China's South-South Cooperation with Pacific Island Countries in the Context of the 2030 Agenda for Sustainable Development

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Series Report: Renewable Energy

United Nations Development Programme in China

2017

Acknowledgement

UNDP would like to thank Mr. George Cater for writing this report as part of the policy series titled "China's South-South Cooperation with Pacific Island Countries in the Context of the 2030 Agenda for Sustainable Development". This report also received invaluable inputs and strong support from Mr. Denghua Zhang as team leader and Ms. Ellen Kulumbu as member of the research team for this policy series. Acknowledgement also goes to all the interviewees for this report, all the reviewers from UNDP Pacific countries offices, as well as experts and officials that actively participated in the international workshop on "China-Pacific Island Countries Cooperation for the Sustainable Development Goals", hosted by UNDP China on 17-18 November, 2016 in Beijing. This report also benefited from the management support, substantive inputs and quality assurance provided by Ms. Christine Han, Mr. Niels Knudsen and other officials from the UNDP China Office. It is hoped that this report, along with the larger policy series, can stimulate further discussion and debate on the topic of China-Pacific development cooperation.

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List of Acronyms

ADB	Asian Development Bank
DPE	Department of Petroleum and Energy (PNG)
EPC	Electric Power Corporation (Samoa)
FDOE	Fiji Department of Energy
FEA	Fiji Electricity Authority
GDP	Gross Domestic Product
GHG	Greenhouse gas
ICCC	Independent Consumer and Competition Commission (PNG)
INDC	Intended Nationally Determined Contribution
IPP	Independent power producer
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
MNRE	Ministry of Natural Resources and Environment (Samoa)
MTDP	Medium-Term Development Plan (PNG)
MWTI	Ministry of Works, Transport & Infrastructure
NDRC	National Development and Reform Commission (China)
PCREE	Pacific Centre for Renewable Energy and Energy Efficiency
PNG	Papua New Guinea
PPA	Pacific Power Association
PPL	Papua New Guinea Power Limited
PV	Photovoltic
SDG	Sustainable Development Goal
SIDS	Small Island Developing State
SNEP	Samoa National Energy Policy
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Program
SROS	Scientific Research Organisation of Samoa
TAACC	Technical Assistance to Address Climate Change
UAE	United Arab Emirates
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Goal 7 of the 2030 Sustainable Development Goals (SDGs) calls for "ensuring access to affordable, reliable, sustainable and modern energy for all". Energy security has been a core regional and national priority for the Pacific for many years and is an important task for achieving the SDGs. This report is part of a policy series that identifies challenges and opportunities for China's South-South cooperation with Pacific island countries (PICs) in the context of the SDGs. This report will look at Samoa, Fiji and Papua New Guinea (PNG) and highlight the energy goals, priorities and opportunities for renewable energy cooperation between China and PICs in the process of reaching the SDGs.

PICs enjoy rich renewable energy resources and have set ambitious renewable energy targets, as the tables below show. The report identifies challenges facing the renewable energy sector in PICs, including: lack of funding; lack of institutional and technical capacities; and vulnerability to natural disasters, to name a few. It finds that PICs have had diverse experience with their renewable energy sources and that renewable energy gaps vary across the region.

Renewable energy resources in Samoa, Fiji and PNG

Country	Hydropower	Wind power	Solar power	Biomass	Geothermal
Samoa	√	√	√	√	
Fiji	√	√	√	√	
PNG	√	√	√	√	√

Renewable energy goals on electricity generation, Samoa, Fiji and PNG

Country	Target	Year	Current share of renewable energy
Samoa	100%	2017	20% (2012)
Fiji	100%	2030	60% (2013)
PNG	100%	2030	39% (2014)

Sources: ESCAP, 2016

The report finds that, to date, there has been very limited Chinese engagement in the renewable energy sector in the Pacific. Given China's rich experience in developing renewable energy and China's recent commitments, including the US$3 billion South-South Cooperation Climate Change Fund and the US$2 billion South-South Cooperation Aid Fund, there is much space for China to enhance renewable energy cooperation with the Pacific. Based on the analysis of PICs' energy needs and challenges, and existing renewable energy cooperation between China and PICs, this report identifies major opportunities for China to expand its renewable energy cooperation with PICs in the context of SDGs, categorized as "upstream level" (supporting the creation of an enabling environment for technology transfer) and "downstream level" (actual transfer and demonstration of technologies).

Upstream level support	Downstream level support
» Develop bilateral and trilateral renewable energy cooperation plans » Engage in regional renewable energy cooperation » Set up a Specific Pacific Renewable Energy Fund » Share expertise and experience in governance and policy to help build a favourable environment for investors	» Support renewable energy research, for example, feasibility studies on untapped renewable energy sources » Enhance renewable energy technology transfers » Emphasize capacity building and skills upgrading

Introduction

Goal 7 of the 2030 Sustainable Development Goals (SDGs) - ensure access to affordable, reliable, sustainable and modern energy for all, is not a new goal for Pacific island countries (PICs) where realizing energy security has been a core regional and national priority for many years. "Energy underpins all aspects of socio-economic development ranging from production, storage and transport to health, education and the sustenance of livelihoods - without energy, there can be no sustainable Pacific communities" (SPC, 2010). The topographic variation of the region translates into extremely high unit costs for services and goods; with a heavy reliance on diesel-fuelled generators in many areas to power homes and businesses, the Pacific faces unique challenges in providing affordable and accessible modern energy services. Furthermore, outdated power infrastructure and limited generation capacity can lead to high electricity tariffs, transmission and distribution costs, as well as low electrification rates especially in some of the bigger PICs (ADB, 2016a). To address energy security issues and ensure reliable and sustainable energy, renewable energy is a significant part of the efforts to complement, or in most countries, reduce dependency on fuel imports.

