# Do high renewable energy targets hinder donor-funded rural electrification in Pacific island countries?

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## Abstract

High renewable energy targets and rural electrification are not necessarily complementary in Pacific island countries (PICs). While PICs need to tackle both high renewable energy targets for climate change and rural electrification for further development, investment in renewable energy in urban areas is a more cost-effective means of achieving renewable energy targets than rural electrification with renewables. In the energy sector in PICs, foreign aid is the single most important source of investment. Thus, this research will investigate donor-funding for energy projects, assess the extent to which the funding is focused on rural electrification, and examine whether the situation has changed over time in this region. A large share of the information about foreign aid for energy projects between 2013 and 2015 are extracted from a database of a think tank. All the energy projects are sorted into four categories: urban power supply, rural electrification, others, and unspecified projects. The results show that PICs are not only improving urban power supply but also enhancing rural electrification currently, and foreign aid for rural electrification has increased over time. This research also suggests policy recommendations for the donor and recipient governments, including data collection and analysis on electricity demand and energy consumption.

**Keywords:** development; foreign aid; Pacific island countries; renewable energy; rural electrification

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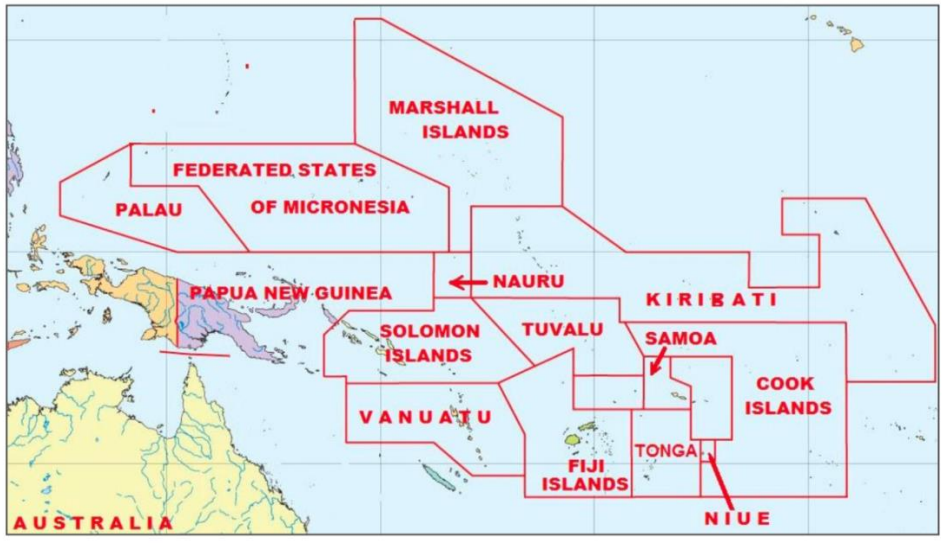
## Introduction

Are high renewable energy targets and rural electrification always complementary in Pacific island countries (PICs)? The answer is "not necessarily". All PICs have high renewable energy targets aimed at shifting away from fossil fuels and to renewable energy. At the same time, PICs face a range of development challenges, including the provision of reliable electricity to un-electrified households — an issue of particular significance in rural areas. A risk associated with a focus on high renewable energy targets is that rural electrification needs may not be addressed, owing to the fact that urban investment in renewable energy is a more cost-effective means for governments to achieve those targets. High renewable energy targets and rural electrification are therefore not necessarily complementary.

In the energy sector in PICs, foreign aid is the single most important source of investment. Thus, this research will investigate donor-funding for energy projects, assess the extent to which the funding is focused on rural electrification, and examine whether the situation has changed over time in this region (see Figure 1). This study will be used to assess whether high renewable energy targets of PICs have hindered donor-funded rural electrification.

This paper is structured as follows. Section two presents context and literature review. Section three describes methodology and data. Sections four and five explore results, and offer discussion (respectively) on how rural electrification is proceeding. The final section concludes.

Figure 1. Map of the Pacific island countries.




Source: Dornan, 2015b

## Literature Review

### *High renewable energy targets and its drivers*

PICs are the countries most at risk in the world from climate change (Barnett & Campbell, 2010). Several PICs will probably lose a considerable percentage of their land due to sea-level rise (Kelman & West, 2009). Floods, droughts, heat waves, and tropical cyclones have occurred more frequently and intensely, and these have more negative effects on households, industries such as agriculture and fishery, and the environment (Mertz, Halsnæs, Olesen, & Rasmussen, 2009).

Considering these severe climate change situations, PICs have decided to significantly reduce their emissions of greenhouse gases (GHGs) such as carbon dioxide ($CO_2$)[1]. The Cook Islands, Papua New Guinea (PNG), Samoa, Tuvalu, and Vanuatu aim to achieve 100 percent of renewable energy sourced electricity supply (see Table 1). The other PICs also have high renewable energy national targets (see Table 1).

Foreign aid is crucial if PICs are to achieve these targets. PICs depend on foreign aid not only for climate change and rural electrification investment but also for other infrastructure investment (Dornan & Shah, 2016). ODA as a proportion of GNI is quite high in all PICs (see Table 1).

Foreign aid for energy projects is especially significant when compared to domestic expenditure in PICs (Keeley, 2017). Private investment in energy projects is limited mainly due to the small size of electricity markets and poor regulatory frameworks (Dornan & Shah, 2016). As a result, most energy projects have been implemented by foreign aid in the energy sector in PICs.

In addition to their own efforts to reduce GHGs, PICs urge many other countries around the world to have much higher targets and take actions to reduce GHGs at the international climate change negotiation table (Dornan & Shah, 2016). High renewable energy targets at home are useful in this regard. Through such targets, PICs aim both to reduce GHGs domestically and to encourage countries outside of the region to do the same.

[1] The intentions of PICs to reduce GHGs are seen in their commitments to an international climate change framework, the Intended Nationally Determined Contribution (INDC), which determines a country's contribution to climate change in the framework of the Paris Agreement (see Table 1). Most of the PICs have committed to implementing energy transition from fossil fuels to renewable energy, at least in the power sector.

PICs also have economic reasons for expanding renewable energy generation. One important objective is to escape from oil dependence. PICs' economies are vulnerable to international oil price volatility because they rely heavily on oil imports such as diesel, heavy oil, and kerosene (Weisser, 2004; Dornan, 2015b; Dornan & Shah, 2016). Consequently, oil imports have caused major difficulties for their economies due to international oil price vulnerability (Yu & Taplin, 1997).

