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Paths of renewable energy development in small island developing states of the South Pacific

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ABSTRACT

Pacific Small Island Developing States (PSIDS) are small and remote island economies highly reliant on fossil fuels. Although they are mainly self-governing nations, they are highly vulnerable to exogenous events such as global fuel price volatility and tropical cyclones. The work presented here targets 12 PSIDS located in the South Pacific. The analysis takes a functional approach to assess the state of the energy governance system and to determine its relationship to renewable energy (RE) penetration. Using a suite of governance, market and financial progress indicators, a range of RE preparedness levels was identified in PSIDS. Analysis demonstrated that strengthening of RE enabling indicators led to only a limited increase of RE penetration; consequently, the region has fallen behind global rates of RE uptake. Inward investment by development partners for RE demonstration projects failed to be upscaled by government-facilitated private sector. The focus on mitigating global climate change has failed to put RE into a local context; this contrasts to the strong "sense of place" and spiritual-nature of traditional Pacific communities. Thus, in energy terms, PSIDS are yet to attain a self-defined energy identity

1. Introduction

1.1. The islands of the South Pacific

The Pacific Small Island Developing States (PSIDS) are a collection of small islands located in the South Pacific and scattered over an area equivalent to 15% of the globe's surface [1]. The work presented here concerns 12 PSIDS: Cook Islands, Republic of Fiji, Republic of Kiribati, Republic of the Marshall Islands, Republic of Nauru, Niue, Independent State of Samoa, Solomon Islands, Tokelau, Kingdom of Tonga, Tuvalu and Republic of Vanuatu. These PSIDS vary in population size, from Niue (1190 in 2014) to Fiji (886,450 in 2014) and are geographically remote and dispersed. Kiribati, for instance, has 112,000 inhabitants on 33 coral atolls spread over 3.5 million km^2 of ocean; an area larger than India.

The majority of PSIDs are independent developing nations with political systems which have jurisdictional autonomy and are part of international decision-making entities such as the United Nations. The way that the islands use this jurisdiction has very real consequences for the islands own identity and empowerment [2] and to the trajectory of development which they pursue. The economic situation in PSIDS is challenging, limited natural resources, narrowly-based economies, large distances to major markets, and high vulnerability to exogenous shocks. This is represented in various economic indicators, for example, in 2012-13, the Solomon Islands had a GNI < $1200, Kiribati had a −57% trade balance and Fiji had > 30% of the population living below the poverty line [3]. Even areas for potential economic growth such as tourism development [4] are impacted by climate change, pressures on natural, cultural and heritage resources as well as economic and social inequality [5]. However, there are significant inflows of development assistance into PSIDS which support the economy, for example, $431 per capita in the Solomon Islands (over 60% of its Gross National Income [1])and $749 per capita in Kiribati in 2014 [6]. As Stuart, 2006 argues "outside solutions are often preferred over those that are home-grown, denying and overwhelming locally-based innovation and entrepreneurship" [7].

1.2. Challenges to a RE future in the Pacific

The Pacific islands form small energy systems with a limited capacity to host energy technologies [8]. As in similar cases [9,10], on island archipelagos, such as the Marshall Islands and Solomon islands, electric power demands need to be met by either stand-alone generation systems or through expensive grid extensions, thus many remote users

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Nomenclature

ADB	Asian Development Bank
CROP	Council for Regional Organisations for the Pacific
EU	European Union
ESCO	Energy Service Company (or Energy Savings Company)
GCF	Green Climate Fund
GGH	Ghreenhouse Gaz Emissions
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit Gmbh
GNI	Gross National Income
INDCs	Intended Nationally Determined Contributions
IPP	Independent Power Producers
IRENA	International Renewable Energy Association
OECD	Organisation for Economic Co-operation and Development
PSIDS	Pacific Island Countries and Territories
PPA	Pacific Power Association
RE	Renewable Energy
SIDS	Small Island Developing States
UNEP	United Nations Environmental Program
UNFCCC; COP21	United Nations Framework Convention on Climate Change; Conference of Parties 21 (also known as "2015 Paris Climate Conference")

employ diesel generation due to its low initial cost, easy maintenance and simple operation [11]. Access to electricity through grid connection may be high in urban centres, from 61% (Vanuatu, Kiribati) to 97–99% (Cook Islands, Samoa) [1], but can be low in remote rural area such as 18% in Fiji [12]. Increasing electricity access and use also means increases in demand, for example electricity demand in Fiji has recently been increased by 5% per annum [13]. Further generating burden is created through high average distribution grid losses in Pacific islands of 14% [14], compared to grid losses in UK, the Netherlands and USA of between 4.4–7.9% [15]. Scattered data show, that, in PSIDS the main RE electricity users are government consumers, residential customers and commercial customers [16,17].