The renewable energy needs of the region are diverse. Practical renewable energy options vary among PICs, and are being pursued with different levels of success. For some PICs in Polynesia with higher (some attaining full) levels of electrification, their priority is the replacement of fossil fuel sources with renewable energy. For smaller PICs like those in Micronesia, the aim is to maintain and accelerate the existing sustainable renewable energy pathway. In Melanesia, where 95 per cent of the region's population have on average less than 20 per cent household electrification rate, the focus is to complement renewable energy sources and fossil fuel generation, with the main priority of increasing access to electricity in the rural areas (Pacific Energy Conference, 2016). Overall, the long-term priority for the Pacific is "increased level of investment in proven renewable energy technologies, as part of the region's strategic response to mitigating the harmful effects of petroleum fuels on environments and economies and, where feasible, supplementing and replacing petroleum fuels as the predominant source of energy, particularly noting the price volatility of this market" (Secretariat of the Pacific Community, 2010).

To date, China's engagement in the renewable energy sector in the Pacific has been limited to small community-based hydro, wind and solar projects. Needless to say, China's climate change funding announcements over the years, coupled with its research and renewable energy technology advancements both domestically and in renewable energy cooperation projects in other regions, are a source of encouragement for China to be an active partner in the renewable energy sector in the Pacific. This report will highlight the energy goals, priorities and opportunities for three countries: Samoa, Fiji and Papua New Guinea (PNG). By emphasizing country priorities and looking at existing Chinese-funded projects, this report will recommend ways forward as to how China's development cooperation in the Pacific could help PICs achieve the SDG 7 of ensuring affordable, reliable and sustainable modern energy for all.

Country Analysis: Energy Sector Overview

Samoa

Energy demand in Samoa is met by three main sources: biomass, fossil fuel, and renewable energy. The value of petroleum imports in 2011 represented 12.2 per cent of Samoa's Gross Domestic Product (GDP) (ADB, 2016b). Samoa has achieved full electrification with 100 per cent of the population having access to electricity (Pacific Energy Conference, 2016): 95 per cent are served through the main grid while the rest through small diesel or solar systems (ADB, 2016a). For electricity generation, 67.7 per cent of the total electricity generation in the fiscal year 2010/2011 was based on diesel generation, while the remaining share was based on hydropower generation (ADB, 2016b). However, these figures continue to fall as the number of renewable energy projects in solar and wind rises. Thus, the promotion of energy efficiency and conservation, and the development of clean, indigenous, and renewable energy resources to reduce the economy's risk exposure to foreign exchange fluctuations and fuel price increases are of high development priority for Samoa.

Samoa's energy sector is coordinated through the National Energy Coordinating Committee, co-chaired by the Ministry of Finance, Ministry of Natural Resources and the Environment (MNRE), and the Ministry of Works, Transport and Infrastructure (MWTI). The overall monitoring and evaluation of Samoa's Energy Sector Plan, including coordination of all national and regional energy cooperation projects, is the responsibility of the Ministry of Finance's Energy Policy and Coordination Division. The same division also arranges for and negotiates five-year contracts of all supply and distribution of petroleum (national bulk-buying initiative) from government-owned fuel storage. The MNRE is responsible for all aspects of environmental issues including greenhouse gas (GHG) emissions, renewable energy and climate change policies. The state-owned enterprise Electric Power Cooperation (EPC) which is the only electricity provider in Samoa, utilizes both fossil fuels and renewable energy technology. It reports to the MWTI.

The goal of the Samoa National Energy Policy (SNEP) 2007 was to increase the contribution of renewable energy to energy services and supply by 20 per cent by the year 2030 (Samoa Ministry of Finance, 2007). The renewable energy sub-sector is one of the five strategic areas of the SNEP with the objective of successfully shifting from fossil fuel dependency to renewable energy investment. This main policy is supported by other strategies that target renewable energy, including: Samoa Energy Sector Plan 2012-2016; Greenhouse Gas Abatement Strategy 2008-2018; Intended Nationally Determined Contributions (INDCs); Renewable Energy and Energy Efficiency Policy Framework; and the Nationally Appropriate Mitigation Actions Framework.

Fiji

Similar to Samoa, energy in Fiji is supplied by three main sources: biomass, fossil fuels and renewable energy. Fiji is heavily dependent on imported petroleum-based products to supply its energy needs, which in 2008 represented 17 per cent of its GDP (IRENA, 2015). The country is also the biggest regional distribution centre for petroleum to countries like Tuvalu and Kiribati. Despite being energy-intensive with its emerging industries such as mining, manufacturing and construction, as of 2016, 13 per cent of the population have no access to electricity (New Zealand Ministry of Foreign Affairs and Trade, 2016). Electricity generation, of which 94 per cent is operated by the Fiji Electricity Authority (FEA), comprises about 55 per cent hydro, 40 per cent diesel and 1 per cent wind, with the remaining 4 per cent supplied by the co-generators: Tropik Woods and the Fiji Sugar Corporation (FSC) (IRENA, 2015). Fiji has set the renewable energy target for electricity generation of reaching 100 per cent by 2030 (Government of Fiji, 2015).

