

# **Renewable Technologies for Energy Security: Institutions and Investment in Fiji's Electricity Sector**

**By**

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**RESOURCE MANAGEMENT IN ASIA PACIFIC PROGRAM  
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## Declaration

I, Matthew Dornan, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Resource Management in Asia Pacific Program, Crawford School of Economics and Government, College of Asia and the Pacific, the Australian National University, is wholly my own work unless otherwise referenced or acknowledged (as is the case for part of Chapter 3). This thesis has not been submitted for qualifications at any other academic institutions.

The word count of the body of this thesis is 94,000 including all tables and figures, which is in accordance with the Australian National University's 100,000 word limit. Preliminary information, references and appendices are not included in this count.

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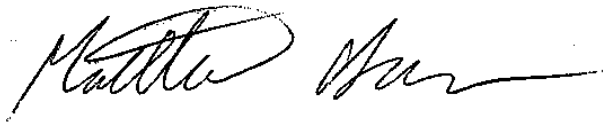
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Signed

A handwritten signature in black ink, appearing to read 'Matthew Dornan', written in a cursive style.

On the 21<sup>st</sup> December 2011

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## Abstract

Renewable energy technologies have been advocated in Fiji's electricity sector on the basis that they improve energy security and serve as a risk-mitigation measure against oil price increases. This follows a decade of significant oil price volatility and historically high oil prices, which negatively affected the oil-dependent electricity sector in Fiji and other Small Island Developing States in the Pacific. This dissertation examines the extent to which renewable technologies can improve energy security in the electricity grid and in rural off-grid areas of Fiji. The main contributions from the research are a novel empirical analysis of generation cost-risk in the electricity grid; an analysis of institutions governing power sector investment; a survey, interview and focus group-based analysis of rural electricity supply; and an evaluation of implications of the research findings for policy.

In Fiji's electricity grid, threats to energy security are primarily the result of increased generation costs and their impact on electricity prices. Risk is therefore financial. In this thesis, it is assessed using portfolio theory. Detailed data on costs and variability is fed into a stochastic portfolio model, which is developed to analyse the impact of renewable technologies on generation costs and financial risk in Fiji's electricity grid looking forward to 2025. The analysis demonstrates that renewable technologies can be expected to significantly improve the security of electricity supply through diversification, as the cost streams of renewable technologies are neither correlated with those of oil-based power generation, nor strongly correlated with each other. Importantly, investment in hydro, geothermal, biomass and bagasse-based power generation is found to lower expected average generation costs in the electricity grid. The implementation of energy efficiency measures also lowers generation costs and risk in the electricity grid.

Renewable technology investment that is forecast in Fiji's electricity grid is found to fall short of what would be desirable based on the analysis, despite being significant. This investment deficit can be explained by institutional arrangements in the power sector. The research shows that barriers to investment in renewable technologies include political uncertainty, lack of available finance, and historically low feed-in and retail tariff rates. Regulatory reform now occurring is found to be promising in this regard, and is likely to

attract increased investment in renewable technologies. Continuing political uncertainty nonetheless remains a barrier to investment, given the regulatory risk it entails.

In rural off-grid areas of Fiji, energy security needs to be understood differently, with fuels such as kerosene commonly used as substitutes for electricity in the provision of services. This dissertation examines energy security and power generation in four rural communities in Vanua Levu (in northern Fiji), where there is widespread use of village diesel generators and household solar photovoltaic systems installed under government rural electrification programs. A survey, interviews and focus group discussions conducted for this dissertation show that un-electrified households were disproportionately impacted by oil price volatility in recent years, due to their reliance on fossil fuels. Power outages in electrified households were also found to be common. For village diesel systems, collective responsibility for financing fuel and maintenance is problematic. Informal norms and governance arrangements at the village level only partially resolve these issues. Solar photovoltaic systems in these communities also commonly perform poorly, primarily as a result of inadequate arrangements for maintenance established by government.

A number of policy implications are identified in the dissertation. Forecast renewable technology investments in the electricity grid are worthwhile in light of their financial and risk mitigation benefits. Regulatory reform now underway and high retail and feed-in tariff rates already in place are facilitating such investment. Policy measures that could further encourage investment in renewable technologies include those designed to strengthen political and regulatory certainty; improve access to finance, land, and renewable energy resources; reform the sugar industry; and support research on renewable energy resources. Mechanisms designed to encourage the use of energy efficiency technologies should also be adopted. In rural off-grid areas, there are strong financial and social benefits from electricity provision, but reform of rural electrification programs is needed.

