Final Report

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Fiji Renewable Energy Power Project (FREPP)

Waste to Energy Resource Assessment in Fiji

Report on Quantification and Assessment on the Amount and Types of Resources for Waste-to-Energy Power Generation in Fiji

July -2014

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Abbreviations & Acronyms

BOD	Bio-chemical Oxygen Demand
CBH	Central Board of Health
COD	Chemical Oxygen Demand
CSA	Commercial Statutory Authority
DoE	Department of Energy (Govt. of Fiji)
EMA	Environment Management Act
FAO	Food and Agricultural Organization of the United Nations
FEA	Fiji Electricity Authority
FREPP	Fiji Renewable Energy Power Project
FSC	Fiji Sugar Corporation
FPT	Fiji Pine Trust
GEF	Global Environment Facility
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
HFO	Heavy Fuel Oil
IPPs	Independent Power Producers
MSW	Municipal Solid Waste
NCCP	National Climate Change Policy
NEP	National Energy Policy
NGOs	Non-Governmental Organizations
NSWMS	National Solid Waste Management Strategy
PWD	Public Works Department
RE	Renewable Energy
REBREPPE	Renewable Energy Based Rural Electrification with Participation of Private Enterprise
REP	Rural Electrification Policy
RESCO	Renewable Energy Service Companies
REU	Rural Electrification Unit
SNC	Second National Communication to the UNFCCC
STP	Sewage Treatment Plant
TWIL	Tropik Wood Industries Ltd.
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USP	University of the South Pacific
WAF	Water Authority of Fiji

Executive Summary

Fiji is heavily dependent on imported petroleum products as a source of energy for its industrial, commercial and transportation sectors, as well as to supplement electricity generation for domestic consumption. Power generation in Fiji is dominated by the renewable energy sources (67% from Hydro, Biomass and Wind) and the Government of Fiji has an ambitious target to achieve 90% of total energy generation from renewable energy sources by 2015.

In 2013, the Government of Fiji undertook major policy review and formulated a new national energy policy (NEP) (under consideration by cabinet for approval). The new NEP has given strong emphasis on private sector-led development of renewable energy resources. Government of Fiji is also keen on utilizing the various waste resources available for power generation in Fiji apart from various other renewable energy sources. Utilizing waste resources is envisaged to assist in sustainable waste management in the country which has become the major issue mainly with growing population, increased urbanization, and changing consumption patterns.

The existing biomass resources in Fiji consist of bagasse and forestry wastes, both of which are already used for the generation of power and heat to a large degree. Further traditional biomass resources (wood, agricultural wastes) still meet a large proportion of the energy demand of rural communities and there seems to be no constraint in supply.

This study under the “Fiji Renewable Energy Power Project (FREPP) intends to quantify and assess the amount of waste resources available in Fiji for power generation and identify technology options for feasible implementation of waste to energy projects in Fiji.

This report focuses on quantification and assessment of the amount and types of waste resources available in Fiji for waste-to-energy power generation. The report includes the quantitative and qualitative assessment of various potential wastes to energy resource generated and characteristics of waste resources for each identified waste streams in Fiji. This includes as Municipal Solid Waste (MSW); Sewage and Sludge (Waste Water); Livestock Waste; Biomass Waste; Non Hazardous Industrial Organic Waste and Agricultural Crop Residues.

Based on the assessment of waste resources, it appears that some (MSW, biomass, livestock) of the waste streams identified in Fiji have reasonable potential for power generation. The next reports under the study will assess the feasibility of quantified waste resources and sites for power generation. Some of these potential projects could play a valuable role in stand-alone electricity applications and be particularly effective for rural electrification in remote rural areas with no or very limited grid connectivity. On the other hand, waste residues and resources, resulting mainly from medium and large sources and enterprises provide opportunities for large-scale centralized power generation.

Further, the use of waste resources as substitute for fossil-based fuels offers many attractive benefits for Fiji. The key socio-economic benefits include private sector investment opportunities, employment generation, rural electrification and poverty alleviation. There are additional benefits to the environment in terms of offsetting the GHG emissions associated with burning fossil fuels and anaerobic digestion of biogenic waste and waste utilization.

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Background

This study report on "Quantification and Assessment on the Amount and Types of Resources for Waste-to-Energy Power Generation in Fiji" is part of "Resource Assessment study for Waste-to-Energy Resources in Fiji" under the "Fiji Renewable Energy Power Project (FREPP[1])"; implemented by Department of Energy (DoE), Govt. of Fiji with financial and technical support from United Nations Development Programme (UNDP)-Global Environment Facility (GEF). The overall goal of FREPP is to reduce greenhouse gas (GHG) emissions from Fiji's power sector[2]. This is planned to be accomplished by replacing fossil fuels with other renewable energy resources including waste to energy resources. The objective of this project is to remove barriers for widespread and cost-effective grid-based renewable energy supply via commercially viable renewable energy technologies in Fiji.

The FREPP is in line with the Government of Fiji's "Roadmap for Democracy and Sustainable Socio-Economic Development[3] 2009 - 2014". Furthermore, the FREPP is also consistent with the priorities outlined in the National Energy Policy (NEP) that has the vision of 'A sustainable energy sector for Fiji' and a mission 'To provide an enabling environment for a sustainable energy sector'. The FREPP also complements Fiji's climate change mitigation strategy developed through Second National Communications (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC). The project also intends helping in enhancing the performance of public sector institutions in participatory national planning and policy development.

The FREPP project consists of four main components and each of these component addresses specific barriers i.e. (1) Energy Policy & Regulatory Frameworks; (2) Renewable Energy Resource Assessments and Renewable Energy-based Project Assessments; (3) Renewable Energy based Power Generation Demonstrations and (4) Renewable Energy Institutional Strengthening.

The major outputs of FREPP includes: (i) Enactment and Enforcement of Fiji Biofuel Act; (ii) Enforcement of Implementing Rules and Regulations for the Fiji Energy Act; (iii) Establishment of a Centralized Energy Database System; (iv) Completion and Publishing of Renewable Energy Resource Assessments in Fiji; (v) Completion of Feasibility Assessments of Renewable Energy Investments; (vi) Designing and Implementation of Renewable Energy-based Power Generation Demonstration; (vii) Completion of Training Programme on Integrated Energy Planning and Administrative Policy for Government Personnel and (viii) Completion and Approval of National Electrification Master Plan. Further to this, FREPP is expected to facilitate investments in renewable energy-based power generation in Fiji, which will not only support the socio-economic development of the country, but also make use of the country's renewable energy resources and reduce greenhouse gas (GHG) emissions.

The implementation of FREPP started in year 2011 with the total estimated budget of US$975,000 and expected end date is year 2016. The project is currently ongoing and this study report is a part of FREPP implementation.

[1] http://www.fj.undp.org/content/dam/fiji/docs/ProDocs/Fij_FREPP_00076656.pdf
http://www.fdoe.gov.fj/index.php/energy-planning/frepp

[2] The estimated CO_2 emissions from energy generation was 186 Gg of CO_2 in 2004 – using the sectoral approach – compares with emissions of 36 Gg of CO_2 in 1994 (Source: Draft SNC of Fiji)

[3] http://www.fiji.gov.fj/getattachment/Govt--Publications/Peoples-Charter/RSSED.pdf.aspx

Introduction

Fiji is one of the fastest developing economies[4] in the Pacific. However, Fiji is heavily dependent on imported petroleum products as a source of energy for its industrial, commercial and transportation sectors, as well as to supplement electricity generation for domestic consumption[5]. Nearly half of Fiji's total energy is imported from Australia, New Zealand and Singapore. Hence, Fiji is among the most vulnerable countries to oil price volatility in the Asia-Pacific which includes inflation, reductions in real household income and worsening of the terms of trade and balance of payments.

The majority of the imported petroleum fuel in Fiji is used in the transportation and power generation sectors. Power generation in Fiji is dominated by renewable energy sources (67% from Hydro, Biomass and Wind) and the Government of Fiji has an ambitious target to achieve 90% of total energy generation from renewable energy sources by 2015. Several initiatives to explore and promote renewable energy sources (Biomass, Biofuel, Biogas, Solar, Wind, Hydro, Ocean, and Geothermal) are being explored to achieve energy security and long term economic and climate change benefits.