The energy sector is guided by the National Energy Policy 2006, with the latest version currently under review.[1] The 2006 policy has four key strategic areas: energy planning; energy security; power sector reform; and renewable energy. The renewable energy sub-sector is supported by the power sector reform with the goals of establishing renewable energy service companies and increasing funding for rural electrification programmes. The Fiji Department of Energy (FDOE) coordinates and has oversight of the existing energy policy, which houses the Renewable Energy and Rural Electrification Units and overlooks off-grid renewable energy projects. The government-owned FEA carries out the majority of renewable energy projects for grid-connected electrification. The various legislation and policy frameworks for renewable energy in Fiji can be found in: The Green Growth Framework 2014, Draft Energy Policy 2013, Draft Energy Strategic Action Plan 2013, Sustainable Energy for All global report, FEA draft Power Development Plan, Electricity Act (Cap.180), and Clean Development Mechanism Policy Guideline 2010.

Papua New Guinea

PNG is a net energy exporter, and its self-sufficiency in fossil fuels puts it in a different position from other PICs. Its energy demand in 2011 was met by fossil fuel (57 per cent), biomass (37 per cent), and other renewables (6 per cent) (IRENA, 2013b). With the commissioning of its first oil refinery plant in 2004, crude oil is now being refined locally and meets its energy requirements: 65 per cent for domestic market and 35 per cent exported

1. The Energy Policy was reviewed in 2013 with wide public consultation; however government has not endorsed that new draft version to date. According to a SE4ALL Report in 2014, the draft National Energy Policy looks to incorporate and prioritize the areas of grid-based power supply, rural electrification, renewable energy, transport, petroleum and bi-fuels, and energy efficiency (Fiji Department of Energy, 2014).

overseas. Despite this energy abundance, only 13 per cent of the population had access to electricity as of 2016 (New Zealand Ministry of Foreign Affairs and Trade, 2016). PNG's main energy priority is electricity connectivity, with its target of 70 per cent of all households having access to electricity by 2030 (New Zealand Ministry of Foreign Affairs and Trade, 2016). The difficult topography, the considerable distances between various towns or load centres, poor infrastructure and policy planning (and inaction) have hampered electricity connectivity throughout the country. The provision of electricity is mainly through three main grids (that caters the Capital Port Moresby and Ramu) and through private generation mostly undertaken by large mines, plantations and other extractive industries. The government of PNG has identified three primary goals for the energy sector: improve access to electricity; improve the reliability of electricity; and ensure power is affordable for consumers (ADB, 2016a).

The Energy Division of the Department of Petroleum and Energy (DPE) is responsible for preparing energy policies, planning initiatives, data collection and analysis as well as advising the government on energy sector issues. Two policies have been drafted, namely, the Energy Policy and Electricity Industry Policy, both of which have yet to be adopted, while the Rural Electrification Policy was recently passed and the government assured that it would be implemented (Government of Papua New Guinea, 2016). The PNG Power Limited (PPL) undertakes power sector planning and operates the three main electricity grids and 100 small rural electricity centres. These systems are run through diesel generators, small hydro and solar photovoltaics (PV). Price and other aspects of electricity supply operations in PNG are regulated by the Independent Consumer and Competition Commission (ICCC), an independent regulator of the electricity industry established through an Act of Parliament in 2002. There are two Acts covering the provision of power supplies: The Electricity Industry Act of 2000 and the Government Power Stations Act. Since 2013, the government has taken out a World Bank loan for a long-term project where one of its priorities is to strengthen institutional and policy development for renewable energy and rural electrification (World Bank, 2016).

Country Analysis: Renewable Energy Targets, Sources and Experience to Date

Samoa

Samoa's target for renewable energy has increased dramatically as a new commitment under its United Nations Framework Convention on Climate Change (UNFCCC) INDC 2015. This ambitious commitment is proposed to be implemented over two time periods: to reach 100 per cent renewable electricity generation by 2017; and maintain 100 per cent contribution through to 2025 (Government of Samoa, 2015). These targets, as indicated in the INDC, are conditional on both domestic finance and international development cooperation. This political commitment is part of the government's priority to mainstream climate change issues in all sectors by accelerating progress to reduce GHG emissions.

Samoa has capitalized on four sources of renewable energy: hydropower, wind, solar and bioenergy, where the EPC took the lead in numerous projects. A Renewable Energy Unit was set up within the EPC in 2007 to manage and develop projects associated with renewable energy activities such as wind, solar, hydro and bio-energy (Samoa Electricity Power Corporation, 2016). Bilateral partners such as Japan, the United Arab Emirates (UAE), China, Australia, US and New Zealand, and regional and multilateral institutions such as the European Union (EU), Asian Development Bank (ADB), United Nations Development Programme (UNDP), World Bank and the Secretariat of the Pacific Regional Environment Program (SPREP) have supported Samoa with feasibility studies and projects in hydro, wind and solar. One of the recent enablers for EPC came about in its recent reform that allowed power generation from independent power producers (IPPs), which has seen an increase in private ventures in renewable energy supply. As for specific renewable energy sources:

- **Hydropower:** Hydroelectric power generation in Samoa is only found on the main island of Upolu, where in 2012 it met 50 per cent of the island's power needs (IRENA, 2013c). This energy source is supplied through one main 4MW storage system (Afulilo Dam) and six run-off water systems.
- **Wind power:** In 2014, a UAE Madasar project installed a wind farm in eastern Upolu. A second wind farm approved in 2016 will be provided by a local IPP: The Pacific Renewable Energy Limited (Savali News, 2015).

