The Role of Renewable Energy in Addressing the Challenge of Climate Change in the Pacific Region

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Abstract — This paper is based on the experiences gained by "The Small Developing Island Renewable Energy Knowledge and Technology Transfer Network (DIREKT)", which is a cooperation scheme involving universities from Germany, Fiji, Mauritius, Barbados, and Trinidad and Tobago, with the aim of strengthening science and technology capacity in the field of renewable energy of a sample of ACP (Africa, Caribbean, Pacific) small island developing states, by means of technology transfer, information exchange and networking. Developing countries are especially vulnerable to problems associated with climate change and much can be gained by raising their capacity in the field of renewable energy, which is a key area. The project is funded by the ACP Science and Technology Programme, an EU programme for cooperation between the European Union and the ACP region (Africa, Caribbean, Pacific). This paper discusses the contribution that can be made by renewable energy as a tool in addressing the challenge of climate change on a global level. It shows the extent to which renewable energy systems are being used in order to satisfy current energy demands and which positive effects have been achieved with these measures. The paper also discusses some of the empirical evidence available and outlines some of the actions currently being taken in the Pacific region. Finally, it summarises some of the lessons learned from the Pacific region and lists some of the challenges and measures that need to be implemented in order to achieve a better integration between the use of renewable energy and climate change goals in the Pacific region.

Keywords — Climate change, Pacific region, renewable energy, small island developing states

1 Introduction

Accordant to the report recently published by the IPCC, the main cause for the rising of the global temperature is the accumulation of CO_2 and other greenhouse gases (IPCC, 2007) [1]. For small island states, which are numerous in the Pacific region, the effects of climate change comprise a double risk. Many island states are low-lying or have geological features which make their coastal zones vulnerable. This geological basis implies a high sensitivity to natural disasters. Furthermore, beside the negative effects on the biodiversity, the sea-level rise can lead to disturbances to the water supplies for these countries in particular.

The application of renewable energy (RE) offers great potential for the reduction of greenhouse gases, which is considered as a central cause of climate change.

As the Pacific island countries (PIC) have no fossil fuels, and are remote and poor, renewable energy has the potential to make PICs independent of imported oil and oil prices. Pacific island countries (PICs) are currently heavily dependent on fossil fuels, with petroleum accounting for an estimated 90% of commercial energy consumption [2].

Petroleum consumption is largely responsible for greenhouse gas (GHG) emissions in PICs. A regional synthesis of PICs' greenhouse gas inventories from their first National Communication under the United Nations Framework Convention on Climate Change (UNFCCC) highlighted that the GHG emission per capita in PICs is almost 25% of the global carbon dioxide (CO_2) emissions per capita arising from fossil fuel combustion. Most of the GHG emissions in PICs are from the combustion of fossil fuels for power generation and in transportation. Power is only generated from fossil fuel in most PICs and the transport sector utilises 100% fossil fuel [2].

2 Overview of the energy sector in the Pacific region

Pacific island countries (PICs) share the same energy challenges. They largely lack indigenous fossil fuel sources and their remoteness from traditional fuel suppliers and inadequate bulk storage facilities means they have to pay very high prices for their fuels. In 2008, Fiji spent $1 billion (one third of the total import bill) on fuel imports. [3] Many PICs depend entirely on imported diesel fuel for the generation of their grid electricity. Tonga, Kiribati,

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Nauru and the Solomon Islands are examples of such countries. This leads to high inflation rates and makes the economies of these countries vulnerable to oil price shocks. Renewable energy resources vary widely amongst the PICs. While the larger volcanic islands may possess hydropower, biomass, biofuel and geothermal energy resources as well as wind and solar energy, the smaller coral atolls such as Kiribati, Nauru and Tuvalu can only rely on solar energy and perhaps some wind energy and biofuels.

