A database and online tool for decarbonization in the Pacific Island Countries and Territories

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Abstract

Pacific Island Countries and Territories (PICTs) present unique energy challenges and opportunities. They are constituted mostly of countries with small economies that are highly dependent on fossil fuel imports to meet their energy and transport needs, spending a considerable share of their GDP on importing fuels. There have been studies on the decarbonization of PICTs, and some of the countries were found to have sufficient renewable energy resources to self-supply their energy. However, there is still a lack of thorough investigation for decarbonization of PICTs, mainly due to the lack of reliable data from the demand, and renewable energy potential. This paper presents an online tool for evaluating the technical and economic potential of decarbonization and self-supplying the demand via renewable energy in 15 PICTs.

Keywords: renewable energy, decarbonization, energy security, microgrids, developing countries

Introduction

Ambitious targets have been set for Pacific Island Countries and Territories (PICTs) in terms of improving energy security and reducing fossil fuel imports, including diesel for electricity generation and transport. Achieving 100% renewable energy by 2030 is in progress in many of PICTs. To achieve these targets, international and sector-specific plans have been introduced, resulting in some progress [1]. However, the unique economic and geographical challenges that PICTs face, and lack of reliable data from the current energy demand and energy systems, are barriers to making achievable plans for achieving the ambitious but important targets [1]. To address the problems arising from the lack of data, an online tool has been developed in this study to present the most recent available data from energy demand and renewable energy potential, and then evaluate the potential for meeting the demand in PICTs from their local renewable resources. The investigated countries are Tuvalu, Niue, Nauru, Cook Islands, Kiribati, Micronesia, Tonga, Palau, Vanuatu, Samoa, Solomon Islands, French Polynesia, Fiji, New Caledonia, and Papua New Guinea (PNG).

Method

The methodology used to collect and analyse the data can be broken down into different sections.

- **Demand**

UNStats database [2] is used in this study for collecting data of energy imports, export, generation and consumption. The dataset includes energy imports by fuel type, primary energy production by source, transformations and losses, final consumption broken down by sector, and consumption by international bunkers, both aviation and maritime applications.

Since the dataset provides the breakdown of electricity generation from different sources, the electricity generated from non-renewable sources can be obtained by subtracting the electricity generated from renewable sources from total electricity generation. This is equal to the required renewable energy generation to decarbonize the electricity sector of each PICT, known as decarbonization of electricity sector scenario.

In the final demand scenario, it is assumed that all sectors including transport, households, manufacturing, and commerce are electrified. Electrification improves the energy efficiency of the country. For instance, replacing the existing cars and trucks with their electric counterparts reduces the total demand in the country, even if they are charged with the electricity generated from non-renewable sources. Another example of improving energy efficiency is replacing open fire water or resistance heating systems with heat pumps. A 40% reduction in energy consumption is assumed in this study.

The third demand scenario is based on the demand projected by IEA for the net zero emission by 2050 [3]. The projection is around 5 MWh/person. To consider losses through conversation, we consider 10 MWh/person in this study, and calculate the total demand in each country.

- **Renewable energy potential**

The World Bank Global Solar and Wind Atlases [4] have been used to broadly categorise the quality of the wind and solar resource for each jurisdiction. Then, a technical potential is calculated based on the available land, coastline, and homes for rooftop Photovoltaics (PV). Therefore, as a rough estimate, it is assumed that 10% of coastlines are suitable for wind turbine installation, 30% of homes have the potential for rooftop PV installation (2.5 kW PV system with 5 kWh battery energy storage), and 2% of arable land and pastures can be used to install utility-scale PV.

Bioenergy potential in each country and their experience with bioenergy is summarized with the available data presented in Energy Profiles, published by IRENA [5]. For geothermal energy, the potential assessment conducted by McCoy-West et al. [6] is used that provides the most complete investigation in the literature for the majority of PICTs. There are also other studies investigating one or a small number of PICTs [7-9].

- **Economic potential**

The main fuel imported by almost all countries in the Pacific is diesel, used in a range of industries, including power generation and transportation. Most recent diesel retail prices are collected and presented in the tool that can be used for the economic analysis of replacing the diesel fleet with renewables. Prices for renewable energy technologies are collected from historical prices [10] collected from the previous projects in the region.

- **Decarbonization modelling**

Using the data collected for demand, renewable energy potential, and fuel and technology prices, a decarbonization modelling section is added to the tool to evaluate the technical and economic potential of decarbonization, considering three different demand scenarios. Using a set of inputs including discount and interest rates, decarbonization target year, technology cost, diesel price, total battery energy storage capacity, the payback period is calculated. It is assumed that the capacity of battery energy storage (small-scale and community battery) should cover five days of demand in each country, when all the demand is met by renewable energy.

To access the tool, please visit the GitHub page of the first author [11] to find the link to the online tool.

