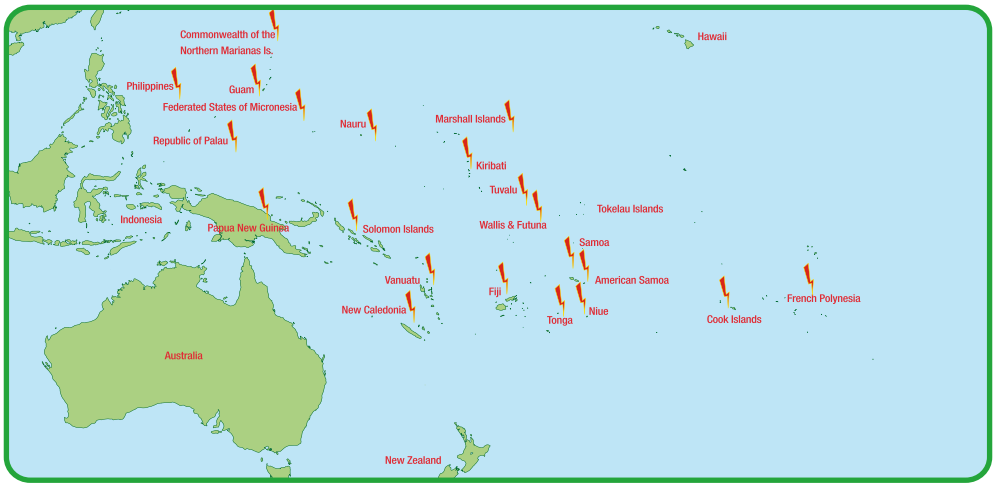

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Editor's Notes

Andrew D. Daka
Executive Director

Bula vinaka and greetings from Suva.

These are interesting times for utilities with the utility business not only in our region but also globally as utilities are having to deal with the "push" for high levels of renewable energy integration into the grid. More often than not, the renewable energy resources are intermittent or are Variable Renewable Energy (VRE) sources. The utility not only has to deal with the technical issues of integrating high levels of VRE, it also has to consider the potential impact on its sales through reduced consumption. Utilities will need to explore behind the meter services or other areas such as the electric vehicle markets that can take up the reduced demand especially in the domestic customer category. New technology is now available or being developed to help utilities make the integration of VRE achievable.

With the 26th Annual Conference and Trade Exhibition in Apia, Samoa, just around the corner, I hope that Members have taken the time to organise travel for the event which we anticipate will be another record turnout following the high standards set by Tonga Power Ltd when it hosted the conference last year in Nuku'alofa.

We thank the Electric Power Corporation (EPC) of Samoa, who are the hosts of this year's conference, for taking up the challenge. This year's conference will be the second time EPC is hosting, having done so previously in 1996.

This year for the first time we are inviting a number of Pacific Island Country Ministers responsible for Energy to join us at the conference. The Pacific Power Association and its Members recognise the need to engage with the National Governments to ensure smooth progression to achieving the renewable energy targets and sustainability of the utilities. The National Governments play a vital role in the success of the utilities as owners and policy makes; roles that impact significantly on the utilities. We look forward to the discussions in Apia and what we see as the beginning of a long partnership.

In this issue of magazine we continue with the series of papers presented at the 25th Annual Conference and Trade Exhibition. The subject matters include heat recovery to improve engine efficiency, renewable energy integration, project planning and a couple of case studies from the region. This should be interesting reading as we gather again this year to continue the discussions on the role renewable energy plays in making electricity affordable for the people of the region.

Before I conclude, let me welcome all the new Allied Members who have joined the Association since our last issue of the magazine; APR Energy, B&R Enclosures Pty Ltd, Busk Prestressed Concrete Ltd, Chapman Tripp, Progetti Plant S.R.L, Schweitzer Engineering Laboratories and Vortex Group Limited. Hope that you can join us at the conference.

See you in Apia, Samoa, at the 26th Annual Conference and Trade Exhibition.

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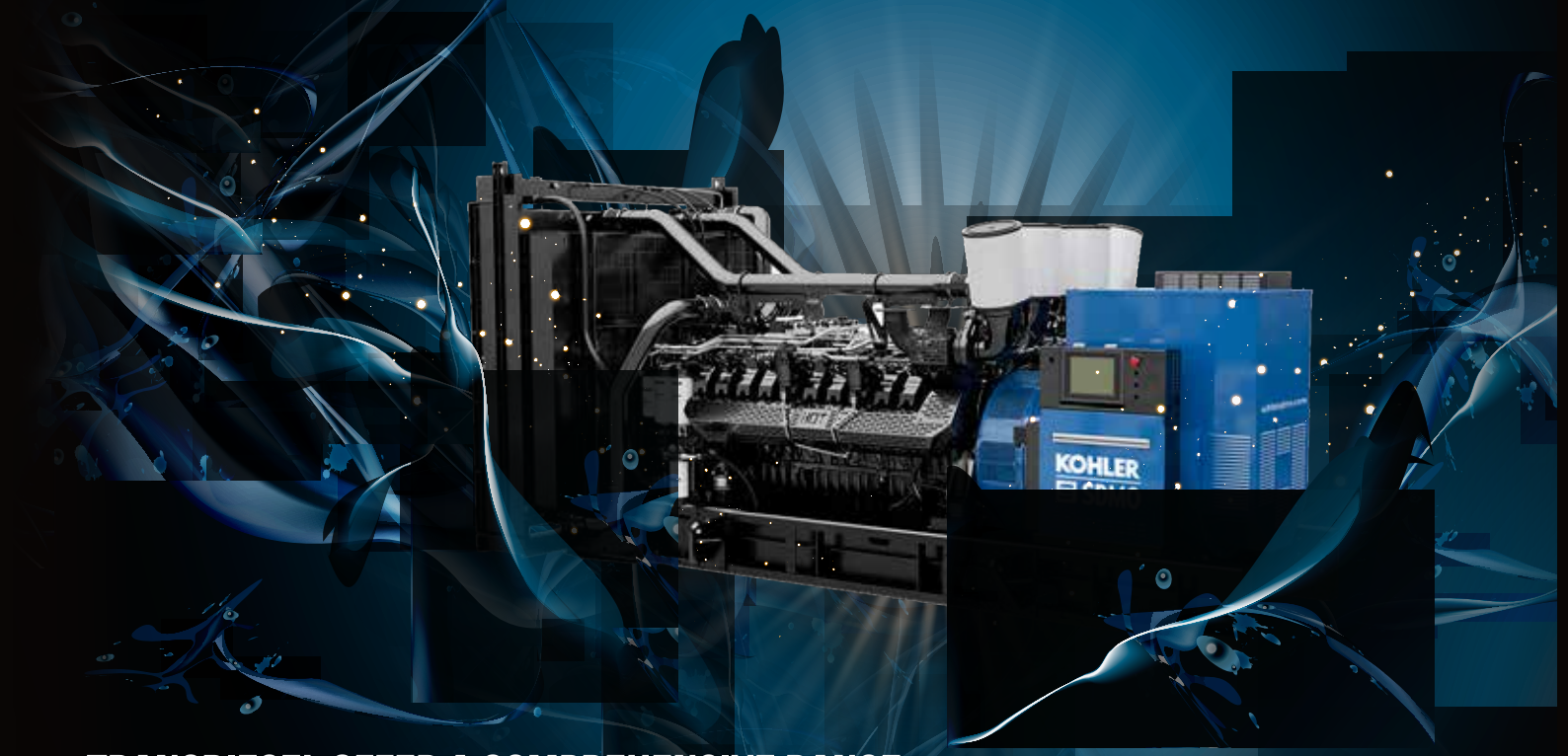

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Efficiency Gains using Waste Heat to Power on Reciprocating Engines

Robert Emrich
Vice President, ElectraTherm, Inc.

Continuous duty gensets provide base load power generation in diverse applications around the globe. However, high fuel costs and engine maintenance are pain points felt by operators as they deliver this critical service. A low maintenance path to significant fuel savings and lower emissions is what the U.S. Department of Defense (DoD) had in mind when they approached ElectraTherm to integrate the Power+ Generator™ with a Cummins KTA-50 1.1 megawatt generator. The DoD wanted to investigate the performance impact and economics for their diesel engine fleet. Between the DoD project and the 50+ Power+ Generators running in the field, ElectraTherm has demonstrated more than 10% increase in fuel efficiency along with simple installation, mobility and low maintenance. The Power+ Generator can replace the engine's radiator entirely and deliver a payback of two years or less for diesel or heavy fuel oil-fired gensets. In effect, the engine's waste heat becomes a source of cost savings by displacing the radiator's capital cost and parasitic load, i.e. more power with a quick payback.

In the past, there were no proven commercial products for converting engine heat to power so operators had little choice but to accept the heat loss to the atmosphere. Today ElectraTherm has deployed more than 50 units worldwide with over 60 years of cumulative fleet experience at 97%+ availability. ElectraTherm is the leader in small-scale, distributed power generation from waste heat; we utilize Organic Rankine Cycle (ORC) and proprietary technologies to generate power from low temperature heat ranging from 77-121°C. ElectraTherm's Waste Heat to Power (WHP) technology converts various sources of heat into power, including internal combustion engines, small geothermal, biomass, concentrated solar and process heat. ElectraTherm's primary market is waste heat from stationary internal combustion engines. With the typical engine running at about 33% efficiency, there is considerable waste heat between the jacket water and the exhaust. Typical engine sites include: prime power production in remote areas, island and developing nations, biogas gensets including landfill and wastewater treatment plants, natural gas compression stations and renewable biofuels.

Many Benefits of Heat-to-Power for Stationary Engines

There are multiple benefits to integrating an ORC heat to power generator with an engine genset and we can confidently say that we have created the world's most efficient engine cooling device. The first benefit is clear: the additional electrical output from the conversion of the waste heat to electricity with no additional fuel consumption or emissions. Second and less obvious is the reduction or elimination of the parasitic load from the engine cooling fans. The Power+ Generator acts as the radiator and, therefore, the engine-driven radiator fans can actually be disconnected, allowing more work to be performed by the engine to generate additional electricity. A third benefit can be achieved in hot climates or seasonally high ambient conditions, due to the fact that the ORC has a greater cooling capacity than the engine requires. So for very high ambients when the engine radiator limits the output of the engine the increased cooling capacity provided by the ORC's radiator allows for increased performance. The Power+ electricity output combined with reduced parasitics account for 10%+ fuel efficiency gain depending on engine size and configuration. The additional benefit from decreasing the engine's de-rate period or the amount of de-rate will, of course, vary with ambient conditions.

The Department of Defense Projects

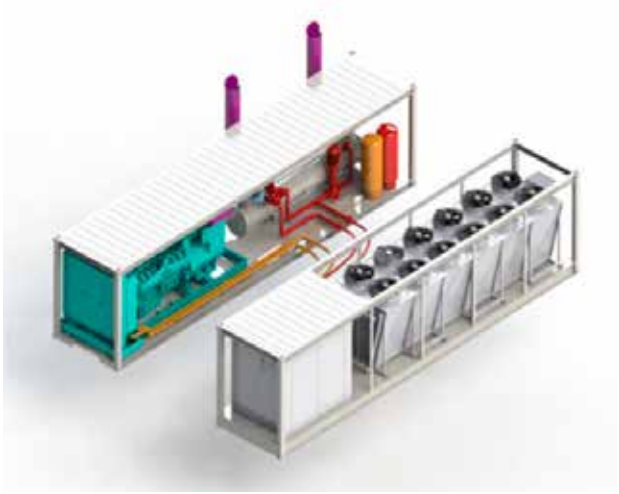
Our first project with the DoD was to simulate various engine models and ORC integration schemes, and fully test those configurations on ElectraTherm's test cell. A matrix was developed consisting of five engine models and two engine configurations over different ambient conditions for waste heat capture: jacket water only and jacket water boosted with exhaust energy for higher ORC efficiencies and output. U.S. Navy personnel visited ElectraTherm several times during the first project for training and inspection of our test cell and facilities. At the conclusion of this project a very favorable report was issued by the Navy.

The next step was to develop a higher output, fully integrated ORC specific to a Cummins KTA-50 1.1 megawatt engine for DoD deployment. The ORC and all balance of plant was packaged in ISO shipping containers for ease of deployment and mobility throughout the world. Funding for this second project came from DoD's Environmental Security Technology Certification Program (ESTCP) through Southern Research Institute (SRI)

who is independently monitoring the performance and fuel efficiency gains.

Figure 1 shows the configuration, comprised of two 40' ISO shipping containers. The Cummins genset, engine controls, switch gear and exhaust gas heat exchanger were housed in a Combined Heat and Power (CHP) module packaged under ElectraTherm's direction by Cummins Rocky Mountain from Denver, Colorado. The ORC module contained the Power+ Generator and associated controls, liquid loop radiator (combined radiator for the engine and ORC) and the corresponding balance of plant (piping, pumps and expansion tank, etc). The system was tested with the Mobile Utilities Support Equipment (MUSE) group at the Port Hueneme, CA Navy facility for fuel efficiency testing by SRI.

