

**Identifying and Managing system weaknesses and
challenges for a successful Renewable Energy
Technologies' deployment in Small Island
Developing States**

Exploring the case of Seychelles

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Abstract

Dependence on fossil fuel is an issue for the many countries, it is particularly challenging for Small Island Developing States. Reliance on fossil fuel is becoming for many SIDS an economic burden. Due to the constant fluctuation in oil prices which leads to high fuel prices, high cost of living, and high electricity bills when the price of this commodity is high. This results in constant pressure on the government to provide more subsidies; which is not a long term economic solution. As a result many SIDS have started to see the benefits of harnessing the local energy resources they possess as a means to reduce their dependence on fossil fuel, diversify their energy mix and ensure long term energy security for their country. The introduction of Renewable Energy is seen as an economic viable solution in this uncertain environment. This study identifies the potential of Renewable Energy in the Islands of Seychelles, the barriers faced by the country in deploying Renewable Energy technology to harness such potential and also provide solutions and recommendations to create a more enabling environment for the deployment of Renewable Energy.

To assess the potential, the barriers and provide solutions an analytical framework was developed to analyse the data collected and findings from the research. The main framework for analysing the local energy system and identify the barriers to Renewable Energy, is the Innovation system framework and to assess the Renewable Energy potential an adapted framework from Mundaca et al. and Van Alphen et al. was used. Findings from the research show that there is potential in the Seychelles for the deployment of Renewable Energy technologies. However the barriers identified if not managed appropriately will lead to the failure of the emerging innovation system.

Keywords: Renewable Energy, Innovation System, Renewable energy Technology, SIDS, Energy diversification

Executive Summary

Seychelles is a small island developing states located in the Indian Ocean and like many other small islands states it is heavily dependent on fossil fuel in fact it is 100% dependent on fossil fuel for its electricity and transportation needs. This dependence cost the country about 10% of its GDP every year and with the increasingly fluctuating price of oil this percentage also fluctuates. The result being that the price of electricity has increased by more than 25% in the last 3 years. This brings with it many social and economic consequences both for the country and for its people. Due to the heavy economic burden of fossil oil the government has recognised the importance of developing and harnessing the country's abundant natural resources to provide clean sustainable energy for the country. This will have the benefits of reducing the country's dependence on fossil fuel, reduce the amount of money spent on importing fossil fuel and improve the country's energy security. The government has set a target for a 15% share of renewable energy within the country's energy supply mix by the year 2020.

This study tries to bring in a new angle on the topic of Renewable Energy (RE) a discourse which is still in its emerging phase in the Seychelles. This study is different from past studies as it looks at the potential but also explores the current local Innovation System and how this can guide the deployment of RE in the country. With past researches especially regional ones the focus have been primarily on regional potential and as a small country such research does not provide an in depth analysis. While research on Seychelles have focus on the energy system as it is and not much depth with regards to RE potential or the challenges which exists within the country to deploy Renewable Energy Technologies (RET). This research thus focuses on analysing the current local energy environment and how this can aid or impede the deployment of RET within the Seychelles and also provides an analysis of the country's RE potential. The research thus tries to answer these following questions:

RQ-1 What type of RET have the potential of being deployed in the Seychelles?

RQ-2 What are the challenges and weaknesses that are impeding the deployment of RET in the country?

RQ-3 How can these weaknesses be surmounted to create an environment conducive to the deployment of RET and the growth of the local RE system?

For the research a number of frameworks have been used to guide the analysis. The innovation system framework is the overarching framework being used to analyse the current local energy environment. This will help to assess how conducive it is to deploy of RET in the Seychelles and through the same framework identify where weaknesses lies. The analysis will also be a means to propose solutions which could be used to convert these weaknesses. Thereby helping in the creation of a more enabling environment for the introduction of RE. The second framework being used is a mixed framework one developed by Mundaca et al. to assess Clean Development Mechanism (CDM) wind projects in India in combination with a framework developed by Van Alphen et al. to assess renewable potential in the Maldives. This mix will be used to assess the Seychelles RE potential.

Interviews with various stakeholders have been an important prerequisite to gather information on the current energy system, its issues and to gather information on past researches that have been done in Seychelles with regards to assessing the various RE sources. The findings from the interviews and other literature on the current energy situation where the basis for the analysis.

From the assessment of the RE potential within the country against the mixed framework which also answers the first research question the best potential exists with regards to solar Photovoltaic (PV) and Solar Water Heater (SWH) for households and tourism development, there is also potential for the deployment of wind especially offshore or in conjunction with solar PV, there is also a good potential to deploy landfill gas, while biogas is a solution for the long term future or can be implemented in parallel to the landfill gas though this will require the implementation of a Waste Management Plan. While there is natural resource potential for these technologies in many cases these are economically and technically not viable due to the lack of a conducive RE environment. The Innovation System framework was thus used to analyse the current local RE environment to identify system and functional weaknesses and to also formulate solutions and recommendations which will help remove these impediments.

Therefore to answer the second research questions these weaknesses were identified from the analysis. These are a lack of capacity and qualified human resources to guide this deployment through the creation of policies, regulations, to assess potential and development proposal. There are no fiscal incentives to increase entrepreneurial activities, create markets and demand and to further mobilise resources. There is a lack of information and know how available to users, decision makers and investors and the network used to share the available knowledge is limited leading to information not reaching stakeholders. There is also a lack of consultation and public participation to further strengthen the Knowledge creation process and aid diffusion of said knowledge.

Therefore to ensure that the current emerging RE innovation system, though, deficient does not fail but grows and strengthens over time more needs to be done by government as the private sector cannot do all on its own. While government may not have the intention of doing more after the wind farm which it will run is commissioned, this can change if more interest is shown as NGOs, the private sector and foreign investors can and should exert pressure on them to create an environment conducive to RET with policies, regulations and fiscal incentives. If this does not happen, the fear with the lack of a conducive environment is that if the price of fuel oil drops on the international market, or due to the high cost associated with RET and the high transaction cost associated with RE deployment is that the country will go back to the status quo being dependent on fossil oil.

To prevent this from occurring a number of solutions and recommendations have been formulated which will help create a more conducive environment which will aid the deployment of RE within the Seychelles. This will also answer the third research question posed. The suggested solutions vary and have been formulated to help remove specific barriers impeding the systems functions. Refer to Table I below for the suggested solutions and recommendations.

Table I- Suggested solutions and recommendations

1.	Develop Local technical and institutional capacity through training, the sharing of foreign know how and through identifying where knowledge weaknesses exists so that programmes can be developed to manage these.
2.	Develop RE awareness amongst people to form advocacy coalition, this should be done by the NGO through workshops and educational programmes in the various districts to raise awareness educate people and get them to back such projects.
3.	Create supportive policy to guide and help RE deployment as the current environment is not conducive to RE deployment therefore financial incentives should be provided, laws, policies and guidelines which will help guide the deployment of RE should be provided.
4.	Create an energy strategy for the country to set out the plan of action on how things should be achieved and who is responsible and how long they have to achieve this will make the various department more accountable. In addition clear targets needs to be set by the government of the percentage of RE generated electricity it wants introduced in the electricity mix to ensure that IPPs invests in RET.
5.	Using CDM as a means to deploy RE through the creation of a National CDM authority which will help promote CDM project and help develop the RE potential within the country.
6.	A Resource Assessment should be carried out in the country to assess where the countries potential lays, the extent of this potential. This can be done in partnership with international research institute. This information should be made available to all stakeholders to further broaden the knowledge base.
7.	Create an RE fund to aid the deployment of the technology such a fund can be made available to finance RE projects within the country and will be an additional incentive to aid the deployment of RET.
8.	The provisions of land for the implementation of RET especially those located on reclaimed islands which will be allocated to RE development. These lands can be used for pilot projects, for local research and development and for the implementation of RE projects.
9.	The tourism industry should play an active role in RET deployment through the policy develop by STB to encourage the use of these technologies. The use of RET in the tourism development which exists or proposed will be a great way to showcase the Seychelles as a truly green destination.
10.	Increase Regional Partnership to aid the deployment of RET in Seychelles as it is a member of SADC and COMESA it can through regional cooperation develop its RE sector and benefit from the sharing of knowhow from other country in the region, it can benefit from the importation of RE products from the region at zero tax

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Abbreviations

AfDB- African Development Bank

AOSIS- Alliance of Small Island States

BOAA- Bureau of African Affairs

CAT- Centre for Alternative Technology

CDM- Clean Development Mechanism

COMESA- Common Market of Eastern and Southern Africa

CROP- Committee of Regional Organisations of the Pacific

DESASD- Department of Economic and Social Affairs Statistics Division

DoE- Department of environment

DoET- Department of Energy and Transport

ECOWAS- Economic Community of Western African States

EE- Energy Efficiency

EIA- Environmental Impact Assessment

EUIB- European Union Investment Bank

FED- Forum for Energy and Development

FTC- Fair Trading Commission

GDP- Gross Domestic Product

GEF- Global Environment Facility

GHG- Green House Gas

GoB- Government of Barbados

GoJ- Government of Jamaica

GoM- Government of Mauritius

GoS- Government of Seychelles

GST- Goods and Service Tax

IADB- Inter American Development Bank

IDC- Island Development Company

IEA- International Energy Agency

IMF- International Monetary Fund

IPP- Independent Power Producer

IPCC- Intergovernmental Panel on Climate Change

IS- Innovation System

JPSCo- Jamaican Power Supply Company

LCE- Levelised Cost of Electricity

MEEA- Ministry of Energy and Energy Affairs

NGO- Non Governmental Organisation

NSB- National Statistics Bureau

ODA- Official Development Assistance

PPA- Power Purchasing Agreement

PUC- Public Utilities Corporation

PV- Photovoltaic

R&D- Research and Development

RE- Renewable Energy

REEEP- Renewable Energy and Energy Efficiency Partnership

REP- Renewable Energy Plan

RES- Renewable Energy Sources

RET- Renewable Energy Technology

SADC- Southern African Development Community

SBC- Seychelles Broadcasting Corporation

SCCF- Sustainable Climate Change Fund

SEC- Seychelles Energy Commission

SEF- Sustainable Energy Framework

SEPEC- Seychelles Petroleum Company

SIB- Seychelles Investment Bureau

SIDS- Small Island Developing States

SPV- Solar Photovoltaic

STB- Seychelles Tourism Board

SWH- Solar Water Heater

TT- Technology Transfer

UNCTAD- United Nations Conference on Trade and Development

UNDESA- United Nations Department of Economic and Social Affairs

UNDP- United Nations Development Programme

UNSD- United Nations Statistics Department

UNEP- United Nations Environmental Programme

UNFCCC- United Nations Framework Convention on Climate Change

WB- World Bank

WCED- World Commission on Environment Development

1 Introduction

1.1 The energy situation in Small island Developing States

Energy security¹ is important for all countries in the world and has become a critical element for their survival and development. For Small Island Developing States (SIDS) this has also become an important element to ensure their future development and survival. SIDS are unique in so many ways and face many challenges that other small island developed nations² may not necessarily face. Though SIDS are geographically and culturally diverse they share similar environmental and economic vulnerabilities and have the same sustainable development challenges (AOISIS et al., 2008). This is why in 1989 at the 44th UN General Assembly these islands were given special consideration by the United Nations, due to their size and the special challenges they faced with regards to their environment, economy and development, after decades of advocacy from the United Nations Conference on Trade and Development (UNCTAD) (UNCTAD, 2011; Climatelab, 2011).

The UN Defined SIDS as...

'Low lying coastal countries that tend to share similar sustainable development challenges, including small but growing populations, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, excessive dependence on international trade and fragile environment.'

Though initially no criteria had been defined to determine an official list of SIDS, the United Nations Department of Economic and Social Affairs (UNDESA) made a list of 52 countries which are today defined as SIDS and most of these are located in tropical regions (UNDESA, 2011; Climatelab, 2011). These countries' development and growth is also affected by high communication, expensive public administration, infrastructure, energy and transportation costs. This situation is made worse due to these countries small size, and their lack of opportunity to create economies of scale (Forum for Energy and Development (FED), 2005; UNCTAD, 2011; Climatelab 2011). According to UNCTAD (2011) SIDS are 34% economically more vulnerable than other developing countries. Additionally their level of merchandise import is 24% higher than other developing countries due to declining domestic food production. These small states are also vulnerable to climate change effect though they only contribute 1% of the total GHG emission in the World and probably contributed even less historically (UNFCCC, 2007).

In addition to many of these issues SIDS are also heavily dependent on imported fossil fuel, some examples to outline this dependence include Jamaica and Barbados which are 90% dependent on fossil fuel, while Mauritius is 96% dependent and Cape Verde which has a dependency of about 78% (Weisser, 2004; Stuart, 2006). According to Weisser (2004) petroleum products for many SIDS accounts for more than 12% of imports and these are used mostly for electricity generation and the transport sector. Due to this high dependence on imported fossil fuel such as oil to generate electricity and for the transport sector these countries are easily affected by increased in fuel prices. Oil price volatility has become a significant issue in the world as it affects every sector in society and influences the economic development of many countries. In the past few years such price volatility has become a

¹ Energy security is a function of the ability of a nation to satisfy the energy needs of current and future generations in an affordable manner without adverse impact on the environment and sustainability (Pandey 2008).

² This refers to small islands that are dependent on a developed country example Reunion island economically dependent on France, Hawaii, Guadeloupe and Martinique small islands dependent on France

common occurrence. Triggered by civil unrest and wars in oil producing countries, increasing global oil demand especially from emerging economies, shortages in the supply side which is not enough to meet the growing demand as the resource becomes scarcer and market speculations which can distort market outlook and lead to economically inefficient resource allocations (IEA 2010).

SIDS are also sensitive to economic crisis which can lead to the devaluation of their currencies, increases in price of imported goods, including oil. Such crisis usually leads to fluctuations in the oil prices which in SIDS usually results in higher inflation rates which ends up affecting every aspects of the country from increase food prices, transportation prices and social services (Stuart, 2006).

As a result of all these issues in 1994, after the Barbados UN Global Conference on the Sustainable Development of Small Island Developing States, the Barbados Programme of Action (BPOA) was made. The BPOA was seen by SIDS has the most important framework for guiding development strategies and policies at national, regional and international levels (Weisser, 2004). The BPOA identified priority areas where these countries needed assistance and one such priority area was energy resources, and according to Climate lab, 2011, not much had been done as part of the programme since its creation. As a result of this lack of action the Mauritius Programme of Action (MPOA) was prepared in 2005 to succeed the BPOA, the MPOA reiterated many of the initiatives and recommendations set out in the BPOA (UNCTAD, 2011).

While SIDS are highly dependent on fossil fuel they also have ample alternative energy sources but this potential is at present not being harnessed to its full capacity. According to the Climatelab, (2011) and the SIDSSEI, (nd) the saving potential that can be made due to reduce fossil fuel imports through the introduction of Renewable Energy is immense. It has been estimated that all SIDS collectively in 2008 paid a total of US\$ 90 million each day for more than 900 000 barrels of oil (priced at US\$ 100 a barrel). However if this money was invested in Renewable energy generation about 60 MW of wind energy could be installed (estimation is based on a 1 MW turbines costing US\$ 1.5 million) in 2008. These investments according to Climatelab (2011) will pay for themselves for as long as they can generate clean energy.

Due to their small size, the high transportation cost, infrastructure cost and a lack of grid connection that can service a larger volume of customers at lower costs, SIDS according to Stuart (2006) and Climatelab (2011) tend to pay more per unit of electricity produced compared to other countries in the world. Therefore as a means to help reduce this cost in the long run, improve these countries long term energy security, while also improving these islands social, economic and environmental wellbeing renewable energy is seen as a good way to provide the stated improvements (Climatelab, 2011).

Energy Efficiency (EE) is also an important component in ensuring energy security and it has an important role in reducing GHG emission. It can also help reduce the electricity demand in a country. SIDS have also seen the benefits of EE and are working towards raising awareness amongst population to promote its benefit (GoM 2009, GoJ 2010, MEEA 2011, REEEP 2010abc, and REEEP 2011). According to the IEA (2011a) the EE potential like that of RE is still not being utilised to the maximum, a view shared by UNEP which stated in the 2007 Global trends in Sustainable Energy Investment that the EE market is a significant but largely invisible. However recently due to the high fuel costs and economic crisis, energy efficiency development has found its importance and has increased. EE is seen as a powerful and cost-effective tool for achieving a sustainable energy future. As improvements in EE can reduce

the need for investment in energy infrastructure, cut fuel costs, increase competitiveness, improve welfare and reduce the GHG emissions (IEA 2011b). In addition environmental benefits can also be achieved by the reduction of greenhouse gases emissions and local air pollution. Energy security also benefit from improved energy efficiency through the decrease reliance on imported fossil fuels (IEA 2011b).

1.2 Opportunities for energy diversification in Seychelles

The Seychelles islands are one of these SIDS and like many it has a high dependence on fossil fuel, this is becoming problematic for the country due to high importation cost and fluctuation in oil prices. As a result the government has become interested in reducing this dependency by diversifying the country's energy mix (SEC, 2011). Diversification of the energy mix can help ensure a country's energy Security to help reduce its energy vulnerability

The Seychelles are 100% dependent on fossil fuels for its electricity production and for its transportation needs. This represents a per capita consumption of 2.4 tonnes of oil equivalent per year and this is considerably higher than the African average (REEEP, 2010). Moreover the import of fossil fuel costs 10% of the Country's GDP³ yearly this represented about US\$76.4 million in 2009 (REEEP, 2010). As a result of this high per capita consumption and the complete dependence on fossil fuel for all the country's energy service there is a need to diversify the energy mix. This can be achieved through the introduction of available renewable energy sources to help reduce the country's dependence.

In 2006 the electricity demand and consumption was 218 million kWh however a total of 252 million kWh of electricity was generated in the Seychelles, showing a 13% loss during the transmission and distribution of the generated electricity (REEEP, 2010). The per capita electricity consumption is about 1600 kWh per year according to REEEP, (2010). This represents a total of 141 million kWh for the permanent population. While the per capita electricity use for the 140, 627 visitors who came to Seychelles in 2006 was 533kWh. However this is an assumption as it is not clear how tourists and long term residents are accounted for in the local statistics.

In Seychelles the sole control of providing electricity lies in the hand of the government through a parastatal company called the Public Utilities Corporation (PUC). In addition to the government being solely responsible for electricity production, it is also responsible for the provision and importation of petroleum products. This is done by the Seychelles Petroleum Company Limited (SEPEC) another parastatal company. These state owned companies are vertically integrated authorities (with the same owner) and have the monopoly in their respective sectors (REEEP, 2010). As a result there are no competitions in either of these sectors currently on the islands. This lack of competition and complete monopoly does not create an environment conducive to the introduction of alternative energy source from the private sector within the current energy mix.