It has been argued that the right mix of RE technologies, energy efficiency improvements, and smart management can provide an affordable and reliable power supply [18]. The RE potential to work with conventional fossil fuels [8,19] or to work in hybrid power generation systems [20] so as to reduce risks in the energy mix [8] and fuel prices are some additional reasons for which RE technology in islands has received remarkable attention from both the academia and industry [21–23]. RE penetration, however, is seriously compromised by inappropriateness of technology, unavailability of skilled manpower for maintenance, unavailability of spare parts, high cost and lack of access to credit [24].

RE sources also, especially wind and solar, are inherently stochastic in nature and thus are unreliable power sources by themselves [25] especially for weak grid island systems. Estimates suggest that 26% of peak weekday demand would be the maximum RE penetration permitting grid stability in Kiribati; a similar estimate of 30% has been made for Palau [26]. Hence, especially for PSIDS the integration of intermittent RE sources in energy systems may require the development of energy storage [19]. Furthermore, negative interactions between cyclones and RE systems (such as wind generators and solar systems) further restrict the secure use of RE technologies.

Successful hydropower exploitation has been initiated before 2000 and shows significant generation in some PSIDS: 61% out of 215 MW of total electricity generation installed capacity in Fiji was from hydropower in 2013 [13], while, in Samoa there are eight small hydroelectric plants totalling 9.71 MW [27]. However, even if hydropower is proven in PSIDS, its potential is limited due to island topography island maximum elevation [28] and future projected climate change effects on precipitation [29].

Innovation is considered an effective approach for developing countries [30]. However, special features of PSIDS turn the testing of advanced technologies and creation of commercial economies of scale difficult even with development partner support [31]. Therefore, the use of more advanced technologies, in PSIDS, such as tidal and ocean energy are still are in experimental phases [32], while flexibility offered by smart grids and energy storage technologies [19,33,34] needs further consideration mainly because of the small electricity systems' size, distance between the islands, and need to transport expensive equipment from abroad [35]. This means that RE planning and modelling for islands are complex and demanding. Researchers have explored ways to technically and financially improve the RE penetration level including energy storage, hybrid systems, smart grids, and demand side management techniques [36–39].

International development partners, such as Asian Development Bank (ADB) consider that energy infrastructure and innovations are priorities for the PSIDS [40]. Increasing amounts of development assistance are also targeted at the energy sector, for example, building-up of grid-connected solar in the Pacific during the period 1997–2013 amounted at USD 31 M (55% of which coming from Japan and New Zealand) [41]. This past tendency to focus on energy generation, transmission and distribution systems, as well as tariff studies and rural electrification systems, has now shifted towards national energy policies which will increase public and private intervention on electricity power projects [40]. As a result, involvement of the private sector in islands is expanding and the role of small-medium enterprises (SMEs) towards solving energy problems is being increasingly recognised [13,42], also probably due to a growing awareness that off-grid, low-income customers represent fast-growing markets for goods and services. However, there are notable investment impediments acting against deeper access of the private sector in the electricity market such as a clear regulatory framework for private generation and supply service and the lack of a coherent, credible publicly available data on investment opportunities [40]. The corporate culture of state utilities in islands tends to be conservative, reflecting natural monopoly, technology limits, economies of scale and the drive for profitability based on lowest cost solutions [7,43].

Nowadays, however, reliance on international development assistance in the medium-term is ensured as the majority of PSIDS have announced their Nationally Determined Contribution (NDC), in Paris at the UNFCCC COP21 towards 100% electricity coming from renewable energy, but much of this commitment is conditional of external funding [44].

1.3. Research aims

PSIDS demonstrate low level of development, fragile and un-diverse weak economies and ongoing support from the international community common to much of the developing world, yet they also display miniscule scale of land resources, remoteness and extreme, and in some cases existential, vulnerability to climate change; such vulnerability is a vital area of research. Scientifically PSIDS can be seen as a suite of independent experimental units all progressing towards national and global development goals with an unique energy identify; this is fertile ground for new energy models that need to be developed in collaboration with actors and households [18] and builds on evidence that islands can have creative and sophisticated forms of governance arrangements [45,46].

On a more practical basis, energy data in the Pacific is scattered and fragmentary with little cohesive data collection. This has limited further academic analysis on energy identify and RE transition in SIDS and