Figure 1. DoD funded ORC integration and replacement project



This project forced our engineering team to look hard at the question "Do we need both the engine radiator and ORC radiator?" All ORCs need condensing and all engines need cooling. Could it be done with one radiator, eliminating approximately $75,000 in capital cost for an engine this size? The answer is a resounding "YES". Advanced engine cooling with a payback was born, accomplished with an intermediate heat exchanger to optimize the return temperature to the engine and a bypass to ensure the engine cooling remained operating if the ORC is not running. The impact to the overall installed cost for an ORC can now be reduced by 20-30%.

ElectraTherm currently manufactures a 35 kW unit that fits well with ~500 kW gensets (our 4200 model), a 65 kW unit which fits well with ~800 kW engines (our 4400 model), and our project with the DoD is the first 110 kW unit (our 6500 model), well suited for 1-2 MW engines.

Figure 2. ElectraTherm recently installed ten Power+ Generator 4400s at a district heating plant in Slovakia.

ElectraTherm's experience to date with genset integration has been very successful. Our applications include single engines and multiple engines utilizing jacket water heat alone as well as jacket water combined with exhaust heat. Engine models that have been integrated with the Power+ Generator include Jenbacher, Deutz and MWM engines in Europe as well as CAT and Waukashau engines in North America.

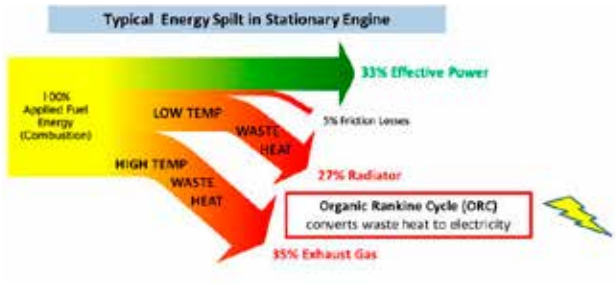
How it Workson

ElectraTherm's Power+ Generator operates using a closed loop ORC, where hot water is the fuel. Hot water from the engine enters a heat exchanger to excite (pressurize) the non- flammable, non-toxic working fluid, driving the twin-screw expander and generator to create electricity. ElectraTherm's patented twin-screw expander is unique in its configuration, lubrication and specifications, but the core technology is based on reliable, proven compressor technology that has been around for more than 20 years.

The twin screw expander has a rotational speed of 1800 - 4900 RPM, considerably less than turbo expanders. Unlike high speed turbo expanders, Screw expanders are robust units that tolerate "wet" dual phase flow. This allows the Power+ Generator to utilize more cost effective and compact heat exchangers that tolerate perturbations in both temperature and flow with turn down ratios of 6:1 available on demand. This is particularly advantageous in low temperature waste heat streams such as engine jacket water. Through a patented lubrication scheme, the Power+ Generator design is simplified and eliminates lubrication reservoirs, oil coolers, pumps, land filters, creating a simple, robust, and efficient system with fewer parasitic loads and maintenance requirements. Figure 3 shows why engine gensets are a great

match for Power+ Generators from ElectraTherm since a significant portion of the waste heat is at low temperatures and engine throttle positions can vary widely depending on the electrical load demand.

Figure 3.



Distributed WHP systems for stationary engines are not yet well known or mainstream, but the technology is field proven, and the economics are now attractive. ElectraTherm's various packaged solutions are making it easier to economically capture waste heat and make emission-free and fuel-free power from sources that already exist. In planning your next genset application, or if you have an existing radiator replacement coming up – consider implementing a radiator with a payback.

Flexible Energy For Efficient and Cost Effective Integration of Renewables in Power Systems

Wartsila

Executive Summary

We are witnessing a sharp increase in the volumes of intermittent renewable generating capacity in electricity markets. The demand for flexible forms of generation to manage this intermittency is expected to grow. Whilst it is likely that Demand Side Response, interconnection, and storage technologies will all have important roles to play, flexibility from generation will remain essential. However, some of the most common forms of providing flexibility from generation may be increasingly inefficient. In particular, part-loading of conventional generation can unnecessarily drive up the cost of providing flexibility, adding to consumers' bills.

In this paper, we set out analysis to demonstrate that using new forms of flexible generation (Smart Power Generation) can achieve significant savings over using traditional forms of flexibility from generation, particularly as the penetration of renewable generation technologies increases in the future. Electricity market arrangements need to value this flexible energy explicitly in order for new technologies to be deployed. Regulators and/or market operators should review their markets to ensure that the signals for flexible energy are fit for purpose given the significant changes in the generation mix on the horizon. The key arrangements to focus on are market balancing and ancillary service arrangements, and the incentives that these place on market participants.

The generation mix of the world's electricity markets is changing

The generation mix in electricity markets around the world is changing. Governments are putting policies in place to address the energy 'trilemma' facing their countries, often in response to national or regional targets that mandate a change in one or more areas. This trilemma is widely accepted to consist of:

•• **Environmental sustainability:** countries need environmentally sustainable ways of generating electricity, without long term dependence on burning of fossil fuels with its associated carbon emissions.

•• **Security of supply:** countries are seeking ways to ensure that 'the lights stay on' while managing growing demand or old generating capacity shutting down, which can be exacerbated by the intermittency of renewable generation.

•• **Affordability:** increasing electricity prices are a concern for all consumers, and have the potential to disrupt economic growth and throw households into fuel poverty.

It is key for governments to balance decarbonisation and security of supply improvements with affordability, especially in times of economic downturn and recession.

Renewable and low carbon forms of generation have a vital role to play in the sustainability effort, and, often, in security of supply. While nuclear technology offers low carbon energy at scale, it faces political challenges after the Fukushima incident in 2011 and has suffered escalating costs in recent projects using latest reactor designs[1]. Carbon Capture and Storage (CCS) may one day offer significant amounts of low carbon energy but it is still a fledgling technology, and it looks unlikely that the world will see commercial scale deployment before 2020.

Of the renewable technologies, hydro-powered and geothermal resources are effective, but their application is limited by geographical constraints. The key focus for renewables deployment in a 2020 timeframe is wind and solar generation. In 2010, wind and solar's contribution to the world's gross electricity production stood at just under 3%, and the IEA estimates that wind and solar would have to grow by 16% and 21% respectively to 2020 in order to follow the pathway required under its 450 scenario[2].

[1] *For example, the new Areva European Pressurised Water Reactor (EPR) designs have suffered delays and escalating costs at Olkiluoto in Finland, and Flamanville in France.*

[2] *The IEA's 450 scenario outlines an energy pathway that would limit the concentration of greenhouse gases in the atmosphere to a level of 450 parts CO2 per million.*
IEA 2011 , "Deploying Renewables: Market development for RE technologies".
IEA 2012, "IEA statistics: Electricity Information 2012".

Increased intermittent generation presents significant operating challenges

Wind and solar forms of renewable energy are intermittent in nature – their output fluctuates as a result of weather conditions. The output of wind turbines fluctuates with changes in wind speed, while solar PV output fluctuates as varying cloud cover impacts light intensity.

This presents an increased challenge for parties responsible for managing flows across the electricity networks, especially where the output of many wind and solar farms are correlated within an area due to regional weather patterns. In most countries this is a role carried out by the transmission system operator (TSO). However it is also a challenge for energy companies looking to ensure that the electricity their consumers need is fulfilled by the energy that they buy or generate. Electricity storage technologies are either not yet commercially developed, or are not available in all areas (such as forms of hydropower), so levels of generation output need to be actively balanced with levels of consumption on a second-by-second basis. At present this is mostly achieved by flexing the output of controllable sources of electricity generation (such as gas, coal, oil and hydro).

Larger volumes of flexibility will be required

System operators hold flexibility in reserve already to cover disturbances in the balance of supply and demand such as surges in demand, or for back-up in case of the failure of a large plant. The impact of large amounts of intermittent renewables on systems will need to be handled in a similar way, though it is widely accepted that the task of balancing wind and solar generation will be far more significant in future. This will mean that system operators may have to hold significantly larger volumes of flexible reserves than they do at present.

Without flexible forms of energy to balance increasing intermittency, the system could become unstable and insecure. It could lead to the system operator taking actions to curtail power from wind, solar or other inflexible generation in order to maintain system security, and in the extreme it could also lead to black-outs.

Question: what is flexibility?

Flexibility can be defined as the ability to change the level of electricity output (or consumption) in response to an instruction or another signal.

All forms of electricity production or consumption are flexible over certain timeframes. For example a combined cycle gas turbine (CCGT) can flex from producing no electricity at standstill to full output over the course of a couple of hours. Similarly some industrial processes take hours to days to entirely shut down to bring their electricity consumption to zero.

Response time is the critical differentiator for valuing flexible forms of energy in the context of balancing intermittent renewables. Flexible forms of energy must be able to ramp their output at the same rate that wind and solar output fluctuates, so that a balance can be maintained. Systems need to respond across different timeframes, from seconds to minutes to hours.

How can flexible energy be provided?

Flexibility in electricity markets is not a new concept. There is already a range of existing technologies that can provide the flexibility on the short timescales that will be required. Some of the common forms of flexible energy technologies are listed in Table 1 below.

Table 1 Common technologies used to provide flexible energy

Technology	Description	Notes
Storage	Includes hydropower, batteries, flywheels, pressurised gas and other developing technologies. Conventional hydropower is the most developed in a commercial sense. It provides flexibility by using the potential energy of water stored at height behind dams to drive turbines when released.	Apart from hydropower, other technologies are still struggling to be demonstrated on a commercial scale. Hydropower has specific geographic requirements (variable relief and water source)
Interconnection	Networks linking adjacent electricity systems to enable cross border trade of electricity – flowing to where prices are highest.	Requires sufficient flexibility to be available in the supplying market.

Thermal generation	Includes conventional turbines and reciprocating engines, with either simple or combined cycles. Simple cycle generators use the combustion process or heated steam alone to drive a generator. Combined cycle generators use the combustion process or heated steam to drive a primary generator, and then they exploit waste heat from the combustion process to drive a secondary generator for increased efficiency. Turbine-based generators are often fuelled by gas, light oils or coal. Reciprocating piston engines are fuelled by gas or oils. CCGTs and coal powered generators tend to require "part loading" so that they are ready to provide flexibility. Open Cycle Gas Turbines (OCGT) can often provide flexibility from standstill but can be inefficient on fuel. Reciprocating engines have highly efficient and flexible output from standstill and when running. For example, some engines are ready to deliver power 30 seconds after starting.	CCGTs and coal generators are very common for providing baseload power to electricity systems. OCGTs are common where there is more value in providing flexible energy. Reciprocating engines were previously used in niche applications – but are growing in range and size of application as flexibility requirements increase in scale and efficiency is required.
Demand side response	Energy consumers reducing their consumption in response to an instruction or signal (making demand fall to match available supply of electricity). Mainly provided by large users in response to spot market electricity prices, or in agreements with their electricity suppliers.	Requires a feedback response, and for businesses, the ability to compensate for lost energy to avoid lost output (eg, onsite energy production capabilities).

Hydropower and interconnection offer flexibility where they are available, and Demand Side Response (DSR) could have significant potential in the medium to long term[3], but it is widely accepted that thermal generation will still be required in most systems for providing flexible energy in the future.

Of the conventional thermal generation technologies used to provide flexibility, OCGTs can provide high levels of flexibility, but they lack the fuel efficiency of a CCGT to be able to generate electricity at regular market prices, which means that they are only used to run for short periods. CCGTs are generally efficient enough to generate electricity at regular market prices, which means that they have more stable running patterns (and revenue profiles), which has made them a popular investment in the past. At present, coal fuelled generators are also economic to run in the market owing to low coal prices, and in Europe, low carbon allowance prices[4].

It follows that many systems rely on CCGTs, or existing coal plant, to provide flexibility. As these plant cannot typically provide flexibility from standstill, they often need to be 'part-loaded' (in the box below). However, while this may have been practical in the past for providing small amounts of flexibility from existing generating resources, it is questionable whether such practices will be efficient for integrating renewable generation in the future.

What is part-loading?