- **Solar energy:** The island of Apolima is fully electrified with five solar plants operating in both Upolu and Savaii. Three of the installations were funded by the Japan International Cooperation Agency (JICA) while the other two were funded by New Zealand. In 2015, a 500kW solar system provided by Sun Pacific Energy (a local IPP) is now connected to the main electricity grid in Upolu (Savali News, 2015). Another IPP named Green Power Solar began work in 2016 for a grid connected with a 2000kW facility (Pacific Regional Data Repository Sustainable Energy for All, 2016).

- **Bioenergy:** Biomass is no longer used for electricity generation in Samoa. However, fuelwood (though declining) is used for household cooking. Biofuel (consisting of 20 per cent coconut oil and 80 per cent diesel) was experimented to fuel generators in the late 2000s, but stopped when the coconut oil supplier went out of business (IRENA, 2013c). The Scientific Research Organization of Samoa (SROS) successfully developed biodiesel technology converted from coconut oil, and tests continue to ensure it becomes marketable and affordable.

Fiji

Fiji has the most diverse mix of renewable energy sources utilized, compared to other PICs. It is well endowed with proven resources from hydro, solar, biomass, wind as well as potentially geothermal energy. Despite this, the exact potential of renewable energy has yet to be fully tapped and made public (IRENA, 2013a). Originally, the renewable energy electricity generation target from the 2006 energy policy was set at 90 per cent by 2011. However, since this target was not reached, it has been revised and listed in the UNFCCC INDC 2015: reaching 100 per cent renewable energy generation by 2030 (Government of Fiji, 2015). Regarding specific renewable energy sources:

- **Coconut oil:** Coconut oil has been used as an alternative to diesel fuel in power generators at several rural locations such as Vanuabalavu, Lau, and Taveuni. Except for Taveuni, two of the projects discontinued due to non-maintenance of generators which resulted in the resort back to diesel fuel (IRENA, 2013a).

- **Biogas:** The limited biogas currently produced is mainly used for cooking, and the digested material is used as fertilizer. For 30 years, biogas digester projects have been conducted for small piggeries and dairies (IRENA, 2013a).

- **Bioethanol:** The FSC and oil companies produce 10–15ML of ethanol per year from sources such as sugar, molasses, or sorghum for blending with petrol. The FSC produces a bi-product, bagasse, as fuel to generate electricity which it sells back to the main electricity grid in Vanua Levu (Chaundry, 2016).

- **Hydropower (large/medium/micro):** Hydropower represents the biggest share in Fiji's electricity supply mix, supplying 258MV. The FEA oversees hydro projects varying from large hydro projects (Monavasu Wailoa, Nadarivatu) to medium-sized (Wainikasou, Nagado/Vaturu, Wainiqeu) (IRENA, 2015). The hydro plant in Nadarivatu of 40MV was funded by the China Development Bank (US$150 million) and constructed by Sinohydro Corporation. The project was commissioned in 2012 and is the second biggest hydro dam in Fiji. Since the 1980s, village-scale hydro systems were built in Fiji for small electrical loads. Combined with difficult site access, there has been lack of access to financial resources and limited technical skills in the villages, resulting in long power outages and high repair costs, and ultimately leading to the abandonment of the systems (IRENA, 2015).

- **Solar PV:** Rural electrification through PV was first tried in the early 1980s in Namara, Vatulele and Totoya villages by the US Agency for International Development (USAID) and the Peace Corps. The Namara cooperative is the only system that continues until today after management was taken over by village leaders. Similar projects were trialled in 100 solar home systems, cane farm settlements in Viti Levu and the village of Naroi. Although all these FDOE-operated projects were considered successful, they experienced high costs due to failure of the expensive pre-payment meters, and the loss of confidence in the programme due to lack of repair. The lessons learned from them were later used in designing the larger-scale Vanua Levu and smaller outer island projects that currently form the FDOE's primary solar-based rural electrification efforts (IRENA, 2013a).

- **Solar thermal and solar pumping:** Solar water heaters are considered commercially viable and have been locally manufactured since the 1970s. Thousands of locally made as well as imported systems have been installed in homes and tourist facilities (IRENA, 2013a).
- **Wind power:** 275kW wind turbines were installed in the Butoni wind farm in 2007. The turbines are able to be tilted down to avoid damage from cyclones, a serious challenge for Fiji (IRENA, 2013a).