The energy problems of the rural communities of these countries are similar. They generally lack grid electricity and usually resort to diesel generators, kerosene lamps and (usually inefficient) wood stoves for their lighting and cooking needs. This limits students' study hours in the evenings and subjects women to smoke and flue gas inhalation while cooking. Many communities also have little knowledge of how renewable energy can be used to help alleviate their energy problems and how this will impact their health, education, economic welfare and socio-economic development. The lack of adequate energy supply often contributes to poverty. However, there is generally a lack of awareness amongst both policy and decision-makers at the national and local levels, and amongst many academics and researchers, of the link between energy and poverty in rural PIC communities.
Some studies (e.g. Vanuatu National Report: Pacific Regional Energy Assessment 2004 "An Assessment of the Key Energy Issues, Barriers to the Development of Renewable Energy to Mitigate Climate Change, and Capacity Development Needs for Removing the Barriers carried out in Pacific island countries") have shown that the application of feasible RE technologies for reducing reliance on fossil fuel and mitigating GHG emissions has been constrained by many closely interrelated and intertwined barriers. These barriers were analysed, verified and confirmed during the regional logical framework analysis (LFA) design workshop that was conducted as part of the Pacific Islands Renewable Energy Project (PIREP) in July 2004 and attended by PICs and key regional project stakeholders. [4] The severity of the barriers in each PIC vary due to the marked differences in the socio-economic, physical and political environment of each country and the available local capacity to address these barriers as outlined in table 1:

Table 1. Common barriers to RE development among PICs [2]

Type	Barriers
Technical	Lack of sustainable RE-based energy system installations on the ground
	Absence of guidelines on RE technical specifications suitable for the PICs
Market	Lack of private sector involvement in RE service delivery
	High costs of delivering RE services
Institutional	Inadequate capacity to address the challenges of climate change, including the design and implementation of RE projects
	Ineffective coordination among stakeholders
Fiscal & Financial	Absence of sustainable capital fund for RE development
	Local investors are not confident on RE application projects
	Biased fiscal policies
Legislative, regulatory and policy	Climate Change and Energy Legislations and Policies are either not in place or ineffective.
Knowledge, awareness and information	PICs lack qualified nationals in the area of RE applications
	Inadequate national public awareness campaigns
	Inadequate dissemination of information on best practices and success stories
	Lack of knowledge about the RE resources potentials in the PICs
	People in rural areas in the PICs lack knowledge about climate change and its links to renewable energy
	Absence of guidelines on RE technical specifications suitable for the PICs

3 EXPERIENCE WITH RENEWABLE ENERGY IN PICS

RE technologies have been known in the region for the last three decades. Interest in them among PICs has mostly been driven by the oil price shocks during those periods, as well as by various donor support programmes and by a general understanding of the potential of RE resources. A number of past RE projects have aimed to demonstrate the adaptability of the technologies to the PICs' environment and for rural development purposes. The development of RE in the PICs is mostly driven from two perspectives: sustainable development and sustainable environment. Some of the experiences in respect of individual RE methods are as follows:

3.1 Biomass

Biomass-based power generation (bagasse and wood waste) with a capacity of several megawatts (MW) has been operating successfully in Fiji for several decades. There have also been trials using various gasification technologies, the most successful of which was the use of gasification units for crop drying. There have also been trials using coconut oil as a diesel fuel substitute in stationary and mobile diesel engines. In line with experiences elsewhere in the world, results of these trials suggest that various diesel engines can be operated using straight vegetable oil or blends. The biofuel option has however never been systematically researched in the Pacific, a task that should be tackled given the strategic potential vegetable oil-based biofuels have for the region.

3.2 Hydro

In the Pacific, hydroelectric systems range in size from a few kilowatts for village electrification to the Monasavu hydro facility in Fiji at 80 megawatts that

provides much of Fiji's electricity. [2]
All but the largest hydro schemes are usually "run-of-the-river" designs with no more than a few hours of water storage available. However, in terms of RE, the hydro installations of the mountainous PICs are major RE resources and have the potential to provide a high percentage of the electricity supply for national utilities. There is also considerable development potential for village-scale mini-grids using hydropower and a number of installations have been made in Papua New Guinea (PNG), Fiji, Vanuatu and the Solomon Islands. Unfortunately, village installations have not generally been reliable power sources due to the inability of the villages to access the technical support necessary. Problems have been primarily with the electrical components, particularly turbine speed controllers and alternators, but designs that have not adequately considered the problem of flooding have also contributed to the problem.

