

Kingdom of Tonga

Kingdom of Tonga

FINAL REPORT

COLLABORATION PROGRAMME WITH THE PRIVATE
SECTOR FOR DISSEMINATING JAPANESE TECHNOLOGY

For

THE NATURAL DISASTER-PROOF OKINAWAN TILTABLE
WIND TURBINE SYSTEM

December 2015

Japan International Cooperation Agency
(JICA)

Progressive Energy Corporation

| |
|--------|
| OS |
| JR |
| 15-096 |

SUMMARY

This programme, through deepening understanding by officials and stakeholders of the developing countries, aims to introduce and demonstrate products, technologies, know-how, its relevant systems and others of Japanese enterprises to identify the viability and applicability in a targeted country for socio-economic development.

A group of companies under the Okinawa Electric Power Company Inc. (hereinafter referred to “OEPC”), which Progressive Energy Corporation (hereinafter referred to “PEC”) belongs, has been successfully introducing a “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” to the small outer islands in Okinawa, where harsh climate conditions prevail. As the system is proven to be functioning well in Okinawa, and for the purpose of introducing this system to the Pacific Island Countries that is facing the similar challenges in climate, geographical and application of renewable energy, the government officials of Tonga were invited to Okinawa to deepen the understanding of the system, as well as the Tongan technical persons to Okinawa to experience the maintenance methods on-site, and promotion and other activities were done in Tonga in this programme to provide one of the options for tackling the challenges.

As a result, PEC has drawn up a plan for introduction of the “Natural Disaster-proof Okinawan Tilttable Wind Turbine System for the Kingdom of Tonga” and has considered possibility for PEC to expand its operations to overseas.

Chapter 1 Overview of the Kingdom of Tonga and its Current Situation

1. Country Overview

① General Information

| | |
|------------------|--|
| Political Status | Independent in 1970 from British Protectorate |
| Capital | Nuku'alofa |
| Population | 105,700 (2014) |
| Main Language | English (Official Language) and Tongan |
| Literacy Rate | 98.9% |
| Land Area | 747 km ² |
| EEZ | 700,000km ² |
| Natural Resource | Fish, fertile land |
| GDP(PPP) | US\$549 million (2008 estimate) |
| Main Industry | Agriculture (copra, coconut oil, squash), fisheries |
| Export Value | 17,514,000 Pa'anga (US\$9.22m) per annum |
| Main Export | Squash, fish, vanilla beans, root crops |
| Import Value | 324,444,000 Pa'anga (US\$170.6m) per annum |
| Main Import | Foodstuff, machinery, transport, fuel, chemical products |
| Legal Tender | (Pa'anga: own currency) |

② Geography

Kingdom of Tonga is one of the southern most Pacific Island Countries, and the Tropic of Capricorn runs in the middle of the Kingdom. It consists of 4 main island groups and the central government is located in Tongatapu, the largest island. Tonga has its own unique language, Tongan, but proficiency of English is very high. People are very friendly; characteristic of Tonga's another name "The Friendly Islands".

③ Electricity in Tonga

Kingdom of Tonga is an island country with 172 islands and the landmass of the largest island, Tongatapu, is similar to that of Tsushima Island in Japan. Electricity in Tongatapu is supplied from a sole 11MW-diesel powerhouse in Popua, managed by Tonga Power Limited (hereinafter referred to "TPL") and a 1.3MW PV system was set up with assistance of New Zealand in Maama Mai (1MW PV system was set up at Vaini as well).

The electricity demand in Tongatapu varies greatly from 4MW in winter to 8MW in summer. Diesel fuel consumed at the Popua Power Station is all imported and the cost of electricity generation is high; the electricity bill is 2.5 to 3 times higher than Japan, therefore it has been a burden to the electricity users and the government as well.

In order to reduce emission of the greenhouse gas and domestic energy security, the Government of Tonga has endorsed the Tonga Energy Road Map 2010-2020 (hereinafter referred to “TERM”) with an aim to provide 50% of the entire electricity from renewal energy and introduction of the systems are being implemented accordingly.