The country does have the technical potential for Renewable Energy which can replace at least some of the fossil fuel currently in use to generate electricity; however this has yet to take off. According to the Renewable Energy and Energy Efficiency Partnership (2010) (REEEP) a number of pilot studies have been carried out in Seychelles to investigate the potential of solar and wind energy. One such project was the investigation of wind potential on the main island Mahe. This project was going to be carried out by the MASDAR group in conjunction with

³ GDP for 2009 was \$764,296,578 according to the World Bank 2011

the Seychelles Government and was supposed to start in 2009 (REEEP, 2010). The main focus of the project according to The Tree Hugger website's 2009 is on the feasibility of wind power with an initial target of generating 18MW of power representing about 10-15% of the main island demand. However as of 2011 the project proposal has been changed and MASDAR will only implement a 6MW wind farm which will cover 3% of the main island electricity need (SEC, 2011). As of June 2011 nothing had been done on site with regards to the project. There is also a 600 Watt Photovoltaic pilot project that has been implemented by the PUC to assess this potential (REEEP, 2010). Renewable Energy in Seychelles is limited to use for solar water heater but even this did not take off as was intended, due to a lack of awareness of the benefits, limited incentive and not much interest from government (SEC; Webber 2011).

It is clear that despite the abundant resource potential of RE in Seychelles and the potential benefits it will bring to the country in terms of energy security little progress has been made to ensure its deployment and use. With the price of fossil fuel fluctuating and rising Seychelles in particular and SIDS in general will do well to try and harness the available resources they possess to ensure that their future development is one that is sustainable for all. The potential reasons for this inaction are numerous. It can be due to a lack of policy, legislations, knowledge and technology or due to a lack of finances but it can also be due to the *laissez faire* attitude that some countries and governments have (Van Alphen et al., 2007; Webber, 2011). However these are all assumptions that also apply to Seychelles and further research will be helpful in identifying the reasons for inaction.

1.3 Research Gap

From the review of literature on Seychelles and its energy system it was found that while many of the research looked at assessing the RE potential in Seychelles none looked at identifying the various barriers at play and how to turn these into enablers except for the Energy policy prepared by Vreden et al. in 2010 which briefly touched upon some of the barriers in the current energy system not specifically that of RE. In addition the past researches were ill documented and did not provide a framework to outline the assessment of the potential or the deployment of RETs in Seychelles for Seychelles. Identifying and assessing the barrier in Seychelles is still an area that needs to be researched. Especially as the country is at a crossroad where the choice made will define the country's future energy outlook and whether it is one that will lead to long term energy security or insecurity and internal energy crisis. Research should be focused on not just pointing the problem but it should also provide solutions on how to ensure that it is the former outcome that prevail which the other research have not emphasised.

1.4 Research Objectives and Outcome

The research aims to contribute to the deployment of renewable energy technologies in the Seychelles. It has a number of objectives, including but not limited to improving the knowledge on the barriers and drivers for RE deployment in SIDS. The research also aims to improve the documented knowledge on the RE potential in Seychelles. It also aims to identify the barriers to RET deployment in the Seychelles so as to provide recommendations to enable and facilitate the deployment of RET.

From the objectives and the intended outcome the following research questions were formulated:

RQ 1-What type of RET have the potential of being deployed in Seychelles?

RQ 2- What are the challenges and weaknesses that are impeding the deployment of RET in the country?

RQ 3- How can these weaknesses be surmounted to create an environment conducive to the deployment of RET and the growth of the local RE system?

1.5 Target Audience

The main audience for this research is the government of Seychelles, the decision makers of the country. However they are not the sole audience for this research hopefully this paper will be useful for other SIDS, UN bodies such as the UNEP and UNDP, International Organisations and economic partners of Seychelles and NGO's to know how and where they can help to bring about change and aid in the deployment of Renewable Energy in SIDS especially in Seychelles.

1.6 Methodology

The research methods employed for the thesis are qualitative in nature. This involved literature review primarily to gather information on the Seychelles and other SIDS. Secondly desktop research was carried out to find information on other SIDS, international organisations, and private companies dealing with deployment of renewable energy. Thirdly the research was based on semi structured interviews with a number of stakeholders in Seychelles. The literature review was used to provide a good background and also set the context of the topic under research. The interviews were used on the one hand to help fill in the gaps that were identified from the literature. Additionally interviews also helped put things in perspective in a real life context which may differ from research data in literatures.

The thesis research was based on the development of a case study which is focused on the Seychelles Islands. The case study is developed from existing research done in Seychelles and identified gaps. The focus of this research is on SIDS which is what Seychelles is.

The first part of the research was to identify what researches have been done in Seychelles on the subject of Renewable Energy. From the initial readings on the topic of Renewable Energy in Seychelles, there is reason to believe that there is some level of research that has been carried out. These researches have been used as part of REEEP information package on their website, from REEEP it seems that research have been carried out on Wind, Solar and to some extent Biomass in Seychelles. However these data needs to be verified to ensure their validity. For the research efforts was made o locate the original research data from the source which is the UNEP Office in Seychelles however this did not yield any success. Confirmation was thus obtained from an employee who had worked on some of these researches.

From these, the point was to identify what are the gaps in the Research and what this thesis can add to the overall Renewable Energy discourse within the Seychelles. In addition to identifying researches done, statistical data was also collected from a number of governmental agencies and from the Seychelles Statistical Bureau for use in the preparation of the case study. The amount of information obtained helped with defining the scope and limitations of the study.

The literature analysis was carried out to identify the barriers and the potentials in Small Island Developing States of the implementation of renewable energy. It also helped to discover what other SIDS are doing with implementation of renewable energy and identify best practices from these countries that can be applied as a solution for Seychelles. Additionally the analysis helped in the identification of funding mechanisms for the implementation of the renewable

energy identified. The literature investigation also helped to identify possible means to transfer technology from developed to developing countries. It was also used in the identification of possible framework to help guide the analysis part of the research. The literature review was used to investigate the potential role of Clean Development Mechanism in the implementation of Renewable Energy in SIDS. Identify the costs and payback time for the alternatives being investigated. Investigate and identify possible financial mechanisms that can be used to support the deployment of the energy sources identified. Look at what is happening in other Small Island Developing States and assess their success and failures and the possible reason for such outcome.

Interviews were carried out in the Seychelles with stakeholders from the various governmental department and ministries. This provided an idea of what the various governmental departments are doing when it comes to Renewable Energy on the islands. Interview was also carried out with a Non Governmental Organisation (NGO) in Seychelles, Sustainability 4 Seychelles (S4S). This is a group that is actively working with Sustainability issues and educating the local community on the islands on the subject. An attempt was made to interview stakeholders from the four SIDS to confirm the information obtained from literature but this was to no avail. Attempt was also made to obtain an interview with the United Nations Development Programme (UNDP) Office in the Seychelles to find out what role they play with regards to renewable energy research and deployment. However the outcome was not positive as I was referred back to the Seychelles Energy Commission. In addition an interview was carried out with a private company working with the introduction and implementation of renewable energy in Seychelles.

For the interviews participants were contacted by an emailed letter initially and phone calls for participants within the Seychelles. This helped schedule the face to face interviews with local stakeholders. Questions for stakeholders outside of Seychelles were emailed to them and they were all contacted via email. Face to face interviewees were made aware of why they were being interviewed and what the research is about, from the initial email sent to them. Interview method was chosen as it is more flexible and can allow for modification and adaptation along the way to probe respondents on the issue. In addition this qualitative research method is ideal for small scale study like this one (Rubin et al., 1995). Interviews were recorded for future references and to ensure that the information obtained is used appropriately. This was used to identify the reasons for inaction in the Seychelles. Once these were identified it was then possible to answer the third research question. And this was answered through lessons learned from other Small Island Developing States' through the literature analysis and through the interviews that were carried out with the various stakeholders.

From the literature review, data collection and interviews carried out in the Seychelles the next step was the analysis phase. Data was analysed using a mix of framework including the Innovation System framework to analyse how best to aid the transfer and deployment of technology. An adapted framework will also be used to analyse the potential of each of the RE sources identified in terms of their cost, how easy it is to deploy these technology in Seychelles, the institution feasibility and how sustainable they are. This phase helped with the formulation of discussion and the development of recommendations to guide future research or development for the island. Refer to Figure 1-1 outlining the research pathways.

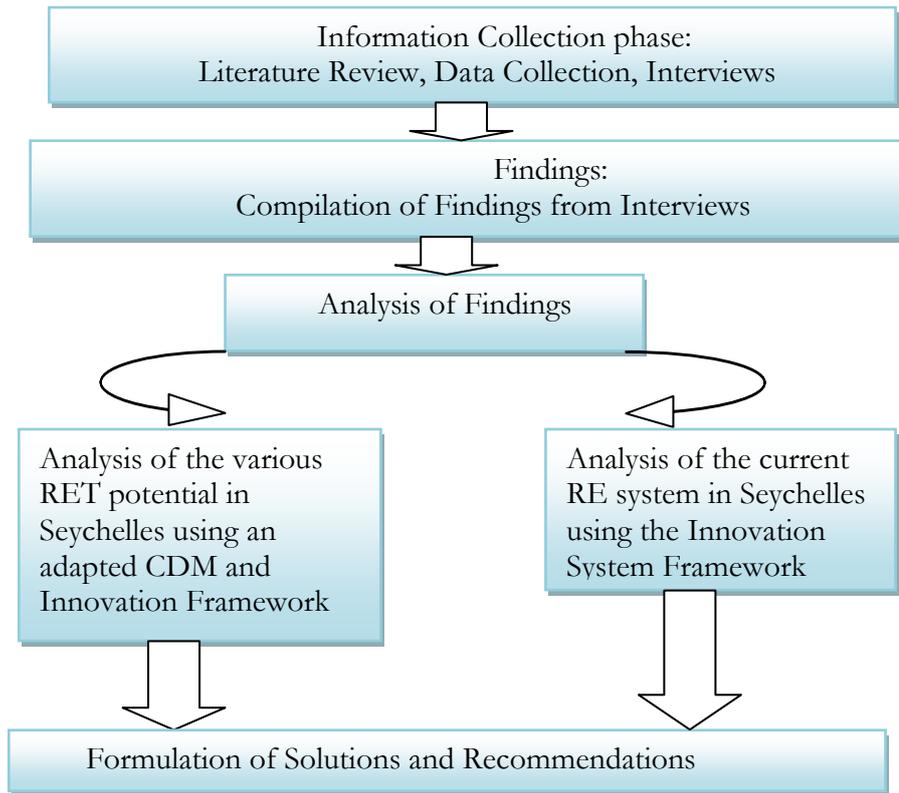


Figure 1-1 Research pathway for the study

1.6.1 Analytical Framework

First part of the analysis will look at the various RE sources and their potential and feasibility. An adapted framework from Mundaca and Rhode, (2005) used in assessing CDM wind projects in India will be used. This will be used together with an analytical framework employed by Van Alphen to assess RE deployment in the Maldives will be used to assess the potential of the different RE system identified in terms of their potential in Seychelles. This will help determine which of the options will be more feasible or that will have the best chance of getting deployed in Seychelles and will help answer the first research question posed. The second part of the analysis will involve understanding the current macro-environment of the Seychelles that is the barriers and drivers which exists and how these have influenced the current energy system. It will also look at how these will influence the energy system in the future. The Innovation system framework (IS) will be used to determine which factors are at play in the current energy system in Seychelles and how these influence the existing system. This framework will also be used to assess whether these options have a chance of being deployed as a result of the current environment in Seychelles. The framework will also help to provide an environment which is conducive to aid the said deployment. The Innovation System framework (IS) is used because like Van Alphen et al., (2007) in their study carried out in the Maldives it is important to have an established and functioning Innovation System before any technology can be successfully transferred. The use of this framework will help answer the second and third research questions being asked.

1.8 Scope and Limitations

The geographical scope of the research being carried out is on SIDS these have been defined in section 1.1. Therefore comparison from Literature reviews is based only on islands that fall within this category which excludes other small islands that are part of or dependent to certain extent on developed countries. The reason is that even though these are small islands there

context and issues might not be the same as those islands identified by the United Nations as SIDS. The case study will focus on one particular SIDS, the Seychelles islands.

In terms of the scope of RE technologies the research will evaluate the potential of various form of RE including solar, hydro, waves, waste to energy, biomass and wind to assess their ease of implementation in the Seychelles.

The focus of the research will be entirely on the energy sub sector of electricity generation and the replacement of the fossil fuel used for that purpose with Renewable Energy and will not look at the transportation sector. Though it is clear that this sector also uses a large quantity of fossil fuel, the potential exists for its transformation especially with the use of electric cars but this is outside of this paper's scope. The research will also not look at the transmission, distribution and the electricity system as this is out of the scope of the research. This research does not aim in turning the island into a Renewable Energy Island with 100% Renewable Energy (FED, 2005) this is too ambitious for the project at hand. The research focuses on RE deployment in the production of electricity and therefore will not look at energy efficiency though its importance has been outlined in section 1.1 this is however out of the scope of the paper.

In terms of access to data, limitations encountered in Seychelles are the lack of Research or should we say a lack of written document on such research. Additionally to this lack of publish material it was really hard to find or get in contact with people who had worked on certain research as they had left their post. The lack of publish document was a limitation, however this was not the only limitation, getting interview with participants was not an easy process and this had an impact on the amount of information that was gathered on site. Interviews with some key stakeholders like the Public Utilities Corporation, Energy Department, the Ministry of Finance and the Seychelles Investment Bureau did not materialise. With the case of the PUC the problem was understandable as the country is going through a drought and the PUC being responsible for supplying the country with water had more pressing issues.

Additionally since the country has just had an election there were shift and changes in government composition which caused further delay getting interviews and the subsequent analysis. Further to this due to the size of the country and the lack of expertise in the field of Renewable Energy in Seychelles the number of participants for interviews is few. This lack of expertise was the biggest challenge which came to the fore while seeking interviews and where all the letters and queries were being forwarded to the Seychelles Energy Commission as most people felt that this was not their field and they therefore had no role to play in this field.

Another limitation encountered is a lack of good statistical data with regards to the energy sector these are too old, incomplete or inaccurate but in many cases these do not exist. This makes it hard to carry proper analysis as in many cases two documents on the same topic might be giving the reader conflicting data and information. The issue with a lack of accurate data is that it is not clear where the mistakes occurs and there are no means to inquire as energy statistics are not collected by the National Statistics Bureau.

Time was also a limitation for this study as it was not possible to get interviews with some key stakeholders in Seychelles.

1.9 Thesis outline

Chapter 1 introduces the topic being researched and how the said research will be carried out. Chapter 2 presents the findings from literature analysis which will look at what other SIDS

have done in the field of RE. The challenges they faced and how these were surmounted. It also presents more information on existing financial assistance that what can be obtained by SIDS. Chapter 3 provides background information on the case study area Seychelles which looks at past research in the country, the energy sector structure, how it functions and provides a comparison between Seychelles and the four identified SIDS. Chapter 4 outlines the findings pertaining to RE potential in the Seychelles and gives the assessment of this potential against the adapted framework described in the methodology. Whereas Chapter 5 gives the findings from the interviews describing the existing energy system in Seychelles and provides the subsequent analysis of the said findings using the IS framework. From the analysis this chapter also offers solutions and recommendations that can be used to aid the deployment of RE in the Seychelles. Chapter 6 summarises the findings and analysis by answering the questions presented in Chapter 1 and provides next step forward for the country.

2 Status of Renewable Energy in Other SIDS

The literature used in the analysis will provide the background information on the topic of RE deployment in SIDS. This will include a look at four SIDS Barbados, Cape Verde, Jamaica and Mauritius. These four countries were chosen as they have implemented RE and they have achieved this using diverse means. It should be noted that there are other SIDS that have successfully deployed RE but due to time constraints this section cannot look at all of them, so these four countries were chosen subjectively by the author. This section will also show the barriers that these countries and other SIDS have faced. It also looks at what these countries and other SIDS have done to convert these barriers into drivers to aid the deployment of RE in their countries. The literature analysis will also explore some of the financial schemes available to SIDS to assist in RE implementation. The review will also provide some ideas for the analytical part of the paper and possible recommendations for the Seychelles.

2.1 Small islands Developing States RE cases

The four cases that will be described were chosen because they have a history with the implementation of RE. These countries have implemented some form of RE within their energy mix and have long term plans for the deployment of RE. All the countries being looked at have very high dependence on fossil fuel but also a high potential for RE which is as yet not being harnessed to its full potential however these countries are trying to remedy this situation through their Energy Plans and strategy.

2.1.1 Barbados

Barbados is an island of about 431km² with about 271 000 people located in the Caribbean. The country is ranked high amongst Latin American and Caribbean countries economically and socially (IADB, 2008). The country has a GDP per capita of US\$14422 and the economy is dependent on its chemicals and metal manufacturing industries (UNSD, 2011). According to UNSD, 2011 the per capita energy use in Barbados is about 1.5 toe. Barbados as a country has a long history with the use of RE. While this is the case the country is 90% dependent on fossil fuel and imports about 9 000 barrel of oil per day in which 50% is used to produce electricity and 33% is used in transportation (IADB, 2008). This according to the Barbados Today (2011) costs the country about US\$230 million about 6% of the country's GDP in 2009. According to the Barbados Today (2011) the aim of the Government is to reduce the use of fossil fuel in the country by 30% through the introduction of RE. It is estimated that the 21% reduction which the government plans to achieve in electricity consumption over a 20 year period will save the country about US\$48 million per year in oil import (Barbados Today, 2011).

In the past a popular form of RE known as bagasse⁴ was used as a source of fuel for heating in industries. As of 2010 according to REEEP, RE contributed about 15% of the total energy supply in Barbados due to its extensive use of SWH (REEEP, 2010b). Barbados is known as a leader in this technology, which is widespread on the island. In 2005 about 35 000 systems was in operation representing a saving of US\$6.5 million annually on oil imports; these SWH are locally built and are today considered a standard equipment for all new buildings (REEEP, 2010b; FTC, 2010). Currently in Barbados RE in the energy mix is mainly from bagasse and SWH.

The country has also outline a number of RE project it has either started, are at the pilot stage or which are at the feasibility study stage. The government has since 2002 started a feasibility

⁴ Cellulose by product of crushed canes

study to assess the potential of using high fiber sugar cane bagasse and biomass as a source for generating electricity and a substitute to fossil fuel (IADB, 2008; REEEP, 2010b). The goal is to provide about 30MW of electricity to the grid from this mix (REEEP, 2010b). As for solar photovoltaic a 17.3 kW system is planned at Harrison's Cave. With regards to wind an impact assessment was carried out in 2006 to look at the possibility of introducing wind on the island through this study the Barbados Light and Power Company (BLP) in partnership with Schneider electric started the construction of a 10 000kW wind farm in the north of the island which will generate 32 million kWh per year enough to cover the average annual electricity needs of 10 600 homes (IADB, 2008; REEEP, 2010b). The government also has plans to build a 1000 to 2000kW Capacity biogas plant at the central Barbados garbage dump to convert landfill gas to electricity (REEEP, 2010b).