3.2 Wind

Although a number of wind generators have been installed in the Pacific over the years, only a few very small privately owned or Telecom-owned units have remained in service for more than four or five years. Currently, two installations are generating electricity for small grids: one in Mangaia, the Cook Islands, and one in Fiji at Nabouwalu, Vanua Levu. The Mangaia installation includes two 20 kW turbines funded by the Pacific Rural Renewable Energy France-Australia Common Endeavour (PREFACE) project (funding from France/Australia) that feed into the Mangaia grid. The Fiji installation includes 8–6.7 kW Bergey wind turbines that, with 37.44 kWp of PV and 200 kVa of diesel generation, comprise the Nabouwalu hybrid generation system serving the Government station at Nabouwalu. Both the Fiji (1998) and the Cook Islands' (2002) installations have been in place too short a time to make recommendations regarding replication. [2]
The Nabouwalu wind array has had problems with maintenance and several times individual turbines have been out of service for extended periods awaiting repair. Both electrical and mechanical problems have occurred although electrical problems seem to be the primary cause of turbine outages. The Mangaia turbines still have not completed the commissioning process and though they have been feeding power into the grid for several months, the units are not yet considered fully operational in all aspects.
A 20 kW wind turbine was installed at the SOPAC site in Fiji (2004-2006) for training but in 2006 the wind turbine fell down and produced no more data. [5]

3.3 Solar thermal

Solar water heaters for domestic, commercial and industrial use are commercially available in PICs. Tonga, Fiji and Papua New Guinea have small manufacturers of solar water heaters and large numbers have also been imported from Australia. The most consistent use for solar water heaters is to provide piped hot water for hotels and guesthouses. A few countries, notably the Cook Islands, have many domestic installations as well, but since piped hot water has not been a common component of housing in the Pacific, solar water heating has not had a strong market in most of the PICs.

3.4 Solar PV

Solar PV first was used as power source for telecommunications in the late 1970s and continues to be used throughout the Pacific for powering remote repeaters and island telephones. The first village-scale trials of solar PV began in Fiji in 1983 and by 1984 Tuvalu and Kiribati had established rural electrification programmes using solar PV as the power source. The early trials had a very low long-term success rate, partly because of poor technical designs and partly because of inadequate provision for long-term maintenance. By the 1990s, technical designs had become more reliable and institutional designs had evolved to better provide for the long-term sustainability of PV-based rural electrification. By 1995, Fiji, Tonga, Tuvalu and Kiribati each had their own style of PV-based rural electrification, incorporating over 1,000 solar home systems (SHS) altogether. From 1995 to the present, the growth in number of systems installed has been rapid and by 2006 several thousand homes in PICs will have been electrified using solar PV. [3] At the same time, system costs have gone down and better and more reliable components are now available on the market. Now a "typical" solar home systems (SHS) unit has a peak capacity of about 150 W, a heavy-duty solar battery, state-of-the-art regulator, a DC/DC converter and a rack. In recent projects, hardware costs for such systems were in the range of US $3,000.

In most of the PICs, village water supply and small-scale water pumping for schools, clinics and houses has been a useful application of PV. Success has been variable but well-designed systems using simple technology have operated successfully for decades and clearly have been cost-effective. More complex installations, notably those using positive displacement pumps with associated electronic controls, have had lower reliability and higher maintenance requirements but, if maintenance is properly carried out and pumps used that have had good prior Pacific experience, such installations can also provide good economic value. There have also been trials of "focal point" electrification using solar PV. That is, just electrification of community facilities without extending electrification to homes. That has not been widely accepted and maintenance of the systems has generally been poor since it has proven difficult to get communities to accept the financial responsibility for battery replacement and other repairs and to have sufficient technical capacity for general preventive maintenance and service of the systems. Most PICs have at one time or another been the recipient of a programme for the electrification of health clinics, usually with the inclusion of a vaccine storage refrigerator, power for lights and for a communications radio. Abuse of the systems, poor maintenance and lack of a financial commitment by the agencies responsible have caused the systems to provide unreliable service and to have a short life. Some PICs have, over a 20-year period, received donor assistance to electrify the same clinics as many as three times because earlier systems have not been maintained and had failed. An exception has been Kiribati where the Department of Health contracts with the Solar Energy Company (SEC) for maintenance has made the necessary financial commitment to maintenance and repair.