Table 1. GDP per capita, renewable sourced energy use targets, electrification rates, and net ODA received (% of GNI).

| | GDP per capita (in 2016, USD) | Renewable sourced energy use targets (including conditional targets) | Electrification rates (in 2014) | Net ODA received % of GNI (in 2016) |
|---|---|---|---|---|
| Cook Islands | 24,614.5 | 50% RE electricity by 2015 ;100% RE electricity by 2020 | [b]99% | n.a. |
| Fiji | 5,357.5 | 99% RE electricity by 2030 ;$CO_2$ reduction by 30% by 2030 | 100% | 2.4% |
| Kiribati | 1,546.9 | $CO_2$ reduction by 48.8% by 2025 ;$CO_2$ reduction by 60% by 2030 | 48% | 24.1% |
| Marshall Islands | 3,591.6 | GHGs reduction by 32% by 2025 ;GHGs reduction by 45% by 2030 | 90% | 4.8% |
| Micronesia, Fed. Sts. | 3,157.5 | $CO_2$ reduction by 35% by 2025 | 72% | 13.2% |
| Nauru | 7,823.6 | Lowest total emissions in the world by 2030 | 99% | 18.3% |
| Niue | [a]12,945.0 | 38% RE electricity by 2020 ;80% RE electricity by 2025 | [b]99% | n.a. |
| Palau | 17,175.5 | GHGs reduction by 22% by 2025 | 99% | 6.3% |
| Papua New Guinea | 2,588.9 | 100% RE electricity by 2030 | 20% | 2.6% |
| Samoa | 4,024.5 | 100% RE electricity by 2017 ;100% RE electricity by 2025 | 98% | 11.4% |
| Solomon Islands | 2,053.2 | $CO_2$ reduction by 45% by 2030 | 35% | 15.7% |
| Tonga | 3,956.8 | 50% RE electricity by 2020 ;70% RE electricity by 2030 | 95% | 19.7% |
| Tuvalu | 3,375.5 | 100% RE electricity by 2025 ;GHGs reduction by 60% by 2025 | 98% | 60.7% |
| Vanuatu | 2,937.9 | 100% RE electricity by 2030 ;$CO_2$ reduction by 30% by 2030 | 34% | [c]12.3% |

*Notes:* (a) Data taken from 2012; (b) Sourced from New Zealand Ministry of Foreign Affairs and Trade (2016); (c) Data taken from 2014.

Sources: Department of Foreign Affairs and Trade, Australian Government, 2018a-n; United Nations Framework Convention on Climate Change, n.d.; World Bank, 2018a; World Bank, 2018c

PICs also stand to benefit from high renewable energy targets insofar as they attract foreign aid assistance for renewable energy projects (Dornan & Shah, 2016). For PICs to deploy renewable energy, "donor funding is a significantly important source

of finance" (Keeley, 2017, p. 36). PICs need to draw the attention of existing and potential donors to receive more foreign aid in this area, and ambitious renewable energy targets can serve this purpose.

### *Role of electricity in development*

In addition to climate change, PICs also face a range of development challenges. The World Bank (2017) states that 5 countries out of 14 countries belong to lower-middle-income economies, 6 countries are upper-middle-income economies, and 3 countries have high-income economies. Most of the PICs have been struggling to achieve high rates of economic growth when compared to other Asian countries.

One of the major obstacles to economic development in the region is the absence of electricity supply. Seventy percent of Pacific Islanders are without electricity supply (Dornan, 2014), with the highest figure in PNG, where 80 percent are without electricity (see Table 1). Electricity is important for a range of reasons. Shyu (2014) states, "electricity serves as the basis for satisfying fundamental human needs, such as food production, clean water, sanitation, education services, health care, and social services" (p. 30). Payne (2010) adds, "electricity plays a vital role in both the production and consumption of goods and services within an economy" (p. 723).

Although there is ongoing debate regarding the causality between electrification and economic growth (Stern, Burke, & Bruns, 2017), it is widely accepted that reliable electricity supply is important for a range of economic activity, thus contributing to economic development.

Some PICs have high electrification rates (see Table 1), but this does not necessarily guarantee that the communities have sufficient electricity supply to improve their economies. Oil-fired generators could be idle for quite a long time during a day because of their high costs (Dornan & Jotzo, 2015). In particular, diesel generators in the rural areas usually operate for just a few hours a day due to fuel costs and inadequate maintenance (Betzold, 2016).

In the countries with lower electrification rates, no access to electricity in rural areas is disruptive to socio-economic development (Yu & Taplin, 1997). Jimenez (2017), for example, in a global study finds that rural electrification "leads to increases of around 7 percent in school enrolment, 25 percent in employment, and 30 percent in incomes" (p. 1) on average at the household level. He continues "that improvements in electricity access and reliability have a positive influence on productivity" (p. 12) at the firm level. Electrification is therefore important for economic development in PICs.

### *Central argument*

PICs need to tackle both their high renewable energy targets for climate change and rural electrification for development. Although rural electrification with renewable energy looks like an optimal solution for PICs, this does not adequately address renewable energy targets (typically a percentage of total generation in a country), which require investment in urban power grids. Investment in renewable energy generation in urban areas is a more cost-effective means of achieving renewable energy targets than rural electrification, owing to the fact that electricity demand in rural areas is low, even when these are connected to the grid. However, this focus can come at the expense of investment in rural electrification.

In this regard, Betzold (2016) states, "PICs are likely to focus attention on urban areas to meet their ambitious renewable energy goals" (p. 316). Dornan and Shah (2016) also argue that high renewable energy targets create incentives for investment in existing electricity grids, which ignore the problem of limited access to modern energy services in PICs. The recent literature suggests that in deploying renewable energy, they might be ignoring rural electrification.

Thus, this research will seek to address the question: do high renewable energy targets hinder donor-funded rural electrification in PICs?

## Methodology

This section will firstly clarify the scope of the term "rural electrification" in this research, suggest a theoretical framework to analyse the situation of rural electrification over time, and explain the database choice, the energy project categories, and the category judgement methods.

