

Comparison of energy systems in Small Island Developing States

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ABSTRACT

Small Island Developing States (SIDS) have been amongst the most neglected group with regard to energy access until recently when several voices were raised to highlight the vulnerabilities of these small nations. Since then, their levels of energy access have become the focus of significant attention. These levels vary over a wide range, where some SIDS still have a low energy access although they may have the resources. The energy mix for electricity production is mostly dominated by fossil fuels where the transportation cost results in high cost of fossil fuels and this leads to a high cost of electricity.

1. Introduction

Small Island Developing States (SIDS)¹ is a diverse group of islands sharing similar social, economic and environmental challenges to achieve sustainable development goals. Physical and human geographies, however vary largely (Kelman and West, 2009). The smallest of SIDS is Nauru with a land area of 20 km² and the largest is Papua New Guinea (PNG) with a land area of 453,000 km² (World Bank, 2017a). Geographically, SIDS exists as single islands (for e.g., Cuba or Jamaica), consolidated group of islands (Fiji or Comoros) or an archipelago of small islands, islets and low-lying atolls (e.g. Maldives). Population count as at 2017, varies from less than 100,000 residents (for e.g., Seychelles, Antigua and Barbuda (AB), Dominica, St. Kitts & Nevis (SKN), Marshall Islands, Nauru, Palau and Tuvalu) to over one million residents (Guinea-Bissau, Mauritius, Singapore, Cuba, Dominican Republic (DR), Haiti, Trinidad & Tobago (TT) and PNG) (World Bank, 2017a). Most of these islands are of volcanic origin and enjoy tropical climatic conditions. Main economic sectors are agriculture, sand mining, tourism, fisheries and forestry (UNEP, 2014). Their relative small physical size, geographic isolation and high dependence on international trade make them 'price-takers' (Briguglio, 1995) and hence, initiatives to make these islands self-sufficient and reduce import costs are encouraged.

SIDS has been in the limelight since 1987 when, at the UN General

Assembly, the President of the Maldives stressed the issue of climate change and the disappearance of its islands under rising sea-level (Wong, 2011). Since then, the UN has adopted the Barbados Program of Action (BPOA) in 1994, the Mauritius Strategy of Implementation (MSI) in 2004 and the SIDS Accelerated Modalities of Action (SAMOA Pathway) in 2014 as policy documents to reflect upon existing challenges in SIDS and to provide mitigation strategies and spur investment in SIDS economies (UN, 1994, 2005; 2014).

Among several thematic issues of the BPOA, MSI and SAMOA Pathway, SIDS' heavy dependence on imported fossil fuels (mainly oil) and the need to diversify their energy mix with indigenous renewable energy sources to ensure access to affordable, reliable, clean and modern energy for all is always on the agenda and often discussed. Over the years, an international panel of researchers has worked on the technical and technological, economical, policy and political aspects of sustainable energy consumption and production but it still appears that more have to be done along the line to low-carbon energy transition. In some SIDS (for e.g. Haiti, Solomon Islands, Vanuatu, PNG, Guinea-Bissau), the issue of low access to energy still persists which has hindered the improvement of multiple facilities like education, proper health care, water, sanitation and slowed down industrial and commercial development affecting employment of residents (Surroop et al., 2018). The lack of sufficient energy thus constitutes a social issue which should be urgently looked into and addressed. Hence, SIDS' energy

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¹ Atlantic, Indian Ocean, Mediterranean and South China Sea (AIMS) SIDS are Mauritius, Maldives, Seychelles, Comoros, Cape Verde (CV), São Tomé & Príncipe (STP), Guinea-Bissau, Singapore; Caribbean SIDS are Trinidad and Tobago (TT), Guyana, St Vincent & Grenadines (SVG), Antigua and Barbuda (AB), Belize, Suriname, Dominican Republic (DR), Dominica, Haiti, St Lucia, Bahamas, Cuba, Grenada, Jamaica, Barbados, St Kitts & Nevis (SKN); Pacific SIDS are Fiji, Vanuatu, Papua New Guinea (PNG), Kiribati, Nauru, Samoa, Tonga, Tuvalu, Federated States of Micronesia (FSM), Marshall Island, Solomon Island, Palau and Timor-Leste. Only SIDS UN Members are considered in this article.

sector is highly complex as they are faced with a trilemma of (a) low energy access, (b) high vulnerability to energy security from high dependence on oil imports and (c) substantial barriers to renewable energy sector development (Raghoo et al., 2018; Surroop et al., 2018; Timilsina and Shah, 2016).

This study is an excellent opportunity to review the present state of energy affairs in SIDS UN member states. The three main aspects of this paper are (a) an overview of research endeavors in SIDS for the last two decades, (b) a comprehensive overview of the current energy situation in SIDS, and (c) recommendations and areas for development for more renewable energy. Such study is essential for policymakers and project developers for judicious decision-making and planning of a more sustainable energy future for these territories. The paper also aims to attract more attention in SIDS for more research in energy and climate change.

The rest of the paper is structured as follows: Section 2 presents an overview of research endeavors in SIDS and Section 3 discusses the energy situation in SIDS and other characteristics of their energy sector. It also gives an overview on the energy access, electricity mix and the cost of electricity in the three SIDS regions. Section 4 provides the challenges and recommendations for greater development of renewable energy in SIDS and conclusions are provided in Section 5.