In the view of stable energy supply, it is essential to bear in mind that output from the renewable energy (especially solar and wind power) fluctuates depending on the natural conditions and that there is a risk of deterioration of electric quality (i.e. stable power supply, voltage, frequency) should the source is solely relied on the renewable energy. Therefore due consideration is needed for pursuing introduction and application of renewable energy.

2 ODA Programmes in the Electricity Fields in the Kingdom of Tonga

① Hybrid Island Initiative (Japan)

As the Pacific Island Countries have set up quantitative targets in introduction and use of renewable energy, Japan and other donors have been assisting by funding mainly solar energy related projects. However, unstable electricity output from PV system has been causing unstable power supply and ineffective operation of diesel power generation is inevitable. Therefore, JICA has launched an initiative called “Hybrid Island Initiative” in 2015 for the Pacific Island Countries for grid stabilisation and make a good use of renewable energy with diesel power generation for reduction of fuel costs.

② Smart Grid System (Japan)

In March 2015, a micro-grid system (including PV power generation system) was inaugurated with funding assistance from the Government of Japan at 1.57 billion Yen in Vaini. As a part of the micro-grid system, the control system, inclusive of a 11.3kWh lithium ion capacitor and the 11kV substation equipment, was installed. Also, for the purpose of stabilising power output from the Maama Mai PV system, the same lithium ion capacitor and 11kV substation were installed there to provide stable power supply to entire Tongatapu by controlling electricity quality from Popua as well. From doing this, it is expected to assist achieving the aims of the TERM through a stable power supply and avoiding frequency surge.


The wind power was also considered for the abovementioned micro-grid system, however, according to the initial study reports, it was ruled out, as thorough Environment Impact Assessment was not carried out and would take substantial time if so decided. In the course of initial stage of the project preparation, the wind conditions were surveyed and were reported to have well met the NEDO requirement.

<<Possibility of Synchronisation between the Existing Micro-grid System and Wind Power>>

Our on-site survey found that it is possible to connect the existing micro-grid data network with the wind power data circuit should it be newly introduced. It was confirmed that PV power output is controlled by PCS by receiving the minimum load signal of the existing diesel generator through grid stabilisation by controlling the PV power output using the Short Term Compensation PCS. Therefore, it is considered that upon introduction of the Tilttable Wind Turbine System, for the purpose of increased efficiency of the existing diesel generator operation and securing back-up power, introducing the Long Term Compensation batteries, may be viable.

Chapter 2 Implementation and Activity Report

1. Visit to Tonga (August 2014)

| | |
|-------------------|---|
| Period: | 26 th August 2014 (Tue) – 30 th August 2014 (Sat) |
| Personnel: | PEC: Ken HIGA, Yoshiki FUKUHARA Omae Ltd.: Ryunosuke OMAE, Atsushi KATO Pacific Frontier Management Tonga: Paul KARALUS |
| Visit & Activity: | <p>27th August 2015 (Wed)</p> <ul style="list-style-type: none"> - Embassy of Japan: Councillor Tetsumi MURATA, JICA Resident Representative Hiroshi KIKAWA - JICA Tonga Office: Resident Representative Hiroshi KIKAWA - TPL: Steven 'ESAU (Ag. CEO), Michael Lani 'AHOKAVA (Technical Manager), Nikolasi FONUA (New Business Development Manager) <div style="display: flex; justify-content: space-around;">   </div> |

28th August 2015 (Thu)

- Ca'Bella (Local Contractor): Paea PAU'U (Director)
- Ministry of Infrastructure: Hon Fe'aomoeata VAKATA (Minister), Siaoisi SOVALENI (Secretary), 2 Directors, an ADB Consultant, Tevita TUKUNGA (Director, TERM Secretariat), TPL Nikolasi FONUA (TPL New Business Development Manager)



29th August 2015 (Fri)





- Ministry of Environment: Sione TUKIA (CEO), Ms. Dorothy
- Inspection to Popua Power Plant: Michael Lani 'AHOKAVA (TPL Technical Manager)
- Meeting with TPL: Steven 'ESAU (Ag. CEO), Michael Lani 'AHOKAVA (Technical Manager), Nikolasi FONUA (New Business Development Manager)
- Inspection to Possible Site





Summary:


Presented the outline of this programme to the TERM Secretariat, Ministry of Public Infrastructure, Ministry of Environment and TPL for the invitation to Japan and confirmed that determination of the schedule and personnel would be coordinated through assistance of JICA Tonga Office.