### *Scope of "rural electrification"*

The term "rural electrification" does not define whether and how communities or households in rural areas have sufficient electricity capacity. As described above, rural electrification can mean any type of electricity supply. Even if a household has one-hour electricity supply a day, the household is electrified. In this sense, the levels of electricity capacity are basically out of the scope of this research. However, since electricity capacity is strongly related to the quality of life of people in rural areas, policy recommendations will involve this issue.

On the other hand, the literature is sometimes divided on the scope of rural electrification. Mandelli, Barbieri, Mereu, and Colombo (2016) focus only on off-grid generation in their study of rural electrification. In contrast, Dornan (2015a)

includes both off-grid generation and grid extension in his analysis of rural electrification in PICs. In the context of PICs, grid extension should be included in rural electrification as long as grid extension to outer islands is distinguishable from grid maintenance in main islands. Both off-grid generation and grid extension are therefore included in the scope of this research.

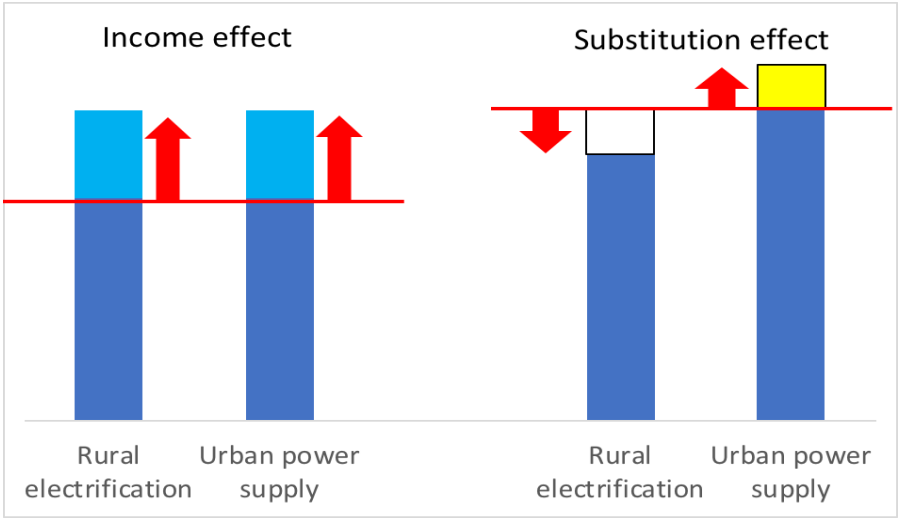
### *Theoretical framework to analyse the rural electrification situation*

To analyse the situation of rural electrification in PICs, this research will apply a microeconomic concept: the income and substitution effects of foreign aid spending on energy projects that results from high renewable energy targets (see Figure 2).

In terms of the income effect, high renewable energy targets can be expected to lead to an increase in foreign aid for all the energy projects. This is because high renewable energy targets increase the priority that energy projects have relative to other projects. As a result, foreign aid spending on renewable energy projects for both urban power supply and rural electrification can be expected to increase.

In terms of the substitution effect, given a fixed amount of foreign aid for all the energy projects, high renewable energy targets encourage spending on renewable energy projects for urban power supply but discourage spending for rural electrification. This is because meeting renewable energy targets — which are focused on renewable energy generation as a percentage of total electricity generation — requires investment in power supply for urban areas, where the vast bulk of electricity in PICs is consumed. Improving urban power supply with renewable energy is also a more cost-effective means of meeting renewable energy targets, given the fact that electricity demand in rural areas is low volume and dispersed. What this means is that high renewable energy targets can have a substitution effect, whereby they encourage foreign aid spending on urban power supply and discourage spending on rural power supply.

Figure 2. Income and substitution effects of foreign aid spending on energy projects that results from high renewable energy targets.




Source: Author

Briefly, the income effect and the substitution effect have opposite impacts on rural electrification.

***Database, project categories, and category judgement methods***

This research utilises the database of the Lowy Institute Pacific Aid Map. This database is an amalgamation of multiple sources of information, such as the OECD (Organisation for Economic Co-operation and Development), the IATI (International Aid Transparency Initiative), and direct reporting from donors (Lowy Institute for International Policy [Lowy], 2018).

It covers a large share of the information about foreign aid, including ODA (Official Development Assistance) and OOF (Other Official Flows), from donors to recipients in this region (Lowy, 2018) [2]. In addition, the database includes detailed descriptions of each project (Lowy, 2018). When there are no descriptions, the donor websites on each project are also useful (Lowy, 2018). This database is more detailed than other databases to analyse foreign aid for energy projects in PICs.

The foreign aid is measured by nominal US dollar (USD) based on the OECD exchange rates for each donor (Lowy, 2018).

[2] Since the data includes not only ODA but also OOF, the term "foreign aid" should be "total official flows" to be accurate. However, this paper uses the term "foreign aid" instead of "total official flows" as a matter of convenience.

Although the dataset is detailed, only three years of comprehensive information is available. This research will use the three years as one period because there may be year-to-year volatility of foreign aid for energy projects.

The data on energy projects used for this analysis are extracted from the database above. The energy projects are sorted into four categories by the author. The four categories are urban power supply projects, rural electrification projects, other projects, and unspecified projects. Urban power supply projects consist of on-grid renewable energy (RE) generation, on-grid non-RE generation, and transmission and distribution maintenance projects. Rural electrification projects are comprised of off-grid RE generation, off-grid non-RE generation, and transmission and distribution extension projects. Other projects are categorised as energy policy and administrative management and capacity building.

Most of the energy project categories are determined by the author on the basis of information in the dataset such as project descriptions and project titles and sectors. In addition, the categories of some projects are judged by the information on donors' websites for each project. When a project belongs to multiple categories, the category of the project is judged by the focus of the project.

## Results

By using the dataset from the Lowy Institute Pacific Aid Map, the data of foreign aid for energy projects in PICs between 2013 and 2015 are collected and analysed as follows.

### *Overview of energy projects in PICs*

The total amount of foreign aid for all the energy projects and rural electrification projects is considered to gauge the current focus on rural electrification and to examine whether that focus has changed over time.

Firstly, analysis of foreign aid for all the energy projects in PICs points to three main features (see Figure 3). The first feature is that the total amount of foreign aid for energy projects was USD 232 million between 2013 and 2015. In 2015, the total amount of foreign aid for energy projects was equal to 0.3 percent of the nominal GDP of PICs. By comparison, the military expenditure of GDP in PNG was between 0.3 and 0.5 percent in recent years (World Bank, 2018b).