In 2006, the National Energy Policy (NEP) was approved by the Government of Fiji. It provides a common framework for both the public and private sector to work towards the optimum utilization of energy resources, for the overall growth and development of the economy. The policy focuses on four key strategic areas: national energy planning, energy security, power sector development, and renewable energy development. In 2013, the Government of Fiji undertook major policy review and formulated a new national energy policy (currently under consideration of cabinet). The new NEP has given strong emphasis on private sector led development of renewable energy resources. Government has also been focusing on increasing access to electricity, particularly in the rural and remote areas. The 2007 Census revealed that 89% of Fiji's population has access to electricity and Government of Fiji has an ambitious target to achieve 100% electricity access by 2030. Government's Rural Electrification Programme has focused on increasing the coverage to the entire population by 2016. However, approximately 10% of the population is still without access to electricity and Fiji is struggling to provide remote areas and isolated islands with access to electricity in a sustainable manner.

Apart from the various available renewable energy sources like hydro, wind, solar and geothermal; DoE is also focusing on utilizing the various waste resources available for power generation in Fiji. Waste management is recognized as a major concern with the potential to cause negative impact on national development activities including public health, the environment, food security, tourism and trade. It is estimated that unmanaged waste is one of the major source of GHG emission; Methane emissions from solid waste disposal sites are calculated to be 3.12 Gg and from wastewater and sludge is 1.10 Gg; total methane emission from waste sector is estimated to be 4.22 Gg (year 2004); which is 14% increase since the last greenhouse gas inventory of 1994 for the Initial National Communication. The rate of methane emission from the waste sector is increasing at a rate of 1.4 % per year[6].

Utilizing waste resources for power generation is envisaged to assist in sustainable waste

[4] In 2012 the Fijian economy grew by 2.2%, up from 1.9% in 2011 and 0.1% in 2010. The economy is projected to grow by a very strong 3.6% in 2013 and forecast growth for 2014 is 3.0% (source: 2014 National Budget Announcement, Govt. of Fiji)

[5] Petroleum consumption in 2007 was about 844 million litres and petroleum demand is projected to be 1003 million litres in 2015 (source: Fiji National Energy Security Situation Report, 2010).

[6] Draft second national communication to UNFCCC

management; which has become a major issue in Fiji and other small island developing states in the Pacific region mainly with growing population, increased urbanization, and changing consumption patterns. Currently there are two IPPs, Fiji Sugar Corporation (FSC) and Tropik Wood Industries Ltd (TWIL) involved in waste-to-energy generation. TWIL has an installed capacity of 12.3MW biomass residue power generation system that produces power from sawmill and chip mill residues. The four sugar mills owned by the Fiji Sugar Corporation (FSC) Limited have a collective electricity generating capacity of around 48 MW during the sugar cane crushing season. The boilers in these mills are fuelled by bagasse, where excess electricity is sold to the Fiji Electricity Authority (FEA) and delivered to the national grid.

However, large amounts of waste to energy resources are currently untapped in Fiji mainly due to lack of information/data availability on the various waste streams and quantities and characteristics; lack of technology know-how for waste resource utilization, lack of infrastructure and other technical and financial constraints. With this view, the DOE is pursuing this study to quantify and assess the amount of waste to energy resources available in Fiji for power generation to maximize the utilization of waste resources and as a positive step towards the sustainable management of waste.

The objective this study is to quantify and assess the amount of biomass, agriculture feed stocks and others wastes that is available in Fiji for power generation and identify technology options for feasible implementation of waste to energy projects. The study aims to:

- Quantify and Assess the Amount and Types of Resources for Waste-to-Energy Power generation in Fiji;
- Assess the Feasibility of Resources and Sites for Waste-to-Energy Power Generations Facilities;
- Suggest Technology research and recommendation on Waste-to-Energy options; and
- Recommend Effective Implementation of Waste-to-Energy Power Generation Facilities in Fiji

This report on ‘Quantification and Assessment on the Amount and Types of Resources for Waste-to-Energy Power Generation in Fiji’ is the first of four reports under the assignment and mainly covers the quantification and assessment of the amount and types of waste resources available in Fiji for waste-to-energy power generation.

Waste to Energy Situational Analysis

Energy Sector Overview

The electricity supply in Fiji is mostly met by the Fiji Electricity Authority[7] (FEA) and the Rural Electrification Unit (REU) which is a part of the Fiji Department of Energy (DoE). The rural electrification schemes are normally diesel powered, which are installed and maintained by Public Works Department (PWD) and solar-powered which are operated under a RESCO model and managed by the DoE.

The PWD is operating in the rural centers of Ahau in Rotuma, Vunisea in Kadavu, Tubou in Lakeba, Dreketi Agricultural Station in Macuata, Lomaloma in Vanua Balavu and Nabouwalu in Bua. A PWD scheme (now part of the rural electrification unit of the Department of Energy) assisted households to install small gensets, and this was later expanded to include facilitation of grid connection, and renewable energy powered systems. Many households and businesses also generate their own electricity, particularly in rural areas or as a backup, such as tourism facilities.

As of year 2012, Fiji had a total installed power generation capacity of 313 MW and total generation during the year was 823GWh. In 2012, the renewable power stations generated 532,070 MWh (64.6%), thermal power stations 271,283 MWh (33%) and Independent Power Producers (IPPs) generated 19,451MWh of electricity (2.4%).

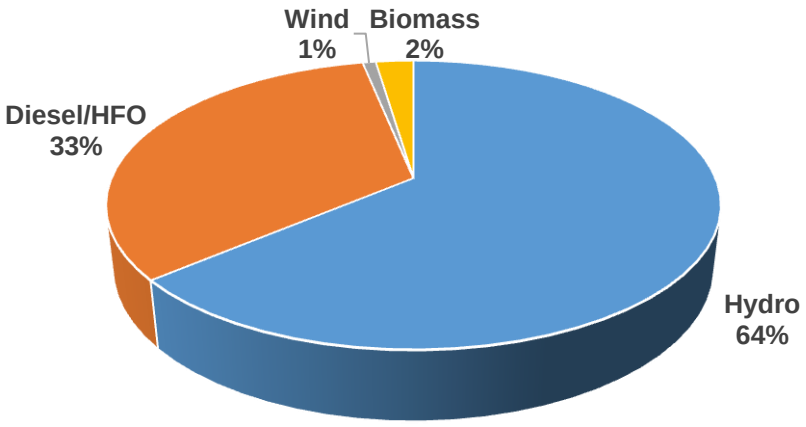

Figure 1: Electricity Generation in Fiji by Source (FEA-2012 Data)

While hydro resources have traditionally been the focus in power generation, other sources such as waste sector (biomass, municipal solid waste, waste water, industrial waste and forest residue etc.) have seen less or no significant development yet. However the new NEP has substantial emphasis on development of other renewable energy sources for power generation including potential waste to energy projects.

[7] The Fiji Electricity Authority (FEA) was established, incorporated and constituted under the provisions of the Electricity Act of 1966 and began operations from August 1st 1966. The FEA is responsible for generating, transmitting and retailing electricity in Fiji

Energy Demand Overview

The grid electricity demand in Fiji has been rather flat in recent years (approximately 800 GWh). The demand from Viti Levu interconnected system accounts for about 90% of all electricity demand. This dominance is explained by both the demographics (80% of Fiji's population lives on Viti Levu) and the fact that commercial and industrial demand is concentrated on this island.

The third largest island of the Fiji group, Taveuni (where 5% of Fiji's population lives) has currently no power grid and there is a considerable demand that is currently only met by small scale diesel generator mini-grids operated by private companies and the PWD and standalone solar power systems managed by the DoE. The FEA's projected supply-demand balance for the period of 2007-2015 (not including the new solar unit) shows the reduction in diesel based thermal power generation by commissioning and operation of new renewable energy projects. However this does not include the demand of grid isolated rural areas of Fiji.