2. Inviting Minister (September 2014)

| | |
|-------------------|---|
| Period: | 28 th September 2014 (Sun) – 02 nd October 2014 (Thu) |
| Personnel: | PEC: TAKAGI, HIGA, YAMASHIRO, ISHIKAWA, TSUHAKE, SHINZATO, FUKUHARA Omae Ltd.: Ryunosuke OMAE, Atsushi KATO |
| Delegation: | Ministry of Public Enterprises (MPE), Government of Tonga: Hon. Sosefo Fe'aomoeata VAKATA (Minister) Siaosi SOVALENI (Secretary) Sione Plotu AKAUORA (Deputy Secretary) Tonga Power Limited (TPL): Graham Steven 'ESAU (Chief Executive Officer) |
| Visit & Activity: | <p>29th September 2014 (Mon)</p> <ul style="list-style-type: none"> Okinawa Prefecture Government: Vice Governor KAWAKAMI, Commerce, Industry & Labour (CI&L) Director General SHIMOJI, CI&L Deputy Director General TAKEDA, CI&L Director KOKEN, CI&L Section Chief KINJO, CI&L Supervisor OOHAMA, JICA Okinawa Director General KASHIWAYA. JICA Okinawa Office: Director General KASHIWAYA, Advisor KASAHARA, Director WAKASUGI OEPC: President OOMINE, Director in-charge of Outer Islands Operation SHIMABUKURO, JICA Okinawa Director General KASHIWAYA. <div style="display: flex; justify-content: space-around;">   </div> <p>30th September 2014 (Tue)</p> <ul style="list-style-type: none"> Inspection of Minami Daito Jima Island Tilttable Wind Turbine Power Station, Minami Daito Jima Island <div style="display: flex; justify-content: space-around;">   </div> |

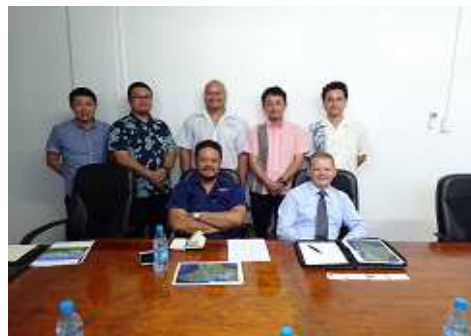
| | |
|-----------------|---|
| | <p>01st October 2014 (Wed)</p> <ul style="list-style-type: none"> - Internal Meeting - Inspection of economic activities in Okinawa <p>02nd October 2014 (Thu)</p> <ul style="list-style-type: none"> - Embassy of the Kingdom of Tonga: HE Ambassador Tania TUPOU <div style="display: flex; justify-content: space-around;">   </div> |
| <p>Summary:</p> | <ul style="list-style-type: none"> - Visited Okinawa Prefecture Government to meet Vice Governor KAWAKAMI with JICA Okinawa Office (JICA Okinawa International Centre) Director General KASHIWAYA. Similarity of Okinawa and Tonga, necessity of introducing the Tilttable Wind Turbine System, and other possible Okinawa environment technologies etc were discussed. - Had a meeting with OEPC President OOMINE. The understanding to the system was deepened by how the Tilttable Wind Turbine System was introduced by OEPC and the presentation of overview of the system. Consensus for mutual cooperation and rapport were built. - On-site inspection at Minami Daito Jima Island assisted deepening understanding of the system by realising similarity between Okinawa and Tonga in climate and natural disasters that the Okinawan experience is indeed applicable in Tonga. |

3. Visit to Tonga (March 2015)

| | | |
|------------------------------|---|---|
| <p>Period:</p> | <p>08th March 2015 (Sun) – 08th March 2015 (Fri)</p> | |
| <p>Personnel:</p> | <p>PEC: Ken HIGA, Naotoshi SHINZATO Omae Ltd.: Ryunosuke OMAE, Atsushi KATO Pacific Frontier Management Tonga: Paul KARALUS</p> | |
| <p>Visit & Activity:</p> | <p>08th March 2015 (Sun)</p> <ul style="list-style-type: none"> - Meeting at Nerima Lodge - On-site inspection at Niutoua•Lapaha - Meeting with NBK Corporation |  |