Barbados has a Sustainable Energy Framework (SEF) developed by the Inter American Development Bank (IADB) in 2008 as part of its technical corporation for the government of Barbados for its use; however the country does not have a National Energy Policy to guide the implementation of RE as yet (REEEP, 2010b). The SEF aims to develop the country's RE potential and help the country's sustainable development in the energy sector and the environment with added benefits to the economy (IADB, 2008). The SEF was prepared to help diversify the energy mix by introducing an appropriate regulatory and technical framework for the adoption of RE and to also use the country's abundant energy resources (IADB, 2008). The government sees the promotion and use of RE as a priority for the country and have set out goals and timetable for the introduction of RE, the aim is to have a 10% of electricity being generated from RE sources by 2012 and 20% by 2026 (IADB, 2008).

About 40 years ago the Barbadian Government decided to introduced a number of fiscal measures to support RE initiatives in the country and increase the share of RE in use (FTC, 2010). One of the incentives introduced was the Fiscal Incentive Act of 1974 granting import benefits and tax exemptions to solar water heater (SWH) producers (IADB, 2008; FTC, 2010). In addition under the countries 1984 Income tax amendments tax payers can fully deduct their Solar water System from their taxes which makes this water heater system more competitive and attractive compare to the electric water heater which do not have those added tax benefits and are subject to a 60% consumption tax (FTC, 2010). It should be noted that in Barbados the law does allow for domestic generation and consumption of electricity, however the law does not facilitate the establishment of Independent Power Producers as the power utility holds monopoly on the generation, transmission and distribution of electricity (REEEP, 2010b). As a result in 2009 the BLP started a pilot programme allowing eligible customers with RE to sell their excess power to the grid (IADB, 2008; REEEP, 2010b).

2.1.2 Cape Verde

Cape Verde is an archipelago of 10 islands in the western coast of Africa, it has a population of about 500 000 people (World Bank, 2011). The country is about 4033 km² and the islands are economically dependent on service sector especially the tourism sector. The country's GDP per capita in 2009 was US\$3355 and is considered as a low middle income country (World Bank, 2011).The country's energy consumption per capita is about 1 Toe with 78% oil dependence (REEEP, 2010c), in addition to its high dependence on fossil fuel, it also faces severe water shortages leading to the use of desalination plants which are high energy consumers which further add to the country's energy cost woes (Monteiro Alves et al., 2000). This 78% oil dependence cost the country about US\$117million per year or about 7% of the country's GDP (Economy watch, 2011).

Cape Verde has an Energy Plan for 2003-2012 which aims to improve the energy needs of the country by diversifying its energy sources through RE to guarantee its energy security

(REEEP, 2010c). The country has set very bold goal with regards to the introduction of RE and intends to meet 50% of the country's overall energy needs by 2020 using RE sources compared to 40% today (REEEP, 2010c).

Diversifying its energy mix can reduce Cape Verde's energy import expenses. Cape Verde has significant wind resources for most of the year one of the best in Africa but this under utilised which is why in the 1980's numerous experiments were carried out to assess the country's technical and economical potential to introduce wind energy technology (Monteiro Alves et al., 2000; REEEP, 2010c). Along with its high wind potential the country also exploits solar energy to produce electricity and for water heaters. Since 1994 three wind farms with a total capacity of 2.4 MW was installed representing about 3% of all the electricity produced in Cape Verde in 2004 (Chen et al., 2007; REEEP, 2010c). SWH is one of the way that solar energy is currently being harnessed and this have been introduced in Cape Verde with some success.

In addition to SWH solar energy is also used in salt mines to distil sea water (Monteiro Alves et al., 2000). Additionally under the EU-CILSS project some schools and private houses have been provided with electricity from photovoltaic modules and within this same project the island of Maio has become entirely supplied from water pumped using solar water pumps (Monteiro Alves et al., 2000). According to REEEP (2010c) the solar potential on the island is high at 6kWh per m² per day and as a result the government wants to ensure that 2% of the total energy consumed comes from solar sources by 2010. This includes two US\$27million solar power plants funded by Portugal which were inaugurated in 2010 with a capacity of 2.5 and 5 MW respectively (Africa Economic Outlook (AEO) 2011). Biomass is another RE that is used in Cape Verde this is mostly used for cooking and represents 37% of the total energy consumed in 2000 and remains unchanged in 2007 (Monteiro Alves et al., 2000; Chen et al., 2007).

In Cape Verde the Ministry of Environment, Rural Development and Marine Resources has the mandate to ensure the implementation of the production and assembly of wind pumps and to also coordinate the solar Regional Program PRS phase 1 and 2 funded by the EU (REEEP, 2010c). The country has also implemented an ambitious plan to reduce the country's high dependence on fuel imports, this plan aims to cover about 25% of its electricity needs with RE by the year 2011 costing about US\$300million from the current 3% (AEO, 2011).

Through the European Investment Bank and the African Development Bank, Cape Verde obtained €60 million (US\$50 million) to construct and operate four onshore wind farms plus connection to the grid with a total capacity of 28 MW (REEEP, 2010c, Economic watch 2011). Additionally to getting finance from the EUIB and the ADB the government have also taken certain measures to facilitate the deployment of RE. The government, has, through a law passed in 2007 allowed the import of RE equipments with tax exemptions (REEEP, 2010c). The country also offers business opportunities for the development of RE and in 2007 the investment strategies had gained up to US\$1Billion in RE investments from external investors. This has been possible through the Cape Verdean Government's commitment and the creation of adequate taxation tariffs and financial mechanisms in favour of RE (REEEP, 2010c).

2.1.3 Jamaica

Jamaica is a SIDS located in the Caribbean; it is about 10990km² large. The island has a population of about 2.8 million people. Jamaica has a GDP per capita of about US\$4500. The economy relies on the export of chemical and metal industries and on the service sector (USSD, 2011). The country is highly dependent on fossil fuel and about 90% of its energy needs are covered by imported fossil oil (REEEP, 2009). This represents about US\$2008

million for 30 million barrels in 2007 representing about 15% of the country's GDP, with a per capita energy use of about 1.3 Toe (REEEP, 2009).

In 2005 the share of RE in the electricity mix in Jamaica was 12% an increase from 10% in 2003, this according to the Government of Jamaica (GoJ) (2006) was partly due to the wind farm which was commissioned at Wigton Manchester in 2004. This wind farm has a capacity of about 21 MW of electricity and cost US\$ 26 Million however the system only averages 7MW per year due to varied wind speed (Loy et al., 2005). In addition to wind energy the government in Jamaica brought six mini hydro plants back online which now accounts for 22MW of electricity in the country (Government of Jamaica, 2006). However though hydro does add to the RE mix it is also contentious due to competitive uses which tend to reduce river flows thus the GoJ have no interests in developing hydropower beyond its existing capacity (Loy et al., 2005; GoJ, 2006). The GoJ feels that future investment in hydropower should come from the private sector as the possibility and potential still exists (Loy et al., 2005; GoJ, 2006). The country also started two photovoltaic programmes to supply off grid electricity which covers about 45 houses in rural Jamaica (Government of Jamaica, 2010).

According to Loy et al., (2005) the government wanted to achieve a target of 15% RE by 2012 which translated to the installment of 175 MW for that year which represents an addition of 820GWh of electricity. This according to REEEP, (2009) has been amended to 10% RE by 2010 and 15% by the year 2020. In 2009 the country RE share contributing to electricity had fallen to only 9% compare to 12% in 2005 (REEEP, 2009). The government as a result of the previous target had plans to build three more wind farms of about 20 MW each within the next few years (Loy et al., 2005). However by 2008 only the existing Wigton wind farm got extended with an additional 17 MW capacity and the other two projects have yet to be materialised (REEEP, 2009). While there are certain use for solar energy in Jamaica this is limited to rural areas and the use of SWH only represents 1% of the domestic market Loy et al., (2005) calculated that if 45 000 homes installed water heaters this will save between 75 GWh to 100 GWh of electricity annually. Jamaica also currently have 350 biodigesters treating animal waste which provides 10 000m³ of biogas it is not clear if this total is per hour, per day or per year, and also have 200 biodigesters septic tank treating domestic sewage these generates about 2000m³ of biogas (GoJ, 2010).

Another RE source with huge potential for electricity generation in Jamaica is bagasse. At present this resource is being wasted in inefficient boilers with cogeneration that covers only the plants heat and electricity needs (Loy et al., 2005; REEEP, 2009) It is estimated that through installation of high pressure boilers and energy efficiency improvements more than 220 GWh per year of excess electricity could be supplied to the grid (Loy et al., 2005). Another source of RE that the government is interested in developing is landfill gas according to the government waste being land filled contains 65% organic matter which represents more than 180m³ of methane per tonne of waste over a 50 to 100 year span (Loy et al., 2005; REEEP, 2009). According to Loy et al., (2005) about 50 to 80% of this gas can be captured by wells and drains and used for cogeneration for heat and electricity production. According to REEEP, (2009) there are plans in Jamaica to construct two Waste to Energy electricity plants which include a 45MW generation plants near Riverton and a 20 MW plants near Retirement (REEEP, 2009). Landfill gas extraction and use also offers good opportunity for additional financing within the flexible mechanisms of the Kyoto protocol Clean Development Mechanism which will be discussed in the next section (Loy et al., 2005; REEEP 2009). The GoJ also have plans to implement 8 more PV projects in rural Jamaica within the next four to five years (2010).

Jamaica has a National Energy Policy 2006-2020 which has a number of objectives including one to promote and stimulate RE development Investment. Additionally to that the country also has a 25 year National Development Plan 2005- 2030 called Vision 2030 and one of the aim of this NDP is to have a diversify energy supply which will improve energy security and make the country's energy sector spend less on fuel imports (REEEP, 2009). As part of this Vision 2030 the country have prepared a Renewable Energy policy 2009-2030 with the aim of having by 2030 20% of the country's energy mix coming from RE sources (REEEP, 2009). The purpose of the strategy is to provide certainty for investors and to encourage continuous research in technologies which have potential to generate energy from all types of RE sources. In addition the RE policy also provides enabling strategies which will help guide the deployment, research and development, as well as investment opportunities in RE over the next 20 years in Jamaica (GoJ, 2010; REEEP, 2009). To ensure the achievement of the RE target set out in the country's National energy policy, the electricity provider JPSCo will be mandated to provide a certain percentage of RE generated electricity annually. This can be generated by JPSCo or can be purchased from external producers. These in 2009, accounted for 25% of electricity generation capacity of the country (GoJ, 2010).

2.1.4 Mauritius

Mauritius is a SIDS of about 2040km² with a population of about 1.2 million people located on the East coast of Africa. The economy relies on the manufacturing financial and tourism sector (BAA, 2011b). The country has a GDP per capita of about US\$7420 one of the highest in Africa according to the BAA, 2011b. The country in 2010 imported about 1 million tonnes of oil per year and about 240 000 tonnes is used for the production of electricity (GoM, 2011). This cost the country about US\$837 million for the year 2010 representing about 9% of the country's GDP (Economy watch, 2011b).

In Mauritius unlike the three other countries the production of electricity is not monopolised by government. The Central Electricity Board only produces 40% of the country's total power requirements and the remaining 60% is purchased from Independent Power Producers (IPP) (Government of Mauritius, 2009). In 2008 19% of the country's total energy requirements were being provided by RE sources this mix composed of 93.2% bagasse, 3.5% hydro, 2.9% fuel wood and 0.4% wind energy (GoM, 2009).

Through government funding feasibility studies for a 25-40 MW wind farm at Curepipe, a wind power projects in Rodrigues which will provide 10% of the islands electricity, a hydro power project at Midlands, a landfill gas to energy project and a waste to energy project has been financed (GoM, 2009). In addition to these government funded project interest have been shown by private sector in assessing the potential to build two additional wind farms of 10 MW capacities each, there is also private interest in carrying out feasibility study for the commissioning of a micro hydro electricity plants of 375kW which will generate 2GWh per year (GoM, 2009). Within the long term energy strategy there are detailed RE development strategy for the various source of RE such as bagasse, wind, solar and hydro and how to further develop each of these. The bulk of RE generated electricity comes from bagasse and hydro. The government thus aims to use bagasse more efficiently and to increase the amount of electricity it produces from 350GWh to 600GWh per year by investing in higher pressure operating power plants (GoM, 2009). In the short to medium term the country aims to prepare a Master Plan for RE to establish long term objectives; this will be done with the help of the World Bank (GoM, 2009).

Mauritius has a long term Energy Strategy for 2009-2025 which is part of the overarching Mauritius Sustainable Island Strategy or Maurice Ile Durable (MID) which aims to turn Mauritius into a self sufficient island in energy and improve the country's energy security by

increasing the use of RE and improving Energy Efficiency measures (GoM, 2009). The aim of the MID is to achieve a 35% introduction of RE by 2025 for electricity supply. To achieve this introduction the government will introduce feed in tariffs and provide incentive schemes for the sale of surplus electricity to the grid (GoM, 2009). As part of the MID strategy a fund was created to promote and increase energy efficiency and the use of RE, for the year 2008/2009 1.3 billion Mauritian Rupees or US\$481 million was provided by the government this was obtained from a 15 cents levy on petroleum products, Liquid Petroleum Gas and coal (GoM, 2009). The objective of the fund with regards to RE deployment is to finance projects to explore and harness all potential of RE and to finance schemes that encourage innovation by households and businesses to produce their own electricity and sell the excess at a premium to the grid (GoM, 2009).

It should also be noted that the Mauritian Government have since the 1990's been actively trying to encourage the use of RE in the homes. In 1992 the Development Bank of Mauritius have been providing concessionary interest rates on loans to purchase SWH but as of 2008 only 25 000 households out of a total of 330 000 had installed SWH system (GoM, 2009). Therefore with the aim of doubling the number of SWH in use by the end of 2009 the government will give an outright loan grant of 10 000 Mauritian Rupees or US\$357 from the MID fund for every SWH bought (GoM, 2009). Solar PV is the other solar technology which the government wants to introduce this at present is not popular in Mauritius due to its price but the government plans to adopt this technology when the cost becomes competitive with other energy technologies (GoM, 2009). The adoption of solar PV will be aided by investment subsidies where part of the installation cost will be refunded and through feed in tariff and net metering (purchasing PV electricity at a guaranteed rate) (GoM, 2009).

2.2 Drivers for RE deployment

The drivers for the introduction of RE in a SIDS energy mix is numerous these are some of the reasons stated by numerous authors such as Monteiro Alves et al. (2000), Weisser (2004b), Loy et al. (2005), GoJ (2006), (2008), IADB (2008), GoM (2009), REEEP (2010b) MEEA (2011). Many SIDS governments have stated that diversifying their countries energy source thus increasing their long term energy security by reducing their dependence on fossil fuel is one of the most important drivers to push for RE introduction. Through the introduction of RE the countries' trade balance will be strengthened as they will no longer be paying a high percentage of their GDP to import fossil fuel. Take for example Barbados due to the introduction of SWH the country is making a saving of US\$6.5 million per year on oil import (REEEP, 2010b). Therefore the country can invest in the people, improve infrastructure and services and ensure the country's development. Another important reason is the creation of employment to construct, operate and maintain the RET's. More importantly RE leads to the improvement of the environment overall and improve the environmental performance of electricity generation.

2.3 The barriers identified by SIDS with RE deployment

The following barriers have been identified by many SIDS. Many of these barriers are the reasons why RE deployment has been slow in many of these countries.

2.3.1 Cost of RET

An issue identified by many SIDS is the price of oil the problem many fear is that once the price of this commodity drops many of the initiatives to introduce RE lose their momentum and the effects to switch to these energy are abandoned (Stuart, 2006; IADB, 2009). Another barrier identified in Barbados and in many SIDS is the cost of generating electricity from green sources. Even though these have fallen, the reality however shows that electricity

generated from RE still cannot compete economically with electricity generated from fossil fuel (FTC 2010). RES are not being subsidised to the extent that fossil fuel is which gives it an unfair advantage leading to wasteful consumption (Weisser, 2004b; Stuart, 2006).

The Institute for Building Efficiency (IBE 2010) also outlines the cost of the technologies and its availability, as some are still at the starting point while those like solar and wind that have been around for longer still have a high price tag. Meaning that these technologies are still out of reach for many countries with limited public capital (IBE 2010) and as a result these countries have to take out loans further indebting themselves or wait for one of their international partners as part of the aid program to implement these projects for them.

2.3.2 Capacity building, policy and investment

Investment in some technology in many SIDS is hampered due to restrictions on investment and the need for increased capacity building (REEEP, 2010b). According to Loy et al. (2005) in Jamaica due to a lack of capacity there is a lack of knowledge of the various technologies. The locals in many cases do not carry out long term wind measurements in the case of wind to ensure that the best location with the highest yield gets chosen and due to this lack of knowledge they have no idea of how to position the turbines for best performance and have no idea of what wind farm size will be suitable for which area. Stuart (2006) also stated that a lack of external and internal institutional support is an obstacle in SIDS with regards to Energy Reform, which prevents aid agencies and Development Bank from investing or financing RE project in these countries. Stuart (2006) further confirmed what Loy et al. (2005) wrote about Jamaica, wrote that many donors sees islands as lacking in skilled human resources and efficient energy institutions to implement RE projects and in many cases the social dynamism in these countries obstruct radical move to replace the status quo.

Weisser (2004) in his study of Rodrigues in Mauritius summed the reasons why technology lagged behind its potential in the country this is supported by the Markowitz (2007), IBE (2010) and the MEEA (2011). These boils down to a lack of policy framework to guide RE implementation, lack of financial schemes and incentives to aid RE initiatives and attract investment, high transaction cost especially when it comes to technology transfers, a lack of institutional capacity to create policy and provide a legal framework to help RE deployment. In addition Weisser (2004) and MEEA (2011) stated that a lack of awareness and information amongst decision makers and users makes it hard to spread the benefits of RE. The IBE (2010) also stated that a lack of legal protection for companies' intellectual property makes many companies apprehensive with working with local companies or governments. Haraksingh (2001) also identified the lack of supervision, monitoring and enforcement of standards and laws as a problem for SIDS in the Caribbean, this problem is not one just for the Caribbean it is a problem encountered in many other countries as attested by Van Alphen et al. (2008) in his study in the Maldives.

2.3.3 Topographical conditions

Another barrier identified by some SIDS like Jamaica is the availability of land to deploy certain technology such as Solar PV. Due to limited land area in SIDS deployment of certain technology is problematic. In many cases appropriate areas to implement such technology have other land uses which might not be compatible (MEEA, 2011). The topographic conditions of some countries as well as the availability of infrastructure such as roads and grid access to implement other RET are not available or are difficult to provide due to these issues the deployment of RET in many SIDS becomes problematic and have led to the best sites not being chosen due to these issues (Loy et al. 2005; Herbert, 2005; MEEA, 2011).