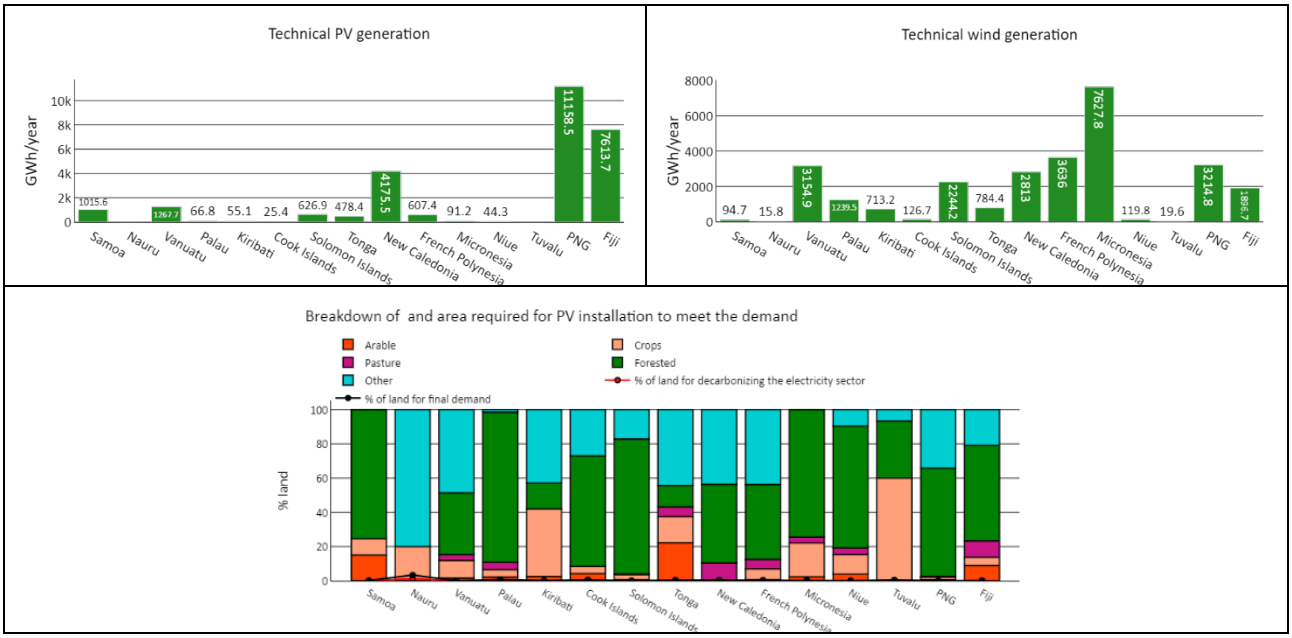
Results and discussion

Figure 1 shows cross country comparison of oil imports, renewable energy consumption and generation, oil used in transformation, breakdown of energy consumed in different transport sectors, and generation mix. Figure 2 presents the technical wind and solar potential. The technical potential is limited because of the available land area for utility-scale PV systems, rooftop PV potential, and available coastline.

Based on the available renewable energy resources, self-supply potential is evaluated and decarbonization is simulated in all countries based on technology costs and a set of inputs. Presented in Table 1, a green cell indicates the country has self-supply potential for a demand

scenario. The obtained payback periods can be as low as 16 years in Niue, and as high as around 28 years for New Caledonia, because of its demand due to its mining industry.

Figure 1 Overview of the energy consumption in all countries



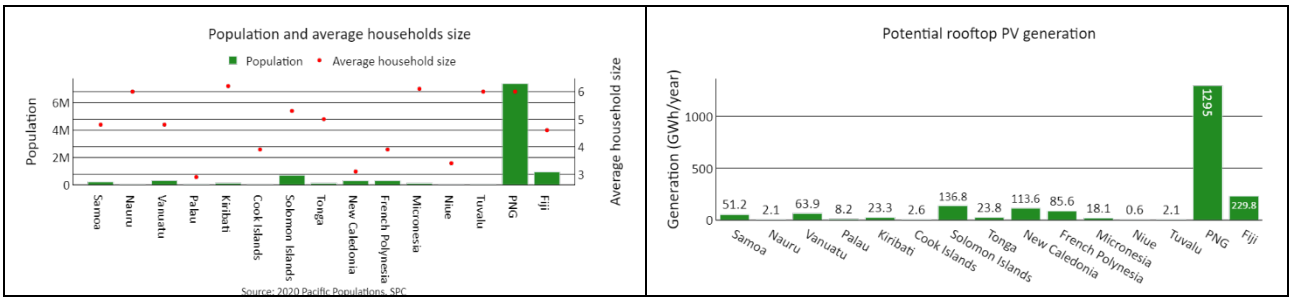


Figure 2 Wind and solar technical potential

Table 1 Self-supply potential and payback period for the different demand scenarios

Country	Technical potential (GWh/year)	Demand (GWh/year)			Payback period (years)
		Decarbonizing the electricity sector	Electrification	Net zero emission	
Samoa	1,198	94	605	2,025	24
Nauru	18	36	102	107	20
Vanuatu	4,569	61	356	3,078	20
Palau	1,355	94	422	179	21
Kiribati	799	26	145	1,190	21
Cook Islands	155	29	167	175	18
Solomon Islands	2,998	95	635	6,529	22
Tonga	1,295	64	337	1,007	21
New Caledonia	7,282	2,873	7,772	2,972	28
French Polynesia	4,409	492	1,818	2,759	21
Micronesia	7,822	64	282	1,045	20
Niue	166	4	12	16	16
Tuvalu	22	7	15	116	21
PNG	15,703	2,494	11,824	89,350	26
Fiji	9,743	449	3,009	9,293	25

Conclusions

An online tool is developed for providing data of energy demand, energy imports, renewable energy consumption, and renewable energy potential from 15 Pacific Island Countries and Territories (PICTs). The data is used to evaluate self-supply potential, and simulating decarbonization in each country. The results shows that most countries can self-supply their energy needs. The payback period of decarbonization is variable withing countries, ranging from 16 to 28 years.

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