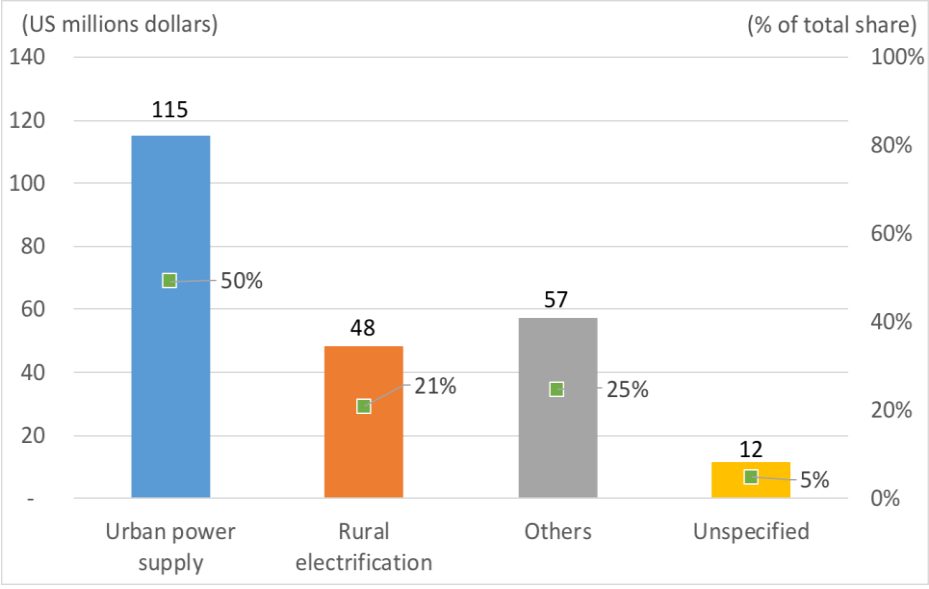
The second feature of foreign aid for all the energy projects is that the biggest spending category was on improving urban power supply. The total foreign aid for

urban power supply projects was USD 115 million, and its share was 50 percent of the total foreign aid for all the energy projects.

The third feature is that foreign aid for rural electrification projects was also significant. The total foreign aid for rural electrification projects over the three-year period was USD 48 million, or 21 percent of the total foreign aid for all the energy projects.

How do the figures presented above compare to foreign aid for all the energy projects in the past? Exact comparisons are not possible, as detailed datasets have not previously existed. However, Betzold (2016) investigates on-grid RE generation, off-grid RE generation, and both on-grid and off-grid RE generation projects between 1990 and 2012 using the OECD CRS (Common Reporting Standard) database, which is not as detailed as the database used in this research. Her analysis shows that over a 23-year period (1990-2012), foreign aid for on-grid RE generation projects measured USD 273 million, aid for off-grid RE generation projects measured USD 29 million, and aid for both on-grid and off-grid RE generation measured USD 11 million for the 23 years. Foreign aid for off-grid RE generation as a percentage of aid for on-grid RE generation was 11 percent during the period.

Figure 3. Foreign aid for energy projects between 2013 and 2015.




Source: Lowy, 2018

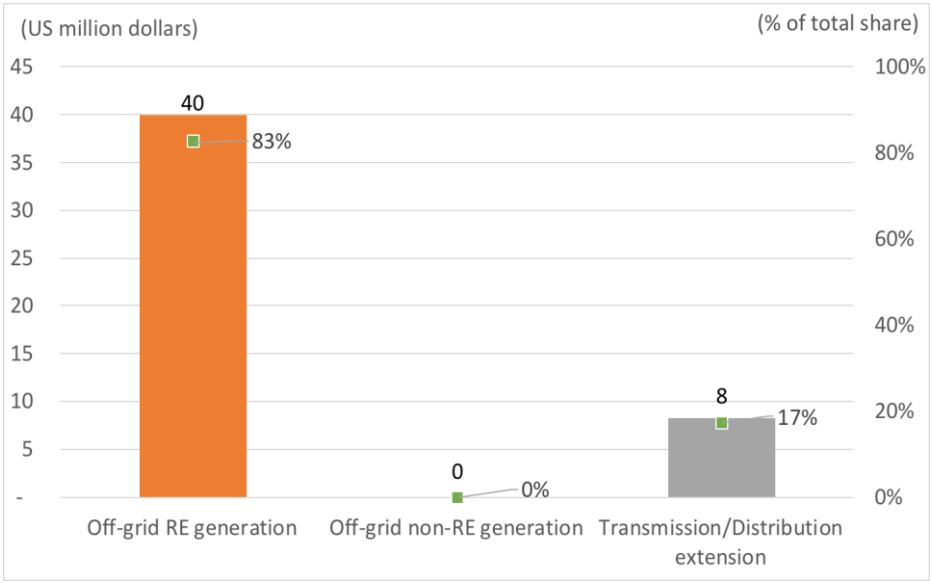
Analysis of the more recent data from the Lowy Institute suggests that foreign aid for rural electrification projects as a percentage of aid for urban power supply projects measured 42 percent (USD 48 million / USD 115 million). In other words, results

suggest that the emphasis on foreign aid for rural electrification projects has become more significant, not less significant, over time.

Secondly, of the total foreign aid for rural electrification projects, aid for off-grid RE generation projects was the largest sub-category, amounting to USD 40 million (see Figure 4). The remainder of USD 8 million was spent on grid extension projects. There was no aid for off-grid non-RE generation projects over the period.

Betzold (2016) finds that, between 1990 and 2012, foreign aid for off-grid RE generation projects measured USD 29 million, and aid for both grid and off-grid RE generation project measured USD 11 million (the caveat being that the databases are not exactly comparable). The sum of projects related to off-grid RE generation was therefore USD 40 million over this 23-year period, which was the same amount spent on off-grid RE generation projects between 2013 and 2015: a three-year period. It is apparent that foreign aid for rural electrification projects with renewable energy has increased remarkably relative to earlier periods.

Figure 4. Foreign aid for rural electrification projects between 2013 and 2015.