3.5 Ocean thermal

In 1981, an experimental 100 kW (gross) closed-cycle ocean thermal energy conversion (OTEC) [7] power plant operated in Nauru but ran into technical problems in its early days. This was the first land-based OTEC installation in the world and since then no other installation has been attempted in PICs. A 150 kW (gross) open-cycle experimental OTEC plant was built in Hawaii in the 1990s and currently a 1 MW (gross) floating open-cycle OTEC plant is being constructed off the coast of India but has faced many delays and engineering problems. [7] Palau is presently liaising with the Saga University of Japan for the setting up of OTEC power plants at seven locations in the country, starting with a 3 MW pilot power plant.

3.6 Hybrid systems

Fiji has installed several hybrid power generation systems. Fiji Telecom installed a wind/diesel hybrid at a site on Viti Levu and has a wind/PV hybrid power system for charging backup batteries at several remote sites. The wind/diesel hybrid power system has been dismantled but the battery charging systems have been satisfactory and continue to be operational. The only installation in the Pacific designed specifically as a hybrid and intended for power generation is the Nabouwalu wind/PV/diesel installation. It includes eight 6.7 kW rated wind turbines, 37.44 kW of solar PV and 200 kVA of diesel generation. The system includes battery storage for the PV to eliminate the rapid power fluctuation from the PV panel in partly cloudy conditions and to help serve the peak demand time, which is in the evening after the sunset. The system design for energy delivery is 720 kWh/day, representing around 60% of total generation from renewable sources. However, over the five years it has been in use, the component of energy from RE has fallen from 60% to less than 15% due to technical problems, the complexities of the system and the lack of training and/or qualified staff to replace those persons originally trained within the PIGGAREP (Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project) project. [2]

Figure 1- The project DIREKT

DIREKT – Small Developing Island Renewable Energy Knowledge and Technology Transfer Network

The Small Developing Island Renewable Energy Knowledge and Technology Transfer Network (DIREKT) is a cooperation scheme involving universities from Germany, Fiji, Mauritius, Barbados, and Trinidad and Tobago with the aim of strengthening science and technology capacity in the field of renewable energy of a sample of ACP (Africa, Caribbean, Pacific) small island developing states by means of technology transfer, information exchange and networking. Developing countries are especially vulnerable to problems associated with climate change and much can be gained by raising their capacity in the field of renewable energy, which is a key area.

The overall objectives of the **DIREKT** project are:

- To strengthen the internal science and technology capacity in the field of renewable energy of ACP-SIDS
- To foster sustainable cooperation between the science and technology community in the participant countries and the EU
- To contribute to the transfer of research results in the key area of renewable energy by means of establishing "technology transfer centres" in the participant countries

Therefore, the specific objectives of the project are:

- To increase the capacity for and the quality of research within the scientific and technological community of ACP-SIDS in the field of renewable energy as a tool to fight climate change

• To develop and establish a market-oriented research framework to better capitalise upon and disseminate research
• To strengthen links between research communities in ACP-SIDS and the regional markets and businesses in the field of renewable energy

An ultimate aim of the project is to establish a long-term EU-ACP Small Island Developing States Science and Technology Network.

For more information about the DIREKT project, please visit www.direkt-project.eu.

4 Opportunities and challenges

The impacts of the extreme weather events attributable to climate change are one of the greatest challenges to the sustainable development of PICs in the 21st century. PICs are among the most vulnerable regions and it is crucial to urgently adapt to the known and potential impacts of climate change, climate variability and sea level rise. Similarly, PICs must urgently join the world community in adopting concrete measures, which will not only reduce the long-term rise in GHG emissions but also support their sustainable development effort.