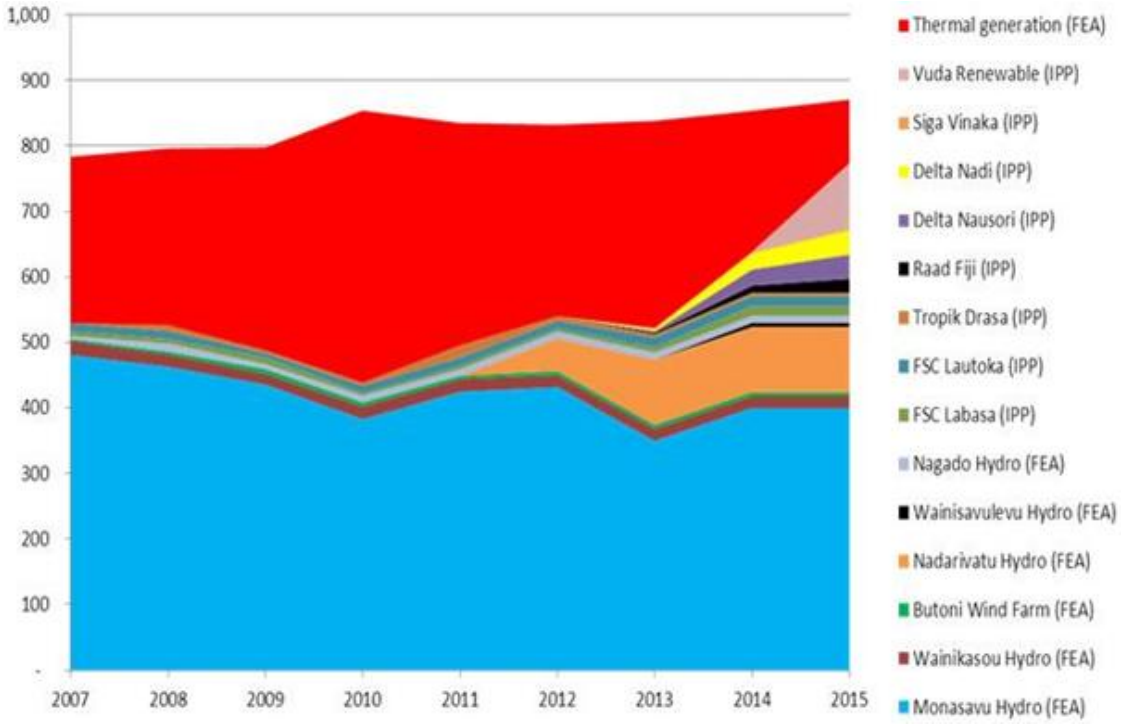

Figure 2: Electricity Demand Forecast for Fiji: 2007-2015[8]

As per the 2007 Census, 89% of Fiji's population has access to electricity. Further it is estimated that the overall grid electricity consumption annual average growth rate during 2007 to 2025 is about 4%. The Government of Fiji has an ambitious target to achieve 100% electricity access by 2030. The Government's Rural Electrification Programme is focused on increasing the electricity coverage to the entire population by 2016. Approximately 10% of the population is still without access to electricity and Fiji is struggling to provide remote areas and isolated islands with access to electricity in a sustainable manner. In conclusion significant measures need to be implemented to attain affordable, stable and secure source of energy for the future economic growth and prosperity of Fiji.

[8] Source: FEA Presentation National Energy Forum April 2013

Waste to Energy Sector in Fiji

As discussed earlier, the energy generation in Fiji has four main sources hydro, diesel & HFO, biomass and wind energy along with several small standalone solar units. The existing biomass resources in Fiji consist of bagasse and forestry wastes, both of which are already used for the generation of power and heat to a large degree. Further traditional biomass resources (wood, agricultural wastes) still meet a large proportion of the energy demand (mainly for cooking) of rural communities and there seems to be no constraint in supply.

Also as discussed in the earlier sections, presently there are two Semi-Independent Power Producers (IPPs) FSC and TWIL having biomass based power generation units. There are also few bio-fuel projects (mostly pilot phase) which have been installed in remote areas. The DoE supports several biofuel projects[9] as part of its electrification programme for remote island communities which include encouraging the production of coconut oil and the blending of coconut oil with diesel. The details of the existing waste to energy plants and waste resource availability/assessment are discussed in later sections of this report.

Energy Sector Major Institutions, Legislation and Policies

The DoE is responsible for national energy policies, energy efficiency and renewable energy development and rural electrification. Its mission is to facilitate the development of a resource-efficient, cost-effective and environmentally sustainable energy sector in Fiji.

The first National Energy Policy[10] (NEP) for Fiji was approved by the Fijian Cabinet in 2006. The main goal of the NEP is Affordable energy for all, ensuring that all Fijians have access to affordable and reliable modern energy services. It provides a common framework for both the public and private sector to work towards the optimum utilization of energy resources for the overall growth and development of the economy. The first NEP was focused on four key strategic areas that include; National Energy Planning, Energy Security, Power Sector and Renewable Energy Development.

The Government of Fiji undertook the review of the NEP aimed at improving overall reliability and security of supply and quality of energy services, as well as continuing work on accessibility, sustainability and efficiency. The new revised NEP (2013), which is awaiting cabinet approval[11] is clearly structured and has set policy priorities for seven individual areas i.e. grid-based power supply, rural electrification, renewable energy, energy efficiency, transport, petroleum products and biofuels and implementation agreements.

The new NEP also has clear targets for energy intensity, renewable energy and access to modern energy; these targets are aligned with the UN Sustainable Energy for All (SE4ALL) objectives. The key aspects of the new NEP include 100% of population with electricity access by 2020; less than 1% of population with primary reliance on wood fuel for cooking by 2030; 5.5% reduction of energy intensity i.e. consumption of fossil fuel per unit of GDP (MJ/FJD) by 2030; 9.1% reduction of energy intensity i.e. power consumption per unit of GDP (kWh/FJD) by 2030; 99% share of renewable energy in power generation by 2030; 25% share of renewable energy in total energy consumption by 2030.

[9] Bio-fuel plants in Koro, Cicia, Rotuma and Gau
[10] http://www.fdoe.gov.fj/index.php/review-energy-policy
[11] http://www.fiji.gov.fj/Media-Center/Press-Releases/NATIONAL-ENERGY-POLICY-TO-BE-FINALISED-SOON.aspx

Government has also been focusing on increasing access to electricity, particularly in the rural and remote areas. The Fiji government had approved the Rural Electrification Policy (REP) in 1993 and has set up a Rural Electrification Unit under the DoE to facilitate the implementation of the REP. Renewable Energy Based Rural Electrification with Participation of Private Enterprise (REBREPPE) charter, approved in February 2003 by Cabinet, incorporated measures to stimulate private sector participation as well as use of indigenous renewable energy resources for provision of rural electrification services and funding from international institutions.

The REP defined the DoE's role as technical regulator, helping setup quality and safety standards, technical specifications, and ensuring quality of systems by conducting equipment testing. The REP also incorporated the Renewable Energy Service Companies (RESCO) model currently used in the implementation of solar home systems and applied it to other RE sources and diesel schemes allowing for hybrid systems as well.

The other important policies, programs and imitative of Fiji, relevant to the waste to energy sector include:

Rural Electrification Policy (REP): The REP had been approved by the Fiji cabinet in 1993. To facilitate the REP, the DoE setup the Rural Electrification Unit (REU). The policy stated that rural villages or settlement could request the Fiji government for rural electrification which could be in the form of FEA grid extension or government station mini-grid to provide 24 hours per day service; a diesel generator with mini-grid system for evening lights and small electrical appliances; and use of locally available renewable energy systems for electricity generation.

Reserve Bank of Fiji Import Substitution Policy: Under this policy, import substitution concessional funding is available to businesses involved in renewable energy activities. This funding attracts an interest rate of only 2%. Renewable energy related products are also exempted from import duty. A 10 year tax holiday is available to anyone undertaking a new activity in processing agricultural commodities into bio-fuels from 1 January 2009 to 31 December 2014. Also, The diesel used for blending with biodiesel attracts a duty of only $0.05/L compared to the normal duty of $0.18/L.

Environment Management Act (EMA, 2005)**:** This Act deals with issues pertaining to the protection of the environment, and provide legislative framework for the sustainable development of land and water resource management. It prohibits any commercial or industrial facility from discharging any waste or pollutant into the environment or handling or storing hazardous materials without a permit and gives the Waste and Pollution Control Administrator power to issue permits. The Act came into force on 1st January 2009 and the Department of Environment has been to date encouraging commercial and industrial facilities to submit in their application for a permit. The EMA 2005 is coupled with the Environment Impacts Assessment Regulations 2007, Waste Disposal and Recycling Regulations 2007 and National Waste Management Strategies (Solid, Liquid, and Air).

Waste Management Policy: To improve the management of solid waste, a number of institutional measures have been implemented such as the review of the National Solid Waste Management Strategy 2005-2010. The new Strategy, covering the period 2011-2014, incorporates a new thematic area of Sustainable Financing to address waste management projects that are not dependent upon Government subsidies. The Litter Decree was amended in 2010 to allow officials as Litter Prevention Officers. There are other policies related to Medical Waste Management, Industrial or Trade Waste and container and plastic recycle are being initiated and under various phase of discussion and finalization.