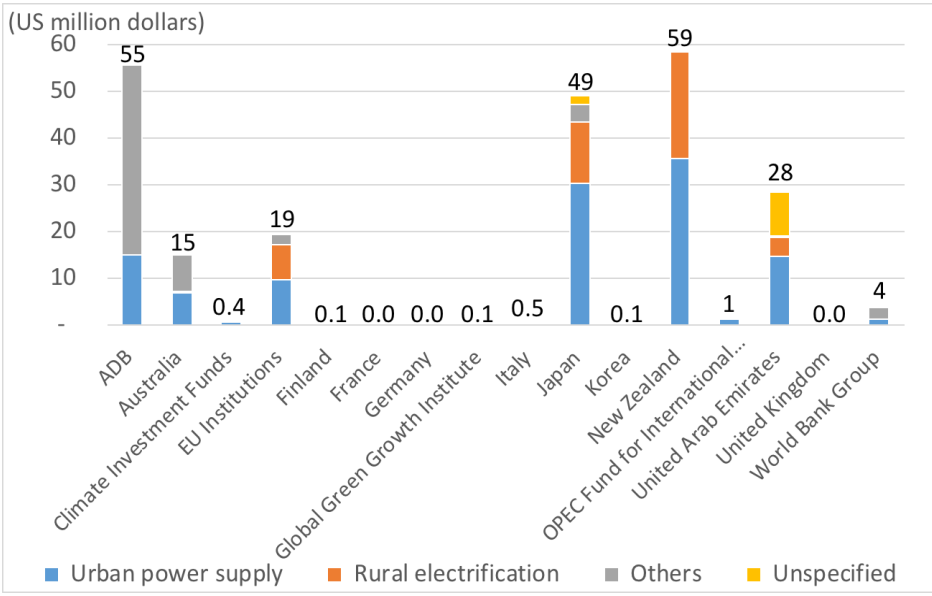



Source: Lowy, 2018

***Rural electrification by donor and by recipient***

This section will analyse foreign aid for rural electrification projects from the viewpoints of donors and recipients.

Figure 5. Foreign aid for energy projects by donor.



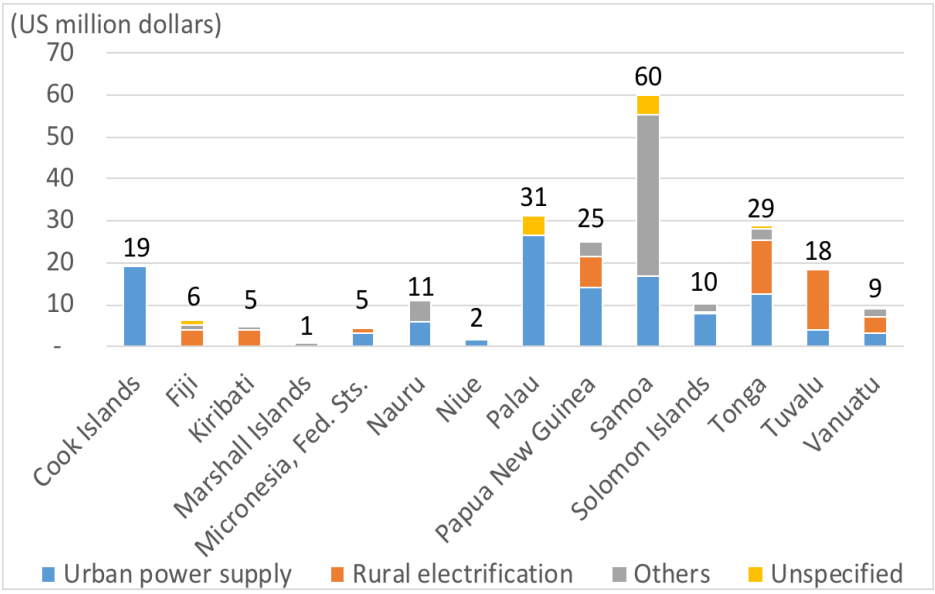

Source: Lowy, 2018

First, this paper analyses rural electrification projects by donor. Major donors for rural electrification in this region are four countries and institutions: New Zealand, Japan, EU institutions (EU), and the United Arab Emirates (UAE) (see Figure 5). New Zealand, Japan, the EU, and the UAE were the largest providers of energy-related aid funding to the region, granting USD 23 million, USD 13 million, USD 8 million, USD 4 million respectively over the three years.

These four donors provided 99 percent of the total foreign aid for rural electrification projects in the region.

Second, this paper reviews rural electrification projects by recipients. Major recipients of foreign aid for rural electrification are eight countries (see Figure 6). Foreign aid for rural electrification projects as a percentage of the total foreign aid for all the energy projects in Kiribati, Tuvalu, and Fiji measured 82 percent, 77 percent, and 64 percent respectively between 2013 and 2015. Tonga, Vanuatu, PNG, Federated States of Micronesia, and the Solomon Islands also received 45 percent, 43 percent, 30 percent, 25 percent, and 5 percent respectively for rural electrification projects during the three years.

Figure 6. Foreign aid for energy projects by recipient.




Source: Lowy, 2018

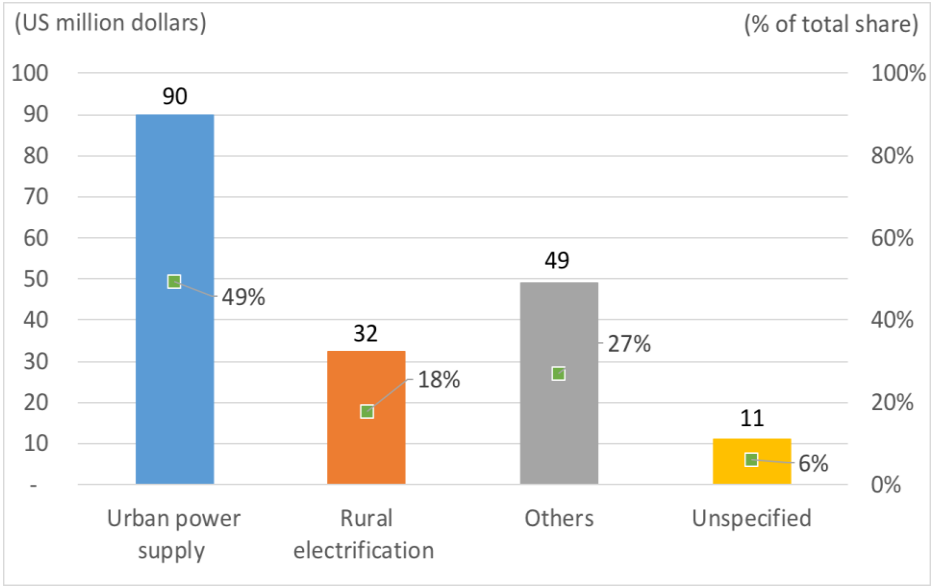
Many of PICs, on the demand side, attracted foreign aid in order to tackle not only urban power supply but also rural electrification for the three years.