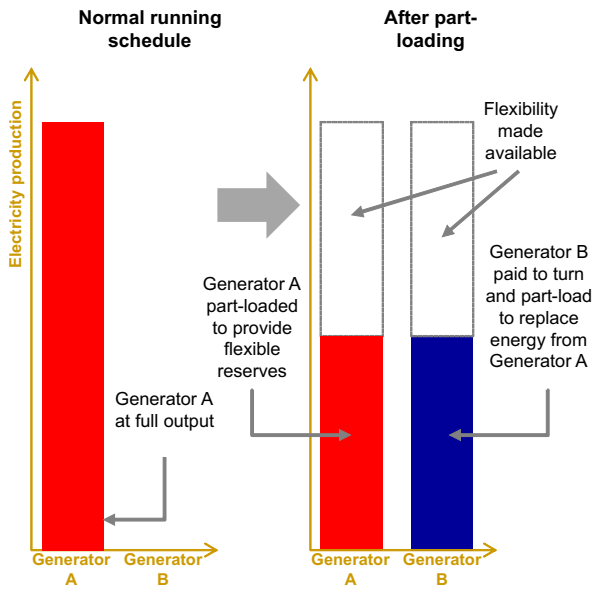
Part-loading is the practice of turning down generating units that would otherwise be running at full load, so that they can be turned up again to provide flexible energy if needed. Similarly, generating units that are not running can be turned on to produce low levels of output as a form of standby. It is a way of creating reserves of flexible energy.

[3]*Many commentators believe smart meters will enable price responsive behaviour (DSR) from a larger portion of consumers as smart meters become established in electricity markets.*

[4]*Plant owners must present European emissions allowances (EUA) for each tonne of carbon dioxide that their plants emit. The price of these allowances has hit all-time lows recently due to economic downturn in Europe and a surplus of allowances (at the time of writing, allowances trade at under €5/t).*

A generating unit that is turned down to part-load will produce less energy. So in practice, as a generating unit is turned down to part-load, another unit is turned up simultaneously to maintain the overall balance of energy[5].

Figure 1 Example of part-loading



In the example shown in Figure 1, in the normal running schedule, Generator A is running, but Generator B is not – often this is because Generator B generates electricity at a higher price than Generator A.

When Generator A is part-loaded to create potential flexible energy, Generator B needs to be turned up to replace the lost energy output from turning down Generator A. As Generator B produces electricity at a higher price than Generator A, the cost of producing the original amount of energy required has increased. This is the cost of part-loading.

Inefficiency of part-loading conventional generation

The practice of part-loading conventional power plants to ensure that they can provide flexibility is a cause for concern where the associated costs are inefficient, as these will be passed through to consumers' bills. These costs arise for a number of reasons:

- part-loading a generating unit that is already supplying energy to customers means paying another unit (probably one with a higher cost of generation) to turn up to replace the energy (as in Figure 1 above),
- part-loading a conventional power plant from standstill incurs large start-up costs owing to the time and fuel required to get the unit running at a stable level, and
- part-loading of conventional power plants also reduces fuel efficiency – because such plants tend to be most fuel efficient at maximum output.

It can be shown that these costs may be significant in some systems, and they could constitute an increasing proportion of consumers' bills as the level of intermittent generation grows in electricity systems. Markets will need to enable more efficient generation solutions for providing flexible energy to reduce these unnecessary operating costs.

Smart Power Generation for more efficient flexibility

Instead of focusing on part-loaded conventional generation to provide the increased flexibility requirement in the future, we believe that electricity markets need to embrace new forms of flexible generation, such as forms of Smart Power Generation (SPG).

SPG is a set of requirements that we believe future generators must be able to deliver to enable the transition to a modern, sustainable power system. These are:

- the need for **very high energy efficiency,**
- the need for **outstanding operational flexibility**, and
- the need for **multi-fuel operation**.

For today's emerging low-carbon power systems, these requirements allow balancing of large input fluctuations of wind and solar power. They also provide for high efficiency baseload, peaking, and load-following power, as well as super-fast and versatile grid reserves on a national power system level.

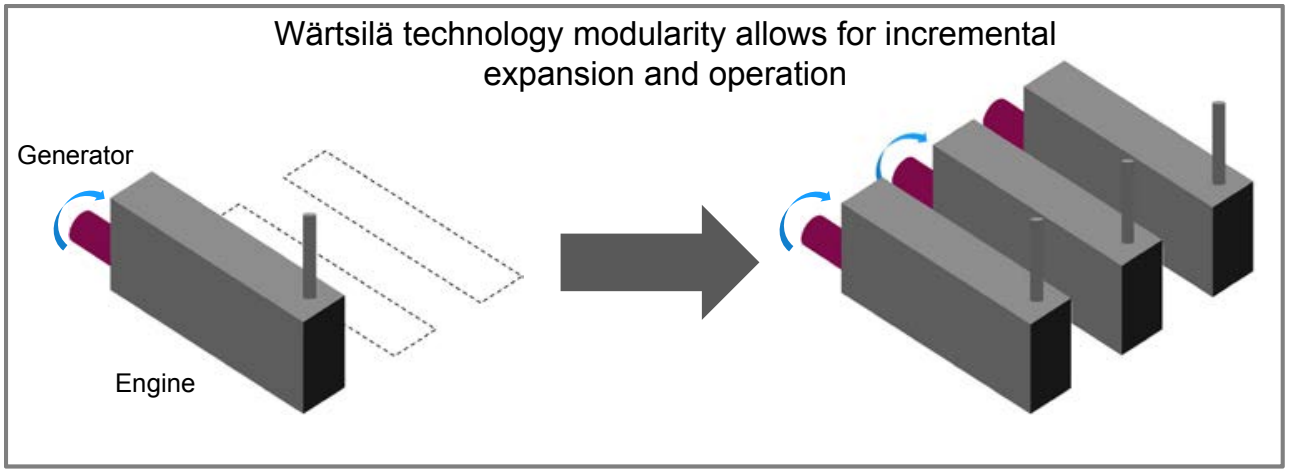
Wärtsilä's technology and power plant solutions have been developed to deliver against the SPG principles to enable sustainable, reliable and affordable power systems in the future (see Table 2 below). They are a form of highly flexible and efficient power plants based on reciprocating engines, covering a capacity range of 10 to over 500MW. These solutions are used across the world in different applications, from flexibility provision to baseload operation.

[5] *Similarly, if a generator is turned on as a form of standby, other generators that are already running will need to have their output reduced.*

Table 2 Wärtsilä engine overview against SPG principles

SPG requirement	Wärtsilä engine performance
Very high fuel efficiency	• More fuel efficient than the most flexible forms of turbine based generators (OCGTs). • Comparable efficiency to a CCGT, (around 50%) which means that it is economic to operate in the day to day electricity market in addition to flexibility provision. • Built and operated using a modular approach, so its load can be reduced without a corresponding drop in fuel efficiency (see Figure 2 below)
Operational flexibility	• Extremely fast start-ups which means that it is able to meet many flexibility requirements from standstill. • Able to produce energy from standstill after 30 seconds. • Reaches full power output after a further 90 seconds. • Does not have penalties for start/stops - more robust to repeated starts and stops than many turbine designs, which often require shorter periods of time between scheduled maintenance if subjected to abrupt changes in their running patterns such as increasing number of start/stops.
Multi-fuel operation	• Available for multi-fuel operation (either gas or biogas and a number of other liquid fuels including light and heavy fuel oils and biofuels).

Figure 2 Wärtsilä technology modularity



Estimating savings using Smart Power Generation

We have commissioned Redpoint Energy[6] to undertake analysis of the potential savings from using SPG for flexibility in the Great Britain electricity system instead of using new conventional plant. This modelling indicated that significant savings could be possible in managing the costs of intermittent wind output. Compared to using current practices, we estimate savings between £381 million to £545 million per annum in 2020 under different scenarios, and modelled savings are estimated to be even higher in 2030. The results are summarised in the box below.

Analysis of savings in flexible energy provision in GB from using Smart Power Generation instead of CCGT in 2020 and 2030

Methodology
We looked into the difference in costs of providing flexibility from a version of Smart Power Generation technology (referred to here as simply SPG), compared to using current practices of part-loading in the Great Britain electricity market.

The GB electricity market is characterised by an increasing wind penetration, with the UK Government aiming for 31% of electricity from renewables to meet its 2020 renewable energy targets. It has low levels of access to other sources of flexibility, (such as hydropower) and significant levels of installed fossil fuel powered conventional generation (77% in 2011[7]).
We modelled the GB market in 2020 and 2030,

[6] *A business of Baringa Partners LLP*

[7] *The Department of Energy and Climate Change, "Digest of United Kingdom energy statistics (DUKES)"*

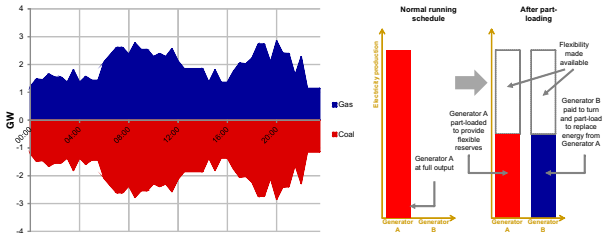
considering two scenarios for the trajectory of wind generation deployment – 'base wind' and 'high wind'[8]. In each of these scenarios, we replaced 4.8GW[9] of new build

CCGT generating capacity with 4.8GW of SPG. We used a power market simulation tool (PLEXOS) to determine the least cost dispatch of generators in the GB market, and also to simulate the actions that the system operator would have to take to create the flexible reserves of energy needed to integrate wind (known as reserve creation), and any constraints caused

by the GB network configuration. This allowed us to compare the costs of creating flexibility using SPG compared to the costs of creating flexibility using CCGT.

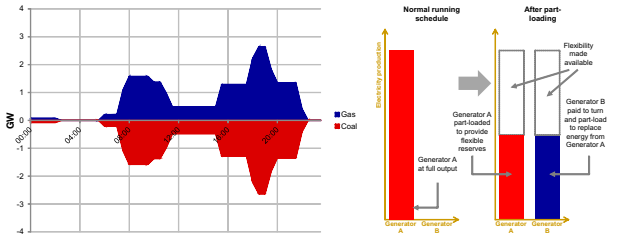
Results

Figure 3 Actions taken for flexible reserve creation (no SPG)



Taking a typical business day in 2020 from the base scenario as an example, the chart on the left of Figure 3 shows how the GB system operator would need to take actions throughout the day to turn down coal powered generation (the red area) while simultaneously replacing this energy with Gas CCGT (the blue area) to provide flexibility[10]. The chart to the right of Figure 3 illustrates the system operator's actions in part-loading terms.

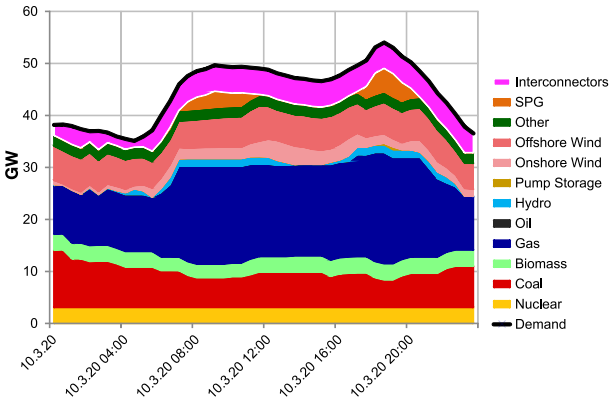
Figure 4 Actions taken for flexible reserve creation (with SPG)



In comparison, Figure 4 shows how the volume of part-loading is reduced when SPG replaces CCGT in the market. The need for flexibility has not disappeared, but rather, because SPG can be quickly dispatched from standstill in response to fluctuations in wind, there is a reduced need to take actions to prepare flexible sources of energy through part-loading of conventional generators.

High volumes of part-loading of conventional plant are still required across peak periods of the day (0700-1100, and 1500-2100) partly because market prices at this time are driven to levels where it is economic to sell SPG output in the market, which means it is unavailable to provide flexible energy. This is shown in the dispatch of different generating technologies in the market across the typical day in Figure 5.

Figure 5 System generation with SPG



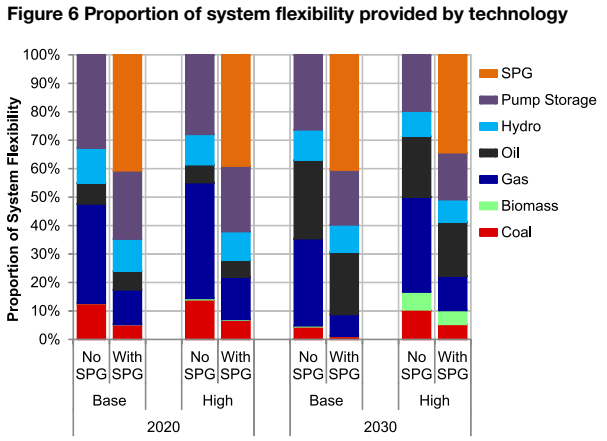
[8] *The key difference between the two scenarios is the volume of offshore wind capacity. The base wind scenario includes around 10 GW of offshore wind in 2020 and around 15 GW in 2030. The high wind scenario includes around 20 GW in 2020 and close to 40 GW in 2030. Base wind uses a capacity mix that is consistent with the Central scenario of the UK Government's Updated Emissions Projections (2011). High wind has a higher capacity of onshore and offshore wind, in line with the system operator National Grid's latest Gone Green scenario (as published in the UK Future Energy Scenarios in October 2012).*

[9] *Which aligns with our assumptions on new build CCGT in GB to 2020*

[10] *The modelling assumptions were such that electricity produced from coal was calculated to be lower cost than electricity produced from gas, meaning that coal was already in the market and available to be turned down to part-load.*

The proportion of flexible reserves provided by SPG across all years and scenarios modelled is shown in Figure 6 below. Where SPG is included on the system, it is the single biggest provider of flexibility across all years and scenarios modelled, mainly having the impact of displacing the use of gas CCGT and coal for providing flexibility.