09th March 2015 (Mon)

- Courtesy Call to Deputy Prime Minister: Hon. Siaosi SOVALENI
- Micro-grid on-site inspection: Susumu Sato, Fuji Electric Co., Ltd.
- TPL: Former CEO John van BRINK, Current CEO Robert MATTHEWS, Power Manager Michael Lani 'AHOKAVA, Viliami ONGOSIA
- Wakachiku Construction Co., Ltd.: Hiromi HIRAKI, Kensaku KUBO



10th March 2015 (Tue)


- TPL: Director in-charge of Finance Graham Steven 'ESAU, Power Manager Michael Lani 'Ahokava
- JICA Tonga Office: Resident Representative Hiroshi KIKAWA, Shouichi IWATA, JICA Mission Director Kei MATSUNAGA, Kaori KOBAYASHI



11th March 2015 (Wed)

- Meeting with TPL: CEO Robert MATTHEWS, Valium ONGOSIA
- On-site inspection at Niutoa and Lapaha: TPL Power Manager Michael Lani 'AHOKAVA, Valium ONGOSIA, JICA Tonga Office Resident Representative Hiroshi KIKAWA, Shouichi IWATA, JICA Mission Director Kei MATSUNAGA, Kaori KOBAYASHI



| | |
|----------|---|
| | <p><u>12th March 2015 (Thu)</u></p> <ul style="list-style-type: none"> - OFA Construction: Ofa LATU - TERM Secretariat: Inoke VALA - TPL: Director in-charge of Finance Graham Steven 'ESAU, Power Manager Michael Lani 'AHOKAVA  |
| Summary: | <ul style="list-style-type: none"> - Reviewed the outcome of the first invitation and did selection of the personnel and reviewed the programme with TPL for the 2nd invitation. - Conducted information collection and on-site inspection of the existing micro-grid system as well as its survey on possibility of the synchronisation with the proposed wind turbine system. Also information was gathered from local contractors for construction works. |

4. Inviting Engineers (May 2015)

| | |
|------------------|--|
| Period: | 14 th May 2015 (Thu) – 22 nd May 2015 (Fri) |
| Personnel | <p>PEC: TAKAGI, HIGA, YAMASHIRO, ISHIKAWA, TSUHAKE, SHINZATO, FUKUHARA</p> <p>Omae Ltd.: Atsushi KATO</p> |
| Delegation | <p>Tonga Power Limited (TPL)</p> <p>Power Manager Michael Lani AHOKAVA, Superintendent Lolohea HALAUFIA</p> |
| Visit & Activity | <p><u>15th May 2015 (Fri)</u></p> <ul style="list-style-type: none"> - Courtesy Call to OEPC Outer Island Company: Director Kiyohito SHIMABUKURO, Outer Islands Technical Manager Yoshitsugu UEHARA  |

16th May 2015 (Sat) – 18th May 2015 (Mon)

– Tilttable Wind Turbine Maintenance Training (Hateruma Island)



The on-site training on the 6-month-regular-maintenance was conducted to the TPL engineers under guidance of PEC.

Upon commencing the work, a briefing was held to go through the maintenance items and methods by using the instruction manual and the check list. For tilting the tower, each supporting wire and base were checked, followed by placing the hydraulic devise for tilting and the tilting procedure. It was a great opportunity that the very characteristic of the Tilttable Wind Turbine System was demonstrated. After the tilting, the nasal cover was removed for degassing and flashing the pitch hydraulic devise and greasing-up of the blade bearing at the ground level was carried out. Furthermore, the TPL engineers actually did a greasing-up of the yo-yo ring bearing, the generator, the gear box bearing and the router bearing, replacement of the slip ring brush and the brake pad, refilling the brake oil, checking up the electric box and others. As there is a similar procedure in greasing-up in Tonga, the TPL engineers seemed quite accustomed to this work. Upon completion of the ground level maintenance, filling the pitch hydraulic devise, prior-to-erection test, erection procedures (setting up the hydraulic devise and the hand winch operation) and the after-erection test operation were carried out.