2.3.4 Technology

In some instances the technology that gets deployed fail to take off, this has been experienced in Fiji and Jamaica where PV system failed due to a lack of monitoring and maintenance and a lack of funding for spare parts and rehabilitation (Loy et al. 2005; Dornan, 2011). In other cases the RE being deployed like wind and solar to a lesser extent are intermittent thus cannot be relied on to ensure energy security. Reliability and stability in supply becomes an issue when the supply of energy cannot meet the demand, especially during the rainy periods or change in wind direction which leads to technical issue of grid integration (Chen et al. 2007; GoM, 2009). This is made worse in islands as electricity produced cannot be stored for future use as existing storage technology are not suited to accommodate large scale penetration of intermittent RES. Therefore intermittent RES needs to be coupled off with other non intermittent RE sources to be successful (GoM, 2009). In other cases these will need to be coupled with appropriate energy storage technology which can ensure continuous supply when the wind and sun are not generating at their capacity.

Any technology that gets implemented in SIDS needs to be developed in a way that it can withstand local conditions. A case in point is the situation of wind technology that was implemented in Mauritius in the 1980's. Wind turbines in a pilot project were damaged due to high cyclonic winds of 280km/h. Therefore to ensure that this technology gets implemented wind turbines needs to be constructed so as to be able to withstand such high wind speed when they occur in these countries (GoM, 2009). As many SIDS are located within cyclonic and hurricane belts. Dornan (2011) in his study of Fiji's PV system and its subsequent failure stated that a reason for failure was because the system being proposed was done by the donor country without getting inputs from the Fijian Department of Energy and other local stakeholders. As a result the Government could not implement the program the way the donor country wanted leading to its failure (Dornan, 2011).

2.4 Solutions applied in Small Island Developing States

While SIDS have abundant RE sources these are still underdeveloped in many of these countries. Deploying RE requires the transfer of technology from one country to another; this requires that the country introducing the technology have in place certain conditions that will be conducive to such transfer. The IPCC have identified certain important dimensions necessary to ensure successful deployment, this includes capacity building and an enabling environment (IPCC, 2000). In addition to these, other solutions that have been tried in some SIDS are included in this section.

2.4.1 Capacity Building

For successful RE implementation adopting countries need to have the skills, knowledge, the infrastructure and institutional capabilities to ensure success. Adequate human capacity locally is important to facilitate the flow of international capital a lack of this was seen as a barrier in many SIDS. Increasing human capacity can be achieved in two ways firstly this can be done by developed country's government by ensuring that the capacity programmes they sponsor provide a full range of information, including financial, legal, engineering services and business consulting additional that these information are tailored to the local situation (IPCC, 2000). This requires cooperation with local governments, institutions, stakeholders and users. The other way is through the local country's training and human resource development which will focus on other aspects of technology transfer such as improving agencies competence, organisational know how and regulatory management along with developing technical skills (IPCC, 2000; MEEA, 2011). Another form of capacity building is through the assessment and monitoring of information. Countries can create indicators and collect data on the potential of certain RET's being implemented and through improving information systems and linking

them to international or regional networks (IPCC, 2000). This has the added benefits of allowing knowledge sharing and best practices between SIDS.

2.4.2 Enabling environments, role of Government and policies

To ensure that technology transfer occurs there needs to be an enabling environment that is conducive to the deployment of RE. This includes having in place legal and regulatory frameworks, transparency, economic policy and political stability (IPCC, 2000). This can be achieved by creating measures including well enforced regulations, taxes, codes and standards to aid with the transfer of RET's. Additionally the removal of import tariffs on RET technology can aid the deployment of these technology and make them cheaper to be imported (Markowitz, 2007). In Barbados and elsewhere in the world the governments are trying to make RE more competitive by providing an enabling platform for the adoption and application of RE system (FTC, 2010). In Cape Verde the government has provided taxation and financial mechanisms that favour RE these have been actively promoted. This is primarily due to the existence of a reliable legal framework that guarantees the intellectual property rights and which guarantees investment safety (Markowitz, 2007; REEEP, 2010b). Haraksingh (2001) sees the role of government not just as one where they make policy and provide legal framework to guide implementation, they should also develop and take their responsibility as the ones responsible to supervise, monitor and enforce the standards and laws they introduce. This can be achieved through capacity building, through knowledge sharing and awareness raising, education and clear and well defined role and responsibilities of the stakeholders involve in RE deployment.

In Mauritius the government sees the need to ensure that a holistic approach is taken with sustainable development and should thus be multi sectoral. This should include capacity building and research financing with tertiary institutions and identifying development partners to develop skills in the field of RE and to encourage research and development (GoM, 2009). Stuart (2006) agrees that RE deployment needs to be multi sectoral and also argues that the local population needs to be able to participate in such decision to ensure their support and successful implementation of such project. This requires that government reduces bureaucracy and political interferences which only leads to delays and expensive enforcement contracts which can scare away investors. Government also needs to liberalised the energy system and open up the economy as private sector participation is required to ensure success (Haraksingh, 2001; IPCC, 2000; MEEA, 2011). Additionally the IPCC (2000) also stated that to ensure successful technology transfer it was important that technology being transferred is designed to meet local conditions and that government ensures that assessment of local needs and social impact of technologies meet local demands and have their support. This will ensure interest from private sector and subsequent investment from this sector.

The subsequent paragraphs will outline some of the policies that have been tried in SIDS to aid the penetration of RE within these countries. There is a need to create a level playing field for RE which will give RET the same footing as Fossil fuel this can be achieved through government regulation, technical support or by providing incentives to users to change their behaviour (Stuart, 2006; IPCC, 2000). These are some of the policies that have been implemented in some SIDS to increase the contribution of RE in their country's Energy mix. In Cyprus which is a developed small island the government provided technical support, removed fuel subsidies and also removed import duty on materials for SWH systems thus achieving a penetration of 92% for houses and 50% for hotels a saving of 550kWh per m² (Stuart, 2006).

In Jamaica as a means to avoid being flooded with unfeasible proposal the government is planning to develop goals and create an outline of the kind of project that will be welcome in

the country this will also help avoid the deployment of too many different technologies which will be counterproductive in the sense of spreading existing capacity and funding over various technologies and will not deliver the result hoped for (Loy et al. 2005). As a result in Jamaica to achieve the targets set for the introduction of RE generated electricity the government has set up a tendering procedure for RE projects that will generate and provide 15% of its total installed capacity to the electricity system (Loy et al. 2005). Such projects also go through a simplified procurement process as such facilities also qualify for a premium of 15% above the avoided costs of electricity provider's least cost facility.

In Barbados the government is working towards providing policy support for RE through technical assistance to support the preparation of a Power Purchase scheme to aid the purchase of Electricity to the grid and by complementing existing financial instruments like the Smart Energy Fund with other financing scheme to promote RE (IADB, 2009).

In Mauritius like in Barbados the government have decided to provide grants of Mauritian Rs 10 000 or US\$357 for every SWH purchased through the solar water Heater loan scheme operated by the Mauritius Development Bank (GoM, 2009).

2.4.3 IPP's and PPA's, Feed in tariffs and Net metering

In many SIDS such as Mauritius, to some extent Jamaica and Barbados have introduced Individual Power Producers (IPP) and have created Power Purchasing Agreements⁵ (PPA) to aid the good functioning of agreements between IPPs and Purchaser. Power reform is seen as a good way to introduce RET's as it has the benefit of improving foreign direct investment, financing credibility and the operating performance of the supply system (Weisser, 2004). Even though SIDS are considered as having limited demand to allow for competition for bulk electricity generation, competition and contribution from small scale RETs can be created by allowing IPPs to sell electricity under conditions set up under a predetermined PPA to the island utility (Weisser, 2004).

This requires a specific mandate in the legal framework that allows IPPs to sell excess electricity to the grid; otherwise RETs will not be able to contribute the excess electricity generated (Weisser, 2004). Thus to ensure the penetration of RE in the energy mix the solution is to create a regulatory framework that allow for fair competition or tender for power production from IPPs as well as creating PPAs while ensuring that the process is transparent and that there is a stable electricity tariff in place (Weisser, 2004). IPPs have some benefits for the country as it helps diversify the energy mix, ensure energy security, it helps stimulate RET deployment where there are feed in subsidies, it leads to reduce emission and higher efficiency from generation (Weisser, 2004). Weisser (2004) also stated certain shortfall with IPPs/PPAs, as in some countries PPAs were based on short term avoided cost thus with the decrease in the price of imported oil the utilities reduced PPA tariffs making the supplying of this excess electricity from IPP unattractive. The solution according to Weisser (2004) is to ensure that PPA tariffs are stable or predetermined for a certain period of time and that Conditions, role and responsibilities set out in these contracts are clear to provide a safe investment environment for IPPs.

Feed in tariff on the other hand is an energy supply policy which can help support the development of new RE power generation by setting the right price to drive RE deployment. Through this mechanism Electricity Utilities are obligated to purchase electricity generated from RES at a calculated percent of the retail price or its avoided cost (MEEA, 2011).

⁵ PPA's are Legal contracts between Independent Power Producers and Purchaser such as the Utilities company

Therefore there is a need for countries to develop the appropriate legal and regulatory framework for pricing and tariff structures to support the integration of RE into the Energy mix so as to attract investment in RE (GoJ 2010). Good feed in tariff can be attractive for Independent RE producers.

The Net metering⁶ programme however is designed to allow small electricity customers who generate their own renewable electricity to store their excess power on the grid and to take power from the grid in times of need (MEEA 2011). There is a need to ensure the establishment of net metering strategies that will allow public utility networks to provide energy storage for small users, while ensuring that these strategies support RE production (GoJ 2010). This can be done by specifying that these small producers must be generating their power from RES, this requirement can be checked when agreements are signed by both parties.

To ensure the success of IPP/PPA, the setting up of feed in tariffs and net metering there needs to be clear legal and regulatory framework in place to guide these and to outline who is responsible for the provision of infrastructure for IPPs and those within the Net Metering programme to connect to the grid as this will have an impact on the number of participants within these schemes.

2.4.4. Regional Partnership

Good regional partnership is important to ensure knowledge sharing, capacity building and the identification of barriers and issues that are common to SIDS. Every region with SIDS has a regional organisation⁷ where issues can be discussed, financial assistance can be identified and solutions can be found. In the Pacific and the Caribbean SIDS through GEF funding have established a number of regional cooperation designed to build capacity to remove barriers to RE and to facilitate the widespread use of RET (UNFCCC, 2005). Additionally in the Pacific, the countries have created a Regional energy policy and plan to coordinate energy programmes in regional organisations and development partners, in areas where international co-operation is required (CROP, 2002). By increasing the Official Development Assistance (ODA) and financing from International and Multilateral partners and the private sector (CROP, 2002). The REPP is also intended to offer guidelines for adaptation to the circumstances of Pacific island countries and territories in areas of domestic implementation by building improving Institutional and Human capacity within the region (CROP, 2002).

In a study of the Caribbean SIDS Haraksingh (2001) stated that as a means of ensuring energy security, increase capacity buildings and financial assistance in implementing RE and in developing policies to guide such implementation. These countries also needed to widen its relations within the region but also with Europe and the pacific basin (Haraksingh, 2001). To prevent the risk of RE initiatives losing momentum if and when oil prices drops some government such as that of Barbados is mitigating this risk by applying for GEF funding to finance pilot projects to provide both qualitative and quantitative to make a stronger case economically and environmentally (IADB, 2009). In other countries like Cape Verde the solution to ensure that the impetus is not lost is through partnership building with regional

⁶ 'Net metering allows customers with generating facilities to "turn their electric meters backwards" when feeding power into the grid; they receive retail prices for the excess electricity they generate. This encourages customer investment in distributed generation, including RE.' (GoJ 2010)

⁷ The regional organisations of SIDS are the Indian Ocean Commission (IOC), Caricom or Caribbean Community, Pacific Island Forum (PIF), Africa Indian Ocean Mediterranean and South China Sea (AIMS)

organisation in the case of Cape Verde this is with ECOWAS⁸ from this partnership a centre for Renewable Energy and Energy Efficiency was established in the capital Praia which aim to promote and establish demonstrations Renewable projects in the island to ECOWAS members and to the rest of Africa (REEEP, 2010b). This is also the step that Trinidad and Tobago has taken to become the regions RE Research Centre. The setting up of such a centre will be done through technical and strategic assistance from the US DoE (MEEA, 2011).

2.4.5 Technology improvements

This involves ensuring that what is being deployed is appropriate for the country or region and brings benefit to the area. In Jamaica the government as part of its solution is thinking of running existing sewage plants on standalone electricity generated from Biogas using the plants sewage hence creating a self sufficient sewage plant which will provide both Electricity for the grid and cover the plants electricity needs (Loy et al. 2005). Through this self sufficiency the fossil fuel which would have been used to power the sewage plants can be used for other purpose or can be part of the saving that government can make as a result of RE penetration.

Prices for wind turbine is decreasing continually Loy et al. (2005) stated that the price of a wind turbine including its transportation minus infrastructure, planning and finance were US\$1 Million per MW, which represented a fifth of the total investment. As wind turbines have to be imported these should benefit from import tax exemption in adopting country to ensure the success of future wind projects deployment (Loy et al. 2005). It is also very important to be well informed on the technology being implemented and to include in the deployment budget the cost of operation, maintenance and spare parts which represents three to five percent of the investment cost annually (Loy et al. 2005). This entails that the adopting country need to have a budget and clear guidelines that will cover the deployment cost including the purchasing, transportation, infrastructure, planning, operation and maintenance to ensure that there is enough money while the RET is operational.

2.5 Financial Mechanism Available for RE Deployment

Currently in these countries private sector investment is not very high investment cost associated with RE deployment, the slow rate of return on investment in some cases and the lack of proper incentives to encourage private sector (Van Alphen et al. 2007). However there are a number of financial schemes that can guide RE deployment in SIDS apart from public funds created in these countries. These include loans and grants from donor countries and organisation like the World Bank, various Development Banks in the world such as the African Development Bank, Bilateral and Multilateral partners, Global Environment Facility (GEF) and other funds dedicated to sustainable Development.

2.5.1 Official Development Assistance

Are assistance granted to developing countries to aid the successful implementation of RET's. Such aid can also assist with the improvement of policy frameworks and aid with long term capacity building (IPCC, 2000). The IPCC however sees ODA as a means to mobilise and multiply additional financial assistance from other sources to aid the implementation of RET's.

⁸ ECOWAS Economic Community of West African States is an organisation 15 West African countries with a mission to promote economic integration in the region

2.5.2 Global Environment Facility and Special Climate Change Fund

GEF is an operating entity of the UNFCCC Financial mechanism and it is an important multilateral institution for transfer of RET's for many country. The GEF has been facilitating technology transfer through financial support, exchange of knowhow, equipments, organisational and management procedures (GEF, 2010). Since its inception in 1991 nearly US\$ three billion has been allocated to support climate change activities and have leveraged more than US\$15 Billion in co financing (GEF, 2010). GEF provides one time investments in mitigation projects that promote technology diffusion while helping host country's to develop their ability to understand, absorb and share these technologies (IPCC, 2000).

The SCCF was established in 2001 and is seen as additional channel for mobilising resources to support the implementation of climate change activities in SIDS. This fund can be accessed by SIDS and other countries wanting to develop and implement activities in adaptation and technology transfer and in capacity building (UNFCCC, 2005).

2.5.3 Multilateral Development Bank

In some countries like in Cape Verde, Mauritius and Barbados as was said in their case study have been assisted by Multilateral Development Bank, to help these countries carry out assessment of their RE potential, to build their capacity and in helping them create their Sustainable Energy Framework as in the case of Mauritius with the World Bank (GoM, 2009). In the case of Cape Verde the AfDB and the EUIB have provided financial assistance for the construction of a wind farm in the country (REEEP, 2010c).

These multilateral and bilateral funding mechanisms are some of the funding mechanism that SIDS can access to help them with the transfer of knowledge, expertise and public awareness of technological solutions within their country (Markowitz, 2007).

2.5.4 Role of CDM

Another means available to aid the transfer of technology and knowhow to developing countries like SIDS is through the implementation of CDM projects. CDM project financing can help the deployment of RE projects in SIDS through the selling of CDM credits or CER gained from small scale projects to other countries, this has the added benefit of providing an additional economic incentive to these countries (Markowitz, 2007). CDM is one of the three cross border emission reduction mechanism that annex B countries can apply in order to reduce their cost of commitments under the Kyoto protocol (Duic et al. 2003; Mundaca et al. 2005). Due to the high price of electricity produced from diesel and small electricity systems, the island state offer excellent potential to CDM linked technology transfer though on a small scale (Duic et al. 2003). Wind energy projects are well suited for CDM projects financing due to their higher generation costs compared with fossil fuel plants and the application of wind turbines is in accordance with the additionality⁹ criteria for CDM projects (Loy et al. 2005). According to Duic et al. (2003) CDM can make investment in wind energy attractive by reducing the wind electricity price by 5 to 10%.

When it comes to additionality CDM developers of small scale project must provide information showing that a small scale project would not have been implemented as a result of at least one or more of these barriers such as investment constraints e.g. a profitable

⁹ A CDM project is additional if the man made emissions of GHG by source are reduced below those that would have occurred in the absence of the registered CDM project activity (Duic et al 2003, Mundaca et al 2005).

investment can be implemented but with higher emission, Technological obstacles, Regulatory and policy framework e.g. current legal practices or requirements lead to projects with higher emissions and other constraints such as institutional barriers, lack capacity organisation, existing regulatory framework (Mundaca et al. 2005).

Under the CDM three categories of small scale projects was identified to differentiate them from regular or standard CDM projects making them eligible for certain exemptions. Type 1 is directly related to RE and looks at projects with a maximum output capacity of up to 15MW which benefit from certain exemptions to reduce transaction cost (Mundaca et al. 2005). With regards to CDM projects the transaction costs related to negotiation, validation, monitoring, verification and certification can be high which can be a barrier for the implementation of RET in SIDS. Mundaca et al. (2005) stated that a significant part of the CDM transaction cost is fixed translating to higher transaction cost per Certified Emission Reductions for small scale projects thus discouraging the participation of such projects. As a result of the high transaction cost which can make profitable small scale projects unattractive and less competitive, the CDM executive Board launched the Small scale panel¹⁰ to aid with the development of simplified modalities and procedures for small scale projects. Thereby reducing the transaction cost, to make these projects competitive and ensure that they get developed, this will also aid implementation of RET in SIDS (Mundaca et al. 2005). Where it is not possible to implement only one RET, the bundling of a number of individual projects with a total capacity of 15MW can also fulfill the SCC criteria which can provide a mix of RE sources in the country and also benefit from CDM financing (Loy et al. 2005).