Figure 6 Proportion of system flexibility provided by technology



Savings in the provision of flexibility

In GB, the costs of reserve creation are recovered as a charge collected from market participants, which are passed through to consumers' bills. As SPG reduces the need to create reserve, it produces considerable savings, which are set out in Table 3 below.

Table 3 Costs of creating flexible energy (reserve) with and without SPG

Reserve creation costs for integrating wind)	**2020**		**2030**	
	Base wind	**High wind**	**Base wind**	**High wind**
Costs – no SPG Costs – with 4.8 GW SPG	692 311	1008 464	834 256	2781 1244
Cost savings due to SPG	381	545	578	1537

Separate to the GB study, we have also commissioned a study into the Californian wholesale electricity market in 2020 to estimate the impact that SPG could have in helping the Californian Independent System Operator (CAISO) to manage upcoming challenges such as heavy penetration of renewable generation and other variable sources.

The Californian market is structured differently to the GB market, however the modelling indicated that SPG could still provide significant savings in the different markets' costs, for example:

- In the Californian day-ahead markets, the modelling indicated that SPG would reduce the cost of total energy production in the market in 2020, producing cost savings compared to a base case ranging from 3.9% to 5.1% ($273m to $352m p.a. respectively). This saving is derived from the increased efficiency of SPG over existing forms of generation capacity (such as CCGT).

- The cost of providing ancillary services (flexible reserves) was also reduced by 3.5% to 8.4% ($16m to $39m p.a. respectively) because of SPG's low starting costs and fast starting capabilities.

- On the real time dispatch market on a modelled peak demand day, the efficiency of SPG lowered overall market costs by 38% or $13.6m, with further savings of $2.5m owing to its increased flexibility.

The full results of the Californian study are available on the Smart Power Generation website[11].

Challenges facing SPG and other forms of flexible energy

There are a number of challenges facing the deployment of all new forms of flexible energy across electricity markets that can act as a barrier to market entry, even as the need for flexibility increases with the growing penetration of intermittent renewables. The most common themes are:

- **Prices that do not reflect the real value of flexible energy:** short term prices paid for buying and selling energy do not always reflect the actual costs incurred to balance intermittency. In such systems, market participants do not bear the full consequences of not balancing their generation or consumption, and as a result they are less willing to buy or offer flexible energy capabilities

– in effect, reducing the market for flexible sources of energy, and increasing the likelihood that the system operator will need to rely on part-loading of conventional plant. This is a particular problem in some European markets, where intermittent generation causes large imbalances but is paid through fixed support schemes and as a result it is not required to face market based balancing incentives.

[11] *www.smartpowergeneration.com*

- Lack of liquidity in short term markets: strongly linked to the point above, levels of liquidity in short term markets (such as within day markets) are often low where there are weak incentives to avoid charges for creating imbalances. This reduces the confidence that investors have around whether they will actually be able to sell their flexible energy.

- Poor exit signals for old generators: many governments and regulators have implemented (or are considering implementing) capacity mechanisms and other forms of long term contracts[12] to sustain adequate levels of generation capacity on the system, which can mean that aging and inefficient generation is kept open instead of decommissioning at the end of its life. This old generation blocks the opportunity for new technology to come forward, and often locks in inefficient provision of flexibility through part-loading.

Making markets work for flexible energy

Distortions in market arrangements can be addressed to encourage the deployment of flexible energy sources. Making charges for imbalances more cost reflective is the key prerequisite for creating a market where flexible energy is valued, traded and invested in by all market participants, including intermittent resources of energy.

Markets should also be open for all participants to provide reserves of flexible energy to the System Operator on a short term basis, or equally, for participants to sell reserves to each other to meet their balancing needs. The European Agency for Cooperation of Energy Regulators (ACER) has recently recommended that System Operators should procure reserves on short timescales in preference to long term contracts to increase the efficiency of procuring such reserves, and to enable market entry for small providers of reserves.

Cost reflective prices are assisted by enabling market structures (such as within day net pools for final trades of energy, and platforms for trading reserve) that help participants see prices forming in liquid markets in reaction to changes in the short term balance between electricity supply and demand. This enables participants

to make informed decisions, and provides the opportunity to change positions in response to price signals. A further benefit is that these structures provide robust reference prices from which to base supply agreements and hedging arrangements, which assists new investment.
Finally, governments and regulators that are designing interventions to sustain security of supply, such as capacity mechanisms (contracts for remunerating installed capacity separately from energy generated), should ensure that these interventions do not jeopardise the market signals for flexibility set out above. Ideally, such interventions should use the shortest contracts possible to allow for efficient exit signals and new entry at appropriate times.

It is vital that these areas are addressed in electricity markets ahead of significant deployment of intermittent renewables to protect consumers against unnecessary costs arising from inefficient provision of flexible energy from part-loaded plant in the future.

Smart Power Generation and Wärtsilä

Smart Power Generation enables the transition to a modern, sustainable power system. Its cornerstones are high efficiency, excellent operational flexibility, and multi-fuel capability. For today's emerging low-carbon power systems, it balances large input fluctuations of wind and solar power. It also provides high efficiency base load, peaking, and load-following power, as well as super-fast grid reserves on a national power system level.

Wärtsilä is the global leader in Smart Power Generation. Wärtsilä's technology and power plant solutions have been developed to provide a unique combination of valuable features enabling new horizons for sustainable, reliable and affordable power system of the future. Wärtsilä's portfolio covers the capacity range from 10 to more than 500 MW, with over 52 GW of installed capacity in over 160 countries.

To find out more about Wärtsilä and Smart Power Generation please contact **kimi.arima@wartsila.com**, or visit **www.wartsila.com.**

[12] *Such as some ancillary service contracts.*

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Tightening The Utility Belt: Utilities Agencies In Micronesia Have Multiple Challenges

Joy White

The islands face considerable challenges in providing quality utilities to their residents, ranging from aging or nonexistent infrastructure to securing adequate funding.

Despite many challenges, utility companies say there have been great successes and that they are optimistic.

Joseph Duenas

An overview of utilities in Micronesia

Many of the island communities are growing, in particular Saipan.

"The challenges facing the Commonwealth Utilities Corp. Today are in some ways reminiscent of past boom and bust cycles that have impacted the island. However, the latest economic cycle appears to have significant growth, with the casino and tourist industries expanding rapidly along with resort and support communities for workers in the industry," says Gary Camacho, acting executive director of the CUC.

The CUC produces an average of 11.5 million gallons per day of water and treats approximately 3 million gallons per day for a customer base of 8,139. In addition, the water and wastewater customer base is expected to grow over the next three to four years.

Power demand across the island of Saipan is normally 30 megawatts per day with peak summer demand approaching 39.2 megawatts.

Guam Waterworks Authority and Guam Power Authority are doing well financially and are continually improving internal operations and efficiencies, according to Joseph T. Duenas, chairman of the Consolidated Commission on Utilities. GPA and GWA are public corporations, and rates are determined by Guam's Public Utilities Corp.

"We're doing very well for both companies. They're well managed and operated and they're doing very well financially," Duenas says.

GPA and GWA are the only utilities of the U.S. territories that have investment-grade ratings from three rating agencies, he says. These ratings have allowed the agencies to sell bonds on the market to allow them to finance upgrades and projects.

Work began on Guam's Agat/Santa Rita Wastewater Treatment Plant in 2016 to meet mandates from the Environmental Protection Agency. The plant will receive flow from southern Guam to include Agat and Santa Rita collection basins sewer connections, Cross Island Road and Baza Gardens.

The Marshalls Energy Co., which oversees power and water services with partner utility companies in Majuro and Ebeye, as well as providing power service to the outer islands of Wotje, Jaluit and Rongrorong, is overseeing major improvements in water, sewer and power infrastructure.

MEC provides power to 3,496 residences, 431 businesses and 131 government offices in Majuro. Over 80% of the residences have been converted from post-power use billing to pay-as-you-go cash power meters, which has significantly reduced debt owed by customers as MEC devotes 30% of cash power payments to repaying debt owed by customers.

Mark Waite

Thirty years ago, alternative energy options for power companies in small islands like the Marshall Islands was just talk. Today, the Marshall Islands capital of Majuro has two grid-linked solar arrays, and donor organizations are lining up to fund major new grid-linked renewable energy infrastructure for urban Majuro and Ebeye and several outer islands.

The number of water customers in Majuro is much lower with many illegal hook ups to the city water system on Majuro. Majuro Water and Sewer Co. provides salt water sewer services to 2,287 customers, while 965 customers have fresh water services.

Ebeye's power and water utility, known as Kwajalein Atoll Joint Utilities Resources, has 1,264 cash power customers and 847 residential fresh water connections.

With the various donor-supported infrastructure projects either in motion or expected to come on line over the next couple of years, power, water and sewer services in the Marshall Islands are looking up.

Investment and investment planning is a significant issue in the region, a benchmark report by the Pacific Water and Waste Water Association states. Kosrae never had an investment project, and Southern and Central Yap completed their last investment project more than 10 years ago. Pohnpei Utilities Corp. completed its last investment project four years ago. Majuro completed its report in 2001 and has ongoing projects.

Water and wastewater

Water and wastewater challenges faced by the islands include meeting standards for quality and combating leaking systems and non-revenue water.

Data from the 2016 Pacific Water and Wastewater Association Benchmarking Report shows a need for Micronesian utilities companies to upgrade their water systems.

The report, which includes performance assessments from 2011 to 2015, states that urgent projects needed in the region include

- a $2 million water treatment plant upgrade in Pohnpei;
- a $1 million new water treatment plant in Yap;
- a $300,000 billing system in Kosrae;
- a $500,000 to upgrade Southern Yap's treatment plant and metering.

Photo courtesy of Mark Waite RJE Global PTY Ltd. of Australia was contracted by the Chuuk Public Utilities Corporation for $12 million to construct a new power distribution system on Weno.

A six-year, $19.1 million revamp of Ebeye's antiquated fresh water and sewer system started last year with funding from the U.S. Department of Interior, Australia and the Asian Development Bank. "The sewer system was given a rating of 'black' [the most serious condition] because it is non-operational and the presence of raw sewage is a public health issue," a U.S. Army Corps of Engineers evaluation of Ebeye infrastructure in 2010 states.

"For the last five years, raw sewage from the collection system has been directly pumped into the lagoon without treatment," the evaluation states. On fresh water systems, the Corps of Engineers says, "The water distribution and production system do not have enough capacity nor pressure to support the population. Water is rationed and

is currently being distributed twice a week for durations of 45 minutes. There is a lack of spare parts, pumps, and one of three reverse osmosis (water-making) filtration units is non-operational." Although the water picture has improved since this 2010 report, the ongoing sewer and water overhaul is urgently needed and long overdue.

In the Federated States of Micronesia, Chuuk Public Utility Corp.'s newly refurbished wastewater sewage plant has been operational for 12 months. The state's water wells have also been refurbished.

Some $4 million in Chuuk State compact infrastructure funds went to upgrades to the wastewater system, while $1 million in upgrades to the water system was funded by the Japan Fund for Poverty Reduction, a program funded by the Japanese government to provide grants for projects supporting poverty reduction and related social development activities that can add value to projects financed by ADB, according to the bank's website.

"We are now operating 24 hours a day. Before the investment service was intermittent and unreliable," says Mark Waite, CEO of CPUC.

CPUC has 600 connections for water services and hopes to expand. A barrier to expanding the number of connections is that many people still rely on natural sources of water, including rainwater and shallow water catchment.

Photo courtesy of Kwajalein Atoll Joint Utilities Resource

Photo by Hilary Hosia

(Above) A reverse osmosis unit was expected to arrive on Ebeye Islands in late February as part of a $19.1 million water and sewer improvement project. (Below) The Marshalls Energy Co. in Majuro has six million gallons of fuel storage capacity, the largest bulk fuel facility in this part of the Pacific. The tanks have experienced severe deterioration in recent years and plans are in motion to renovate the tank farm.

Cost recovery for water and wastewater operations has been a challenge for the CPUC, as cost recovery is not at 100% and at the moment power operations support the water and wastewater, Waite says.