Papua New Guinea

The renewable energy potential in PNG is enormous. The Oxford Business Group ranks PNG among the top 10 countries with potential renewable resources unexplored (2016). Nonetheless, most of these resources are in remote locations where there is limited demand and which are not readily exploitable. PNG plans to transition to 100 percent renewable energy by 2030 and the PNG government has announced as a priority the promotion of the use of green energy systems including solar, wind, hydro, bio-fuel and geothermal energy and that it will introduce a zero-tax policy for these items (Government of Papua New Guinea, 2016). However, this will be a long-term and gradual goal; the Medium-Term Development Plan (MTDP) 2016-2017 states that while all energy sources (geothermal, solar, hydro and diesel) are produced locally, given the fact that 83 per cent of population do not have access to electricity, the priority is to increase connectivity and access (IRENA, 2013b). This pressure will only increase with population growth in the future.

The use of renewable energy is mainly driven by the private sector, and churches in remote rural areas that support basic services for health clinics and schools. The coffee industry still uses wood-burning driers; the palm oil industry uses wastes for electricity production; and Ramu Sugar plans to use wood for combustion in its bagasse boilers to increase their energy production (IRENA, 2013b). Yet, barriers to the successful long-term and large-scale use of renewables seem to be considerable. About three quarters of the mini/micro hydro systems installed are no longer in use; a high percentage of residential and public facility PV and wind systems have failed; and the majority of rural community power systems are operating poorly, or not at all (IRENA, 2013b). The failure of these projects was attested to poor maintenance and upkeep by national and provisional officials, lack of capacity of local communities to take over the project, and in some cases, vandalism. Regarding specific renewable energy sources:

- **Geothermal:** There is one commercial geothermal development in Lihir, New Ireland, which is the first in the PICs.
- **Hydropower:** In 2012, there were only seven small hydro dams feeding the three-grid system of PPL. Church missions, non-governmental organizations and community organizations were reported to have their own small-build hydro systems. A US$5 billion dam at Purari river that was planned to feed Port Moresby grids and to be exported by underwater sea cable for northern Australia was aborted in 2014 due to local land ownership disagreements (Energy Business News, 2014).
- **Wind:** In 2002, the Chinese government donated 50 small combined wind/solar generators to the government of PNG (China Aid Data, 2016). China also donated a small wind turbine system to the Duke of York Islands of New Britain to power the local hospital and other facilities (IRENA, 2013b).
- **Solar energy:** Solar water heating systems are growing in urban Port Moresby with over 7,000 household installations. The increasing use of mobile communications in PNG has seen increased use of solar energy by mobile companies like PNG Telecom to power their system into the rural areas and for solar-powered chargers (IRENA, 2013b).
- **Bioenergy:** Biomass is largely used for cooking, with some industrial use in palm oil, sugar and wood product facilities. Gasifiers have been installed around the country for using biomass wastes in the cocoa, copra, coffee and tea industries for replacement fuels (IRENA, 2013b).
- **Hybrid energy:** 50 hybrid energy systems (wind and solar) were provided by China in 2002 for use at coastal provincial centres. According to an IRENA report, only a few had been installed by early 2004 and a number of them soon suffered electronic component failures (IRENA, 2013b).

Country-Specific Priorities and Challenges in Renewable Energy

Samoa

To meet the 100 per cent renewable target by 2017, Samoa is moving towards a more diverse mix of generation technologies; and as of May 2016, has achieved 50 per cent of the target. "The use of intermittent technologies such as solar photovoltaic and wind also puts pressure on the grid to maintain stability of supply-storage and grid improvements become a priority once all these projects are online which are also capital-intensive" (Government of Samoa, 2015). There is room for a more comprehensive renewable energy policy that brings together existing plans under MNRE, EPC and SROS, and which encourages research in other sources and forms of renewable technology. This should include guidelines for appropriate use and standard of such technology. There is an acknowledgement of investment to upgrade and maintain existing infrastructure through support from development partners. Currently, some of the existing partners in the Samoan energy sector are: The ADB, the EU, Japan and the UAE (Pacific Energy Conference, 2016). Samoa has identified the following renewable energy priority projects (New Zealand Ministry of Foreign Affairs and Trade, 2016):

- **Wind and hydropower IPP project:** A new wind farm and pump storage hydro system with the capacity of 25MW will contribute significantly to the network.
- **Taelefaga hydropower:** A third turbine is planned for Taelefaga hydropower station. This will increase the station's capacity by 50 per cent.
- **Savaii hydropower:** Design is under way for a 2MW hydropower system. A 22kV transmission line will be required to connect it to the grid on the southern coastal network.
- **Submarine cable:** A submarine cable between Upolu and Savaii will allow transmission of electricity between the islands.
- **Geothermal energy:** Savaii may have a useable geothermal resource. A feasibility study is required.
- **Storage and "smart" network system:** Higher proportions of intermittent renewable generation necessitate detailed modelling of the electricity system.
- **Vaipu pumping station:** Pumping water between the Vaipu and Afulilo dams could store excess intermittent renewable energy from solar and wind.