Financing through the sale of emission certificates under the Clean Development Mechanism (CDM) can aid the deployment of RE projects. According to the UNEP (2007) CDM is an additional means for Developing countries to make money as CDM approved project can enhance returns on projects by 12% (for wind, hydro, geothermal and by 15 to 17% for Biomass and Municipal waste. For Jamaica and many SIDS small scale projects of up to 15MW capacity scheme are subject to a fast track process and lower transaction cost which are seen as very interesting (Loy et al. 2005). According to Loy et al. (2005) a 5MW hydropower facility at 90% capacity factor would reduce 30 000 tonnes of CO₂ annually and a 5MW wind farm at 35% capacity factor will avoid 34 500 tonnes of CO₂ annually (Loy et al. 2005).

Mauritius like Jamaica and many other countries has seen the importance of the development of CDM project to help the deployment of RE. This is why the country has established a CDM financing office in Mauritius which will study new green projects being proposed and assesses their CER potential, this will be done through the development of expertise and by running awareness programmes in carbon financing to help create and help guide such projects (GoM, 2009).

¹⁰ The SCC criteria includes allowing participants to use simplified baseline and monitoring methodologies, bundling similar type of projects, and they also face shorter review period for the registration of the projects. Additionally registration fees are lower, requirements of the project design documentation have been reduced and the designated operational entity is allowed to undertake the validation, verification and certification of the project activity (Mundaca et al 2005).

3 Seychelles: The current energy situation

The case study of Seychelles will provide a brief introduction on the current economic and energy situations of the Islands. It will also provide an outline of studies that have been carried out in the country.

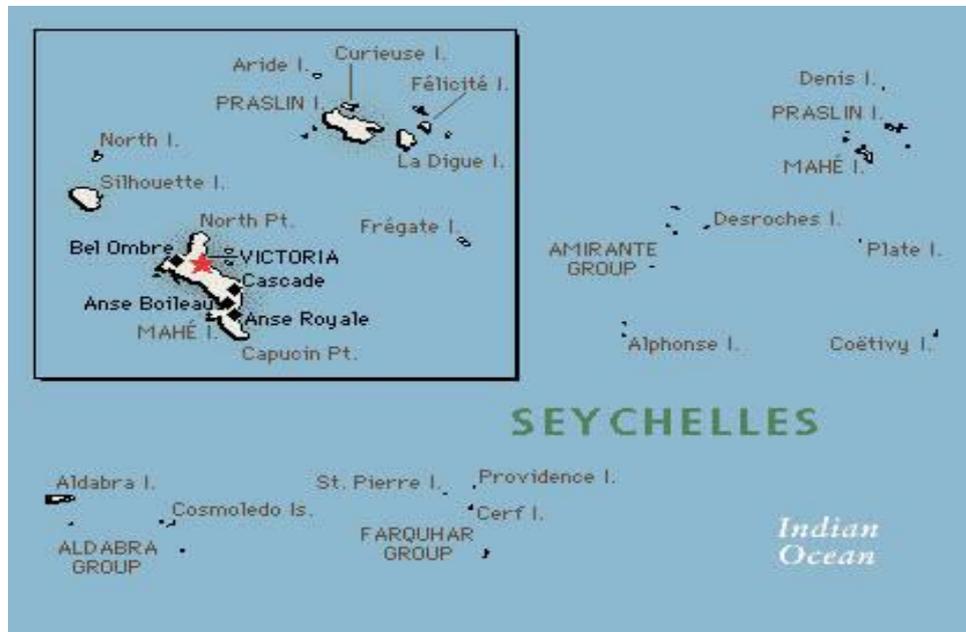


Figure 3-1 The Map of Seychelles

The Seychelles is an archipelago located 1600km east of the African Continent, refer to figure 3-1 above showing the map of the Seychelles; the country is made up of about 115 islands located between the latitude 4° to 10° south of the equator and longitude 52° to 57° east of the Greenwich meridian. The total land area is about 455km² located within a 1.4 million km² Exclusive Economic Zone (Vreden et al. 2010; BAA, 2011). The country has a population of about 88 000 people, which is growing at an estimated rate of two to three percent per year (NSB, 2011). The population is spread out over three islands Mahe where the capital Victoria is located and where nearly 90% of the population also resides. The other 10% is spread out on the second largest island of Praslin and the fourth largest island La Digue. The remainder of the islands are either uninhabited or have a small number of residents working in the tourism establishment located there or with the Island Development Company (IDC) (Vreden et al. 2010; BAA, 2011).

The tourism sector is an important pillar of the Seychelles' economy representing 26% of total GDP this is predicted to increase by 35% by 2017. The country at present welcomes about 160 000 visitors per year, it is predicted that by 2013 an additional 3000 rooms will be built and with existing rooms will welcome about 360 000 visitors by 2017 (Seychelles Tourism Board, 2008; Vreden et al. 2010). Following tourism the second economic pillar of the country is Fisheries which represents about 20% of the country's GDP (BAA, 2011).

The Seychelles historically have strong ties with both the United Kingdom and France as it used to be a colony at one point or another of both countries (BAA, 2011). On June 29th 1976 Seychelles was given its independence by Great Britain and became an independent country. However on the 5th of June 1977 shy of its first birthday as a Republic there was a coup and the country became a one party socialist state (Vreden et al., 2010; BAA, 2011). In 1993 armed

with a new constitution the country entered a new era when multi party elections were held. However according to Vreden et al. (2010) and the Bureau of African Affairs (2011) though the socialist regime helped raised the standard of living it also was the reason for the country to acquire large fiscal deficits due to borrowing on the international capital market. The reason for the deficit was attributed to large concessions granted to foreign investors in the tourism sector therefore between 2003 to 2007 reforms were introduced to manage the deficit (Vreden et al., 2010). However this was too slow resulting in an acute shortage of foreign exchange and the creation of an active black market.

With the creation of the black market the exchange rate for the Seychelles Rupees to the US\$ fluctuated between 5.50 SCR to 18 SCR this has now settled to 12.50 SCR for 1 US\$ (Vreden et al., 2010). As a result arrears on foreign debt to creditors increased, this coupled with the high oil prices during the 2007-2008 period made matters worse in Seychelles, leading to high food prices, increase in electricity prices and public transportation (Vreden et al., 2010). The crisis came to a head in 2008 when the country defaulted on its debt repayment and the country's credit rating was downgraded by Standard and Poor's to 'selective default' (Vreden et al., 2010; BAA, 2011). In that same year the IMF was contacted to help the country undertake a public debt restructuring. This included coherent fiscal reforms to restore external balance and attract support from the international community (Vreden et al., 2010; BAA, 2011).

The Seychelles according to the World Bank (2011) is considered to be an Upper middle class country with a GDP per capita of about US\$8335 (BAA, 2011). As a result as of 2009 the country's external debt stocks (% of Gross National Income) was 248% and the trade deficit (the difference between import and export in % of GDP) was 163% of GDP (World Bank, 2011). The inflation rate for the same year was 37% and during that same period the country's real GDP decreased by 7.5% however it is expected that the GDP will increase by 5% in 2011 (Vreden et al., 2010).

3.1 Energy Demand

Historically oil has been the most cost effective way to provide the country with electricity, transportation and other energy services. In 2007 a third of the oil import to be used locally was for transportation, ten percent was used directly in the industry, commercial and domestic sector while the rest was used for the generation of electricity (SEPEC, 2008; Vreden et al. 2010b). According to REEEP (2010) the annual oil consumption is about 2.4 tonnes per capita and oil import is expected to increase up to 220 000 toe before the year 2030 in 2007 oil import was about 213 000 toe (SEPEC, 2008; Vreden et al. 2010).

Every sector of the economy uses electricity and in 2006 according to REEEP (2010) a total of 252 million kWh was produced and about 218 million kWh of electricity were used. Out of this electricity that was produced fisheries consumes electricity through the two processing plants and canning factory which serves the foreign markets, and also consumes gasoil as a means to operate the fishing vessels and in some cases for the processing plants and canning factory to generate some of its own electricity (PUC, 2007; Vreden et al., 2010). In addition to the processing plants and canning factory, the other big electricity users in the industrial sector are the Seychelles Breweries which serves the local market (PUC, 2007; Vreden et al., 2010). The residential sector which comprises of about 21 000 households in 2010 compared to 20 270 in 2002 when the last census was done representing an increase of 3.4% is another important consumer of electricity (NSB, 2011). In 2010 according to that year's census about 96% of households had access to electricity. There are also plans to build another 5000 new homes by 2011-2012 however this government proposal has been around since 2006 and as yet only about 1500 houses has been constructed (Department of Housing, 2011), but it is

predicted that after this, the rate of house construction will fall to about 200 per year (Vreden et al., 2010).

Another high demand facility is desalination plants these are increasing around Mahe, the nearby islands and the outer islands due to long drought period and lack of dams and reservoir to store the abundant rain water. It is estimated that a desalination plant can consume between 5 to 15kWh per m³ of electricity depending on the system and salt content of feed water (Alonitis et al., 2003). In Seychelles about 3000 to 5000m³ per day of desalinated water is consumed representing 10 million kWh per year about the electricity consumption of 3000 households (PUC, 2007). It should be noted that this number is for all desalination plants including those run by PUC. This is becoming a problem for Seychelles as it is an expensive solution which along with the additional hotel rooms and houses will result in increase electricity demand. This will require the need to increase the generating capacity which might be a way to introduce RE within the country's energy mix along with improvement in EE to be able to meet this demand.

3.2 Energy Supply

Seychelles does not produce any fossil fuel and rely entirely on the import of refined petroleum products to satisfy domestic and international marine and aviation bunker fuels. The country is 100% dependent on gasoil (Diesel fuel) to produce electricity on the main islands and on the outer islands with hotels (REEEP, 2010a; Vreden et al., 2010). According to Vreden et al. (2010ab) and REEEP (2010) in 2008 oil imports represented 10% of the country's GDP a rise of 7.5% from 1997; this might increase further if oil prices keep increasing.

Like most fuel importing countries the Seychelles is vulnerable to oil price fluctuations. Currently the country's use of alternative energy is limited to burning of wood to make charcoal and the use of RE is limited to SWH and PV for remote applications only (SEC, 2011). The primary energy supply of Seychelles increased from 65 Ktoe in 1997 to 213Ktoe in 2007, an increase of 308% in a space of 10 years (Vreden et al., 2010; REEEP, 2010). Though the primary energy supply has increase the Seychelles is considered to be a low energy intensity country with a 0.11 toe per US\$1000 of GDP compare with South Africa with a 0.25 toe per US\$1000 of GDP (Vreden et al., 2010a). The reasons being that the Seychelles does not consume energy for space heating; and air conditioning is still not very popular in the domestic sector and due to the high electricity price the business sector have become more aware of the need to conserve energy (Vreden et al., 2010).

Though the country currently have no RE in its energy supply mix it is interesting to get confirmation on past RE research mentioned on REEEP website from those who actually carried out the research. However no written document was available for further consultation. From the interview with the Seychelles Energy Commission it is clear that the government has no intention of implementing any RE project of its own, once the Abu Dhabi Government hands over control of the proposed wind farm to PUC. Future RE investment will have to come from the private sector. Therefore most projects in Seychelles will therefore be of the Build Design Operate kind (SEC, 2011).

3.3 Electricity Production

Total electricity generated for the year 2006 was 252GWh up from 201GWh in 2001. The PUC had about 330km of high to medium voltage lines and about 1500km of low voltage lines making up the transmission and distribution grid (PUC, 2007; REEEP, 2010). In Seychelles electricity is generated using internal combustion engines running on fuel and gas

oil, these are four stroke engines which are ideal when capital cost is high and fuel price is low this is however not the case today (PUC, 2007). These have an efficiency of about 5% to 38% and grid loss is about 5% to 10%, this represents a loss of about 65% of the energy in the form of heat (Vreden et al., 2010b). In 2000 the fuel consumption for PUC was 30 347 tonnes and gas oil was about 16 813 tonnes (PUC, 2007). (This is the most recent data available). The PUC has an installed capacity of 115 MW as of 2007 for the three inhabited islands, the capacity on the outer islands are currently not known (PUC, 2007; REEEP 2010). In 2007 the electricity price increased by 25% prior to this the price had been unchanged for 11 years due to government subsidies to PUC (Vreden et al 2010).

3.4 The Energy Sector Stakeholders

This section will outline the role of the various stakeholders within the current energy sector in the Seychelles. Refer to figure 3-2 which provides the organistaion of the current energy sector and also see appendix 2 which provides an idea of how this might look in the future.

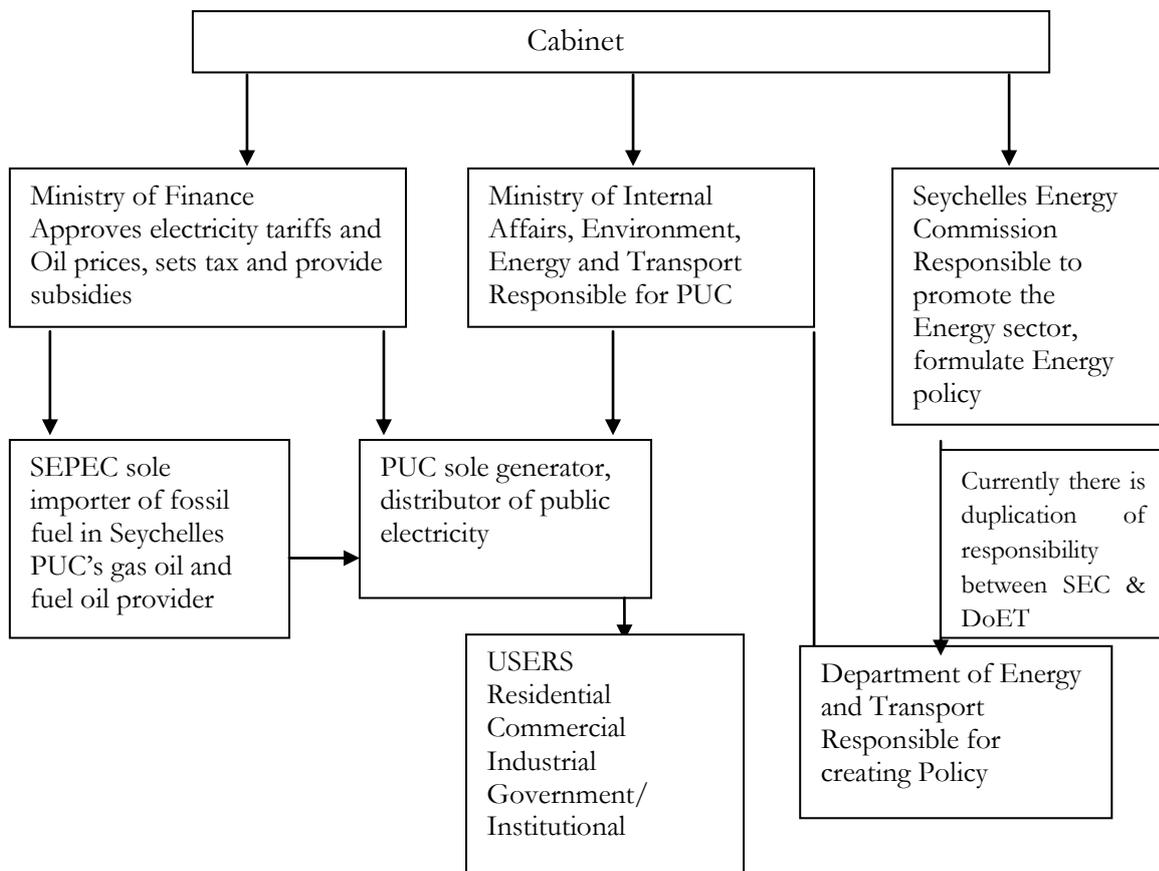


Figure 2-2 Organisation of the energy sector in Seychelles

3.4.1 Ministry of Internal Affairs, Environment, Energy and Transport

The Ministry is responsible for ensuring sustainable conservation of biological diversity and environment protection by creating policies and regulations. The Ministry also has responsibility for the Public Utilities Corporation (PUC) (Vreden et al., 2010). This was transferred from the Ministry of National Development in August 2009. It is also responsible for the energy department a portfolio it obtained after the May 2011 election and the subsequent cabinet reshuffle.

3.4.2 The Department of Energy and Transport

The role of the department is to develop, implement, monitor and evaluate energy Policies, regulations and strategy to guide and ensure the smooth functioning of the Energy sector (SEC, 2011). The department also has a role to play in developing and implementing energy conservation measures and to sensitise the population on the importance of energy conservation (Vreden et al., 2010; SEC, 2011). Another function of the department is to carry out research and to help promote the use of renewable energy resources and technologies (SEC, 2011). However due to the newness of the whole system and the Department most of the work is being carried out by the SEC so there are at present no separation of function. This Department existed under the Ministry of National Development and was abolished in 2008 to create the SEC. Now in 2011 the Department has been recreated however the function it should be doing is currently being done by the SEC.

3.4.3 The Seychelles Energy Commission (SEC)

The Seychelles Energy Commission was formed in 2009 and falls under the Ministry of Environment, Natural Resources and Transport and consists of five staff (SEC, 2011). The commission has the following responsibility outline under the Seychelles Energy Commission Act of 2009:

- To advise the Minister on all matters concerning the national policy objectives for energy supply activities
- To coordinate the development and implementation of national energy policy and strategy and undertake national energy plan
- To coordinate the development and implementation of national energy policy and strategy and undertake national energy plan
- To advise the Minister on all matters relating to energy including renewable energy and other forms of energy
- To implement and enforce the energy supply laws
- To regulate the electrical energy, petroleum and related products, renewable energy and other forms of energy
- To promote research into, and the development and the use of, new techniques relating to energy production, transmission, distribution, supply and use of energy
- To encourage energy efficiency and conservation, and the use of renewable energy
- To promote and safeguard competition and fair and efficient market conduct in the energy sector, in coordination with other statutory authorities and laws¹¹
- To encourage the development of the energy supply industry including in the area of capacity building and

¹¹ This function should rightly be the responsibility of an independent regulator (Vreden et al 2010)

- To review the energy supply laws and to make the necessary recommendations to the Minister and collect and maintain energy data

The SEC is suppose to be an Independent body but at present it is dependent on the Government for its funding hence not as Independent as it should. As can be seen the responsibility of the SEC and that of the Department of Energy overlaps and as was said earlier at present the Department of Energy is not fully functional, hence the work of the Department is currently being carried out by the SEC. However according to the SEC in the near future this will be different.