National Climate Change Policy (NCCP): The NCCP was endorsed by the Fiji cabinet in 2007, formulated based on the Climate Change Policy Framework. It was aligned to the Roadmap for democracy and sustainable socioeconomic development 2009–2014, which highlighted the need for priority protection for the environment, sustainable management and utilisation of natural resources. The NCCP policy has a clear vision “A responsible and exemplary Fiji, leading the Pacific in combating climate change and achieving resilience, while attaining sustainable development”. To realise this vision the policy has eight objectives with specific strategies to implement them. One of these objectives is Mitigation: "Reduce Fiji’s greenhouse gas emissions and implement initiatives to increase the sequestration and storage of greenhouse gases."

Approach & Methodology

As discussed earlier, this study intends to quantify and assess the amount of waste resources available in Fiji for power generation and identify technology options for feasible implementation of waste to energy projects.

This report focuses on quantification and assessment of the amount and types of waste resources available in Fiji for waste-to-energy power generation. The subsequent reports under the study will assess the feasibility of quantified waste resources and sites for power generation, recommend appropriate waste to energy technologies including effective implementation framework for waste to energy power generation facilities in Fiji.

The methodology adopted for the development of this report involved identification, collection, research and review of relevant national and regional data and reports, national policy and regulatory documents, consultation with relevant stakeholders including line ministries, development partners, power utilities, academic institutions, private power produces and NGO's.

The detailed list of collated data and documents has been included in the reference section of the report. The list of stakeholders met and consulted is provided in Annex 1.

Some of the estimates are based on similar studies carried out elsewhere including assumptions and factors that relate domestic, agricultural and demographic statistics to the amount of residue generated. A detailed description of the methodology used is provided throughout the document under various waste streams considered for quantification.

Detailed on-site analysis for the identified potential waste to energy projects will be carried out under the subsequent assessment and reports; however, this analysis should be useful in refining the prospecting process of site identification.

Key Stakeholders for Waste to Energy Sector

Government Ministries and Institutions

Government ministries and institutions play a vital role in terms of promotion and deployment of waste to energy initiatives by providing appropriate support through development of efficient policy and regulatory framework. Some of the key roles include: providing a long term vision and a consistent policy framework; supporting IPP's through attractive fiscal and financial incentives for investment in waste to energy sector initiatives; Training, building capacities including raising awareness on waste to energy among key players; Developing clear strategy and legal framework for waste to energy policy implementation and enforcement; and encouraging private sector participation through initiatives such as public private partnerships.

In Fiji, the key stakeholders under the Government ministries and institutions include:

- Department of Energy(DOE), Ministry of Public Works, Transport and Public Utilities
- Department of Environment, Ministry of Local Government, Urban Development, Housing and Environment
- Ministry of Agriculture, Forestry & Fisheries
- Ministry of Finance Ministry of Lands and Mineral Resources
- Ministry of Strategic Planning, National Development and Statistics
- Climate Change Division, Ministry of Foreign Affairs and International Cooperation(DNA of Fiji)
- City Municipal Councils and local Civic bodies

Non-Government Organizations (NGOs)

Non-Government Organizations (NGOs) can play an effective role in building public awareness including training and capacity building of stakeholders at national and local levels on waste to energy initiatives through mobilization of community action including voicing local concerns. NGOs can also be promoters of such initiatives by supporting implementation of pilot scale demonstration projects. They can also play an advisory role in terms of providing inputs on policy and regulatory aspects.

The key NGO stakeholders in Fiji include:

- WWF Fiji and South Pacific
- International Union for Conservation of Nature (IUCN), Oceania
- Foundation of Peoples from South (FSPI)
- Partners in Community Development (PCDF)

Financial Institutions

Access to short- and long-term finance and related financial services is one of the key drivers for accelerated implementation of waste to energy initiatives. Financial institutions could play a pivotal role in promoting such initiatives through providing ease of access to finance in the form of risk-appropriate instruments at reasonable costs and in appropriate currencies. The absence of such conditions and a lack of liquidity, maturity, and transparency in the financial sector can increase financiers' perceived investment risk and therefore the cost of financing, and thus is a barrier to the development of new sectors such as waste to energy in Fiji. The key financial institution entities include: Investment Fiji; Fiji Development Bank and South Pacific Business Development.

Electricity Utility Companies

The Fiji Electricity Authority (FEA) is the Government-owned authority vested with the responsibility for the generation, transmission and distribution of public electric power supply in Fiji. For market actors to engage at any scale in emerging sectors such as waste to energy in Fiji, there must be guarantees that there is a level playing field with stable conditions and that tariffs offered by FEA permit profits for developers. FEA can encourage waste to energy sector through providing supportive tariff rate and structure, regulations, reforms and incentives for IPP's and project developers.

Academic Institutions

The role of academic institutions would be to research on new and appropriate waste to energy technologies and to build capacities and raise awareness among relevant stakeholders. The institutions can also assist in technical hand-holding of project proponents in terms of developing the project feasibility and design documents, monitoring and reporting. The key academic institutions in Fiji include: University of South Pacific; Fiji National University and University of Fiji.

Regional Institutions

The regional institutions or Council of Regional Organisations in the Pacific (CROP) agencies have a key role to play in terms of coordinating the national and regional stakeholders on waste to energy plan and actions. These agencies also mobilise technical and financial resources in association with development partners for effective implementation of the identified waste to energy plans and actions. The entities include:

- Secretariat of the Pacific Regional Environment Programme (SPREP)
- SPC Applied Geoscience and Technology Division (SOPAC)
- Secretariat of the Pacific Community (SPC)
- Pacific Islands Forum Secretariat

Private Sector (including IPP's)

The private sector including the IPP's is increasingly getting recognized as the engine that will drive capital flows into waste to energy initiatives which also support climate change mitigation. Private sector entities could include project developers (IPP's), commercial banks/financial institutions, technology/equipment suppliers, technical advisors/consultants and industry bodies/associations.

International Development Partners/Organizations/Donor Agencies

These agencies mainly focus on development and implementation of comprehensive strategy and action plans on waste to energy initiatives with the host country as well as in the region in association with the regional and national institutions and stakeholders.

- United Nation Development Programme (UNDP)
- Global Environmental Facility (GEF)
- United Nation Framework Convention on Climate Change (UNFCCC)
- Asian Development Bank (ADB)
- Australian Agency for International Development (AusAID)
- Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)
- United Nations Environment Programme (UNEP)
- World Bank
- European Commission

Quantification and Assessment of Waste Generation in Fiji

This section includes the quantitative and qualitative assessment of various potential waste resources for energy generation and main characteristics of available waste resources for each identified waste streams in Fiji. The potential waste to energy resources discussed in this report includes:

- Municipal Solid Waste (MSW)
- Sewage and Sludge (Waste Water)
- Livestock Waste
- Biomass Waste
- Non Hazardous Industrial Organic Waste
- Agricultural Crop Residues

Municipal Solid Waste (MSW)

In Fiji municipal solid waste (MSW) is generated by the general public during their day to day activities, household solid waste (kitchen waste, plastic, paper etc.), small business activity (like construction, restaurants, hotels etc.) and by market. In general the MSW consist of wood and wood products, pulp, paper and cardboard, food, food waste, beverages, textiles, garden, yard and park waste, glass, plastic, metal, other inert waste.

Under the Environmental Management Act 2005, and 2007 Environmental Management (Environmental Impact Assessment, and Waste Disposal and Recycling) Regulations, the Department of Environment, under the Ministry of Local Government, Urban Development, Housing and Environment, has the authority for waste management and pollution control in Fiji.

In addition, the Department of Environment is also responsible for setting criteria and guidelines for landfill and dumpsites. Under the Public Health Act, the Central Board of Health (CBH) is responsible for monitoring of proper disposal of wastes to minimize risks to public health. Also, under Section 52 of the Public Health Act, councils are required to seek endorsement of the CBH for by-laws that cover charging of fees for solid waste collection.

The National Solid Waste Management Strategy (NSWMS) 2011– 2014 outlines a vision for the management of solid waste in Fiji, and include goals and associated actions for achieving the sector vision.