The International Renewable Energy Agency (IRENA) reported that a barrier for renewable energy deployment and investment has been the low cost of electricity which is offset by hydro resources (2013c). Samoa, like other PICs, has a difficult environment for electrical and mechanical equipment with salt corrosion, high moisture levels and ambient temperatures prevalent (Samoa MNRE, 2015). There remain issues with decreasing load factors, due to changes in climate and in part to the removal of vegetation in the catchments. Some reforestation is proposed along with investigating means to add storage with flood retention schemes upstream of existing facilities (Samoa Ministry of Finance, 2012). More importantly, there is very limited knowledge of alternative renewable energy sources among key decision-makers or the rest of the energy sector that can inform policies and investment (IRENA, 2013c). This is further aggravated by the limited training available on renewable energy, inadequate information on the production, supply, distribution and consumption in the country (Samoa MNRE, 2015). Respondents for this report attest the lack of funding, or complex project proposal process in existing international renewable energy funds as a frustration. Furthermore, if finance was sourced, the lengthy procurement and payment processes and project management arrangements continue to hinder renewable energy projects in the country (Samoa Ministry of Environment and Natural Resource Official, 2016).

Fiji

Fiji continues to prioritize policy work, research and investment in current and new renewable technologies. Further research is needed to look into other sources of renewable technology, including exploration of ocean energy, geothermal energy, wave energy and generation of energy from waste geothermal energy resources.

Fiji has identified the need to promote and improve guidelines and technical standards for renewable energy technologies with more research and development for energy from possible hydro carbon resources and hydrogen fuel cells (Government of Fiji, 2015). All of these projects require both international cooperation and access to special funding and technical capacity, and to ensure that both technology and maintenance can be sustained locally. Currently, some of the existing partners in the Fiji's energy sectors are: The ADB, the UAE, Japan and China (Pacific Energy Conference, 2016). As of 2016, Fiji has identified the following energy priority projects:

- **Hydro IPP proposals:** The FEA is considering three new IPP hydro proposals totalling 32MW. Detailed feasibility work is required to determine which proposal(s) will proceed.
- **2MW to 5MW solar hybrid systems:** The FEA has received proposals for several hybrid solar PV systems with a range from 2MW to 5MW. These will be operated by IPPs (New Zealand Ministry of Foreign Affairs and Trade, 2016).

Fiji's vulnerability to natural disasters, particularly cyclones, has caused damage to many hydro systems, wind farms, and ground-mounted solar farms, including energy-producing resources like coconuts. The recent Cyclone Winston that devastated Fiji in February 2016 left an electricity sector bill of no less than US$19 million (Government of Fiji, 2016). Despite many experiments and explorations in renewable energy technology, the country continues to face many challenges. Lessons learned from past project experiences suggests that renewable energy investment carries risks; without the inclusion of risk abatement incentives, private investment will be slow (IRENA, 2013a). The goal for rural and outer islands electrification is hindered by both costs and limited expertise on the ground. The small populations (especially in outer islands) with irregular consumption make both public and private renewable energy system investment less economically viable. At the moment, some of these remote independent grids are highly subsidized. This challenge is part of a bigger barrier in terms of institutional framework and standardization for energy efficiency. IRENA identified that Fiji had no sustainable institutional frameworks, such as fee collections, to develop, operate and provide reliable services for rural electrification on a commercial basis (2013). Furthermore, there were no national standards or certifications to ensure that imported renewable energy technologies were suitable for local conditions (IRENA, 2013a).

Papua New Guinea

With only 13 per cent of the population having access to electricity in 2016, renewable energy in PNG will have to complement the existing abundant diesel-generated energy sources to ensure that its target of 70 per cent of households having access to electricity by 2030 will be achieved. To this end, the priority should be geared towards large-scale generation and transmission networks that provide low per unit costs and high levels of service for urban and industrial areas (Pacific Energy Conference, 2016). Active partners in the energy sector are: The ADB, New Zealand, the World Bank, Japan and Australia (Pacific Energy Conference, 2016). PNG has identified the following energy sector projects that need priority investment:

- **Hydro IPP proposal:** In early 2016, a 80MVle dam in the Karimui river was formally agreed between provisional government and a private company called Salini Impregelio, to be built from 2017 to 2023 (Yagi, 2016).
- **Ramu 2 hydro public-private partnership:** This 180MW project includes a 30km-long 132 kV transmission line.
- **Port Moresby grid reinforcement:** This involves transmission and distribution network upgrades, a major new substation, and rehabilitation and upgrading of the Rouna, Sirinumu, and Sirinumu Toe of Dam hydro power stations.
- **Distribution network expansions:** Expansion of the PPL's distribution network aiming to connect 300,000 new households by 2031.
- **Town Electrification Investment Programme tranche two:** This covers the development of one new mini hydro and the refurbishment of five others in provincial centres, including new transmission lines.

- **District centres:** Scoping is under way to identify opportunities for taking a cluster approach to developing new renewable-powered networks around such centres.[2]
- **Subsidized solar:** Household systems: Increased funding would increase the number of systems being installed under the scheme, which targets remote areas where electricity networks are not feasible (Pacific Energy Conference, 2016).

The fossil fuel-rich PNG allows a heavily subsidized energy sector: Identical fuel prices in both urban and remote rural areas (where the national electricity tariff is below the cost of power generation in rural areas) and no incentives such as low-cost loans, reduced import duties or reduced taxes for assembling or manufacturing renewable energy technologies (IRENA, 2013b). The priority of the government is electricity accessibility, and there is little attention to targets, legislation or policy support for renewable energy to attract both development partners and private investors. To promote renewable energy, there is need for institutional strengthening across government departments and to tap into existing or potential sources of development partner financing for renewable energy deployment in the country (IRENA, 2013b). There is limited capacity with the Energy Division (of the DPE) for research, energy planning and analysis; lack of support from national, provisional and local governments for rural renewable energy development; lack of public awareness and knowledge about existing technology, and limited capacity (in terms of training, and project evaluation) to develop renewable energy project proposals acceptable to development partner agencies or private investment, all of which continue to hinder the development of this sector. Although renewable energy has been identified as a viable option for rural off-grid systems, it must be acknowledged that conducting projects or businesses in both urban and rural PNG has high costs and risks, including lack of cash in rural communities to pay for renewable energy services, the high cost of initial technology installation, the prevalence of theft and vandalism, land access issues, and vulnerability to natural disasters (IRENA, 2013b).