***Rural electrification and electrification rates***

Betzold (2016), and Dornan and Shah (2016) raise concerns that countries with lower electrification rates might concentrate their efforts on achieving renewable energy targets and that this might come at the expense of rural electrification. To respond to these concerns, this section will analyse the foreign aid for energy projects by dividing the 14 countries into two groups that have higher and lower electrification rates. The four countries with lower electrification rates are Kiribati (where the electrification rate is 48 percent), PNG (20 percent), the Solomon Islands (35 percent), and Vanuatu (34 percent). The other ten PICs have much higher electrification rates (see Table 1).

In the case of the ten countries with higher electrification rates, investment in urban power supply projects is dominant, but investment in rural electrification is also significant (see Figure 7). Foreign aid for urban power supply projects between 2013 and 2015 was USD 90 million, and its share of the total aid for all the energy projects was 49 percent. In contrast, foreign aid for rural electrification projects for the three years was USD 32 million, and its share was 18 percent. All of the rural electrification projects were off-grid RE generation projects, which indicated that there were no aid-funded grid extension projects.

Figure 7. Foreign aid for energy projects in the ten countries with higher electrification rates.



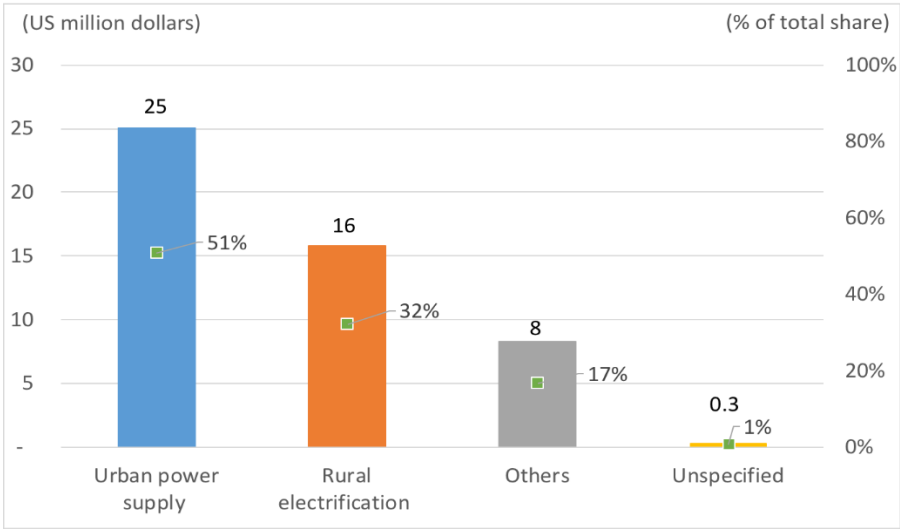

Source: Lowy, 2018

The progress of rural electrification in the countries with higher electrification rates means that rural electrification efforts involve replacement of diesel or petrol generators and kerosene lighting with renewable energy. For example, New Zealand granted USD 12.4 million to Tuvalu to support its government project, "which includes the installation of hybrid solar systems on the three outer islands of Nanumea, Nanumanga and Niutao" (Lowy, 2018, p. 2). These replaced existing diesel generators. In another instance, Japan gave USD 12.9 million to Tonga to introduce, "a micro-grid system with renewable energy along with the Tonga Energy Road Map" (Lowy, 2018, p. 2).

Thus, in the countries with higher electrification rates, rural electrification with renewable energy is significantly in progress, replacing oil-based generators with renewable ones.

In the case of the four countries with lower electrification rates, investment in urban power supply projects is dominant, but investment in rural electrification is also significant (see Figure 8). Foreign aid for urban power supply projects between 2013 and 2015 was USD 25 million, and its share of the total foreign aid for all the energy projects was 51 percent. Foreign aid for rural electrification projects for the three years was USD 16 million, and its share was 32 percent.

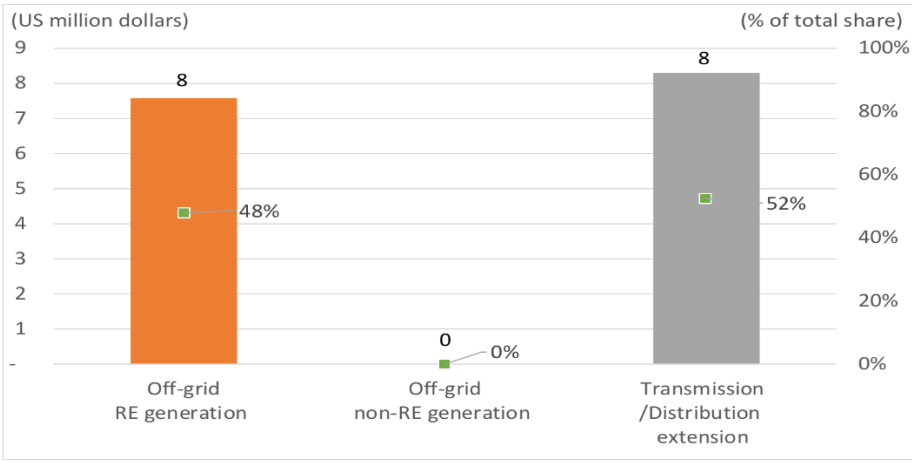
Figure 8. Foreign aid for energy projects in the four countries with lower electrification rates.




Source: Lowy, 2018

The shares of off-grid RE generation and grid extension were almost equal at about 50 percent (see Figure 9). An example of an off-grid RE generation project was the EU's expenditure of USD 2.7 million in Kiribati to supply 2,188 Solar Home Kits, 120 teachers' homes, 20 solar workshops, 100 small business systems, 30 community halls, 7 school systems, 1 village mini-grid, and 1 grid connected systems (Lowy, 2018). An instance of grid extension involved a grant of USD 6.5 million from New Zealand in PNG to help, "extend the power distribution grid to rural communities in Bougainville, West New Britain and Northern Province of PNG" (Lowy, 2018, p. 2).