The CPUC is looking to improve efficiency in its water and wastewater operations to reduce cost and may have to consider increasing the charges for water and wastewater services over the next three to four years.

In the NMI, the CUC has improved delivery to 81% of its customer base in December, and strives to meet water service demand to customers 24/7, Camacho says.

The agency's goals for improving the water system include

- improving leak detection of the distribution system to reduce water loss and increase water supply capacity, and addressing unaccounted for or non-revenue water that is a result of both water produced and water billed;
- addressing meter consumption accuracy issues due to meter failures, theft of water, and unknown connections from the early days of the system;
- making continuing progress to address all of the remaining action items associated

with Stipulated Order #1.

"CUC has made significant strides to complete the list of action items called for, however, completion of the Water and Sewer.

Master Plans is a major item of concern that will require real work to complete, despite having conditional approval of the final draft document," Camacho says.

Improvements to the CUC wastewater system include

- expanding the use of equipment for flushing, cleaning and televising to monitor and capture pipe conditions throughout the system. Potential issues include collapsed mains, tree roots and pipe deterioration due to hydrogen sulfide buildup;
- anticipating the increased wastewater flows coming as a result of economic growth. "[CUC will need to] begin planning for the next plant expansion at one or both wastewater treatment plants, Camacho says.

The continuing issue for Guam Waterworks Authority is meeting Safe Drink Water Act and Clean Water Act requirements mandated by the Environmental Protection Agency through a court order. To meet these requirements, the agency is assessing 30 water tanks and constructing or rehabilitating facilities.

The CCU is selling about $650 million in bonds to meet these requirements and complete other projects, Duenas says.

GWA is also working to address issues surrounding non-revenue water, which is water that is expended but not paid for. Non-revenue water results from leaking storage tanks and pipes, non-functioning water and theft. In addition, Guam's underground water infrastructure in some areas is layered where GWA built infrastructure atop older water infrastructures built by the military, and due to poor record keeping GWA may not know of these pipes. The infrastructure may not have not been receiving maintenance for many years. In time, GWA will standardize the whole water system, Duenas says.

About 53% of water expended is non-revenue water, Duenas says. The goal is to decrease the amount to 20% to 30%. The CCU estimates that about $5.3 million is lost from non-revenue water. To address the non-revenue water issue, GWA is replacing all metal storage tanks to concrete tanks.

GWA is also upgrading Guam's sewer system and improving wastewater treatment methods and facilities. The Northern Wastewater Treatment Plant is being upgraded with the help of Department of Defense funds for the military buildup. GWA broke ground in 2016 on improvements to the Agat/Santa Rita Wastewater Plant, a $54 million undertaking.

EPA is requiring secondary treatment of wastewater for Guam, as the island is currently using advanced primary treatment.

While the issue of wastewater treatment in the northern treatment plant will be funded by DOD, the Hagåtña wastewater treatment facility may not be upgraded for a while. Duenas says the CCU is hoping to work with EPA to delay the deadline to upgrade the system in 25 years. By this time, CCU hopes to be able to pay off existing debt from the 2008 bonds to afford additional upgrades.

"Ratepayers can't afford to borrow anymore," Duenas says. "[…] We're at the point that we can't acquire any more debt. We have to consider affordability."

Palau is faced with issues of its sewage system exceeding its capacity.

The Palau Public Utilities Corp. has commenced on a $17 million project to strengthen the transmission main from Airai Water Treatment Plant to Ngerkosowaol service tank. The project will also include the construction of a new Malakal tank, the replacement of aging asbestos-cement pipes and the installation of new pipelines.

Work is also expected to start on Palau's Koror-Airai Sanitation Project. The PPUC on Oct. 21 signed two contracts for sewerage network, which were to start in January. The work is funded by an Asian Development Bank loan of $28 million.

Progetti Plant of Italy and Pacific Engineering Projects Ltd. of New Zealand signed the contract agreements to begin construction work for two of four major components of the sanitation project.

Progetti Plant was awarded sewer network rehabilitation and expansion work in the Malakal and Meyuns areas, while Pacific Engineering Projects was awarded the contract for sewer network rehabilitation and expansion in Koror.

New hotels being constructed are no longer allowed to connect to the main sewage system and are required to build their own holding tanks.

In the Marshall Islands, the U.S. government

is funding preparation of a 20-year strategic development plan for Majuro Water and Sewer Co.'s struggling fresh water and sewage systems. This includes options for fixing a sewage system and outfall pipe that has been broken for decades, spewing untreated sewage onto the reef that is then spread along reef areas used by local residents for fishing and swimming for miles down current.

Power generation and distribution

Power generation and distribution in Micronesia is improving gradually.

CPUC in Chuuk is nearing the completion of a $12 million investment for a new power plant and distribution system on Weno, the state's capital, which is expected to be completed by May 2017.

The contractor for the power plant is RJE Global PTY Ltd. of Australia. The project was funded through Chuuk State compact sector funds and a loan from the Asian Development Bank, which the agency is repaying.

"The power business is now commercially viable with full cost recovery," Waite says.

Once the facility is complete, the next step is to expand services across Chuuk state, as only 27% of the state has coverage. The CPUC has 1,800 connections for electricity in Weno, Waite says.

"We'll be rebuilding the power distribution in Tonoas south of the main island later in 2017, and we're undertaking an

investment master plan, funded by the World Bank, to map out service provisions to all the unserved islands in the state. Once the master plan is complete, we'll have a clear idea of how much it will cost to deliver electricity across the rest of the state in a sustainable manner," Waite says.

Implementation of the investment master plan is expected to take four to five years, and the agency will source funding for the projects from development partners and the private sector.

Photos by Ongerung Kambes Kesolei
Construction continues in Koror as the Palau Public Utilities Corp. works on projects to improve water and wastewater systems.

The CPUC expansion will be designed to include a high level of renewable energy through solar power in order to achieve the state target of 30% generation by renewable energy. Currently power in Weno is generated by a combination of diesel and solar power with only 2.5% coming from solar.

Following the devastation of Typhoon Soudelor in August 2015, the CUC in the NMI has spent considerable effort in rebuilding the power distribution system.

"That effort, the savagery of the event, the importance [that] power plays on the island as well as water and sewer, took a monumental toll on the utility," Camacho says.

The success of the CUC following the typhoon was made with the assistance of other utility companies from Guam, Kosrae, Palau, Pohnpei and Yap, as well as Primary Source from Colorado.

Efforts continue, as the CUC works to install 700 concrete poles and install new transformers to upgrade and downsize temporary transformers that had been used to reestablish power across the island.

In addition, CUC has plans to improve its power systems. "Power systems require significant lead time for planning, scheduling

and timing when the current reserve power available at the plant should be expanded to anticipate and assure users that CUC is prepared to meet their electrical service demands," Camacho says.

CUC's focuses for power system improvement include

- installing one new 8-megawatt engine

to replace an engine at one of its power plants;

- hiring a consultant to support the one new engine installation and assist with authoring a new RFP for securing five additional engines and expand the plant for planned growth requirements;

- completing the installation and closure of work around Stipulated Order #2 that involved a new pipeline and storage tank for the power plant.

Guam Power Authority also struggles with power generation, as the island's power plants age. Cabras 1 and 2 are two or three generations behind, Duenas says, and are due for replacement.

GPA has a capacity of 355 megawatts, with efforts ongoing to increase generation by 40 megawatts with two units in Dededo and to replace Cabras 3 and 4, which were severely damaged in August 2015 by an explosion.

GPA is working to improve the alternative renewable energy aspect of power generation.

Due to the tendency of intermittent rain and cloud cover, the energy farm in Layon has not been as successful as initially hoped. The energy farm struggles to produce energy at a steady rate. Currently GPA produces 25 megawatts while 12 megawatts are generated from the private community.

"The problem is renewable energy is still evolving. It hasn't reached the point where its reliable, robust and economical enough," Duenas says.

The next phase of GPA's renewable energy efforts will include a requirement that contractors include energy storage to alleviate intermittency in energy productions.

A $20 million to $30 million plan for outfitting Ebeye with a massive solar panel "farm" to produce 40% of the island's power now generated by diesel engines, as well as shifting Wotje, Jaluit and Rongrong islands from diesel generators to 95% solar power, is in progress. If this comes to fruition, it is estimated it would save the government utility company between $2 million and $3 million annually on diesel. The United Arab Emirates Abu Dhabi Fund for Development has approved an $11 million low-interest loan for this solar project, with the World Bank reviewing a larger investment in the solar plan.

In the meantime, the Marshalls Energy Co. is preparing to purchase two new 2.5 megawatt diesel engines in the near future to

give it backup power generating capacity it now lacks. The challenging power supply situation was worsened in mid-February when a fire damaged one engine in MEC's power plant, reducing the number of working generators to four — from seven previously available.

The four original 2.6 megawatt engines in MEC's original power plant were installed in 1982, and two are not currently in operation. "New engines will be more efficient, so we'll save on fuel costs to operate them," says MEC CEO Jack Chong Gum, who added the utility is applying to the U.S. Rural Utilities Service for funding for the engine purchase.

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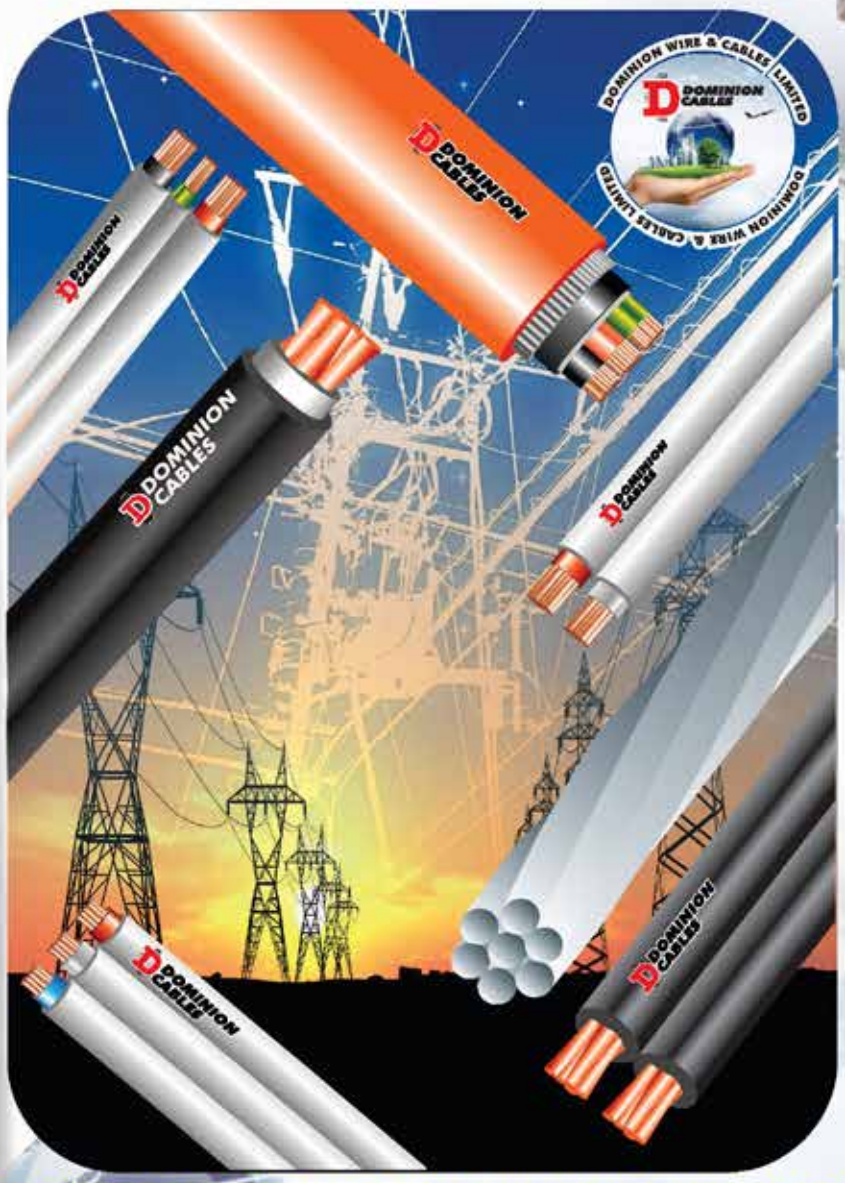

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Backwards Into The Future

Wartsila

Science geek turned clean-energy CEO Geof Syphers says that solving problems backwards is the key to unlocking solar power's enormous potential in the state of California. A falling monkey, wastewater ponds and old-fashioned number crunching also played their parts.

Sonoma County's half-million population has more renewable power per capita than any other county in the United States, thanks to a year-old publicly run agency called Sonoma Clean Power (SCP). While its name is straightforward, its achievements are nothing but groundbreaking. In less than a year, SCP has saved the county 100,000 metric tons in emissions, equivalent to taking more than 21,000 vehicles off the road.