After leaving the wind turbine site, the TPL engineers were escorted to the Hateruma Control Site and were shown that remote control to the system can be done by SCADA (Supervisory Control And Data Acquisition).

In the course of training, there was a comment from the Power Manager LANI that he is strongly confident the Tilttable Wind Turbine System is viable by learning that the Hateruma Station now provides 50% of the entire electricity on the island, which is the very target in Tonga.

From the training, a confidence was expressed that the maintenance work is doable in Tonga, as it is relatively easy for them, except for major maintenance.

20th May 2015 (Tue)

- Meeting at JICA Headquarter: South East Asia and the Pacific Department Director Takashi TOYAMA, South East Asia and the Pacific Department Machiko NUNOTANI, Industrial Development and Public Policy Department Director Kei MATSUNAGA, Industrial Development and Public Policy Department Kaori KOBAYASHI, Private Sector Partnership Department Hiroto YASUHARA.

5. Conclusion

After the visit to Japan by Tongan government and TPL officials, understanding to the Tilttable Wind Turbine System was deepened, the TPL engineers acquired preliminary knowledge of the Tilttable Wind Turbine System and learnt that its maintenance is actually easy after participating the practical training.

Also, through interaction with OEPC that operates the system, and learnt the process of introduction of the system and status current operation in Okinawa, where it has the similar environment with Tonga, the visiting officials now realise advantage of the Tilttable Wind Turbine System.

In Tonga, through interaction with the government officials and stakeholders, contacts were established and a demand for the Tilttable Wind Turbine System was confirmed. It was found that TPL is active and keen in introducing the Tilttable Wind Turbine System by conducting the Environment Impact Assessment, operation of the pilot system(s), and collection of the wind condition in Niutoa for a feasibility study by New Zealand.

As the Kingdom of Tonga aims to provide 50% of the entire electricity from renewal energy by 2020 through the TERM, and also to increase efficiency of the existing micro-grid system, the best option, therefore, is introduction of the Tilttable Wind Turbine System.

Chapter 3 Outlook of the Wind Turbine System Proposal

Kingdom of Tonga is an island country located in the Tropical Rain Forest Climate with similar characteristics in geographical and climate conditions with Okinawa. Also, while in a lesser extent than Okinawa, it is frequented by cyclones. A “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” developed by PEC is the only introduced and operated tilttable wind turbine system in Okinawa, where the natural environment is harsh by frequently hit by typhoon with high temperature and humidity. A wind turbine system project suitable for the conditions in Tonga will be proposed with “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” as its project core.

The “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” proposed here is designed to cope with the harsh natural conditions in Okinawa, with its windmill being a truss structure that can stand against a gust of 60m/s while it is erected, and 85m/s by tilting it when hit by typhoon. By introducing this windmill in Tonga, similar damages caused by cyclone can be avoided. The Okinawan truss structure tower (maximum wind speed of 60m) is far advantageous in wind resistance than conventional tube tower (maximum wind speed of 42.5m). It meets Japan’s strict architecture standards and is suitable for island environment being able to dismantle and no heavy equipment is needed for transportation and assembling.

Since the Niutoa Site is covered with around 20m high trees, it is planned that the height of the tower is extended to usual 38m to over 50m to avoid wind disturbance caused by the trees.



Fig 5-1 “Natural Disaster-proof Okinawan Tilttable Wind Turbine System”

Table 5-1 Summary of the “Natural Disaster-proof Okinawan Tilttable Wind Turbine System”

| Item | Note |
|---|--|
| “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” | 5 towers, 275kW, truss structure tower of +50m high, accessories |
| Grid Connection System | Power receiving equipment, protection devises, loop design |
| Site preparation and foundation | 100m×500m |
| Windmill Installation | On-site installation, pre-commissioning and adjustment |
| Equipment Transportation | Okinawa – Niutoa Site |
| Power Conditioner System | 600kVA (300kVA×2) |
| Lead Storage Battery | Approx. 4,000kWh |