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## Abbreviations

ADB	Asian Development Bank
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamps
CRF	Capital Recovery Factor
EU	European Union
DoE	Department of Energy (Fiji)
EIA	Energy Information Administration (US Government)
FEA	Fiji Electricity Authority
FJc	Fiji cents
FLP	Fiji Labour Party
FSC	Fiji Sugar Corporation
GDP	Gross Domestic Product
GEF	Global Environment Facility
GFC	Global Financial Crisis
GNI	Gross National Income
GoF	Government of Fiji
HFO	Heavy Fuel Oil
IAD	Institutional Analysis and Development
IEA	International Energy Agency
IPP	Independent Power Producer
MEPS	Minimum Energy Performance Standards
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
PICs	Pacific island countries
PNG	Papua New Guinea
PPA	Power Purchase Agreement
RESCO	Renewable Energy Service Company
SDL	<i>Soqosoqo Duavata Lewanivanua</i> (Fijian political party)
SHS	Solar Home Systems
SOPAC	Pacific Islands Applied GeoScience Commission



SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SVT	<i>Soqosoqo ni Vakavulewa ni Taukei</i> (Fijian political party)
UN	United Nations
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollar
VLIS	Viti Levu Interconnected System

## Units of Measurement

J	joule of energy
kW	kilowatt (one thousand watts)
kWh	kilowatt hours
kV	thousand volts
GW	Gigawatt (one thousand megawatts)
GWh	Gigawatt hours
L	Litre
MW	Megawatt (one thousand kilowatts)
MWh	Megawatt hours
TJ	Terajoules (one trillion joules)
V	Volt
W	Watt

## Glossary of Terms

- bagasse – a by-product of the sugar cane crushing process, bagasse is a form of biomass that can be used to generate electricity.
- base load – refers to the minimum amount of electricity that is required at all times, including when demand is lowest.
- benzine – a term commonly used for referring to petroleum ether. Benzine is used for lighting in rural areas of Fiji.
- biomass – refers to wood or fuel crops that can be used to generate electricity.
- busbar cost – is the cost of electricity generation, excluding all distribution and transmission costs.
- capital recovery factor – converts an initial investment cost into a stream of equal annual payments using a discount rate.
- capacity factor – actual electricity generation as a percentage of possible generation
- common good – a common good is a) non-excludable, meaning that it is consumed simultaneously by the public, irrespective of whether individuals contribute resources towards the provision of that good, and b) rivalrous, meaning that consumption of the good by an individual subtracts from its consumption by another person.
- distribution – electricity distribution refers to the delivery of electricity from a transmission network to end users.
- energy ladder – the energy ladder concept explains the movement towards more efficient sources of energy as income rises.
- generation capacity – potential electricity generation from a power plant.
- geothermal – refers to power generation using geothermal energy generated and stored below the earth's surface.
- kerekere* – is a gift exchange system that enables members of a village or kinship group to ask for a range of items from other members of the same group. Reciprocal obligations are established as a result of such gifts.
- levelised cost - The levelised unit cost of electricity refers to the cost of generating electricity, averaged over the life of the generation technology. It is expressed in terms of cost per unit of electricity generated, and incorporates the capital

cost, operation and maintenance (O&M) costs, and fuel costs of power generation.

*mataqali* – is an extended kinship group, and is the basis for customary land ownership in Fiji.

monopsony – refers to a situation where a buyer is the single purchaser of a product from several sellers.

negawatt – is a kilowatt of avoided electricity generation.

Pacific Islands Forum – is an intergovernmental organisation which incorporates independent states in the Pacific islands.

Pacific Islands Forum Secretariat – is tasked with implementing the decisions of the Pacific Islands Forum.

peak load – refers to electricity supplied only at times when demand for electricity is at its highest.

*sevusevu* – is a ritualistic offering of kava to ancestors, commonly used for social purposes in indigenous Fijian communities.

solar photovoltaic – an electricity generation technology which converts sunlight into electrical energy through an array of panels.

*solu* – a regular collection of money for community purposes, which include assistance for poorer families, purchase of diesel fuel for the generator, and contributions to the provincial council.

solid electricity generation – refers to electricity generation capacity that is reliable and can be used whenever is convenient.

transmission – electricity transmission refers to the delivery of electricity from a power generation plant to a distribution network, which delivers power to end users.

*Tui* – the village chief in Fiji. In most of Fiji, this position is hereditary and can be occupied only by males from the chiefly *mataqali*.

*turaga ni koro* – the elected village headman implements decision of the *Tui*, and oversees daily operation of the village. The position is prized given it attracts a small government salary.

unbundle – the term used to describe the separation of ownership and management of electricity generation, transmission and distribution infrastructure.

*Yasana* – is the indigenous Fijian provincial council in each province of Fiji, and is responsible for overseeing municipal functions for indigenous Fijians.

*Yasuva* – is an indigenous Fijian grouping that normally equates to a village.