"We're saving people money while we're doing that," points out CEO Geof Syphers, who at 44 has gone from teenage science enthusiast to major clean-energy actor in a few decades. His agency has shaved 6 to 9% off Sonoma family's electricity bills already. "It's about making a market," he says. "More renewable energy is not the goal. Lower greenhouse gas emissions: that's the goal. Stronger economies, lower bills, having a climate your kids can live in. Those are the real goals."

The agency's latest idea is one they hope will be replicated across the state of California, whose large population has put such a burden on water supply that in spring 2015 rationing was introduced. Solar panels on top of water-treatment ponds not only use what little available space there is – as SCP must brush elbows with farmers and developers alike for land – but help conserve water as the installations reduce evaporation due to wind. It will serve as a blanket, more or less critical in California where pumping, treating and transporting water consumes 20 percent of the electricity.

Most of all, the sprawling 12.5-megawatt solar park being built atop six storage ponds reflects the growing clout of Syphers's government agency, which is leading a robust clean energy movement called Community Choice Aggregation (CCA) that is gaining speed nationwide. Through CCA, publicly run power agencies like Sonoma's let communities decide where their energy comes from, while working with traditional investor-owned utilities to distribute that power—striking a unique blend between public and private control.

Syphers, whose agency has already made more than USD 16 million providing energy with 34 percent reduced emissions to more than 155,000 households, likens the model to a new form of energy bank. "It's a way of taking on debt in the form of power contracts and producing income in the form of energy bills," he says. "There's no other model that I've seen where you can invest as fast in renewables."

So how did a mechanical engineer and energy efficiency expert become one of California's lead actors helping propel the expansion of clean power? He says it's key to work backwards. "I'm a believer that when you play and you let yourself imagine a future and then work backward from it, you can tell stories about how you got there, instead of working forward [where] you talk about barriers and obstacles," he says. "The story today is 'What did we do to get to 100% renewable energy with good local economy?' and making that story more and more detailed over time."

Syphers, wasn't always a storyteller. He became interested in physics on the first day of high school when his teacher told students to go outside and shoot a dart gun at a stuffed monkey in a tree. "We had to learn that the dart was falling [to the ground] just as fast as the monkey," he says, and from that moment "I was hooked – it inspired me to enjoy science and have fun with it." As an applied physics undergraduate at Sonoma State University, he built a superconductor and a solar panel using materials

he'd ordered from a chemistry supply lab. After completing graduate studies in the country's only dual nuclear and solar programme at the University of Massachusetts Lowell, Syphers went to work as a utility engineer. That's where he realised that designing green buildings and energy efficiency programmes wasn't enough.

There was a "huge missing piece in that industry: the translator function," he says. "You had building owners and utility executives and banks and finance people all being told to do things by engineers because it was technically the right thing to do – but the bottom line on energy performance wasn't presented in a way they could understand." So Syphers shifted into a "facilitative" role, because "I was really good at taking what the engineers were saying and communicating it" in words the

decision makers could grasp. He's been doing that – as a designer, developer, consultant and spokesperson – ever since.

The floating solar farm is one of those attempts. It will be the US's largest and the world's second-largest floating solar farm and if it succeeds, the payoffs could be huge. Syphers says the project could pioneer a wave of similar parks across the county – the wine industry alone has more than 10,000 ponds – and eventually across the state. "If this works, let's do another one at 10 times the scale," he says. "California has a huge amount of treated wastewater storage ponds, they're all over the place," especially in the south, so "you could be talking about gigawatts statewide, not just megawatts." Syphers staked his bet on Sonoma as a solar leader, he says, because here "people are trying to think really big and change the world. We have to try things, even if we fail." So far they're far from failing and California expects to create 9,000 new solar jobs this year alone. The economics have spoken, says Syphers. Now it's about generating the political will to spread the community-choice model far and wide. "This is the single biggest action Sonoma County has ever taken on climate change, and it's going to keep paying us. It's the kind of tool that we've been looking for for a really long time."

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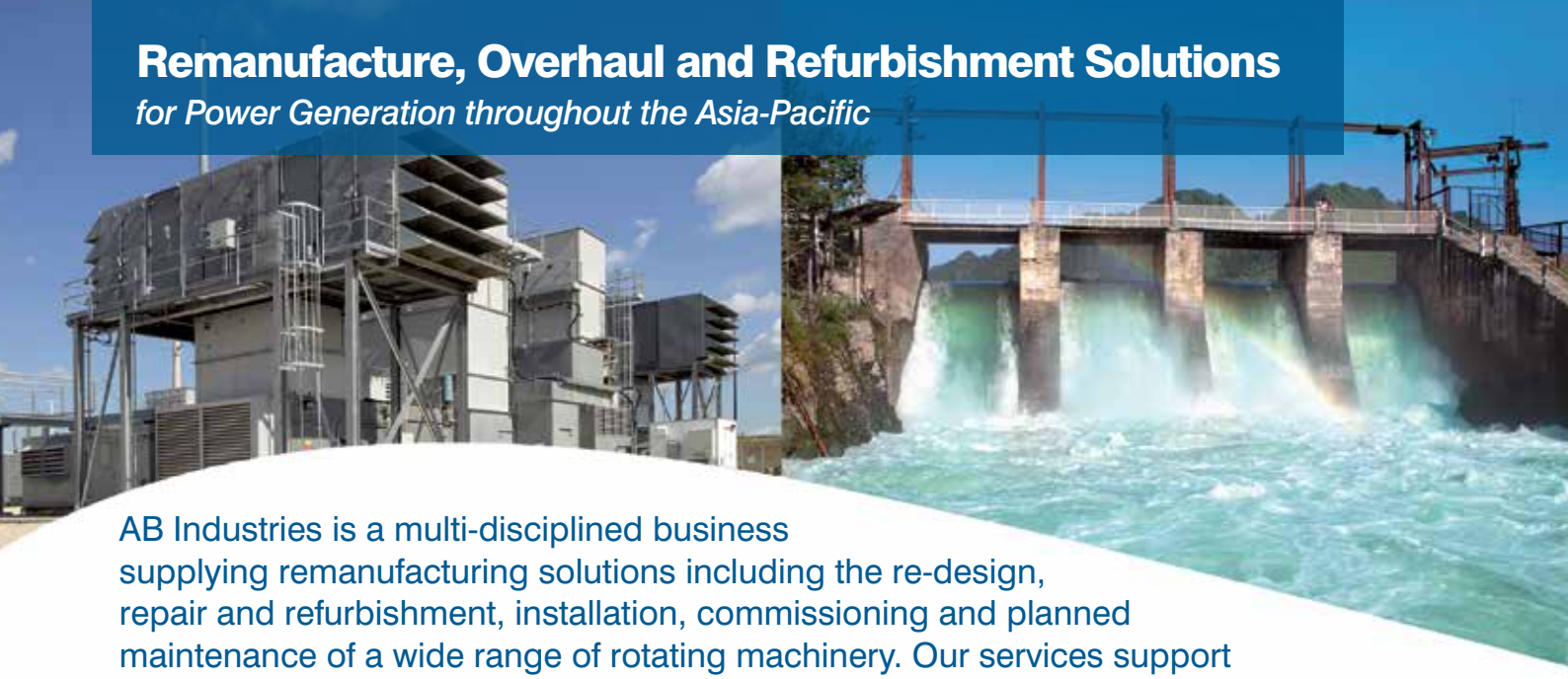

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Grid Connection of Renewable Energies

Luis Calzado
Senior Project Advisor, Global Sustainable Electricity Project

The Pacific Island Countries are facing the direct and urgent risks of global warming. Power utilities from Pacific Island Countries are interested in sustainable energy resources to reduce both CO2 emissions and costs associated with importing fossil fuels.

The Pacific Power Association (PPA) expressed its interest in receiving support and training from the Global Sustainable Electricity Partnership (GSEP) in order to enhance local capacities and technical know-how in grid connected renewable energies. Mr. Andrew Daka, Executive Director of the PPA, requested to pursue this series of workshops, building on workshops previously developed based on the training necessities requested by PPA. The workshops developed since 2005 with PPA have included those on renewable energies, photovoltaic systems, demand side management, grid connected systems and energy efficiency improvement.

This workshop was led by Kansai Electric Power Company, a GSEP member, and was structured into the following sections. Experts were provided on a pro-bono basis for the workshop's delivery:

- Day 1: Introduction and presentation of each utility's renewable energy program / Current status of renewable energies in the PPA countries
- Day 2: Current status of renewable energies in Japan / Procedures to integrate renewable energy to the grid in PPA countries
- Day 3: How to increase grid connection of renewable energies in PPA countries
- Day 4: Renewable energy integration into micro grids and smart grids / Site visit
- Day 5: Participant surveys and closing ceremony

In addition to the case studies that were presented during the workshop, a site visit to the Butoni Wind Farm was prepared by the local electricity company.

The first workshop was held in the Republic of Fiji from March 27-31, 2017 with 19 participants from 10 PPA member utilities in the Southern Hemisphere. The second workshop will be held in Guam, from June 12 -16, 2017 and will be open to member utilities from the Northern Hemisphere.

The final agenda is provided as an attachment. A list of participants is included in this report (Appendix 1). Group photos of the workshop were taken and distributed to the participants. Participants were also asked to evaluate the workshop through a questionnaire. A summary of results is included in Appendix 2.

The workshop proceedings, presentations and other documents were compiled on a USB key, which was handed out to all attendees at the end of the workshop. All contents of this USB key are also available on the GSEP's website (www.globalelectricity.org).

WORKSHOP SUMMARY

OPENING CEREMONY

- Mr. Andrew Daka (Executive Director) welcomed the attendees to the joint GSEP/PPA workshop. He thanked the GSEP for sending their experts to Fiji and he mentioned that the workshop will enhance the abilities of PPA members to incorporate more renewable energy into their energy mix. Since 2005, the GSEP and PPA have been working together to improve the capacities of local utilities. These workshops have helped Small Island utilities improve their knowledge of renewable energy and increase the share of renewables to help combat climate change. The conference is quite timely, as many of PPA's members are now increasing the capacity of renewable energy connected to their grids.
- Mr. Toshikazu Ohashi (GSEP member and Manager, Strategy and Cooperation Group, International Business and Cooperation Division from Kansai Electric Power Company) opened the workshop on behalf of the GSEP. He introduced the GSEP experts to the audience and expressed his hope that the workshop participants would make the best use of the opportunity to learn from the material presented during the week. He invited them

to actively participate and to interact with the GSEP experts.

- Mr. Luis Calzado (GSEP Senior Project Advisor) made a presentation on the GSEP's mission, its member companies, objectives, priorities, and the structure of its organization. He gave examples of the different GSEP activities: capital projects, capacity-building activities and the scholarship program.

DAY 1

- Participants from each utility presented their renewable energy programs.

- Dr. Herbert Wade (GSEP Consultant) presented the current situation and status of renewable energy installation in PPA countries. He provided an overview of the various types of renewable energies. He provided examples of the various renewable energy projects developed in the Pacific Islands. At the end of the day, the participants were tested on the material of the day. The results of the quizzes were reviewed on the second day of the workshop.

- Mr. Rapa Young (World Bank Consultant) presented the Pacific Island Sustainable Energy Industry Development Project.

DAY 2

- In the morning, Kansai Electric Power Company presented the current situation and status of renewable energy installation in Japan. Ms. Hatsuki Mizuno presented the targets toward 2030 and improvement of the FIT mechanism. Mr. Shota Miyake and Mr. Noriaki Kano presented the application and control technology of battery energy storage for power systems. Mr. Kano also presented the grid connection requirements and regulations.

- In the afternoon, Dr. Herbert Wade presented the components of a solar grid-connected project. He provided his recommendations for each of the components to ensure durability.

DAY 3

- In the morning, presenters concentrated on how to increase grid connection of renewable energies. Mr. Noriaki Kano presented the ways of improving voltage control techniques. This was followed by the presentation of Mr. Shota Miyake on short time PV output forecasting systems.

- In the afternoon, Dr. Herbert Wade presented small roof-top solar metering and payment. He provided two case studies: a power house fire linked to a solar installation in Niue and cyclone damage to solar installations in Yap, and ways these installations were made more secure.

DAY 4

- In the morning, Mr. Toshikazu Ohashi presented the grid-connected GSEP projects developed by Kansai Electric Power Company. Mr. Shota Miyake presented the integration of renewable energy in the grids of remote islands of Japan. Mr. Noriaki Kano presented the use of smart grid technology for the integration of renewable energies.

- In the afternoon, participants attended a site visit to a grid-connected renewable energy facility of the Fiji Electricity Authority (FEA). The Butoni Wind Farm located in the city of Lautoka is a 275 kW grid-connected wind site.