Under the Local Government Act, City and Town Councils are responsible for the management of solid waste. The Act requires councils to “do all such things as it lawfully may and as it considers expedient to promote the health, welfare, and convenience of the inhabitants.” Councils are permitted under the Act to make by-laws for these purposes. Councils also play a vital role in protecting the environment through enforcement of the Litter Decree 2010, Public Health Act, and Open Fires by-laws; recycling activities; collection of garbage; and provision of other services, such as street sweeping.

Table 1: City and Town Councils in Fiji under various divisions and the corresponding MSW disposal sites

Division	City/Town Council	Disposal Site
Central	Lami	*Naboro Landfill*
	Nausori	
	Nasinu	
	Suva	
Western	Lautoka	*Lautoka Dump*
	Ba	*Ba Dump*
	Tavua	
	Sigatoka	*Sigatoka Dump*
	Rakiraki	*Rakiraki Dump*
Northern	Savusavu	*Savusavu Dump*
	Labasa	*Labasa Dump*
Eastern	Levuka	*Levuka Dump*

The NSWMS (based on the HYDEA study[1]) estimates the MSW generated in Fiji based on the population (2007 census) and per capita generation rate of 0.4kg/person/day.Table 2 below summarizes the quantity of waste generated in each division as per the NSWMS

Figure 3: Naboro Landfill, Suva (Source: Department of Environment)

Figure 4: Vunato Rubbish Dump, Lautoka (Source: Lautoka City Council)

Table 2: Estimated Quantity of MSW Generated in Fiji

Division	Population (2007 Census)	Annual MSW Generation (Ton/year)
Central	342,386	49,988[12]
Western	319,611	46,663
Northern	135,961	19,850
Eastern	39,313	5,739
Total	**837,271**	**122,240**

Table 3 below provides the estimated annual quantity of MSW (includes all waste) disposed to landfills or dumps in Fiji. The data for Naboro landfill and Lautoka dump are from actual weighbridge returns. The MSW quantities for other dumps have been estimated based on various sources such NSWMS, DoE survey from 2011, per capita generation and population assessment etc.

Table 3: Estimated Quantity of MSW Landfilled/Dumped in Fiji

Location of Landfill/Dump	Estimated MSW Received (Ton)	Estimated Biogenic (Organic) MSW Received (Ton) [13]
Naboro Landfill	65,145	42,344
Lautoka Dump	24,954	16,220
Ba Dump	3,000	1,950
Sigatoka Dump	7,300	4,745
Rakiraki Dump	1,500	975
Savusavu Dump	1,000	650
Labasa Dump	2,500	1,625
Levuka Dump	1,300	845
TOTAL Landfilled/Dumped (Ton/Year)	**106,699**	**69,354**

The disparity in the figures used to determine waste generated and actual waste collected and disposed could be due to a significant amount of waste that is not collected possibly due to lack of resources. For the purpose of this study, the MSW that is currently being collected and disposed at the landfill or dump site is considered as the potential waste resource available to explore energy generation opportunities.

Sewerage and Sludge

The Fiji National Liquid Waste Management Strategy and Action Plan, 2006, provide overall guidance on the management and disposal of liquid wastes in Fiji. The Department of Environment, under the Ministry of Local Government, Urban Development, Housing and Environment is the nodal agency for regulating liquid waste management strategy in Fiji.

[12] Excludes market waste from Suva which contributes to 20% of Suva's waste

[13] Based on Suva City Council MSW characterization study – 65% organic matter including green waste

The Water Authority of Fiji (WAF or Water Authority) is the Commercial Statutory Authority (CSA) established by the Government of Fiji to provide efficient and effective water and wastewater services in an environmentally sound and sustainable manner. WAF is responsible for providing access to quality drinking water and waste water services to over 144,000 residential and non-residential metered customers reaching over 800,000 people nationwide and is in charge of public water supplies, sewerage services and energy in Fiji.

Public sewerage systems in Fiji consist of the collection of sewage wastewater from houses, institutions and hotels by an underground piping system flowing to a sewage treatment plant. There are 11 public sewerage systems operating, and most of them service urban populations. Significant portions of the population in these centers are not connected, although the carrying capacity of most of the STPs is underutilized[14].

Currently there are 11 major domestic wastewater treatment facilities in Fiji. The table 4 below provides an overview of the major sewage treatments plants in Fiji including the applied method of treatment and volume of sewage treated.

Figure 5: Kinoya Sewage Treatment Plant, Suva-Nausori (Source: WAF)

[14] Government of Fiji (2006), Fiji National Liquid Waste Management Strategy and Action Plan

Table 4: Major Sewage Treatments Plants in Fiji and Volume of Sewage Treated

Centre	Treatment Method	Volume of Sewage Treated (m^3/day)	Average BOD[15] in Raw Effluent (mg/l)
Suva	3 – primary clarifiers	24,500	420
	3 – trickling filters		
	2 – secondary clarifiers		
	2- sludge digester		
	1 enclosed flare		
	1 SBR plant		
	3 – sludge lagoons		
	20 – Drying beds		
Nausori	1 clarifier with 4 Aerators, 1 sludge lagoon and 2 maturation ponds	600	420
Pacific Harbour	1 – Primary clarifier	691	280
	2 – Trickling Filters		
	1 – Secondary Clarifier		
	4- Drying beds		
Lautoka	2 – Anaerobic Ponds	6,750	300
	2 – Facultative Ponds		
	2 – Maturation Ponds		
Nadi	2 Oxidation ditches, 1 clarifier, 2 digesters lagoons, 2 idea lagoons, 1 final effluent lagoon and 1 belt press system	3,000	250
Sigatoka	2 anaerobic lagoons, 1 facultative lagoons and 2 maturation ponds	600	320
Ba	2 anaerobic lagoons, 2 facultative lagoons and 1 maturation pond with 3 baffles	975	350
Labasa	2 anaerobic lagoons, 2 facultative lagoons and 1 maturation pond	900	250
Adi Cakobau School	1 primary clarifier, 2 filters, 1 secondary clarifier	150	290
Wailada	1 clarifier	150	100
Naboro	1 Oxidation ditch, and 1 clarifier.	300	200

[15] Biochemical oxygen demand (BOD) is a measure of the quantity of oxygen used by microorganisms (e.g., aerobic bacteria) in the oxidation of organic matter. The BOD values could be used to determine the methane generation potential from wastewater.

Livestock Waste

Livestock farming in Fiji consists of dairy and beef cattle, sheep, goats, pigs and poultry. It has been evident from the 2009 Agricultural census that the expiry of land leases has significantly reduced the amount of agriculture land available for livestock and to the decrease in livestock numbers. The Animal Health and Production division under the Ministry of Agriculture is the nodal agency for livestock in Fiji.

Ruminant feeding systems rely predominantly on tethering and enclosed grazing, with some cut and carry feeding. Commercial dairy cattle receive a lot of supplementary feed. Pigs are often kept in large communal stone-walled enclosures located separately from garden lands in protected secondary forest stands, often between villages and inland gardens. The total cattle herd reported in 2009 Agricultural census was 134,411 heads, with 22,155 farms involved in cattle farming and with an average of 6 heads per reporting farm. The Western Division is the major cattle farming region, with nearly 48% of the total herd. Lau Province is the largest cattle farming province with 45% of the total herd, followed by Naitasiri with 43.9% of the herd.

As per the 2009 census, the Central Division has dominated the dairy farming with approximately 70% of the total of 1,126 farms involved in commercial dairy farming. A total of 22,551 dairy cattle were reported in the 2009 census of which 10,175 were milking cows.

The larger beef farms are located in Yaqara, Taveuni, Uluisaivou and Yalavou and are mainly supervised while the other farms are categorized as semi commercial and smallholder farms. The total number of beef cattle (20,263) in each division in 2009 was reported as 3,205 in Central Division, 12,704 in Western Division, 4,162 in Northern Division and 192 in Eastern Division.

Table 5: Overview of Cattle Farms, Heads and Estimated Volume of Dung Generated

Division	No. of Cattle Farms	No. of Cattle	Estimated Quantity of Dung Generated (t/day) [16]
Central	4,628	44,827	448.27
Western	10,803	57,630	576.3
Northern	6,359	30,529	305.29
Eastern	365	1426	142.6
Total	**22,155**	**134,412**	**1,472.46**

Farms with pigs are found in all of the islands at commercial, semi-commercial and subsistence level. The highest percentage (31%) of pigs is in the Central Division according to the 2009 census.