3.4.4 Seychelles Petroleum Company (SEPEC)

The SEPEC is a parastatal body and the sole importer and distributor of petroleum products in Seychelles. Fuel is imported from the Gulf States and stored in storage facilities at Port Victoria, the storage facilities can supply the country with fuel oil for two months before this runs out (Vreden et al., 2010; REEEP, 2010). SEPEC then distributes the fuel via pipelines to the New Port for International Marine Bunker, to the international Airport for International Aviation Bunker and domestic aviation and to the PUC for electricity generation (Vreden et al., 2010). SEPEC is also responsible for supplying outer islands, hotels and the few households that generate their own electricity for own consumption. SEPEC has also entered the oil re exporting business as a bunkering operation for shipping as a means to bring in foreign currency to the company and cover the loss on the local market. However even with this endeavour the company is making a loss on the local market to the tune of SCR 20 million or US\$6.4 million per year due to the low fuel prices set by government (SEPEC, 2008; Vreden et al., 2010). As the sole importer and distributor of oil in Seychelles hence the only supplier for the PUC, SEPEC is an important stakeholder in ensuring that the country at present can generate electricity to allow for a smooth running of all the economic sectors of the country.

3.4.5 Public Utilities Corporation (PUC)

The PUC is the sole producer and distributor of electricity in the country and produces about 95% of the electricity in the country the remaining 5% is produced by individual for own consumption (PUC, 2009). The PUC operates four power stations, three on Mahe and one on Praslin which also supplies the island of La Digue. The corporation was established by the PUC Act of 1985 and it is a parastatal body which was formed on the 1st of January 1986 with amalgamation of the Water Authority and the Electricity Corporation Ltd (PUC, 2007; REEEP, 2010). The corporation falls under the responsibility of the Ministry of Internal Affairs, Environment, Energy and Transport.

In 2009 the PUC signed a two year management contract with SUEZ Energy a French Company (Vreden et al., 2010). This was part of the government strategy to somewhat liberalise the PUC even if this was a limited independence, the partnership dissolved in 2010 when the government took back total control of the PUC, the reason for the dissolution is still unknown. Currently the PUC has the responsibility to regulate the electricity sector (however in the future once the Electricity Act comes in force this responsibility will be in the hands of the SEC) and provide the country with electricity, water and sewerage services. Under the PUC Act, PUC must not only provide, but must also ensure continued supply of electricity, potable water and sewerage services to the people of Seychelles (REEEP, 2010). This however is becoming somewhat challenging for the corporation especially with the provision of water and sewerage and to a lesser extent with electricity especially during peak demand.

The Electricity Division comprises two main sections: (i) the Generation Section and (ii) the Electricity Transmission & Distribution Section. The Generation Section is responsible for the safe and continuous production of electricity from the generating stations it manages (PUC, 2009). The Electricity Transmission & Distribution Section is responsible for transmission and distribution of electricity apart from Mahé, the section manages an integrated distribution network on the islands of Praslin and La Digue (PUC, 2009; Vreden et al., 2010). In addition, it provides an inspectorate service to the public in order to ensure that a high standard of electrical components is maintained in all installations (Vreden et al., 2010). PUC is also responsible for issuing permits for private producers as a result of difficulties encountered to acquire the necessary funding for new power facilities, not all demand for electricity on Mahé, Praslin and La Digue can be met by PUC (it is not clear in the Act who bears the cost of installing facilities for remote locations, if PUC chooses to serve these installations) (Vreden et al., 2010; SEC, 2011). This has forced some hotels to establish their own production facilities to ensure continuous electricity supply.

The PUC Act as it is currently does not allow IPPs to supply electricity to the grid and it does not mention the possibility to sell electricity to PUC even at negotiated price (Vreden et al., 2010). As yet there is no dedicated regulatory framework for the development of sustainable Electricity in the country (REEEP, 2010; Vreden et al., 2010).

3.4.6 Ministry of Finance

The Ministry of Finance plays a major role in the running of the PUC as a corporation its economy is closely connected to the country's economy. As per the PUC Act, the Minister for Finance can lend public money to PUC, and approves the corporation annual budget (Vreden et al., 2010; SEC 2011). The 'at any time valid tariffs' are written directly into the Act, and can only be changed by parliament (Government of Seychelles, 1991; Vreden et al., 2010). Though this might be the case tariff changes that have taken place in the past have not been through Parliament according to the SEC (2011) when PUC wants to change the tariff it only needs the approval of the Ministry of Finance. However there is limited guidance in the Act regarding how the tariff should be set as a means of controlling the corporation (Vreden et al., 2010). The PUC Act also stipulates that PUC cannot enter into any contract exceeding SCR 500 000 (US\$ 40 000) without approval from the Minister of Finance (Government of Seychelles, 1991). This makes it difficult for PUC to raise tariffs to a sufficient level to cover its costs and this has led to difficulty in obtaining approval for financing of planned and needed additional production and transmission capacity (Vreden et al., 2010).

3.4.7 Electricity Consumers

In 2007 the residential electricity consumption was about 71 GWh with about 21000 households. This represents about 36% of PUC consumers and 33% of the electricity demand (Vreden et al., 2010; REEEP, 2010). (Refer to Figure 3-3 which provides a breakdown of the electricity consumption in Seychelles). According to Vreden et al., (2010) from 1997 to 2007 the household spending for gas, water, electricity and housing have more than doubled from 14% up to 31% and electricity rose up to 79% of the housing and utilities total for 2007 especially for low income households. A study was carried out in two households one a household of six and the other a household of five. The household of six is an extended family of five adults and a child, it is not a conventional family structure but it is one that is common in Seychelles. All adults within the Household are employed; two people are responsible for the electricity bill. This family can be classified as middle income, note Seychelles does not have a class system. The total income in the house is SCR18 000¹² or

¹² 1US\$ equals to 12.5 SCR as per the Seychelles Central Bank Rates August 2011

US\$1440 per month. The electricity Bill is SCR700 or US\$56 a month a total of 417kWh¹³ representing 4% of the total income.

The other household consists of 5 people, 4 adults and 1 child only two adults' work. In addition 2 adults and child resides in the house for a period of two weeks every month. This can be considered a well off family with a total income of about SCR40 000 or US\$3200 per month. Electricity bill is SCR1094 or US\$87.5 this represents 532 kWh of electricity in the month of July, 3% of the total income.

According to the Welfare Commission (2011) a low income household uses about 300 to 400 kWh of electricity per month costing about SCR350 (US\$28) to SCR610 (US\$48.8). Assumption is being made that this is a single family household with a salary of SCR3500 or US\$280 electricity represents about 10 to 17% of the household spending. According to the Welfare Agency (2011) about 2500 low income households needs assistance to pay their electricity bill.

The Industry sector is dominated by three large Industries namely the Indian Ocean Tuna canning factory, the Foodpro- food processing plant and the Seychelles Breweries the local brewery. This sector electricity consumption has increased by 35% from 1997 to 2007 (PUC, 2009). The electricity consumed by this sector in 2007 was 30GWh of which the three mentioned companies' accounts for 75%. The Commercial sector encompasses mostly hotels, guesthouses, commercial centres, shops, banks, offices and Restaurants. This sector consumed about 15000 Toe of gasoil in 2007 of which 75% was for electricity production which amounted to about 50GWh of electricity including PUC generated electricity (PUC, 2007; Vreden et al., 2010). An example taken from Vreden et al., (2010) showing the consumption of the Banyan Tree hotel which has 60 villas and consumes about 6GWh per year of electricity of which 40% is generated by the hotel using gasoil in its three 1MW generators. More than 60% of the electricity consumed is attributed to the air condition, water heating for Jacuzzis, freezers and refrigeration and in the desalination plant high pressure pumps. The Industry sector along with the commercial sector represents 50% of the total electricity consumed and represents about 36% of electricity consumer (REEEP, 2010). Vreden et al (2010) however stated that care should be taken with the consumption data as PUC cannot differentiate between electricity sale to Industrial and Commercial customers.

The government and Institution sector includes schools, hospitals, Ministries, Department and other governmental agencies and in 2007 represented 14% of consumers and consumed about 19% or 41GWh of electricity produced.

¹³ Electricity rates 1st 200 kWh costs SCR1.10 or US\$0.09, next 100kWh costs SCR1.30 or US\$0.1, the other 100kWh costs SCR2.60 or US\$0.21 and the other kWh costs SCR2.80 or US\$0.22 with the demand charge of SCR33.77 or US\$2.7

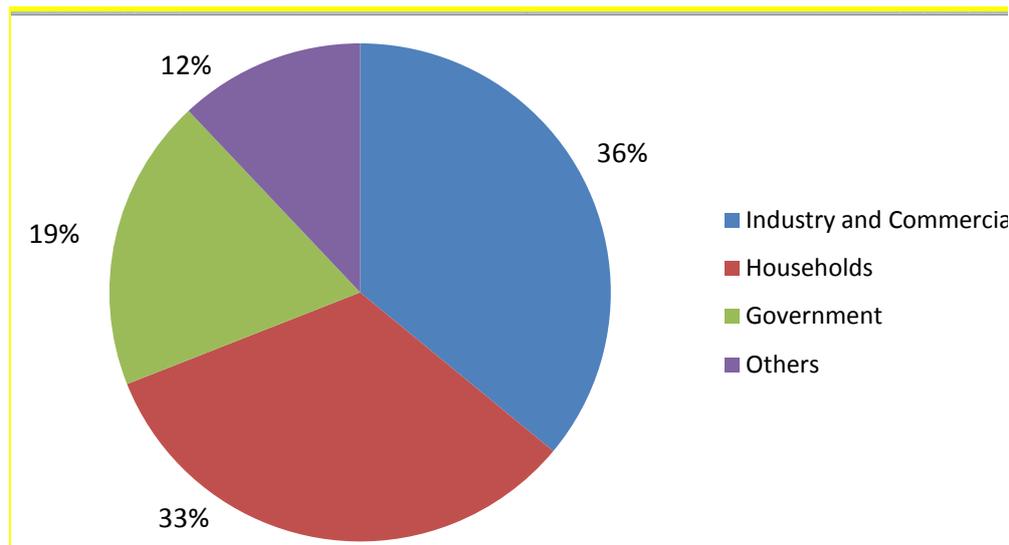


Figure 3-3 The Electricity consumption breakdown in Seychelles (REEEP, 2010)

3.5 Status of Energy policy

In 2009 the Seychelles commissioned a new energy policy this project was supported by the UNDP, through the provision of experts and consultant. The policy aim to improve the energy supply security of the country modernised the energy service to the population and implementing energy conservation projects (REEEP, 2010a; Vreden et al., 2010). The policy also set out short to long term actions and outlines the roles and responsibility of the various governmental agencies. The policy made a number of recommendations, including outlining the role of the Ministry responsible for Energy which is provided in table 3-1 below.

In addition as Seychelles is a member of COMESA it is also affected by the policy created at the regional level. COMESA created the COMESA model Energy Policy Framework 2009 which aims to provide an outline of contents expected in National Energy Policy which countries can adopt or customised thereby ensuring harmonisation of policies at a regional level (REEEP, 2010a; COMESA, 2009). The energy framework was created as the member states of COMESA saw the high energy cost as an impediment to COMESA’s competitiveness in the extra regional markets. In 2009 the average cost of electricity in the region was 0.09 US\$ per Kilowatt hour (COMESA, 2009) it is not clear if this is production or retail cost. The energy policy is also a means to aid the trade in energy services amongst member countries which will help facilitate the movement of goods, capital, services, knowledge and persons (COMESA, 2009). This policy also aims to help share knowledge and serve as a means to raise capital to finance projects at a local level.

As of August 2011, many of the recommendations and actions that had been set for the period 2010 and the first six months of 2011 in the energy policy had not been implemented. These included the creation of energy strategies and scenarios along with revising energy legislations (Vreden et al., 2010). The SEC along with a consultant are currently working on changes to the PUC Act to create the Electricity Act, this according to Vreden et al. (2010) should have been done in 2010. With regards to the COMESA policy there are little sign in Seychelles showing that this is having any effect on the current energy system of the country.

Table 3-1 Energy Policy recommendations for the Ministry of Internal Affairs, Environment, Energy and Transport

General Recommendations for the Ministry of Internal Affairs, Environment, Energy and Transport
The Ministry must assume the role of facilitator and regulator and should therefore be more dedicated to formulating, coordinating, monitoring and evaluating the implementation of relevant energy policies and instruments.
Should have the ability to develop coherent energy strategies and scenarios and ability to aid in revising energy-related legislation.
Should provide information to stakeholders and the public regarding efficient energy consumption and renewable energy options
Institutional and legal Recommendations for electricity production
The creation of an independent Energy regulator responsible for the regulation of energy prices and services, including private participation in electricity supply
Change PUC act to Electricity act which will define the division of responsibilities between PUC (production, transmission and distribution) and Independent Power Producers (production).
Develop rules for IPP connection (Grid Code) on both Low Voltage level and High Voltage level.
Develop IRP this must describe the development of the electricity sector in the short term (five years) and in the long term (fifteen years), including grid expansion plan and must include financing needs, targets for renewable integration, fuel mix and energy efficiency projects.
Develop work plan for RE demonstration projects in wind, solar PV large scale, landfill gas business plan

Source Vredin et al., 2010

3.6 Commonalities and differences between Seychelles and the other SIDS

The table was developed as a means to show the most glaring differences and common aspects between the four island cases and Seychelles in a few aspects. Table 3-2 provides a quick overview of the detailed information outline in the literature analysis to some extent with some additional information and provides a brief snapshot of the current system in Seychelles.

From the table it can be seen that Seychelles compared with the other four countries is performing very poorly with regards to RE implementation within its energy mix. The Seychelles is currently 100% dependent on fossil fuel. The four other countries though they also have high dependence this is however less than 100% ranging from 96% in Mauritius to 78% in Cape Verde. (The high percentage of 96% in Mauritius is due to the use of coal to supplement bagasse in the Sugar industry.) The various degree of RE penetration can be attributed to these countries desire to be less dependent on fossil fuel, the availability of cheap fuel source like bagasse and on their long term plans to be more energy secure through the introduction RE within their total energy mix.

Like Barbados and Jamaica, Seychelles does have Independent producers and this represents an estimated 5% of the total electricity produce. However like these countries it does not allow IPPs to sell their excess electricity to the grid, while in Barbados they have moved one step closer to allowing IPPs to sell excess electricity through a pilot project carried out in 2009 to assess the potential and see how this will work. In Jamaica they have gone one step further by mandating the Utility Company to provide a set percentage of RE generated electricity into its electricity mix which it can either purchase from IPPs or generate it themselves. While Mauritius and Jamaica have data on the mix of fuel used by IPPs to generate electricity the mix as can be seen is still very dependent on fossil fuel such as oil and coal. This can therefore mean that even when IPP generated electricity enter the grid these are not necessarily more sustainable than the electricity being generated by the Public Utilities.

Currently all four countries have a certain percentage of RE in its energy mix ranging from 40% in Cape Verde to 12% in Jamaica. Cape Verde has a high percentage of RE in its energy mix due to the high use of Biomass in the form of fire woods in rural areas which represents 37% of its total RE. Loy et al. (2005) also noted that in Jamaica biomass in the form of fire woods is widely used in rural areas by about 41% of the rural population however this is not properly accounted in the energy statistics of the country.

When looking at the countries install electricity capacity it is clear to see that Cape Verde has the lowest install capacity which might explain why the country has got a high RE percentage in its energy mix. For those four countries the penetration of RE in the electricity mix is not very high ranging from 9% in Barbados and Jamaica to 4% in Mauritius and 3% in Cape Verde. From this it can be deduced that in these countries about 91% of electricity in Barbados and Jamaica, about 96% and 97% in Mauritius and Cape Verde respectively is generated from fossil fuel. From these countries the most common form of RE to generate electricity is Bagasse common to both Mauritius and Barbados, Wind is an important source in Cape Verde and Jamaica, hydro is a source common to both Jamaica and Mauritius and finally Solar in the form of SWH in Barbados. While these countries have been exploiting these sources of Energy, in Seychelles the only RET currently in use in SWH but the use of this is still not that common as people prefer the cheaper electric water heater.

Three out of the four island cases have a Renewable Energy Plan which provides long term development goals to guide RE deployment in these countries however none could be found for Cape Verde or the Seychelles. All countries however have set targets for RE deployment in the short to medium and long term. In Barbados the plan is for 10% in the short term and 20% in the long term, while in Cape Verde their aim is for 50% in the long term and in Mauritius and Jamaica it is 35% by 2025 and 20% by 2020 respectively. In Seychelles the country has set a target of 15% by 2020 and 30% by 2030 which are very ambitious targets for the country but a good start on the road to RE deployment.

Data with regards to GDP or amount of money spend on oil importation shows that all of the five countries spend a considerable amount of their foreign earnings to cover the cost of importing fossil fuel. The percentage of GDP to import oil is higher in Jamaica due to the lower GDP per capita leading to higher importation cost compared to Seychelles and the other countries. While the cost in Cape Verde is lower than the Jamaica, Mauritius and Seychelles this can be due to the low penetration of electricity throughout the country compare to the other four countries, leaving the majority of oil imported for use by the transport sector. The cost of import of oil in these five countries ranges from 6% of the GDP in Barbados, 7% in Cape Verde, 9% in Mauritius, 10% in Seychelles and up to 15% in Jamaica; this is predicted to fluctuate depending on the price of oil which means that this can be higher when the price of oil increases.

The price of oil is one of the drivers for introducing RE in the energy mix however to ensure that RE does get deployed setting targets are not enough it requires policy commitment and incentives currently the Seychelles does not have any incentives financial or otherwise. On the other hand the four other countries have dedicated funds which will help with R&D, Pilot projects and implementation of RE and EE programmes in their respective country. In addition these countries have also created fiscal incentives such as tax exemptions, concessionary taxes and interest rates, investment subsidies, removal of import duty on RE and EE products, legal framework to protect Property rights, high consumption tax on certain energy intensive products, Financial loans and grants to purchaser of RETs and creation of CDM project to gain monetary benefit through the sale of credits are some of the solutions that have been tried in these four Island cases.

Table 3-2 Comparison between Seychelles and the four Island Cases

Countries	Barbados	Cape Verde	Jamaica	Mauritius	Seychelles
Criteria					
Nominal GDP per capita	US\$14 422	US\$3 355	US\$4 500	US\$7 420	US\$8 335
Install electricity capacity	240MW	75MW	1.5GW	670MW	115.5MW
Country's dependence on oil	90%	78%	90%	96%	100%
Fossil fuel use in electricity	91%	97%	91%	96%	100%
Current RE Level in energy mix	15% 9% for electricity	40% 3% for electricity	12% 9% for electricity	19% 4% for electricity	0%
Targeted RE level in energy mix	10% by 2012 20% by 2026	50% by 2020	20% in 2020	35% in 2025	15% by 2020 30% by 2030
Common RE in use	SWH, Bagasse	Wind and Biomass	Wind and Hydro	Bagasse and Hydro	SWH small scale, none
Have a Renewable Energy plan	yes	no	yes	yes	no
Percentage of GDP use in oil import or cost to the country in US\$	6% of GDP US\$230 million	7% of GDP US\$117 million	15% of GDP US\$2008 million	9% of GDP US\$837 million	10% of GDP US\$76.4 million
Have funds dedicated to RE and EE	Yes	Yes	Yes	Yes	No
Type of Incentives available	Tax exemptions, Consumption tax on electric Heaters, no import duty on RETs	Tax exemptions, good taxation tariffs, Intellectual property rights protection, financial loans	Financial Loans, creation of CDM projects to generate credits, Strategy to guide R&D in RE	Financial loans, concessionary interest rates, investment subsidies for RE, CDM Projects to generate credits	Limited financial incentive

Adapted from: Barbados Time 2011, Economy watch 2011, FTC 2010, LADB 2008, GoJ 2006, 2010, GoM 2009, 2011, Loy et al 2005, Monteiro Alves et al 2000, REEEP 2009,2010abcd, Vreden et al 2010.