China's Renewable Energy Cooperation in the Pacific

In Samoa

In recent years, Chinese development cooperation in Samoa in the area of renewable energy has only been a Technical Assistance to Address Climate Change (TAACC) project, funded by the National Development and Reform Commission (NDRC) of China. This project was in the form of energy-efficient electrical appliances, implemented in two phases (Samoa Ministry of Environment and Natural Resource Official, 2016). During the first phase (TAACC1), China supplied air-conditioning units worth about US$2 million as part of its support to Samoa's hosting of the Third UN Small Islands Developing States (SIDS) Conference in 2014. The second phase, TAACC2, involved the supply of LED lights, solar LED streetlights and LED tubes, all of which reached a total value of US$2.5 million. The first shipment of 2500 LED streetlights was received by the government of Samoa through MNRE, and later handed over to the EPC which is currently installing them around the country (Samoa MNRE Official, 2016).

In Fiji

China's participation in Fiji's development of renewable energy dates back to 1988, when China helped construct the hydropower station in Bukuya (Zhang, 2015). The Nadarivatu Hydropower station funded by China's loans (US$150 million) was launched in 2012 and was incorporated into local power networks in Fiji. With an installed capacity of 45MW, the station's annual power generation is around 101 million kWh, providing a big boost to the

2. The cluster approach refers to identifying multiple renewable energy sources around a city or district centre that can be connected to feed energy supply in that area, without necessarily being connected or dependent on a main grid. The PNG Climate Change Development Authority is promoting a small scale community-based mini hydro with potential for mini grid at the community level under a project called Facilitating Renewable Energy & Energy Efficiency Applications for Greenhouse Gas Emission Reduction (FREAGER).

power supplies in Viti Levu of Fiji through renewable energy (Zhang, 2015). The Somosomo mini hydropower project (Taveuni Island) was supported by China's grants with installed capacity of 700kW; the US$7.5 million project is expected to be completed in 2016 (Drauna, 2016). In addition, during Chinese President Xi Jinping's visit to Fiji in November 2014, China and Fiji signed a memorandum of understanding (MoU) on China's provision of goods for addressing climate change in Fiji (Zhang, 2015).

In Papua New Guinea

Over the past five years, China has been indirectly involved in the energy sector through its loan to the Ramu Nickel Mine. In China's first white paper on foreign aid, it emphasizes that it has contributed to renewable energy projects in PNG. As indicated earlier, Chinese renewable energy cooperation in the early 2000s focused on community grid systems and generators that were powered by wind and solar. However, there have been no official reports regarding whether these projects have continued to date.

Opportunities for China to Enhance Renewable Energy Cooperation with the Pacific

Opportune moment for deepening China-PICs cooperation in renewable energy

China is an active development partner in the Pacific region in many sectors such as infrastructure, agriculture, human capacity and trade. However, this research finds very limited Chinese engagement by far in the energy sector, especially renewable energy. At best, its renewable energy projects have been sporadic and ad hoc and not administered through a coordinated regional or bilateral energy cooperation plan. Most of the existing and recent renewable energy projects have materialized only owing to political gestures, announcements made in conjunction with high-level visits/meetings, or global forums taking place in the region. The ad hoc nature of renewable energy cooperation results in one-off projects and not necessarily a long-term sustainable cooperation programme.

China is a leading renewable energy producer in the world (Rose, 2016). Its energy demand domestically has led to huge advancements in its research and technology capacities in renewable energy, growing faster than those of fossil fuel and nuclear energy. The experience in renewable energy technology and research is a potential source for deeper engagement by China in the renewable energy sector in the Pacific. As the table below shows,China's climate change announcements, including the RMB 20 billion (US$3 billion) South-South Cooperation Climate Change Fund by President Xi in September 2015 (over the next five years) that will focus on least developed countries and SIDS' renewable energy technology transfer, among other areas, provide optimism for the region (Zhang, 2015). There is potential for Pacific countries to learn and utilize renewable energy policies and technologies through South-South cooperation with China.

Table 1. China's pledges on climate change

Occasions	Climate change pledges
Rio+20 Summit, June 2012	China's former Premier Wen Jiabao pledged that China would provide RMB 200 million (US$30.8 million) to support SIDS, African nations and LDCs.
UN Climate Summit, September 2014	Chinese Vice Premier Zhang Gaoli pledged that China would establish the South-South Cooperation Climate Change Fund and double its annual support since 2015, and provide US$6 million to support UN Secretary-General in combating climate change.
2011-2015	China provided a total of RMB 400 million (US$61.6 million) to SIDS, African nations and LDCs to address climate change, including through material donations and human resources training.