DAY 5

- Participants filled in surveys from the GSEP and PPA. The closing ceremony was then held. Each participant received a certificate of participation and a USB key with all presentations and a group picture.

FEEDBACK AND ACKNOWLEDGEMENTS

- As part of the evaluation, all trainees were tested at the end of each section and were able to review the test questions with their respective instructor.

- Case studies were provided to help illustrate the various concepts.

- At the end of the workshop, trainees were requested to provide comments and suggestions on the material presented. Their recommendations and requests will be taken into consideration for the workshop in June 2017 for utilities from the Northern Hemisphere.

- The interaction with workshop attendees was perfect. The manageable size of the group (19 participants) facilitated communication between the presenter(s) and attendees and gave sufficient opportunities for questions and comments.

- The collaboration with the Pacific Power Association (PPA) was excellent. PPA produced the workshop binders from a master copy provided by the GSEP Secretariat for download on the Internet. The GSEP would like to acknowledge Mr. Andrew Daka (PPA's Executive Director) and Mr. Gordon Chang (PPA's Deputy Executive Director), who attended the workshop throughout the week and gave great support to the GSEP team.

APPENDIX 1 – WORKSHOP PARTICIPANTS

Name	Organization	Title	Country	Email address
Mr. Eparama Tawake	Fiji Electricity Authority	General Manager (Generation)	Fiji	Eparama@fea.com.fj
Mr. Karunesh Rao	Fiji Electricity Authority	Executive Manager (Projects & Public Relation)	Fiji	karuneshrao@fea.com.fj
Mr.Teafa Tautu	Tuvalu Electricity Corporation	Distribution Enginee	Tuvalu	ttautu@gmail.com
Mr. Fatonga Talama	Tuvalu Electricity Corporation	Generation Manager	Tuvalu	fatonga.talama@gmail.com
Mr. Javu Dube	Nauru Utilities Corporation	Renewable Energy Superviso	Nauru	apenisa.manuduitagi@nuc.com.nr
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Mr. Paul Tararo	Te Aponga Uira O Tumu-Te- Varovaro	Electrical Apprentice (Generation)	Cook Islands	karoT@electricity.co.ck
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Mr. Tenikoria Katauea	Public Utilities Board, Kiribati	Power Engineering Manager	Kiribati	katauea@gmail.com
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Mr. Victor Afamasaga	Electric Power Corporation, Samoa	Chief Engineer (National Control)	Samoa	afamasaga_v@epc.ws

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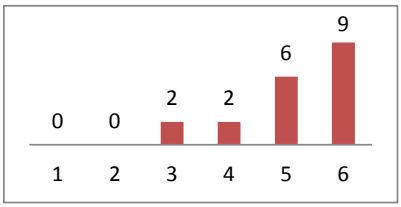
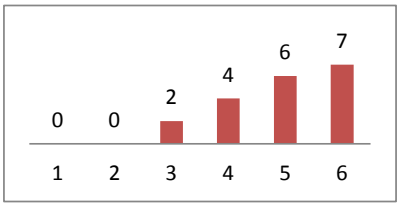
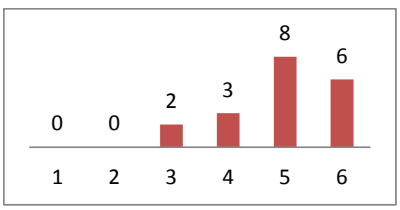
Mr. Joshua Chalapan Nari	Department of Energy	Verification officer	Vanuatu	jnari@vanuatu.gov.vu
Mr. Tuni L. Tauiliili	American Samoa Power Authority	Renewable Energy Technician	American Samoa	wallon@aspower.com
Mr. Ulysses Hopkinson	American Samoa Power Authority	Electrical Technician	American Samoa	wallon@aspower.com

APPENDIX 2 – SURVEY RESULTS

All surveys were scored on a scale of 1 to 6, with 6 being "excellent" and 1 being "poor".

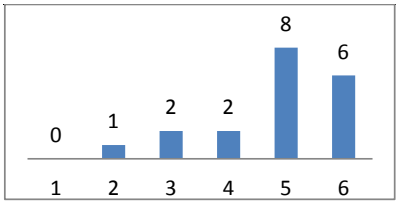
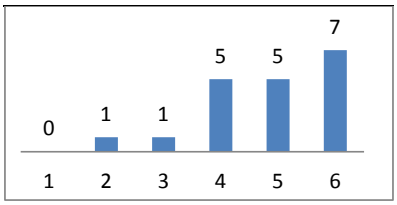
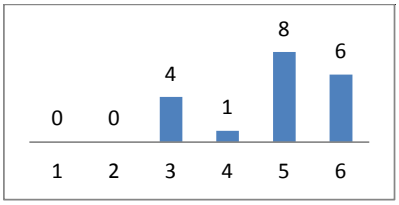
OBJECTIVES

	Average score	Score breakdown
The objectives were clear	5.16	
The workshop fulfilled my expectations	4.95	
The objectives were obtained	4.95	

Comments :

- Well-presented in a clear and simple manner
- Visuals were provided to follow the presentations

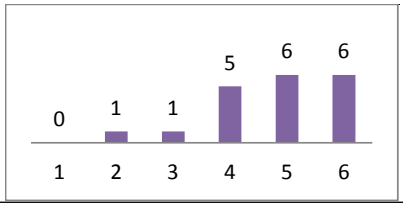
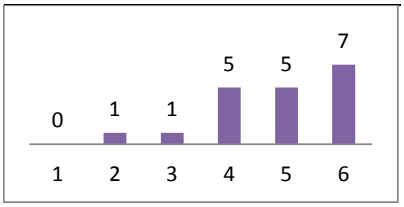
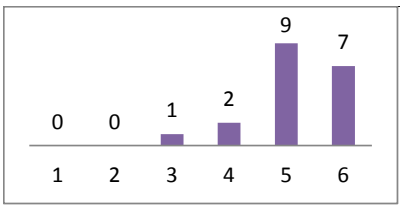
CONTENT

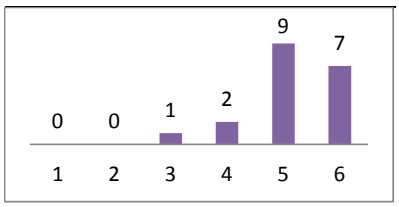
	Average score	Score breakdown
The content was well structured from the simplest to the more complex	4.84	
The important concepts for each topic were well covered	4.84	
The content was adapted to the context of my work	4.84	

Comments:

- Colour printing would be nice
- Most of the contents of the topics were well covered. Some of the material was very advanced for utilities in the Pacific Islands.
- The delivery of the content was delivered by experts in the field.
- It would be good to include renewable projections based on current and planned RE projects for each utility.

METHODOLOGY

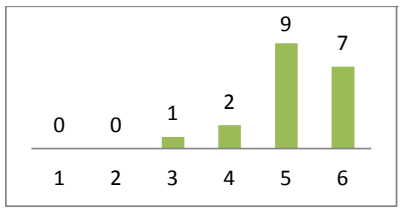
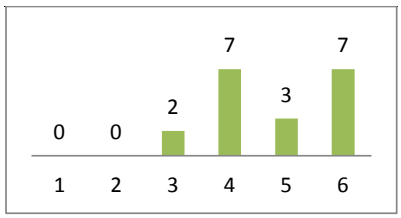
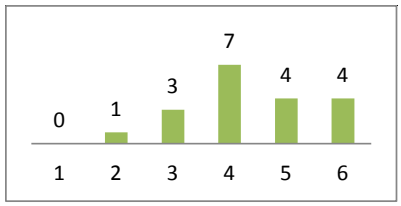
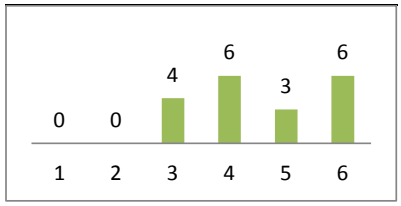
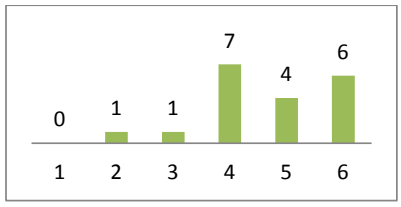
	Average score	Score breakdown
Good balance between presentations, discussions and practical exercises	4.74	
Examples and applications were sufficient to illustrate theories	4.84	
Time allowed for questions by participant was sufficient	5.16	

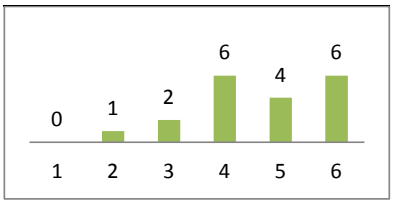
Workshop length was sufficient	5.11	

Comments:

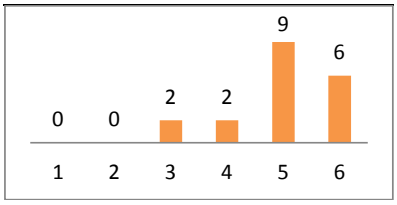
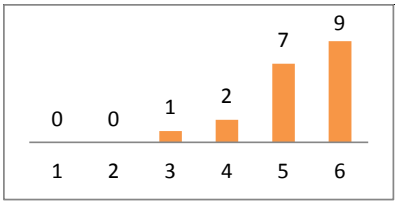
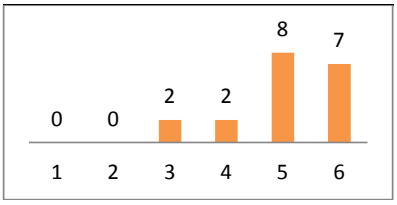
- The technologies presented by Kansai are advanced and are good for information
- Length for questions, discussions and practical exercises were sufficient
- It can help that the presenters question the participants to motivate discussion
- Two weeks would be better to go in more depth in the material

PRESENTERS

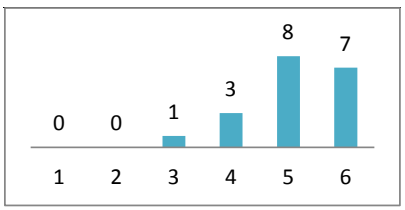
	Average score	Score breakdown
The presenter established and maintained a good rapport with participants	4.63	
They explained clearly the objectives of each presentation	4.79	
They captured the participants' interest	4.37	
They presented the content in a clear and comprehensible way	4.58	
They facilitated participant involvement	4.68	

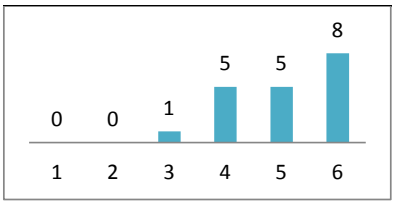
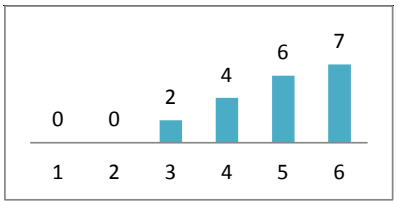
Questions were well answered	4.63	
Comments : • The presenters did their best during their presentations. • Most of the questions were well answered. Interpretation would help improve this area. • The presentations had good visuals, some presenters were affected by language barrier		

EDUCATIONAL VALUE OF PRESENTATION MATERIAL

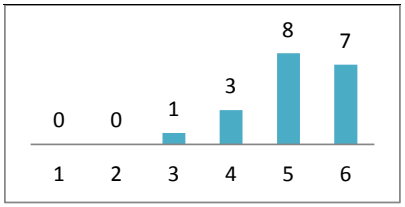
	Average score	Score breakdown
The presentation material was of good quality	5.00	
The material covered a wide range	5.26	
The material supported adequately the content presented	5.05	
Comments : • Colour printing would be nicer • There was depth in the presentations		

WORKSHOP BINDER

	Average score	Score breakdown
The workshop agenda described adequately the content	5.11	

The binder was a good complement to the presentation	5.05	
The binder was clear and easy to use	4.95	
Comments : • The binder was clean and easy to use		

GENERAL SATISFACTION

	Average score	Score breakdown
Globally, I am satisfied	5.26	
Comments : • I am satisfied with the workshop. It provides us good information on renewable energy project development. • Well-administered, delivered and coordinated.		