The total number of pig farms recorded in 2009 was 12,981 with a total population of 73,698 pigs, and an average of 6 pigs per farm. The major pig producers are Lau with 10,290 heads followed by Cakaudrove which accounted for 9275 heads.

[16] Based on 10kg/head/day manure generation for cattle

Figure 6: Cattle Farm in Fiji (Source: Department of Agriculture)

Figure 7: Piggery at the Naboro Correctional Facility (Source: IUCN)

Table 6: Summary of Piggeries in Fiji

Division	No. of Piggeries	No. of Pigs	Estimated Quantity of Manure Generated (t/day) [17]
Central	4,126	22,498	33.75
Western	2,274	14,677	22
Northern	4,439	19,692	29.5
Eastern	2,142	16,832	25.25
Total	**12,981**	**73,699**	**110.5**

[17] Based on 1.5kg/head/day manure generation for Pigs

There has been a large increase in poultry production as a result of high local demand for chicken and eggs and higher preference for chicken compared to lamb and beef.

As per the 2009 census, there are 2,706 farms in Central Division, 9,385 in Western Division, 10,958 in Northern Division and 366 in Eastern Division with a total of 3,734,835 chickens and ducks. The key issues experienced by the poultry industry include high mortality rates due to unfavorable weather conditions, damages to infrastructure as a result of cyclones, flooding and the high cost of feed.

Figure 8: Rooster Poultry Farm, Ba (Source: Sunergise)

Table 7: Summary of Poultry[18] Farms in Fiji

Division	No. of Poultry Farms	No. of Poultry	Estimated Quantity of Manure Generated (t/day) [19]
Central	2,706	3,23,387	32.33
Western	9,385	3,231,156	323.1
Northern	10,958	1,74,354	17.4
Eastern	366	5,938	0.6
Total	**22,155**	**134,412**	**373.4**

The total number of sheep as per the 2009 census was 14,068 animals with more than 95% of this number in the Northern and Western Divisions. Key issues experienced by the industry include high mortality rates from dog attacks, worms and deaths from unfavorable weather conditions.

[18] Poultry includes Chicken and Ducks

[19] Based on 0.1kg/head/day manure generation for Poultry

Table 8: Summary of Sheep Farms in Fiji

Division	No. of Sheep Farms	No. of Sheep	Estimated Quantity of Manure Generated (t/day) [20]
Central	47	516	1
Western	355	6,537	13
Northern	409	6,873	13.74
Eastern	8	142	0.28
Total	**819**	**14,068**	**28.02**

Goat industry has been the sole supplier of goat meat to the local market with a small proportion through imports. There has been a high demand of goat meat in the domestic market. The 2009 census results reveal that there were a total of 101,196 goats in 2009 which declined from 187,235 goats in 1991. Among various constraints of the industry are inadequate housing and fencing which give rise to predators (dogs/humans), to deaths from unfavorable weather conditions, to inconsistent supply of drenches and lack of breeding stock for genetic improvements.

Table 9: Summary of Goat Farms in Fiji

Division	No. of Goat Farms	No. of Goat	Estimated Quantity of Manure Generated (t/day)
Central	464	4,640	9.28
Western	4,772	48,186	96.37
Northern	4,029	46,995	94
Eastern	144	1,376	2.75
Total	**9,409**	**101,197**	**202.4**

Table 10: Summary of Estimated Livestock Waste Generation data for Fiji

Type of Livestock	Estimated Quantity of Waste Generated (t/day)
Cattle	1,472.46
Pigs	110.5
Poultry	373.4
Sheep	28.02
Goat	202.4

Biomass Waste

The DoE in association with Japan International Cooperation Agency (JICA) is currently undertaking a comprehensive assessment of hydro and biomass resources for power generation in Fiji. Hence, this section on biomass waste assessment is envisaged to compliment the JICA study and assessment on biomass waste resources.

[20] Based on 2 kg/head/day manure generation for Sheep and Goat

Bagasse

In Fiji sugar contributes to about 2.2% of GDP and accounts for nearly 11.7% of Fiji's total merchandise export. Sugar cane production used to be the backbone of Fiji's economy; that supports the livelihoods of approximately 200,000 Fijians. However, it has declined by around 34% from a total of 3,380,000 tons in 1991 to 2,197,950 tons in 2009. The total area under sugarcane has decreased from 112,192 hectares in 1991 to 57,177 hectares in 2009.

The Fiji Sugar Corporation (FSC) is the government-owned sugar milling company in Fiji having monopoly on production of raw sugar in Fiji. The Government of Fiji is a major shareholder that owns 68% of shares while statutory bodies, local companies and individuals own the remaining shares. FSC owns and operates four sugar mills located at Lautoka, Ba and Rakiraki on the main island of Viti Levu while Labasa mill is located on the second largest island of Vanua Levu.

FSC plans to crush around 1.85 million tons of sugarcane during 2014. FSC estimates that around 25% of the quantity of sugarcane crushed will be the bagasse generated.

Figure 9: FSC Lautoka Sugar Mill (Source: FSC)

Table 11: Quantity of Cane Crushed and Bagasse Produced at FSC Sugar Mills

Name of Sugar mill	Quantity of Cane Crushed (ton/year) (2013)	Quantity of Bagasse Produced (ton/year)
Lautoka	484,600	121,150
Rarawai	581,000	145,250
Labasa	612,000	153,000
Penang	180,000	45,000
Total	**1,857,600**	**464,400**

The four sugar mills owned by the Fiji Sugar Corporation (FSC) Limited have a collective electricity generating capacity of around 48 MW during the sugar cane crushing season. The boilers in these mills are fuelled by bagasse. Wood chips/Firewood is used to supplement bagasse in some mills during off-season when there is shortage of bagasse or when the open-

air-stored bagasse is in an advanced stage of decay. The bagasse is generated on site while whatever wood chips/firewood used is purchased locally. FSC mainly depends on electricity from the FEA grid during the off-season period.

Table 12: Installed Capacity and Electricity Production by FSC Sugar Mills

Name of Sugar mill	Installed Capacity (MW)	Power Export During Crushing Season (MW)	Total Power Generated (2013) (KWh)
Lautoka	12	6	17,474,151
Rarawai	9	3	8,990,508
Labasa	24	14	15,208,450
Penang	3	0	3,738,200
Total	**47**	**23**	**45,411,309**

The FSC is also planning to install new power generation facilities at Labasa (10 MW) and Rarawai (40 MW). The proposed cogeneration facility at Labasa is being planned to operate even during off-season using surplus bagasse and wood chips procured from third party sources. The plant is expected to be commissioned during late 2014. The feasibility study for the Rarawai plant has been completed and the plant is expected to be operational by 2016. The cogeneration plant is expected to run throughout the year using bagasse generated from Rarawai (70%), Lautoka (15%) and Penang (15%) mills.

The steady fall in sugar cane production since 2006 has made uncertain the prospects for continued bagasse based power generation. The sugar cane production in Fiji has fallen from 3.2 million tons to 1.5 million tons in 2011. In turn, the quantity of bagasse available has fallen accordingly. Although the Fijian Government has invested considerably in re-vitalizing the sugar industry, its future remains uncertain and with it the future of thermal generation from this waste product.

Logging and Forest Industries

Fiji has around 52% of the land area covered by forest with indigenous forest accounting for around 90 percent (857,530 hectares) followed by hardwood plantations 5.5 percent (52,950 hectares) and softwood plantations 4.5 percent (46,380 hectares). On an average indigenous forests are being consistently logged at a rate between 100,000 to 150,000 cubic meters annually.

The key varieties logged over rainforests in the wet regions on Viti Levu and Vanua Levu includes the Caribbean pine and mahogany. Logging is managed by Fiji Government-owned commercial companies, Fiji Pine Limited and the Fiji Hardwood Corporation Limited. Fiji Pine Trust, a trust for the landowners of the Pine plantations, manges pine plantations in the outer islands of Fiji.

According to FAO, the trend in native forest harvesting is now declining in Fiji with 61,000 m^3 logged in 2007. It is expected that the native forest harvesting would remain constant and/or decline till 2020. However, pine harvesting is expected to increase to 850,000 m^3 and mahogany logging to 200,000 m^3 by 2020. Log production in 2020 is estimated to reach 1.1 million m^3/year, mainly from plantation forests.