The PICs agreed and requested the United Nations Development Programme (UNDP) and the Secretariat of the Pacific Regional Environmental Programme (SPREP) to pursue a regional GHG mitigation project on RE within the framework of its Climate Change, Sea Level Rise and Variability programme.
The Global Environmental Facility approved a preparatory exercise in 2002, which is entitled the Pacific Islands Renewable Energy Project (PIREP). The implementation of the PIREP commenced in May 2003 and focussed on the development of a regional approach to the removal of barriers to the widespread utilisation and commercialisation of feasible renewable energy technologies. [6]
This was done through a series of studies, consultations and the establishment of synergies with other related national, regional and international initiatives. Such an approach is embodied in the implementation of this proposed comprehensive regional RE project, which was designed under PIREP.

PIREP identified major national and regional initiatives, which offer excellent synergies with other projects in this field.

Most of these projects are technology demonstration and "equipment-based" projects, which involve the installation of RE-based energy systems. Some of these projects have been subsumed into the proposed regional project as demonstration activities. With the permission of their owners, specific components/features have been added to these parallel demonstration projects to ensure the sustainability of the RE delivery mechanisms applied in each of them, and their ability to enhance commercial viability. These demonstration projects are meant to showcase/demonstrate the design, development, engineering, financing, operation, maintenance, monitoring and evaluation of sustainable and commercially viable RE-based energy system projects. The "business angle" of such projects will be demonstrated. Some of these projects are designed to apply certain RE delivery mechanisms, which are considered more sustainable, and/or supportive of productive uses. These demonstrations are also meant to contribute to the removal of technical, market, finance, policy, institutional and awareness barriers, so that they can operate sustainably and cost competitively against fossil fuel-based systems. Discussions with the proponents/owners of some these projects led to mutually beneficial understandings that made these projects integral parts of the proposed comprehensive regional RE project.
All these projects are examples of the possibilities and challenges for PICs in the context of climate change and renewable energy, and they will use this opportunity to design more projects in the Pacific region.

5 Conclusion

Because of the variability in renewable energy resources in these regions, there is a need to identify the right renewable energy mix that can best supply the energy needs of each of these communities, and contribute to poverty reduction, improve the quality of life and lead to socio-economic development.
The first step could be to analyse energy demand and supply for rural communities and linkages between poverty and energy and to develop recommendations for defining and implementing the right renewable energy mix for rural Pacific communities with varying renewable energy resources.
Below is a summary of the most important steps for the removal of the barriers mentioned in this paper and in order to accomplish the following:

- To improve productive uses of RE, particularly in rural and remote communities for use in schools, health centres, water supply, agriculture and fishery, telecommunication, etc.

- To improve local expertise, experiences and skills to: (1) Monitor and analyse RE resources measurements and data; (2) Plan, design, install, monitor and maintain RE installations; (3) Formulate and review legislation, regulations and policies; and, (4) Effectively campaign, lobby for and disseminate RE success stories

- Availability of legal, financial, technical advice and equipment support for RE-based energy system projects in PICs
- To enhance understanding of the mitigation of GHG emissions through the application of RE technologies in order to support the sustainable development efforts of PICs
- To strengthen legal and regulatory, planning and coordination structures for the mitigation of GHG through the widespread utilisation of RE
- To enhance understanding of the potential of RE, and knowledge about the availability of RE resources in PICs
- To identify financially viable and "bankable" climate change mitigation and RE projects and the deployment of an identified number of RE technologies that are sustainable and competitive with fossil fuel-based alternatives
- To implement financially sustainable RE demonstration projects that successfully showcase the design, development, engineering, financing, implementation, operation, maintenance, monitoring and evaluation of RE-based energy system projects that can support the sustainable development of PICs
- To establish a sustainable capital base for supporting RE-based energy system (electricity and non-electricity) projects in the region

Of course, climate change is an important topic but also a challenge for Pacific island countries.
They are faced with the challenge of dealing with a problem which is mostly caused elsewhere. Renewable energy is an area that can help to address the issue, but it needs to be seen as one of many solutions.

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