Chapter 4 Prospect of Overseas Expansion by the Proposing Company

1. Objective of Overseas Expansion by the Proposing Company

As Okinawa has been repeatedly suffered by damages caused by typhoons for being the one of the most typhoon hit areas in the world. In 2003, a stand-alone windmill in Miyako Island was buckled by a series of gusts. A tiltable wind turbine system is designed for operation in smaller outer islands primarily to “avoid typhoon” and “increasing maintenance-ability by tilting”. Due to these characteristics, there is more demand in overseas, able to fully utilise our know-how, than the main islands of Japan for lesser landing of typhoons. It is especially feasible in the Pacific Island Countries where we can apply our experience fully. Therefore we are aiming to penetrate into the markets there.

2. Contribution to the Local Economy by the Proposing Company

The characteristics of our products are “Natural Disaster-proof” and “Okinawan Style”. In terms of the “Natural Disaster-proof” design, the tower, which is the main part of this Tilttable Wind Turbine System, can cope up to the maximum of 85m/s from a lattice embedding created from the Okinawan experience and its climate (typhoon and seawater spray etc). High durability is achieved against the seawater spray from hot-dip galvanised coating. Introducing Okinawan experience and know-how will increase the publicity of Okinawa, thus, its marketability, to Tonga and its neighbouring countries and more business chance may arise. It will certainly contribute to vitalisation of the local economy in Okinawa.

3. Prospect of Overseas Expansion by the Proposing Company

① Identification of Advantage in Pricing against the Competitors

Competitors of “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” include Enercon GmbH, Northern Power Systems Inc., to name a few. They relatively offer lower initial costs than ours. However, they are all stand-alone type windmills. If repair is required to the stand-alone type windmills due to typhoon damages, a large crane of several hundred tonnes will be needed, which its hire costs alone could be thousands, if not millions, of dollars. Furthermore, hiring the large crane from overseas would force the repair period extended, thus, the running cost will increase eventually. As a matter of fact, there had been several stand-alone windmills introduced in Okinawa, however, series of typhoons and malfunctioning of the devises left no option but a prolonged out-of-order that would also cause deterioration of other equipment. Therefore many stand-alone types were abandoned for reducing profitability, and more Tilttable Wind Turbine System is introduced for its capability of tilting for typhoon and repair.



Fig 6-1 Damages to OEPC's Windmills Caused by Typhoon

In the recent years, the strength of cyclones in the Pacific Islands is intensifying. Cyclone Ian in 2014 and Cyclone Pam in 2015 left massive damages to the Pacific Island Countries. In taking into account the intensified strength of cyclones and proven applicability in Okinawa that has the similar environment, it can be considered that introducing “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” is the best option for supplying stable renewable energy in wind power generated power in such a long period as over a decade in Tonga and other Pacific Island Countries.

② Local Market Scale

While there is a demand, the market scale of wind turbine system in the Pacific Island Countries is considered very not big. This is due to lower level of the system utilisation than the developed countries for existence of the Region of Calms around the Equator, difficulties in securing enough land space for being the island countries, and difficulties in access to the funding.

Proper Operation and Maintenance (hereinafter referred to “O&M”) is essential for a long term stable operation of such infrastructure as this system. It is a mandatory for the O&M implemented by the OEPC Group to include trainings at the initial stage of windmill project. Tilting and erecting the tower is on the OEPC licence basis and only licence holder is permitted to do these, while simple replacement of spare parts can be done by the on-site maintenance personnel. Large scale maintenance and repair are done by our engineers or the contracted engineers. There will be therefore a commercial opportunity in trainings for new engineers and large scale works after introduction of the system.

③ Prospect of the Overseas Expansion

As discussed above, the local market scale is not very big, therefore, it is not viable to establish a base in overseas. Upon successful introduction of the “Natural Disaster-proof Okinawan Tilttable Wind Turbine System” in Tonga, a patient promotion to its neighbouring countries, which includes convincing the potential buyer for the cost effectiveness in the running costs, will be required with utilisation of assistance schemes offered by the government authorities.

It is considered continuous demands for O&M after introduction of the system will surely exist as long as each system is in operation.

(End)