President Xi's visit to the US, September 2015	Chinese President Xi pledged to provide RMB 20 billion (US$3 billion) to set up the South-South Cooperation Climate Change Fund.
COP21, December 2015	Chinese President Xi announced the "10+100+1000" scheme for other developing countries, including: pilot 10 low-carbon industrial parks; conduct 100 mitigation and adaptation programmes; and provide 1000 training opportunities on climate change.

Source: Made by Denghua Zhang in the Overarching Analysis of this policy series

Electricity generation is a common priority in all three countries (and the wider Pacific), most notably PNG. Some countries like Samoa and Fiji have already put forth and been pushing ahead to achieve specific renewable energy targets. However, to achieve these targets, there needs to be more private sector investment so that they are viable with current infrastructure capacities and buy-back rates. The three countries will continue to need support, both in terms of policy and physical infrastructure, to create an enabling environment to attract private investors in renewable energy. At the same time, the governments in the Pacific are engaged in the current process of translating the SDGs into both national development strategies and energy policies. The global policy agenda setting, China's climate change pledges, as well as the priority needs of PICs such as Samoa, Fiji and PNG, make it the opportune moment for deep and sustainable cooperation between China and Pacific in the renewable energy sector.

Recommendations

The following recommendations underscore the value in engaging at the "upstream level" (supporting the creation of an enabling environment for technology transfer) and "downstream level" (actual transfer and demonstration of technologies with potential up-scaling by the private sector) (UNDP China, 2014).

- **Develop bilateral and trilateral renewable energy cooperation plans.** There is potential for China to become a leading and sustainable partner by developing renewable energy cooperation plans for PICs. China-Pacific (and individual bilateral) cooperation plans must go beyond one-off projects to target longer-term programming tailored towards meeting partner country's long-term energy priorities. There is opportunity for both bilateral and trilateral cooperation with existing development partners already engaged in the renewable energy sector. These renewable energy cooperation plans should be country-tailored to meet the diverse energy needs, and support energy efficiency of existing energy sources. For countries like Samoa and Fiji that have a high level of household electrification, there is a higher propensity to replace fossil fuel with renewable energy. In this regard, efforts should be tailored to technology transfer connected to main power grids. For PNG (as well as Vanuatu and the Solomon Islands), the priority is increasing accessibility from its low rate of less than 20 per cent. Efforts should be tailored towards access to energy through off-grid and community-based power that could be later connected to main grids.

- **Engage in regional renewable energy cooperation.** As a development partner, it is recommended that China engage with national economic planning and energy agencies and other relevant stakeholders in the energy sector both bilaterally and regionally. Regional organizations such as the Secretariat of the Pacific Community (SPC), SPREP, Pacific Islands Development Forum, University of the South Pacific, Pacific Power Association (PPA) and initiatives like the Pacific Centre for Renewable Energy and Energy Efficiency (PCREE), to name a few, all have active renewable energy research and policy units that could benefit from Chinese experience in its energy sector both domestically and internationally through its engagement in other regions of the world.

- **Set up a Special Pacific Renewable Energy Fund.** With a special consideration for SIDS, China could set up a Special Pacific Renewable Energy Fund for PICs. Such a fund should reduce barriers in the proposal phase closely linked to existing project/programming. The special fund could provide the foundation on which China's overall bilateral and regional energy cooperation can be based. The cooperation should be demand-driven and targeting long-term sustainable renewable energy programmes over one-off projects.

- **Experience-sharing on governance and policy.** Despite much advancement in governance through legislations, policies, sector planning and regulatory reforms in many PICs, more efforts are needed. Exiting policies do not fully provide an enabling environment of investors to confidently engage in the region. This is one area of expertise and experience-sharing that China could contribute to, especially policy advice on rural electrification renewable policy and planning. Since the opening up of the energy sector through PPA, there are at least two Chinese IPPs engaged in providing energy through solar and wind farms. This should be complemented with good practices from public and private utilities' implementation of expanding generation, transmission and distribution networks.

- **Support renewable energy research.** China could support existing renewable energy technology research carried out by national (such as the SROS) or regional (such as the SPC, SPREP and PCREE) entities that utilize locally available energy generation sources (e.g. solar, wind, biofuel and biomass). More importantly, China could support feasibility studies on untapped sources of which China is leading the development of technologies (such as geothermal and wave). Awareness programmes should complement these findings for energy stakeholders, including key political and private sector decision-makers.

- **Enhance renewable energy technology transfers.** Providing the right weather-/climate- proof (that is humidity-, cyclone-, flooding-, earthquake- as well as high temperature- and maritime-resistant) renewable energy technology, including battery energy storage and voltage control systems, has been identified by various reports and respondents for this report as the priority support that PICs require. Key areas for China to consider could be financing and operating individual community-level hydropower and solar PV/diesel hybrid initiatives, especially for off-grid and remote locations in PNG and Fiji.

- **Emphasize capacity building.** Renewable energy technology transfer opens up great opportunities but needs to be coupled with capacity building and skills upgrading for local counterparts to maintain technologies. This is a significant lesson from past projects where some were abandoned due to lack of manpower and necessary resources to maintain such projects. China currently has a tertiary and short-term training programme with some countries in the region that take officials and students to study in China. One way forward could be to prioritize scholarships and short-term capacity training for officials on renewable energy.

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Annex 1: List of interviewees

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