4 Assessing the RE potential in Seychelles

To assess the RE potential the findings from the interviews and from desktop research and various literatures will be first outline. From these findings the research will assess the RE potential for the islands of Seychelles. It will outline the opportunities of deployment of the various RES, looking at their socio economic, technological, environmental and Institutional potential. To begin this section we will look at past researches in the field of RE in Seychelles and then outline the findings for the individual RES and then an assessment of RE potential will be done using the Van Alphen et al. and Mundaca et al. mixed framework.

4.1 Past RE researches in Seychelles

In the 1980's the Seychelles Research Development Division which was part of the Ministry of Planning carried out a research on the RE potential of the country. The research according to Webber (2011) was carried out with the assistance of two research partners the Beijer Institute¹⁴ in Sweden and the Twente University of Technology. The role of these two partners was to carry out background research in connection to the pilot projects which will be outlined in the next section. The aim of the research was to showcase the country's RE potential and help the country to develop the said potential (Webber, 2011). The research done in the 80's was never acted upon due to low oil prices at the time and heavy financial aid from the country's ex colonist Great Britain which was a disincentive to implement such project (Webber, 2011).

Additionally to these researches according to SEC in 1997 an Africa wide study was carried out by Stephen Karekezis and Timothy Ranja entitled Renewable energy Technology in Africa which aimed to assess the various countries' Renewable Energy potential. This also included Seychelles and the research looked at all the technologies from wind, solar, waves, Ocean Thermal Energy Conversion, waste and biomass. According to the summary from the AFREPREN website the research examine the African energy sector's overall geo-political and socio-economic setting as well as specific non-technological factors that influences renewable energy development, such as financing, institutional structures for energy management, human resource development, equity and access, and environmental considerations. The book also provided some policy recommendation. This research was supposed to provide future energy specialists with an essential text for future training.

4.2 Findings of RE potential in Seychelles

This section will provide an overview of the findings of the RE potential within the country.

4.2.1 Biomass

There has been a few studies carried out to assess the potential of Biomass in Seychelles and preliminary trials were conducted by the Biomass Technology group with funding from the World Bank. This was a means to generate electricity through gasification in rural communities. The study according to REEEP (2010a) showed promising results which is confirmed by Webber (2011). According to Webber (2011) the Biomass project is an old project called producer gas which was tried in the 1980's the idea was to gasify¹⁵ biomass mainly coconut husk and the coconut shell which were abundant on the outer islands. The

¹⁴ The institute financed research project in developing countries in the 80s. For more information on their role visit <http://www.beijer.kva.se/>

¹⁵ Burn Biomass in limited air to create CO and H₂ these two gases can then be used to generate electricity or can be used to run motors (Webber 2011).

idea behind this project was to introduce RE in outer island and make them self sufficient and therefore instead of using petrol they could use the abundant resources on the islands. The research group of three people carried out a trial project on one of the island the project worked and as a result the biomass gasifier ran a pickup truck and a generator to generate electricity (Webber, 2011). The project is proof that the technology works, but according to Webber (2011) the problem was with the management part of things, the attitudes of people put an end to the project. Webber (2011) stated that because all the outer islands were owned by government this became an issue and he thinks that if the islands were privately managed the technology might have had a chance of being implemented.

According to Sanderson Biomass Gasification is an on demand RE that can be obtained at any moment of the year and has a low installation cost compare to wind and solar. However it also has its disadvantage as it requires good resource management to prevent misuse of the resource currently there are no data on the Biomass potential of the country to ensure sustainable supply. The current price of a Biomass gasifier range from about US\$ 4500 to US\$ 7000 per kW with an operation and maintenance cost of about 2 to 3 cents per kWh (Lilley, 2006). This however does not include the transportation and construction cost of the Biomass gasifier.

4.2.2 Solar PV

Seychelles according to the solar irradiance handbook 2011 currently has irradiance between 5.1 to 6.5 kWh per m² per day depending on the months with an average of 5.8 kWh/m² per day. At present there is a pilot study being carried out in Seychelles for a grid connected PV system, this is a four year (2010-2014) project to assess the potential of PV in Seychelles. This is located at Electricity house and was installed by the PUC with a capacity of 1kW (REEEP, 2010a; SEC, 2011). This project has been partly funded by the UNDP-GEF programme (40%) and the government of Seychelles (60%). The aim of the project is to increase the use of PV systems as a means to generate electricity and to reduce the reliance on fossil fuel. The project is also a means to identify barriers to the deployment, diffusion and transfer of PV systems which will be addressed through the establishment of strategic policy and legal framework, which is another component of the project (REEEP, 2010a; SEC, 2011).

With regards to this project the pilot study for PV is as said before being financed by GEF, whereas the other component which will include identifying barriers and the establishment of strategic policy and legal framework, one component of this will be funded by the IEA and another will be financed by the Commission. Both will according to the Commission be held next year, if all goes well. It is estimated that a 2.5kW SPV will cost about US\$22 500 in Seychelles a per kW cost of US\$9000 or about SCR281 250 this includes the panel, wires, meter, and include the price of transportation, and installation (Webber, 2011). This is very expensive to the lower income Seychellois on a SCR 3500 (US\$200) salary per month and for the majority of Seychelles.

Solar PV has a lifespan of about 20 to 30 years and its efficiency decreases by only 1% per year and over its lifespan and requires minimal maintenance (CAT, 2011). According to Webber the price of SPV has decreased considerably and the current price have been further cut by 25% compare to last year's price. However while this may be the case the current investment cost is still very high about double the cost in Germany and the USA. For such a system to get implemented the payback period should be about 10 years but this requires cheap loans payable over a 10 year period at low interest rates preferably at 3% if the interest rate is more, then the system will be out of reach for many people. In the 80's there was a PV project that was tried on La Digue island to generate electricity. The electricity was used to run a refrigerator to keep vaccine cool as at the time there were no electricity on the island.

Another PV project implemented also in the 80's was solar powered water pump but though this was going to be beneficial due to the price of the PV system at the time both project was shelved as it was too expensive (Webber, 2011).

4.2.3 Solar Water Heater

In the 1980's there was also a SWH project which was started. According to Webber (2011) the three people working for the Research Division in RE even started a company. The company was involved with the manufacturing of SWH and installing them. As part of a pilot project they installed solar water heater on a number of houses in the district of Anse Aux Pins and they also installed SWH on a hotel located in the same district. During that time the salary were not very high about 1200 SCR (in today's term that will be about 100US\$). The cost of one SWH was 8000 SCR (640US\$) back then as a result the SWH was out of reach to many Seychellois resulting in low demand. In addition due to the cost of materials to construct the SWH and the cost of transportation the company was not making any profit and went bankrupt. But the project worked and was viable in hotels and Guesthouses and not private houses (Webber, 2011). In the mid 90's a few SWH Company started popping up one tried manufacturing the SWH but like in the 80's this did not work for the same reason and the company went out of business. Today there are about five companies dealing with the importing and installing of SWH in the country but as there are still no incentives from government many people cannot afford this (SEC, 2011; Webber, 2011).

According to a Sunheat representative (2011) a SWH supplier supplying Solar hart system from Australia which sells two type of SWH, a 180L SWH costs about SCR20 000 (US\$1600) while a 300L costs about SCR 32 000 (US\$2560) compare to about SCR2875 (US\$ 230) for an electric water heater. The price includes all fittings and an electric booster which heats the water in case there are long rainy periods and a lack of sun. To install such a system costs about SCR2000 (US\$160) to about SCR 2500 (US\$200) this depends on the way the roof is constructed and such system have a 20 year lifespan. Sunheat also stated that their SWH had a 5 year warranty and this period they are responsible to maintain the system and checks, they also provide a pamphlet to customers so that they know what they have to do to maintain their water heater and said that maintenance should be done every 8 months to a year. There are other SWH provider the lowest price are for Chinese manufactured SWH which according to some are not very good quality with shorter lifespan costing about SCR10 000 (US\$800). While the minimum Salary has increased up to SCR3500 (280 US\$) from SCR2500 (US\$200) in 2000, due to inflation rate and the high cost of living, goods and service tax at 12% buying a SWH in the 80's is still cheaper than buying one today (Webber, 2011).

4.2.4 Wind

Research into wind have been going on in the Seychelles for quite a while back in the 80's a wind mill was erected on one of the nearby island and the energy generated ran a generator that supplied electricity to a Youth Village located on the island. However the project was abandon after freak wind of up to 95km per hour blew the wind propeller away as a result investors were worried that the same will happen so nothing was done (Webber, 2011).

The potential for generating electricity using wind energy exist in the islands with some sites having an average wind speed of 6.9 to 7.5 m/s at 80 metres. In Seychelles the best wind period is during the Southeast monsoon from May to September which brings with it dry air, high winds, rough seas and dangerous underwater current. In the field of wind in 2009 the Abu Dhabi based energy company MASDAR¹⁶ and the GoS started a wind resource

¹⁶ MASDAR is a company promoting carbon neutral initiatives

assessment to measure wind speed and direction. The next phase of the project was the assessment of the environmental, technical and commercial feasibility of installing wind energy generators on Mahe (REEEP, 2010a; SEC, 2011). As a result of the assessment three sites were selected two on hills located in the south of Mahe and one on the West of Mahe and the last site was the harbour area. This preliminary pilot study was to have been completed by 2009 but due to certain constraints including difficulty in transporting the material to build the Wind turbines due to the terrain and a lack of roads and other infrastructure three of the sites had to be abandoned (SEC, 2011).

The sites abandoned where the best sites has they would have ensure that the wind turbines generated electricity all year round as they have access to both trade winds in Seychelles (Webber, 2011). The site selected at the harbour is not the most appropriate site according to Webber (2011) partly because it is located within a bay and only gets one trade wind and due to the mountain ranges during the Northeasterly wind the amount of wind will be very limited. Additionally according to Webber (2011) the wind speed in the harbour is mostly less than 4m/s and to generate electricity from wind you need at least a wind speed of minimum 4m/s or more. No Pilot study has been carried out in Seychelles to assess the potential of wind energy in the harbor and Webber (2011) stated that the government did not contact the right people to ask for advice and input which might lead to unforeseen issues with regards to the project which could have been avoided.

The project has not been abandoned and MASDAR with the Government of Abu Dhabi through the Abu Dhabi Fund for Development is funding and overseeing the design, development, construction and commissioning of the wind farm. This will cost US\$28 million translating to an investment cost of about US\$4 700 per kW for the country compare to about US\$1500 to US\$2000 for normal onshore wind project (NREL, 2010). Such high investment cost makes future investment in this technology highly uncertain unless this comes from external donors or investors. This wind farm will be transferred once constructed to the PUC. The initial cost also includes the cost of training PUC staff to operate the wind farm.

According to the SEC (2011) PUC will not have to pay for anything until they take over the wind farm which will be in a few years once the project is completed. It should be noted that wind turbines have a lifespan of about 20 years and an estimated maintenance cost of about 1.5% to 2% of the original investment per year and the cost of replacement of components is about 15% to 20% of the price of the turbine (Wind measurement international, 2011). These figures represents a high operation and maintenance cost for the wind farm. This high cost might in the long run be a disincentive for PUC. Experience from Curaçao, Fiji and French Polynesia have shown that high operation and maintenance cost to be the reason for wind farms failures in these countries (Van Alphen et al. 2007; Mehta-Kroll, 2010). The same may also happen in Seychelles. However the incentive for PUC to maintain this wind farm will come if the subsidies on fossil fuel are removed.

This project will be implemented on two uninhabited reclaimed islands Ile du Port and Ile Romainville which has been designated for Green Development (SEC, 2011). According to the SEC (2011) this project will consists of eight 750kW wind turbines. The combined peak capacity for the farm will be 6MW and will generate about 6 to 7 GWh of electricity per year representing about 3% to 5% of the total annual electricity production of Mahe. This gives the wind farm a total capacity of about only 13% compared to about 25% to 35% for most wind farm (NREL, 2010). This shows that the wind farm will not produce a substantial amount of electricity as a result more investment will be needed to harness other form of RE along with the proposed wind. The initial project was for 15MW peak capacity and the supply of 10-15%

of the Mahe's generating capacity, the project has thus been halved. As of yet this is still in the planning stage.

4.2.5 Waste to Energy

The SEC has submitted a request for proposal for the implementation of a waste to energy plant at the existing landfill site on Mahe as an IPP. It is hope that this project will provide 15% of the total electricity need of the country's electricity needs. To date this has generated five proposals for different waste to energy technology this includes an Incineration plant, two biogas plants, a waste gasifier plant and a landfill gas plant. The SEC made it very clear that the onus is on the investors to carry out feasibility studies before they start anything as they will not be responsible if whatever has been proposed does not work. The tender for these projects was put on the SIB website to generate international interest and investment and the government have yet to make a decision on which proposal will be considered (SEC, 2011).

With regards to incineration plant the SEC stated that the minimum amount of waste for incineration was about 100 thousand tonnes per year. At present Seychelles Generates about 50.8 thousand tonnes of waste¹⁷ of which about a third is organic waste representing about 46 tonnes per day (DoE, 2011). When ask if this was a viable option they stated that the waste could be supplemented with coal like in Mauritius where Bagasse is supplemented with coal to meet capacity (SEC, 2011). During the initial discussion of the topic I was told that it requires a population of 100 000 to maintain an incinerator and ensure profitability Seychelles does not have that kind of a population.

According to the SEC there are proposal to start pilot project for Biogas at four animal farms in Seychelles. This project will be financed by the Chinese Government and will be implemented by the Department of Agriculture with the help of the SEC, the cost is not known as the project is still in the proposal phase. The aim is to build four small Biogas plants in the north, west and south of Mahe and one on Praslin. The project will help to educate farmers of the benefits of introducing RE and the savings that they can make from using a raw material which once were only good to help improve the quality of their soil (SEC, 2011).

The project has potential as such a project was tried in the 80's where a farm of about 50 pigs belonging to the state's farming corporation was used. The pig sties were modified so that the animal waste could be captured and diluted and sent to the digester, the gas was used to run a generator to produce electricity. The project showed that the potential and the technical capacity existed however due to people's attitude and perception the project was never fully implemented. According to Webber (2011) people did not see the long term benefit of the project as a result the project was shelved.

4.2.6 Waves and Hydro

No research have been carried out on these two RE source and not one of the people interviewed saw these as technology that will take off in Seychelles.

4.3 Outlining the RE potential in Seychelles

To assess the RE potential in the country the adapted framework from Van Alphen et al. (2007) and Mundaca et al. (2005) will be used. According to Van Alphen et al. (2008) the adoption of an innovation goes through different stages which include awareness, interest, evaluation, trial and adoption/rejection. If an innovation is viewed favourably an

¹⁷ 577kg per person per year according to the Seychelles Nation 2005

implementation phase follows this is important in the diffusion process as it requires commitment and actions from the adopters to put the idea in practice (Van Alphen et al., 2008). Five characteristics have been identified by Van Alphen et al. (2008) for the implementation stage these will be used in conjunction with the CDM adapted framework to assess the RE potential in Seychelles.

The first and second characteristic is common to both Mundaca et al. (2005) and Van Alphen et al. (2007). The first characteristic is the Relative advantage of the technology which looks at whether the innovation is better than the status quo expressed as economic feasibility in the CDM framework or profitability (Mundaca and Rhode, 2005; Van Alphen et al. 2007). The second one looks at the environmental and socio-economic benefits the project will generate i.e. GHG mitigation and job creation and how the introduction of RE will reduce a country's dependence on fossil fuel simply put this will look at *the Sustainability Development of the Project* (Mundaca and Rhode, 2005; Van Alphen et al. 2007). The third is the comparability or the degree of consistency the technology has with existing values and needs of the adopting country, the fourth is its simplicity or how easy it is to introduce and use the technology, the fifth is triability or the degree to which the technology can be experimented on a trial basis and observability or the degree to which the results are visible to others (Van Alphen et al. 2007). Additionally to the 3 steps from Van Alphen et al. (2007), Mundaca and Rhode, (2005) also identified the importance of Institutional Conditions and how they influence the RE potential, this will look at the institutions, legal and policy instruments at play and their influence within the country. Refer to table 4-1 which shows the various potential against the above criteria.

4.3.1 Economic feasibility

The economic feasibility looks at whether the introduction of RE is better than the current situation. The key indicator to determine whether an RET is competitive with fossil oil is the levelised cost of electricity¹⁸. Currently the country spends about US\$74.4 million per year on oil imports; this can fluctuate when the price of oil fluctuates. With regards to economic feasibility as per the WCED 1987 definition of Our Common Future sustainability implies that a development needs to be socially, economically and environmentally beneficial to the current and future generation. At present in Seychelles none of the RET components under proposal are fabricated in the country due to economies of scale, lack finance and lack of/or access to raw materials as was found with the SWH projects tried in the 1980's. The cost of importing raw materials, its transportation and assembly made the fabricating of this technology in Seychelles not profitable. It is thus more profitable to import readymade products for installation in Seychelles (Webber, 2011).

The levelised cost of electricity (LCE) is determined by these key factors. Investment costs which include pre construction costs, construction costs (engineering, procurement, and constructions), and contingency costs along with interest accumulated during construction. The LCE also includes the fuel cost in the case of fossil fuel. It also includes the cost of decommissioning the technology, along with the cost of operating and maintaining the technology over its lifetime at different discount rates (IEA 2010). Currently in Seychelles there is a lack of country specific data for the key factors mentioned above. There are some scattered data available related to the investment costs, costs of the technology and limited operating and maintenance cost. However there is a lack of data with regards to the energy

¹⁸ Levelised cost of electricity is a common way to compare the cost of energy across technologies because it takes into account the installed system price and associated costs such as financing, land, insurance, transmission, operation and maintenance, and depreciation, among other expenses. Carbon emission cost and efficiency can also be taken in consideration in such calculations (Solarplaza, 2008).

production level of RET in Seychelles, the full operating and maintaining cost of the technology over its lifetime. This makes it hard to provide data on the levelised cost of the different RET in Seychelles. There is therefore a need for more and better data on these to allow for a more in-depth assessment.