2. Data sources, method and scope of research

Data and literature for this paper was sourced from peer-reviewed academic papers, conference proceedings, think-tanks and other international and national reports. Publications were retrieved from international organizations, Web of Science and Google Scholar databases. This activity was repeated twice to ensure that no paper was left out of the analysis. Non-English, books, non-dated papers, dissertations and online articles were excluded from the review. Published papers were used as a proxy to evaluate research endeavors in SIDS. A systematic review of existing literature was taken as the methodological framework for this paper as it is a useful method for analyzing, evaluating and monitoring development in a particular field and thus appealing to scholars.

From the list of publications compiled, particulars of these publications related to their authors' affiliations, date of publication, 'renewable energy focus' (whether the study involved a single renewable energy source or discussed renewable energy in general), region (whether the publication is on SIDS regions in general or in a member state) and classifications (whether they discuss technical, social or issues on the economics of renewable energy) among other details were noted. The search retrieved a significant number of publications on SIDS and SIDS member states from 1994 to 2017 on all types of exploitable renewable energy sources. The majority of the publications were peer-reviewed articles and a small number of them were think-tank reports from reliable sources (for e.g. IRENA, 2013 among others). Over the last 23 years, research papers in SIDS have been published in various peer-reviewed outlets in renowned energy journals.

The number of publications in SIDS has seen a rise as from 2010 where this number has increased nearly three-fold. A possible explanation for this increase can be attributed to the special attention that some intergovernmental organizations (like the Intergovernmental Panel on Climate Change) have given to island nations as they recognized islands' vulnerability with regard to the growing threat of climate change. As the extent of research in SIDS has increased, the literature has also become more refined dealing from a wide range of issues and shifting from traditional renewable energy sources like hydropower to modern renewable energy sources like ocean-based energy sources, wind, solar and biofuels.

Fig. 1 illustrates the distribution of publications per year and the 'renewable energy focus' under study in these publications. In all, 65 publications looked at more than one renewable energy source while another 31 were exclusively based on solar energy, 19 on wind energy,

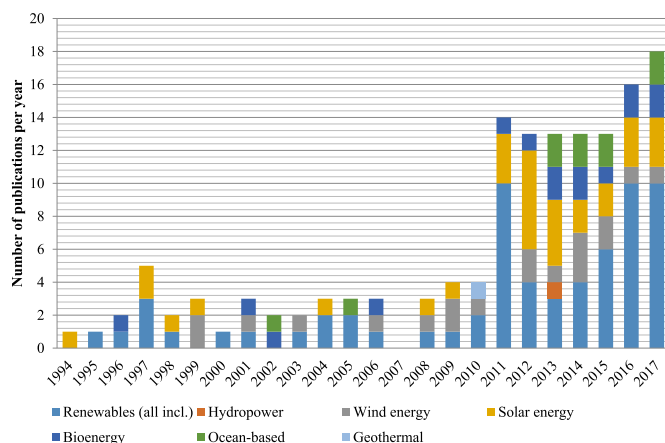


Fig. 1. Number of publications by year and by 'renewable energy focus'.

15 on bioenergy systems, 10 on ocean-based energy and the remaining on hydro and geothermal energy. Eventually, judging from the extent of research in the field, solar and wind energy seemed to be the most preferred, appropriate or exploitable renewable energy sources in SIDS. No publications in 2007 were found during the data search and only one paper on hydropower (see Elahee, 2013) was found.

The nature of these publications is also interesting to note. These publications can be classified into five main categories based on their content which are (a) social, (b) technical or technological, (c) economics, (d) environmental and (e) policy and political aspects.² Fig. 2 gives the distribution of publications based on content of the papers. Five publications have been excluded here because they combined two of the categories listed above in their study and thus difficult to classify them accordingly. Sovacool et al. (2011) discussed about the socio-technical aspect of solar home systems (SHS) in PNG; Hsu et al. (2014) conducted a techno-economic analysis of a photovoltaic system in Kiribati; Kumar and Nair, 2013 determined the wind potential and economics of wind power in Fiji; Chandra et al. (2017) discussed the environ-economic implications of bioethanol in Fiji Islands and Lal and Raturi (2012) focused on the techno-economics of hybrid energy system in Fiji.

Most of the papers collected are either technical (43%) or dealing with policy and political ideas (49%) for renewable energy development in SIDS as shown in Fig. 2. Technical papers are mostly resource-assessment of the particular type of renewable energy under study and policy/political publications elaborated mostly on frameworks for renewable energy development, market-based mechanisms and efforts at governmental level to develop renewable energy resources on these islands. Little research has been conducted on the economics of renewable energy generation and infrastructure – procurement and standards of technologies, freight costs, insurance etc. – as to recall most SIDS do not have any technology manufacturers in their countries and rely entirely on imports of these technologies, thereby increasing costs.

The social/socio-cultural and environmental aspects of renewable energy development remain understudied in SIDS. Previous work by Yaqoot et al. (2016) has highlighted the impacts that social and cultural barriers have on renewable energy development. Social and cultural barriers are related to vandalism, theft of the technology and asymmetry information on the technology leading to poor acceptance of these technologies among residents. For example, over-expectations of residents on the extent SHS can go to power appliances (due to lack of knowledge of the technology) and sabotage, vandalism, tribal wars and

² Fiscal policies given to investors and project developers are included in 'policy/political'. Under 'Economics' categories lie publications dealing with the costs of the renewable energy infrastructure.

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