Figure 10: *Logging residues (Source: SOPAC)*

Between 2004 and 2008, the national annual natural forest log production averaged 125,300 cubic meters per annum. The total log production of natural and pine average around 481,270 cubic meters per annum. The Forestry Department's national target for sustainable harvest of natural forests is 110,000 cubic meters per annum. In Fiji, logs are mainly processed into sawn timber, veneer, plywood, block board, molding, poles and posts, and woodchips. Forestry residues mainly include wood residues from logging and wood-processing activities. Logging residues are the unused portions of trees cut during logging operations and left in the woods. These include stumps, branches, leaves, off-cuts, and sawdust. Wood-processing residues, or primary mill residues, are composed of wood materials (such as discarded logs, bark, sawdust, and shavings) generated at manufacturing plants—sawmill, veneer mill, plywood mill, or pulp mill—when round-wood products are processed into primary wood products.

Figure 11: *Saw milling and Wood Processing residues (Source: TWIL)*

Figure 12: *Plywood and Veneer Residues (Source: SOPAC)*

Tropik Wood Industries Limited (TWIL), one of the biomass wastes based IPP's in Fiji, maintains around 46,000 hectares of pine forests and currently process around 300,000 t/year of logs as part of sawmilling and wood chipping operations. The waste barks and fines (14% of the logs processed) from wood processing operations are currently being used as feedstock for power generation through direct combustion of biomass at the two power plants (3 MW & 9.3MW). According to TWIL, most of the biomass waste generated currently is being consumed by the existing power plants and no excess or surplus biomass waste is available.

Figure 13: TWIL Biomass Waste Power Plant at Drasa (Source: TWIL)

TWIL in association with GIMCO (Korean Company) is also planning to establish a 12 MW wood waste based power generation facility at Nabouwalu during early 2015. The fuel supply is planned to be secured through growing short rotation crops as energy plantation and chipped in a chipping plant to be established on site.

TWIL also operates a saw mill at Wariki in Vanua Levu which is currently being powered through diesel generators. The wood residues and waste biomass from this mill are currently being stock piled and partly used for generating steam to dry timber. TWIL has no immediate plans to install biomass waste power generation faculty at Wariki due to in-adequate grid facility to evacuate the generated electricity. TWIL has expressed willingness to consider establishing power plant in case FEA extends the grid coverage on Vanua Levu.

Fiji Pine Trust (FPT) maintains around 3,100 hectares of pine plantations in the outer islands of Lakeba, Kadavu, Gau, Moturiki, Matuku, Cicia and Beqa. FPT processes logs around 550 m^3/month, as part of its sawmilling activities. It is estimated that approximately 60% - 65% of sawn-logs are turned to waste wood and 35% - 40% are converted to sawn timbers. The biomass residues and wood waste generated from FPT activities are currently being left in the forests or at the processing facilities. Further information on FPT is included in Annex 2.

FEA is planning to establish a 3MW biomass power station near the Waidradra settlement in Deuba (near Navua) at the FEA's existing diesel power station site. It is estimated that around 26,000 tons of biomass feedstock per annum will be required for the plant. The Fiji Hardwood Corporation is expected to supply the feedstock.

A 2MW biomass power station is also being planned in Savusavu, Vanua Levu, close to a timber processing sawmill. The biomass feedstock requirement is around 22,000 tons waste and is expected to be supplied by sawmill in the form of coconut tree waste.

Table 13: Estimated Biomass Residues from Forestry and Log Processing Activities

Activity Type	Volume Processed[21] (m^3/year)	Percentage of Biomass Residues Generated[22]	Estimated Volume Biomass Residues Generated (m^3/year)
Logging			
Natural Forests	64,991	50%	32,496
Pine	294,122	14%	41,177
Mahogany	80,092	25%	20,023
Wood Chips	420,000	15%	63,000
Saw Milling	80,439	60%	24,132
Wood Veneer Sheets	17,000	15%	14,450
Plywood	8,000	50%	4,000

Non Hazardous Industrial Waste Water

Sugar cane normally contains about 70-80 % moisture. Sugar mills generate a considerable amount of waste water during crushing and processing of sugar cane. It has been observed that each ton of cane crushed produces about 0.73 m3 of water if sugar and water are completely separated. Additional water is also required in the sugar mills as mill floor washing, cooling water for barometric condensers, boiler fed water, lime preparation, for power pumps and evaporators.

[21] Based on Key Statistics 2013, Fiji Bureau of Statistics

[22] Based on FAO STATS and Inputs from Department of Forestry, TWIL and FPT

The sugar mills are estimated to generate the waste water in the ratio of 1:2 quantity of sugarcane crushed to waste water generated. The sugar mill effluents are having higher amount of alkalinity, total suspended solids (TSS), dissolved solids TDS, BOD and COD.

As the data on the volume of wastewater generated at the FSC sugar mills was not available while writing this report, the same has been estimated based on the quantity of sugarcane crushed at all the four FSC sugar mills. The general characteristics of the wastewater generated at sugar mills has been included in the table 15 below based on similar studies carried out elsewhere globally.

Table 14 : Estimated Volume of Wastewater Generation from FSC Sugar Mills

Name of Sugar mill	Quantity of Cane Crushed (ton/year) (2013)	Estimated Volume of Wastewater Generated (m^3/year)
Lautoka	484,600	969,200
Rarawai	581,000	1,162,000
Labasa	612,000	1,224,000
Penang	180,000	360,000
Total	**1,857,600**	**3,715,200**

Table 15: Typical Characteristics of Sugar mill Effluent[23]

Parameter	Value
BOD (mg/l)	500
COD (mg/l)	2500
Total Suspended Solids (mg/l)	400
Total Solids (mg/l)	5200

Waste water generated by breweries and distilleries generally contains high organic loading (BOD, COD & TS) levels. It is estimated that breweries produce typically 2-6 to liters of waste water per liter of beer produced. The effluent stream from distilleries also known as spent wash is a dark brown highly organic effluent and is approximately 12-15 times by volume of the product alcohol. Paradise Beverages (Fiji) Limited manufactures and sells beer, ready-to-drink alcoholic beverages, and soft-drinks in Fiji and Samoa. The South Pacific Distilleries uses the molasses from sugarcane to make the Fiji brand of rums. Similar to sugar mill effluents, the data on the volume of wastewater generated by Paradise Beverages and South Pacific distilleries were not available while writing this report; the same has been estimated based on the data available in the draft SNC report on quantity of beer and spirits produced.

[23] International Journal of Chemical and Physical Sciences (2013), Characterization and Comparative study of Cane Sugar Industry Waste Water, ISSN:2319-6602

Table 16: Estimated Volume of Wastewater Generation from Breweries and Distilleries in Fiji

Alcoholic Beverage Type	Quantity Produced (m^3/year)	Estimated Volume of Wastewater Generated (m^3/year)
Beer	19,655	78,620[24]
Spirits	640	8,320[25]

Agricultural Crop Residues

According to the 2009 Census, there are 65,033 agricultural farms in Fiji. Agricultural land use is broken down into temporary crop land, fallow land, permanent crop land, pastures, coconuts, natural forest, planted forest and non-agricultural land. The highest percentage of actual land use (31%) is for permanent crops, pastures (19%) and natural forest (17%).

The main agricultural crops in Fiji include sugar, coconut, yaqona, dalo, rice, ginger, cassava and tropical fruits. In Fiji, ginger is a non-traditional commodity but has become an important export commodity, providing a ready source of income and employment for many rural households.

Coconut is still regarded as a good source of income especially in the maritime areas generally grown in the eastern and northern divisions. As per the 2009 survey, 14,270 hectares was categorized as bearing area out of the total area of coconut planted, a decline from 35,299 hectares in 1991. The total area reported for coconut in 2009 was 17,757 hectares, a significant reduction from the 49,812 hectares in 1991. The key factors influencing the decline in coconut plantation include natural disasters (cyclones and drought), expiry of land leases, industrial developments, low yield (25 nuts per tree per year), high transportation costs and low profitability due to unfavorable market prices.

[24] Based on an estimate of 4 litres of waste water generated per litre of beer produced.

[25] Based on estimate of spent wash is approximately 13 times by volume of the product alcohol.

Figure 14: Vuna Coconut Plantation in Fiji (Source: Department of Agriculture)

Dalo in Fiji is a commonly grown root crop both for domestic consumption and for export. As per the 2009 census, the total area of dalo plantation was 15,194 hectares resulting in production of 56,645 tons.