Figure 9. Foreign aid for rural electrification projects in the four countries.




Source: Lowy, 2018

Thus, in the countries with lower electrification rates, investment in both urban power supply and rural electrification projects is significant. This means that they are trying to penetrate electricity supply in both urban and rural areas with renewable energy.

The data shows clearly that countries with lower electrification rates are focusing not only on improving urban power supply with renewable energy but also on rural electrification. Rural electrification has not been ignored in these countries.

## Discussion

Currently, PICs are using foreign aid funds not only to improve urban power supply but also to enhance rural electrification. Many of the rural electrification projects are off-grid RE generation projects, but some are grid extension projects.

Major donors for rural electrification in this region are New Zealand, Japan, the EU, and the UAE. Their total share of foreign aid for rural electrification projects is 99 percent. Major recipients of these funds are Kiribati, Tuvalu, Fiji, Tonga, Vanuatu, PNG, Federated States of Micronesia, and the Solomon Islands.

In countries with higher electrification rates, rural electrification projects are also significant, with off-grid renewable energy generation technologies replacing diesel generators already installed in rural areas. In countries with lower electrification rates, rural electrification projects comprise an even higher proportion of the total foreign aid for energy projects, with off-grid renewable energy generation projects as well as grid extension projects in place.

It can be therefore concluded that foreign aid for energy projects in PICs has had a strong focus on rural electrification, notwithstanding also being used to assist PICs in meeting high renewable energy targets.

Subsequently, comparison of this analysis with previous studies also suggests that foreign aid for rural electrification projects has increased over time. According to Betzold (2016), the cumulative amount of foreign aid directed towards off-grid RE generation projects between 1990 and 2012 was USD 40 million (including both off-grid and on-grid RE generation projects). This research has shown that the amount of off-grid RE generation projects between 2013 and 2015 also equalled USD 40 million, despite a considerably shorter time period.

The same comparison shows that foreign aid for off-grid RE generation projects as a percentage of aid for on-grid RE generation projects is higher now than in the past. Betzold (2016) indicates that the USD 40 million of investment in off-grid RE generation projects (including both off-grid and on-grid RE generation projects) was

15 percent as a percentage of foreign aid for on-grid RE generation projects. In contrast, this research shows that foreign aid for off-grid RE generation projects was USD 40 million, which became 61 percent as a percentage of aid for on-grid RE generation projects, or USD 66 million.

The weight of rural electrification clearly becomes more significant for the period in this research than that in the prior research. Going back to the theoretical framework presented in Figure 2, the income effect of foreign aid spending on energy projects that results from high renewable energy targets has exceeded the substitution effect.

PICs have expanded rural electrification along with their high renewable energy targets over time. The results of this research strongly support another of Betzold's (2016) conclusions that foreign aid for off-grid RE generation projects is increasing.

Will this situation continue in the future? The current situation shows that PICs are pursuing both high renewable energy targets and rural electrification at the same time. However, as already discussed, more foreign aid does not guarantee more aid for rural electrification. If high renewable energy targets are a motivation for more foreign aid for energy projects, it is possible — at least in theory — that foreign aid for rural electrification projects declines in the future.

There is also the question of what happens as renewable energy targets are met in the future. Would foreign aid be diverted to rural electrification (away from on-grid RE generation projects)? Or would foreign aid for rural electrification decline along with overall aid levels?

## Conclusion and Recommendations

In order to explore whether both high renewable energy targets and reliable rural electrification are being adequately pursued in PICs, this research investigates donor-funding for energy projects, assesses the extent to which the funding is focused on rural electrification, and examines whether the situation has changed over time.

By establishing ambitious renewable energy targets, PICs aim not only to reduce GHGs but also to decrease their dependence on oil imports and to attract more foreign aid to implement renewable energy projects. At the same time, many PICs need to electrify rural areas or enhance reliable electricity supply in rural areas to achieve their development priorities. To some extent, rural electrification can be accelerated using renewable energy technologies. However, there is a risk that high renewable energy targets result in PICs focusing only on urban renewable energy development, at the expense of rural areas not connected to the grid.

Currently, the focus of PICs on energy projects, including high renewable energy targets, has meant that more foreign aid is spent on rural electrification. Major donors for rural electrification are New Zealand, Japan, the EU, and the UAE. With their grants, most of PICs tackle rural electrification. Not only the countries with higher electrification rates, but also the countries with lower electrification rates enhance rural electrification with renewable energy. High renewable energy targets and rural electrification are being pursued at the same time.

In addition, foreign aid for rural electrification projects has increased remarkably over time. Compared to the prior research examining the period between 1990 and 2012, off-grid RE generation projects have drastically increased for the period between 2013 and 2015, on which this research focuses. The theoretical framework suggests that the income effect of foreign aid spending on rural electrification projects that results from high renewable energy targets has exceeded the substitution effect. Rural electrification with renewable energy has been enhanced.

However, there is uncertainty for future rural electrification, given the theoretical framework that suggests that more foreign aid does not guarantee more aid for rural electrification projects. Furthermore, what will happen to foreign aid for all the energy projects once the renewable energy targets of PICs are met? How will this affect foreign aid for rural electrification projects? These points are difficult to predict.

This study has identified and employed detailed data on foreign aid for energy projects from the donor side, or the supply side. Unfortunately, there is insufficient data on levels of electrification in rural areas in PICs, or in the demand side, to analyse changes in electrification over time. There are similar limitations with respect to analysis of energy consumption.

These data limitations are the primary focus of the policy recommendations. The first recommendation is that the donor and recipient governments collect and analyse data on basic or minimum demand for electricity and energy at the household level in rural areas in each country. The collected data should be used for estimating and introducing the minimum electricity and energy capacity for lighting and cooking in rural areas. Since the minimum levels of required electricity and energy supply is unlikely to be very different among different areas in a country, the data collection and analysis will be useful to decide the basic electricity and energy capacity nationwide.

Linked to this, the second recommendation is that the donor and recipient governments start collecting, accumulating, and analysing more detailed data about the productive use of energy. This would lead governments to collect and accumulate

the data of energy consumption not only for lighting and cooking but also for using machines and improving mobility at the household, firm, and industry levels in rural communities (Sovacool et al., 2012). The data on energy demand will be different among different communities due to their locations, population density, existing and potential industries, etc. This is strongly related to improving the quality of life and creating commerce and industries in rural communities.