COMMENTS AND SUGGESTIONS

What were your good experiences during the workshop? • It helped understand the penetration of renewable energies • It helped us learn about solar renewable energies • Being able to share our problems in our utilities • Good quality of the materials • Broad comparison of renewable energy technologies • Wind farm visit • Question and answer period • Learn how to fix issues related to renewable energies we are currently facing • The quizzes helped you think • Case studies in the Pacific Islands
What were your bad experiences during the workshop? • Language barrier
Which aspects would you suggest to improve in a future workshop? • Translator • More fluent English speaking presenters • More practical • More interactions with participants • Divide the class in small groups for case study discussions

What would you wish to be able to apply to your work after the workshop? • The solutions mentioned in the training • To have a realistic renewable energy plan • Energy storage and other renewable energy technologies • Solar design and installation
Why is it important? • Because it is what other countries have experienced to improve • To achieve the renewable energy targets set by our governments • Alleviate stress among generators • A proper design that reduces maintenance and prolongs the life of the system
What benefits do you foresee? • Which technologies are /not applicable to our countries • Case studies from case studies • Help with the penetration of renewable energy technologies. • Save money in maintenance
What would happen if you applied what you wanted? • It would change the company and the country • Provide justification for solar energy projects • It is learning towards mix generation • Better product for consumers
Within the context of your work, who and what could help you the most? • PPA and the PIC to provide us with guidelines and technical specifications for solar energy • Funding • Experience and training • CEO • Additional support from presenters • Energy storage
What difficulties do you foresee? • Funds • Implementing standards
What can be done to surmount these difficulties? • Have guidelines for the company • Help with tender documentation • Seek management approvals • Submit a report to the management • Present training materials for the colleagues • Regional support if possible • Development partners • Consult with experts
What are the first steps necessary in order to render applicable what you would like to implement? • Building capacity within my company • More capacity on solar energy

AGENDA

The objective of this workshop is to support electricity utilities in the Pacific Islands in increasing grid connection of renewable energies in the region. This workshop, organized jointly between the Global Sustainable Electricity Partnership and the Pacific Power Association, will target utilities from the Southern Pacific Islands (Fiji, Tuvalu, Kiribati, Samoa, Tonga, Solomon Islands, Papua New Guinea, Niue, Cook Island, Nauru, Vanuatu, and American Samoa). This workshop is an initiative under the World Bank's Pacific Islands Sustainable Energy Industry Development Project

MARCH 27 – DAY 1

8:30 - 9:00 **Arrival and Registration**

9:00 - 9:30 **OPENING CEREMONY**

Welcome by the organizing partners: the Global Sustainable Electricity Partnership (GSEP) and the Pacific Power Association (PPA).

Andrew Daka – PPA Executive Director
Toshikazu Ohashi – Representative from Kansai Electric Power Co. Luis Calzado – GSEP Senior Project Advisor

9:30 - 12:00 **Session 1**
INTRODUCTION AND PRESENTATION OF EACH UTILITY

Each PPA utility will present basic data and information about the company and any issues it may be encountering. These presentations will be used as a point of reference to identify the challenges that remain in moving towards grid connection of renewable energies.

13:30 - 16:00 **Session 2**
CURRENT STATUS OF RENEWABLE ENERGIES IN PPA COUNTRIES

During this session, the current situation and status of renewable energy installation in PPA countries will be discussed. This will include discussion on: solar PV, wind, other renewable energy sources, and tariffs for renewable energies.

Presented by: Dr. Herbert Wade

19:00 **Welcome Reception**

END OF DAY 1

MARCH 28 – DAY 2

9:00 – 12:00 **Session 3**
CURRENT STATUS OF RENEWABLE ENERGIES IN JAPAN

Kansai Electric Power Co. will present the current situation and status of renewable energy installation in Japan, focusing on the areas of the country in which the company is active. A background will be provided, followed by a presentation of basic mechanisms for implementing renewable energies, challenges encountered, grid connection requirements and regulations, and the management required to maintain a system's quality. The presentations made by the Kansai experts will focus on:

- Targets toward 2030 and improvement of the FIT mechanism
  Presented by: Hatsuki Mizuno

- Issues and measures associated with the introduction of large amounts of renewable energy
  Presented by: Syota Miyake and Noriaki Kano

- Application and control technology of battery energy storage for power systems
  Presented by: Syota Miyake

- Grid connection requirements and regulations
  Presented by: Noriaki Kano

13:30 – 16:00 **Session 4**
PROCEDURES FOR RENEWABLE ENERGY GRID CONNECTION IN PPA COUNTRIES

During this session, the procedures and considerations for renewable energy grid connection in PPA countries will be discussed.
Presented by: Dr. Herbert Wade

END OF DAY 2
MARCH 29 – DAY 3

9:00 – 12:00 **Session 5**
HOW TO INCREASE GRID CONNECTION OF RENEWABLE ENERGIES
In this session, presenters will discuss the R&D required to prepare for increasing renewable energy grid connection (including short-term forecasting models for PV) and the procedures to request grid connection of renewable energies.
- Improving voltage control technique
  Presented by: Noriaki Kano
- Short time PV output forecasting system
  Presented by: Syota Miyake

13:30 – 16:00 **Session 6**
HOW TO INCREASE GRID CONNECTION OF RENEWABLE ENERGIES IN PPA COUNTRIES
During this session, presenters will discuss the challenges encountered in PPA countries to increase grid connection of renewable energies and how they can be resolved.
Presented by: Dr. Herbert Wade

END OF DAY 3

MARCH 30 – DAY 4

9:00 – 12:00 **Session 7**
RENEWABLE ENERGY INTEGRATION INTO MICRO GRIDS AND SMART GRIDS

Kansai Electric Power Co. will present:

- GSEP capital projects: the Tuvalu Solar Power Project and the Dhiffushi Solar Ice Project.
  Presented by: Toshikazu Ohashi
- Integration of renewable energy into remote island grids in Japan
  Presented by: Syota Miyake
- Smart grid technology for renewable energy.
  Presented by: Noriaki Kano

END OF DAY 4

MARCH 31 – DAY 5

9:00 **OPEN SESSION – QUESTIONS TO PRESENTERS ON TOPICS DISCUSSED DURING THE WEEK**

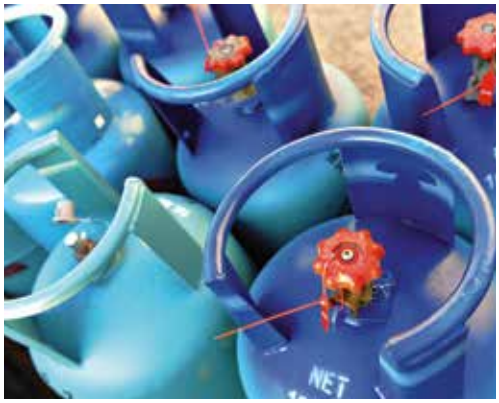
EVALUATION SURVEY

DISTRIBUTION OF CERTIFICATES

13:00 **CLOSING CEREMONY**

PACIFIC BULK FUEL

Keeping the Pacific Running



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Pacific Register of Qualifications and Standards Approves Three Australian Units of Competence related to Design and Install of Grid Connected PV Systems

Geoff Stapleton
Managing Director, Global Sustainable Energy Solutions

The University of the South Pacific (USP) on behalf of the European Union Pacific Technical and Vocational Education and Training on Sustainable Energy and Climate Change Adaptation (PACTVET) project contracted The Sustainable Energy Industries Association of the Pacific Islands (SEIAPI) to put the following 3 Units onto the Pacific Register of Qualifications and Standards PQRS in a format that is relevant and appropriate for use across the region:

1) Solve basic problems in photovoltaic energy apparatus and systems;
2) Design grid connected photovoltaic power supply systems and
3) Install, configure and commission Low Voltage grid connected photovoltaic power systems.

These three units were submitted for registration because they have been used by Global Sustainable Energy Solutions (GSES) for conducting numerous training courses on behalf of SEIAPI within the Pacific Region over the last 3 years and in essence were the de facto standards. Completion of those courses allowed the successful course attendees to apply for their provisional certification within the industry based technician certification program that is managed jointly by the Pacific Power Association (PPA) and SEIAPI.

GSES, as the secretariat for SEIAPI, commenced the project on 4th July 2016 and obtained confirmation on 8th December 2016 from the Educational Quality and Assessment Programme (EQAP), that " the approval for the recognition and registration of the 3 Units of Learning (Solve basic problems in PV systems, Design Grid Connect Systems Applications and Install Grid Connect Systems Applications) on the PRQS has been granted by the Accreditation Committee."

GSES prepared separate submissions for each of the following three Australian developed units of competencies:

- UEENEEK125A Solve basic problems in photovoltaic energy apparatus and systems
- UEENEEK135A Design grid connected photovoltaic power supply systems
- UEENEEK148A Install, configure and commission LV grid connected photovoltaic power systems

The submissions were submitted as joint SEIAPI/ GSES documents however the application form did require the main applicant to be a training centre and hence GSES took the lead because GSES is a Registered Training Organisation (RTO) under the Australian Skills Quality Authority.

Within the applications the technical knowledge and skills within the three units were not altered, however within Australia these units do have a number of electrical prerequisites which relate to Australian requirements. To meet the current training needs of the Pacific Industry the Australian prerequisites were not listed on the application and were replaced by the requirement that any person applying to undertake training in any of the three units shall meet, as a minimum, one of the following:

1) Having successfully undertaken and completed relevant courses as required to be an electrician within the country they are working: or
2) Holding a degree or diploma in electrical engineering or
3) Having worked in the solar industry for a minimum period of 5 years and completed school (or have equivalence) to the national secondary school certificate for their country.

The application stated the three units of competency could be offered within any of the following three skillsets.

Skillset 1: Design of Grid Connected PV Systems which comprises:

- UEENEEK125A Solve Basic problems in photovoltaic energy apparatus and
- UEENEEK135A Design grid connected power supply systems.

Skillset 2: Design and Install Grid connected PV systems which comprises:

- UEENEEK125A Solve Basic problems in photovoltaic energy apparatus;
- UEENEEK135A Design grid connected power supply systems and
- UEENEEK148A Install, configure and commission Low Voltage grid connected photovoltaic power systems

Skillset 3: Install Grid connected PV systems which comprises:

- UEENEEK125A Solve Basic problems in photovoltaic energy apparatus and
- UEENEEK148A Install, configure and commission Low Voltage grid connected photovoltaic power systems

These skillsets (and units of competency) can be used as part of a Certificate 4 in Solar Energy that will be developed and offered in the future.

The intention is that since these units are based on the Australian units they will be updated every time the Australian units are modified, but consideration will be given on how they can also be reviewed and updated within the Sustainable Energy Industry Standards Advisory Committee that was formed in early 2016.

It is proposed that in 2017 GSES/SEIAPI will submit the 5 Australian units of competency for off grid and hybrid systems.

This then will provide three design and install skill sets for the Pacific region: Design and Install Grid connect (total 12 PQF credits), Design and Install Stand-alone (total 24 PQF credits) and Design Hybrid Systems (8 PQF credits). These are the courses that are commonly requested by SEIAPI and PPA members.

These total 44 credits and therefore the combined three skill sets will form a Certificate 4 in Design/Install off grid/hybrid and grid connect solar systems. When the applications for the 5 units are submitted there will be a separate submission of recognition and approval of the Certificate 4.

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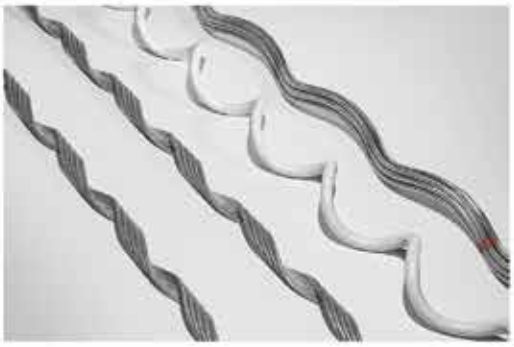

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Welcome! To New Allied Members

Seven (7) new companies have joined PPA as Allied Members since our last PPA Magazine. The new members are:

APR ENERGY: APR Energy is based in Florida, United States of America. Their primary activity is pones generation.

B&R ENCLOSURES PTY LTD: B&R Enclosures Pty Ltd is based in Queensland, Australia. Their primary activity is electrical data and data enclosure manufacturer. Their secondary activity is enclosure solutions.

BUSCK PRESTRESSED CONCRETE LIMTED: Busck Prestressed Concrete Limited is based in Whangarei, New Zealand. Their primary activity is prestressed concrete poles. Their secondary activity is precast associated products, transformers/switchgear pads.

CHAPMAN TRIPP: Chapman Tripp is based in Auckland, New Zealand. Their primary activity is construction projects lawyer.

PROGETTI PLANT S.R.L: Progetti Plant S.R.L is based in Altavilla Vicentina, Italy. Their primary activity is prestressed concrete poles. Their secondary activity is precast associated products, transformers/switchgear pads.

SCHWEITZER ENGINEERING LABORATORIES: Schweitzer Engineering Laboratories is based in Rangiora, New Zealand. Their primary activity is equipment manufacturer and engineering services provider.

VORTEX GROUP LIMITED: Vortex Group Limited is based in Rotorua, New Zealand. Their primary activity is hydro power Engineering. Their secondary activity is hydro power design.

NAN

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