Cassava is one of the root crops grown throughout the year at subsistence and commercial Level and is one of the most common staple foods in the diet of ethnic Fijians. The area of cassava plantation was 15,447 hectares in 2009 with annual production of 58,772 tons. The main cassava producing provinces were Naitasiri, Tailevu, Ra and Cakaudrove.

Figure 15: Sugarcane Residues during Harvest (Source: SPC)

Yaqona (Kava) is an important cash crop for the rural farmers and is produced in all divisions across Fiji. The northern division accounted for around 41% of the production in 2009.

Kava (processed yaqona) is a traditional drink and is also a common social drink in Fiji and other Pacific Island countries. The total area of yaqona plantation was 8,884 hectares but as per the 2009 census only 3,601 hectares were matured.

Figure 16: *Cassava Plantation in Fiji (Source: Department of Agriculture)*

Rice is a staple crop in Fiji, consumed by all communities and is cultivated under three farming schemes: irrigated, rain-fed dry land and dry land farming. There has been a constant decline in rice production in Fiji with an estimated 4,288 tons, in 2009.

As per the 2009 census, the major fruits grown in Fiji include paw paw, pineapple, and banana with plantation area of 220, 445 and 1,087 hectares respectively.

Fiji produces a variety of basic food crops, including rice, cassava, other roots and tubers, sugarcane, vegetables, coconuts and tropical fruits. After these crops have been harvested and processed, various residues and by-products remain, such as stalks, straw, husks, and shells. No data have been published on the quantities of crop residues and agro-industrial by-products produced in Fiji. However, the agricultural crop residues in Fiji has been estimated based on crop production statistics (Agricultural Census 2009) and using appropriate crop to residue ratios (FAO STATS).

Table 16: Estimation of Agricultural Crop Residues in Fiji

Crop Type	Production (Tons)	Type of Residue	Crop to Residue Ratio[26]	Moisture Content (%)	Residue (Dry) (Tons)
Cassava	58,772	Stalk	0.06	15	2,997
Dalo	56,645	Stalk	0.06	15	2,889
Yaqona	6,067	Stalk	0.06	15	310
Coconut	10,634	Husk	0.42	10	6,476
		Shells	0.7	13	4,020
	17,757	Fronds	2.4 dry tons/ha/yr	N/A	42,617
Rice	4,288	Straw	0.45	12.71	1,684
		Husk	0.27	12.37	1,015
Pawpaw	335	Peels	0.25	15	71
	220 ha	Stem/Leaves	89 dry tons/ha/yr	N/A	19,580
Banana	3,392	Peels	0.25	15	721
	1,087 ha	Stem/Leaves	89 dry tons/ha/yr	N/A	96,743
Pineapple	445 ha	Leaves	80 tons/ha/yr	80	35,600

[26]Based on FAO STATS (www.fao.org/docrep/006/AD576E/ad576e00.pdf)

Socio-economic and Environmental Implications of Waste to Energy Projects in Fiji

Management of waste resources and utilization could play a major role towards creating a sustainable low carbon economy. This would result in minimization of waste generation, reuse and recycling of waste resources which could to avoid damage to the environment and human health. Waste is now not only a risk, but also an opportunity to be utilized as an energy source to feed into the national energy demands to some extent (if strategically utilized). Energy is one of the most influencing sectors of any country for its GDP growth and sustainable development.

Like any other country in the region, Fiji is heavily dependent on imported petroleum products as a source of energy for its industrial, commercial and transportation sectors, as well as to supplement electricity generation for domestic consumption. The majority of the imported petroleum fuel is used in the transportation and power generation, both these rely heavily on imported fossil fuels.

In SIDS like Fiji, Waste to Energy projects could play a vital role to achieve national goals of waste management, clean energy development including socio-economic and environment sustainability of the country towards ultimate goal of sustainable development.

Utilization of available waste resources to generate electricity as substitute for fossil-based fuels offers many attractive benefits for Fiji. Pursuing waste to energy projects in Fiji could accelerate agricultural development, assist in technological advancement and bring employment opportunities resulting in improved quality of life. Utilization of waste to energy resources can increase access to modern forms of energy for the Fijian people as these can be converted to gaseous fuels, electricity and process heat. In addition, producing generating electricity through waste resources reduces the country's dependence on foreign energy sources and vulnerability to supply disruptions. Mainly the commercial viability of waste to energy projects would significantly increase through avoided waste disposal costs by using the waste material as a resource.

The major environmental benefit from using biomass to displace fossil fuels is the reduction of greenhouse gas emissions. Associated benefits to the reduction in GHG emissions include efficient utilization of waste resources, protecting natural habitat including improving biodiversity.

The waste to energy initiatives could further contribute to economic sustainability of Fiji through the establishment of new enterprises and subsequently more jobs, affordable access to carbon neutral energy, the gain of economic value from materials otherwise considered waste, and cost savings through zero or less waste and emissions from waste to energy facility and entire operation chain. However, efficient and effective channeling of funds and investment needs to happen in order to develop appropriate practices, infrastructure, equipment and services.

Waste to energy technologies are envisaged to provide benefits to the whole macro-economy by creating jobs and improving social welfare. In the social context these projects generate new jobs, create learning opportunities, build and transfer new skills including training and educational opportunities. Development of waste to energy distributed energy systems and independent power production could potentially lead to decline in urban drift as rural communities can participate, develop and grow utilizing the new source of energy generation. This could assist in development of a sense of pride and independence, which is of particular importance to rural communities who are struggling to maintain their cultural identities.

Waste to energy generation sector as a whole and its individual operations have the potential to contribute in numerous ways for Fiji to become a sustainable economy, however to do so minimum social, environmental and economic standards and practices need to be met and upheld.

On the other hand, absence of sustainable waste management and energy generation from waste practices could have an adverse impact on the economy and in turn negative impacts on socio-economic aspects and the environment ultimately resulting in a net cost to the economic system.

Conclusion & Next Steps

This report estimates the waste to energy resources currently and potentially available in Fiji. As discussed in the report, a variety of waste to energy resources exists in the country with large quantities and opportunities for expansion.

Based on the assessment of waste resources, it appears that some (MSW, biomass, livestock) of the waste streams identified in Fiji have reasonable potential for power generation. The next reports under the study will assess the feasibility of quantified waste resources and sites for power generation. Some of these potential projects could play a valuable role in stand-alone electricity applications and be particularly effective for rural electrification in remote rural areas. On the other hand, waste residues and resources, resulting mainly from medium and large sources and enterprises; provide opportunities for large-scale centralized power generation.

The next step now is to assess the feasibility of resources and identify potential sites suitable for establishing Waste-to-Energy power generations facilities in Fiji. The second report under the assignment will specifically address this aspect through carrying out site specific surveys of identified potential projects.

Further, the use of waste resources as substitute for fossil-based fuels offers many attractive benefits for Fiji. The key socio-economic benefits include private sector investment opportunities, employment generation, rural electrification and poverty alleviation. There are additional benefits to the environment in terms of offsetting the GHG emissions associated with burning fossil fuels and anaerobic digestion of biogenic waste and waste utilization.

Annex 1: List of Key Stakeholders Consulted

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Annex 2: Information on Fiji Pine Trust (FPT)

Area of Pine Forest managed by the Fiji Pine Trust in the outer islands.	1.Lakeba Pine Scheme = 1,600ha 2. Kadavu = 910ha. 3. Gau = 300ha 4. Moturiki = 140ha 5.Matuku = 95ha 6. Cicia = 50ha 7. Beqa = 25ha Other islands requesting to be registered under the Fiji Pine Trust are: Ono-i-Lau; Moala; Totoya; Vanua Balavu; Vanuaso, Gau.
Name and location of processing facilities.	1. Tubou, Lakeba with 3 Portable sawmills. 2. Makadru, Matuku 1 Portable Mill 3. Lovu, Gau 1portable sawmill will be launch next month - a government Project. 4. Cicia in Lau 1 Portable mill as in 3 above. 5. Moturiki 1 Portable mill is inplace -we are still applying for a License with Forestry.
Quantity of logs processed at each of the above facilities	1. Lakeba= 150m³/month 2. Matuku= 60m³/month 3. Gau = 100m³/month 4. Cicia = 150mm³/month 5. Moturiki = 100m³/month
Quantity of waste wood during processing at each of the above facilities.	Approximately between 60% - 65% of saw-logs are turned towaste wood and therefore 35% - 40% are converted to sawn timbers. It should be noted also that about 10% of the volume of pine trees in the forest are of bad forms/or poor qualities that cannot be utilized commercially.

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