Lastly, the third recommendation is that the governments in PICs allocate more resources to rural electrification, including the resources needed for the first and second recommendations. Currently, most of the spending for rural electrification comes from foreign aid (Dornan & Shah, 2016). In the future, even if foreign aid is reduced due to donors' intentions, the governments should keep the spending for rural electrification. Rural electrification is the foundation to pursue both climate and development goals.

At the moment, PICs are successfully pursuing both high renewable energy targets and rural electrification at the same time, meaning that high renewable energy targets do not hinder donor-funded rural electrification. However, there is no guarantee this will be the case in the future. PICs need to ensure that both foreign aid and government expenditure on rural electrification projects in the future are directed towards helping their people realise further development.

## References

Barnett, J., & Campbell, J. (2010). *Climate change and small island states: Power, knowledge and the South Pacific*. London, UK: Earthscan.

Betzold, C. (2016). Fuelling the Pacific: aid for renewable energy across Pacific island countries. *Renewable and Sustainable Energy Reviews*, *58*, 311–318.

Department of Foreign Affairs and Trade, Australian Government. (2018a). *Cook Islands*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/cook.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018b). *Federated States of Micronesia*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/micr.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018c). *Fiji*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/fiji.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018d). *Kiribati*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/kiri.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018e). *Marshall Islands*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/mars.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018f). *Nauru*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/naur.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018g). *Niue*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/niue.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018h). *Palau*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/pala.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018i). *Papua New Guinea*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/png.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018j). *Samoa*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/samo.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018k). *Solomon Islands*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/solo.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018l). *Tonga*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/tnga.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018m). *Tuvalu*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/tuva.pdf.

Department of Foreign Affairs and Trade, Australian Government. (2018n). *Vanuatu*. Department of Foreign Affairs and Trade, Australian Government. Retrieved from https://dfat.gov.au/trade/resources/Documents/vanu.pdf.

Dornan, M. (2014). Access to electricity in small island developing states of the Pacific: Issues and challenges. *Renewable and Sustainable Energy Reviews, 31*, 726–735.

Dornan, M. (2015a). Reforms for the expansion of electricity access and rural electrification in small island developing states. *AIMS Energy, 3*(3), 463–479.

Dornan, M. (2015b). Renewable energy development in small island developing states of the Pacific. *Resources, 4*(3), 490–506.

Dornan, M., & Jotzo, F. (2015). Renewable technologies and risk mitigation in small island developing states: Fiji's electricity sector. *Renewable and Sustainable Energy Reviews, 48*, 35–48.

Dornan, M., & Shah, K. U. (2016). Energy policy, aid, and the development of renewable energy resources in Small Island Developing States. *Energy Policy, 98*, 759–767.

Jimenez, R. (2017). *Development effects of rural electrification*. Inter-American Development Bank. Retrieved from https://publications.iadb.org/bitstream/handle/11319/8157/Development-Effects-of-Rural-Electrification.pdf?sequence=3.

Keeley, A. R. (2017). Renewable energy in Pacific small island developing states: The role of international aid and the enabling environment from donor's perspectives. *Journal of Cleaner Production, 146*, 29–36.

Kelman, I., & West, J. J. (2009). Climate change and small island developing states: A critical review. *Ecological and Environmental Anthropology, 5*(1), 1–16.

Lowy Institute for International Policy. (2018). *Lowy Institute Pacific Aid Map*. Sydney, Australia: Lowy Institute for International Policy.

Mandelli, S., Barbieri, J., Mereu, R., & Colombo, E. (2016). Off-grid systems for rural electrification in developing countries: Definitions, classification and a comprehensive literature review. *Renewable and Sustainable Energy Reviews, 58*, 1621–1646.

Mertz, O., Halsnæs, K., Olesen, J. E., & Rasmussen, K. (2009). Adaptation to climate change in developing countries. *Environmental Management, 43*(5), 743–752.

New Zealand Ministry of Foreign Affairs & Trade. (2016). *Pacific energy country profiles*. New Zealand Ministry of Foreign Affairs & Trade. Retrieved from

https://www.mfat.govt.nz/assets/Peace.../Pacific-Energy-Country-Profiles-2016.pdf.

Payne, J. E. (2010). A survey of the electricity consumption-growth literature. *Applied Energy*, *87*(3), 723–731.

Shyu, C. W. (2014). Ensuring access to electricity and minimum basic electricity needs as a goal for the post-MDG development agenda after 2015. *Energy for Sustainable Development*, *19*, 29–38.

Sovacool, B. K., Cooper, C., Bazilian, M., Johnson, K., Zoppo, D., Clarke, S., Eidsness, J., Crafton, M., Velumail, T., & Raza, H. A. (2012). What moves and works: Broadening the consideration of energy poverty. *Energy Policy*, *42*, 715–719.

Stern, D. I., Burke, P. J., & Bruns, S. B. (2017) The impact of electricity on economic development: A macroeconomic perspective. *The Applied Research Programme on Energy and Economic Growth*, *1.1*, 1–42.

United Nations Framework Convention on Climate Change. (n.d.). *INDCs as communicated by Parties*. United Nations Framework Convention on Climate Change. Retrieved from http://www4.unfccc.int/submissions/indc.

Weisser, D. (2004). On the economics of electricity consumption in small island developing states: A role for renewable energy technologies? *Energy Policy*, *32*(1), 127–140.

World Bank. (2017). *World Bank list of economies (June 2017)*. The World Bank. Retrieved from databank.worldbank.org/data/download/site-content/CLASS.xls.

World Bank. (2018a). *Access to electricity (% of population)*. The World Bank. Retrieved from https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS.

World Bank. (2018b). *Military expenditure (% of GDP)*. The World Bank. Retrieved from https://data.worldbank.org/indicator/MS.MIL.XPND.GD.ZS.

World Bank. (2018c). *Net ODA received (% of GNI)*. The World Bank. Retrieved from https://data.worldbank.org/indicator/DT.ODA.ODAT.GN.ZS.

Yu, X., & Taplin, R. (1997). A survey: International aid for renewable energy in the Pacific islands since the 1970s. *Energy Policy*, *25*(5), 501–516.