Data of the levelised electricity cost of two RETs will be provided however comparison cannot be made as Seychelles and these countries have got different climatic conditions. The data is provided however to give an idea of the possible cost of RE generated electricity in Seychelles. Data used will be from the IEA projected cost of generating electricity in 2010. In Belgium a 6MW wind farm has a levelised electricity cost ranging from US\$95.65 to US\$136.23 per MWh. This includes the investment costs and operation and maintenance cost of the project. In Seychelles due to the high capital, operation and maintenance costs this will be much higher. However cost could be the same if a better location with all year round wind is found. In this case while the investment costs will be high, the associated cost might be less however this is just speculation. The capital cost per kW in Seychelles is US\$4700 compared to US\$2615 in Belgium. With an associated maintenance cost per MWh of US\$46.66 in Seychelles compared US\$20.54 in Belgium.

With regards to SPV data is taken from a 1MW system in the Czech Republic. The levelised cost of SPV electricity in the Czech Republic ranges from US\$392.88 to US\$611.28 per MWh (IEA 2010). The levelised electricity cost will also be higher in the Seychelles due to high capital cost, however due to higher solar radiation in Seychelles the cost might be about the same as that of the Czech Republic or lower. The capital cost in Seychelles is about US\$9000 per kW compare to US\$7381 in Czech Rep. With oil the data used will be from South Africa. South Africa has a levelised electricity cost of US\$393.24 to US\$396.62 per MWh for oil. This will be much lower in Seychelles, as less electricity is being generated. All this however are speculations not based on concrete evidence as was said before more research on this criterion is needed. While economic data available on RET in Seychelles are scattered and incomplete, some data do exists.

The Seychelles will get its first wind farm which is being sponsored by the Government of Abu Dhabi for a sum of US\$28 million. This includes the cost of designing, transportation, construction, commissioning and training of staff. This money is supposed to ensure the provision of eight 750kW wind turbines. According to NREL (2010) onshore wind technology costs between US\$1500 to US\$2000 per kW. While the wires and control panel ranges between US\$800 to US\$1200 per kW (Van Alphen et al., 2007). Engineering and Installation costs according to Van Alphen et al. (2007) are about US\$1300 to US\$5000 per kW. This does not include the cost of construction, transportation and commissioning. Therefore the cost of 1 wind turbine being implemented in Seychelles will cost US\$3.5 million this includes the cost of construction, transportation, training and operating the facility which is not being borne by the government of Seychelles.

Once the wind farm is transferred to PUC the operation and maintenance costs will be borne by PUC. Wind turbine have a 20 year life span, therefore the operation and maintenance will cost PUC about 1 to 2% of the initial investment per year a total of US\$280 000 to US\$560 000. (This represents a production cost of US9.3 cents per kWh if annual electricity output is 6GWh). Current electricity retail price ranges from US0.09 cents to US0.22cents. This represents a high production costs for wind translating to a high retail price making it not very competitive with the current heavily subsidies fossil fuel electricity system. The PUC in addition will also in the long run be responsible to replace components of the wind turbines such as the blades, gearbox and generator this will cost about 15 to 20% the price of the turbine about US\$168 750 per turbine (Wind measurement International, 2011).

However replacement of spare parts will not be needed every year if the turbine is being maintained appropriately. Otherwise if the maintenance cost remains high there is a possibility that this program might get abandoned. This is a realistic concern, proven in many small islands like in Fiji, French Polynesia where wind projects failed due to higher cost of maintenance and those that did survive were not producing electricity effectively in these places maintenance cost was as high as 4 to 5% of the initial investment per year (Van Alphen et al., 2007). This represents a total of US\$1.1 million at such high rates of maintenance in the case of Seychelles. The government will need to be prepared for such a possibility and plan ahead how it will raise the fund for maintaining and operating the wind farm. This will make wind technology not an economically viable RE option for government.

With solar, be it PV or SWH the cost of maintenance over the 20 to 30 year lifespan is minimal about 1 to 2% of the equipment cost according to Van Alphen et al. (2007). This involves ensuring that the panels are clean and properly installed. The initial cost of PV however is very high per kW according to Van Alphen et al., (2007) between US\$4200 to US\$6000 per kW this price is predicted to go down to US\$3200 and US\$ 4000 per kW. This is the price of the panel only. There is an additional cost for the other components between US\$610 and US\$ 1100 per kW for the wires, hardware and controls. The initial cost of PV is quite high for Seychelles between US\$6000 to US\$9000 not including transportation and installation cost which will depend on the size of the project.

PV at current price might not be feasible for household but it can be an option for commercial enterprise currently paying higher electricity rates than households (ranging from US0.22 cents to US0.28cents per kWh). For it to be attractive however the payback period should be about 10 years and this will require cheap loans with low interest rate of about 3%. Otherwise the payback period will be longer and will make it economically not viable for businesses and households. Both PV and wind turbines systems requires a storage facility if operated as standalone system. Cost ranges from US\$1000 to US\$2000 initially for all components such as the battery, inverter and charger and an additional cost of about US\$ 150 to US\$225 for a lead battery with a lifespan of 5 years. Better batteries with longer lifespan will cost more (Van Alphen et al., 2007).

For SWH the current price for such a system is between US\$800 for 180L to US\$2560 for 300L with an installation cost of US\$160 to US\$ 200. For SWH the cost of maintenance is low as this can be done by the purchaser and this involves the cleaning of the system every 8 months or every year. At its current price SWH is still very costly for most Seychellois households, but a worthwhile investment in the long run especially for tourism development. According to the Green Power Market Development Group (2007) a SWH system has a payback period of about 4 to 8 years. This shows that such a system will be providing savings for many years. For SWH to be competitive in Seychelles incentives needs to be provided by government to make this technology affordable to more households.

For Biomass gasifier according to (Lilley, 2006) the price ranges from US\$4500 to US\$7000 per kW with an operation and cost of about 2 to 3% per kWh. This however does not include the transportation and installation cost. With regards to the cost of Biogas and landfill currently I have no data of the cost, however there is potential and this potential when harness will be an economically viable enterprise and according to Vredon et al. (2010b) this can replace about 8 000 tonnes of oil. With the case of the Biogas plant the potential exists as currently the country is generating about 46 tonnes of organic waste per day and the potential is also there for farms to generate some of their electricity and save to invest in the further development of their farm and to contribute further in the country's food security. Whereas Incineration though the cost of building a small plant is not known it is economically not a

viable option as it the current population size the country only generates about 50 thousand tonnes of waste per year and to run an incinerator to be economically viable about 100 thousand tonnes of waste is needed. The idea being proposed is to supplement the waste with coal which will involve shipping another dirty fossil fuel to replace another one this is not a solution for the future.

It is clear that with many of these technologies the implementation cost is high however the long term benefits and savings will however be better than the status quo. It will mean a reduce dependence on fossil oil; energy security and a reduction of the amount of money spend on fossil fuel importation. However more research and better data is required for a proper assessment of the economic feasibility of RET.

4.3.2 Socio Economic Benefits

As for socio economic benefits this looks at the potential of the RET in creating jobs and reducing the country's dependence on fossil oil. From the findings it is not clear which company will get to construct these proposed RET whether this will be carried out by local company or an International one. In both cases it will mean the creation of jobs in the construction phase for local people. However if it is carried out by a local company with the technical assistance of local engineering firms this will mean more jobs for local construction workers and engineers. The proposed wind farm will also generate more local jobs especially at PUC for those who will be trained to manage, operate and maintain the proposed wind farm.

From table 4-3 as can be seen most of the RET assessed will generate jobs for the local population this can be during construction, after construction for the running and maintaining of the projects. This can range from all Seychellois in the case of PUC to some Seychellois in the case of the waste to energy project which will be implemented by an international investor. However all of these staff depending on the jobs that they will do will require training especially if this involves working with the technical aspect of the project. As most of these projects are still either in the planning or proposed stage it is still not clear how many jobs will be created.

In addition to job creation it is hope that the introduction of RE will improve the standard of living of most Seychellois. Through the reduction of the cost of electricity or to prevent further price increase which has risen by 30% since 2007. As a result of the continual increase of fossil fuel oil on the international market, RE generated electricity is seen as being more competitive today against fossil oil. However as none of the projects have come online it is difficult to predict the production cost of these projects. However if the production cost is less than the current cost of producing electricity this will result in lower electricity price for consumers, currently the price of retail electricity per kWh ranges from US\$0.09 to US\$0.22. This will have the added benefits of allowing people to make a savings on their electricity bill which can be used on other necessities. In addition the introduction of RE in the country will be a way to build capacity and knowledge in a new field which will benefit the country in the long run.

In addition the use of available energy sources is a way to reduce the country's dependency on oil producing nation and on imported fossil fuel. This will represent a saving for the country in the long run as less oil will have to be imported. There will therefore be more money available to develop the countries services and infrastructure to ensure more development for the country.

4.3.3 Environment Benefits

Environmental benefits looks at the potential of the various technology in reducing the adverse environmental effect. All the sources of RE such as solar technologies and wind have great environment advantages as they reduce the amount of GHG that gets release in the atmosphere during their life cycle compared to the fossil fuel that they will replace. This is also true for Biogas which reduces the amount of methane gas that gets release into the atmosphere by converting this into useful energy to power a generator to produce electricity. Currently the country generates about 46 tonnes of organic waste per day which instead of being land filled can be used to produce electricity and reduce the GHG emission of the country. Landfill gas collection is also a good option to generate electricity with good environmental results as it is a means to collect the already available methane gas in the landfill and prevent it from being released into the atmosphere. In addition the byproduct of biogas is also useful in farm to improve soil quality.

With Biomass if built correctly and according to manufacturers standards can reduce the amount of GHG released compare to a fossil fuel plant or a fossil oil powered generator. With the use of biomass, this requires good resource management to ensure that this does not lead to deforestation of islands. As for incineration the burning of all waste can lead to the emission of GHG and harmful substances which can be just as worse as a fossil fuel powered plant even if built properly. Emission from incinerator is an issue for all country with this technology and as yet there is no incineration plant that produces zero emission. In addition in Seychelles as there are not enough waste to run an incineration plant. The notion of supplementing the available waste with coal is only exchanging one fossil fuel for an equally worse fossil fuel which can release high amount of sulphur and CO₂ in the atmosphere.

With regards to waves as this is an untried technology in Seychelles which may have its potential at certain location. However if interest is shown for this technology environmental care should be taken. As the country has a fragile marine environment thus consideration should be taken that this technology does not affect the habitat of sea creatures or their ability to reproduce. Care should also be taken to ensure that these does not release harmful substances in the water or affect the migratory pattern of fish to and from Seychelles and that they do not pose a threat to protected marine species such as whales, dolphins and sea turtles.

4.3.4 Compatibility

Compatibility involves ensuring the project is consistent with a country's values and needs and the cost of operating and maintaining the projects. To ensure that these proposed RE projects does not fail it is important that the local people who will take over the operation and maintenance are trained appropriately to ensure the good functioning of the project. The cost of training will depend on the size of the development and how complex the project is and to some extent on the location of the project. Currently all planned projects will be located on the main island of Mahe; this will facilitate the maintenance of the wind farm once it is handed over to PUC. With regards to the wind farm the training to operate and maintain the farm will be provided by the company donating the wind farm.

For the proposed large scale Biogas plant it is assumed that if feasibility study shows potential and once the plant is operational that the company will provide training for local people on how to maintain and operate the plant. Assumption is also made that the demonstration projects for small scale Biogas on the four farms being proposed by the government of China with the Department of Agriculture will also provide training to farmers on how to run such a facility. With regards to Solar PV and SWH as maintenance cost is low it is assumed that

training on how to maintain these will be carried out by the company deploying the technology which is currently the case for SWH.

Another aspect with compatibility which applies for the proposed waste to energy proposal is that currently the country does not have a waste management strategy and most household waste are land filled without sorting. While some household and hotels donate their leftover food to pig farms this does not include all hotels and does not include shops and other establishment and these ends up being land filled. There is a need therefore before implementing a large scale biogas plant to educate people and raise awareness so that people start sorting their waste. It will not be hard as some household are doing this without being asked. With incineration it might be hard for people to accept such a technology as people usually equate smoke stacks with pollution, black fumes possible smell which can lead to uproar from the general population if such a project gets proposed. However as Seychellois is a nation where reaction comes after the fact and where public participation is not an activity people like we can only wait and see how people will take such a proposal if and when it comes.

As Seychelles does not have any RE projects that have been implemented as yet to be able to compare past experience and to learn from past mistakes, we can therefore only learn from past pilot projects. These pilot projects failed due to people's attitude, cheap cost of fuel oil and financial aid to build fossil fuel power plants. From this it is clear that it is important to educate people, raise awareness amongst the population to ensure that they accept and support such projects which will benefit them in the long run. All the proposed projects in the country aim to introduce clean energy source within the energy mix. As a country that is highly dependent on fossil fuel and one which is very conscious of the need to protect the environment the introduction of RE goes well with the environmental values. RET deployment also goes well with the country's need and desire to reduce its dependence on fossil fuel which is currently costing the Seychelles 10% of its GDP.

4.3.5 Simplicity

This relates to how easy it is to understand a given technology, if it is easy to understand, build, operate and maintain then it will get implemented quickly. This is the case for SPV, SWH, small scale biogas and biomass gasifier, these will be easily adapted as they are not complex or difficult to manage. However when it comes to wind technology this becomes more complex as there are so many parts involved and if one is not working properly it affects the whole system. While the cost of training staff to operate and maintain the wind farm is included in the initial cost in the long run the operation and maintenance cost will be borne by PUC and the government of Seychelles. As was said in the economic profitability part this might prove too costly and make the project not viable in the long run, which might lead to the abandonment of the project. The degree of complexity also increases with the size of a project which might make large scale Biogas, landfill gas and incineration plant a bit more complex to manage and run. However the best thing with these projects being proposed in Seychelles is that these are not being implemented by government. It is therefore up to the private investors to bare the operation and maintenance cost regardless of the complexity of the project for new RE project. It is assumed that these companies will include an assessment of such cost within their feasibility study to see if the project will be profitable for them.

4.3.6 Triability and Observability

These two criteria relate to the ease of trying these projects as pilot, how easy, it is to showcase these and share the findings. In Seychelles the only RET that has been tried and implemented is SWH though this is not very widespread. SWH has proven that it can work in

Seychelles as the number of such companies has increased from two in the 90's to about six currently. The local NGO Sustainability for Seychelles did a pilot study with SWH and Energy efficient appliances available on the local market in three houses to show how this influences the electricity consumption in a house. According to them the result was very promising as it showed a reduction in the amount of electricity consumed and the cost of electricity for the house.

SPV, biogas, biomass have been tried in Seychelles in the 80's with success though these projects were abandoned due to short sightedness at the time, there are plans to implement such projects at certain farms on a small scale to assess its potential. From past project result that showed promise it is assumed that with new development in the field that these trials will also show positive result and will be taken up by animal farms once they see its potential and result. With regards to SPV there is also a 1kW pilot project being tried by PUC at the Electricity house which is generating 5.6kWh of electricity per day it is hope that once this project is over that the government will encourage investment in this Technology to further supplement the electricity supply from RET in the country and reduce our dependence on fossil oil. As for the wind farm no pilot study was carried out due to the size and complexity of the technology.

In addition due to terrain condition during the feasibility assessment the best sites on three hillsides had to be abandoned. Additionally due to a lack of consultation with stakeholders it is felt that the chosen site is not the most appropriate location for a wind farm as it is in a bay where the mountains act as a barrier to the wind. While wind measurements were carried out on the site, one particular stakeholder stated that there were other islands in the vicinity that would have been more suited for such a project as they had better wind potential. As a result the area only gets wind speed of up to 4m/s or less which is the minimum wind speed to generate electricity during the northwest monsoon the calmest period for the country. The three other sites had wind speed of 6.9 to 7.5 m/s all year round. With regards to wind trial this was not done due to the high risk and cost associated with transportation and construction of one wind turbine just to assess the potential, the cost of trying the technology is included within the investment cost of US\$28million.

For the large scale biogas/landfill gas project it is assumed that during the initial feasibility study that a pilot project to assess the potential will be tried before implementing a larger plant as this will be in their best interest investment wise, however this only speculation at present. With incineration you cannot implement a trial project the potential will be assessed within its feasibility study which will assess the potential in Seychelles. As per the economic feasibility the potential for this technology is rather low in Seychelles.

4.3.7 Institutional conditions

This looks at the current institutional conditions and how it helps or hinders the RE potential development. Currently the Seychelles has low institutional capacity and know how. It has limited amount of people with knowledge in the field of RE to create policies. This has lead to a lack of policy and regulations to guide the development and implementation of RET. There are currently no incentives financial or otherwise to help the uptake of this technology. There is also a lack of trained personnel or a facility where these people can get trained to operate, maintain and manage these projects. There is also a lack of training for government staff that has to assess these developments and ensure that these are built up to appropriate standards.

There is a lack of building codes and standards to help with the implementation of these technologies or its inclusion in the design of houses currently. This lack of knowledge and capacity leads to delays on decisions which can lead to investors abandoning the project or

going elsewhere. The country also has a lack of feasibility research in the potential of the various RE sources it possess. An example is wave though this is a new technology the country does have some potential, however the extent is not known and might never be known unless a private investor wishing to invest in this technology carry its own feasibility study. As a result of this the country in the end do not get access to this private research hence loses the means of updating its existing RE potential data. Another issue with Seychelles is a lack of energy data; this is incomplete, too old or not available making it hard to carry out research in the energy field.

Table 4-1 The RET potential in Seychelles

Criteria/ RE Source	Potential	Environment Sustainability	Economic Feasibility	Socio Economic Benefits	Triability	Simplicity	Observability	Institutional Conditions
Wind	**	***	*	***	*	*	***	*
SPV	***	***	**	***	***	***	***	*
SWH	***	***	**	***	***	***	***	*
Waves	?	**	?	***	*	*	**	*
Waste to Energy	***	***	?	***	**	**	***	*
Bio gas	***	***	?	***	**	**	***	*
Landfill gas	***	***	?	***	**	**	**	*
Incineration	*	*	?	***	*	*	***	*
Biomass	**	**	**	***	***	**	***	*
Hydro	*	**	*	*	*	*	*	*

*Low **Adequate ***Good? Unknown

4.3.8 Assessing the potential of Waves and Hydro

Table 4-1 shows the potential of various energy sources in Seychelles from the table it is clear that solar, wind, biomass, landfill gas biogas have better chances of being deployed in Seychelles this can be both on a small and large scale. Except for wind which will be more feasible on a large scale, due to the associated investment, maintenance and operation cost and economies of scale. The other RE sources such as incineration its potential is low compare to the other RET as per the table and the above analysis.

For hydro the potential is also low due to the fact that the Seychelles have few rivers and these are usually very small with very low water pressure. Most rivers in Seychelles form part of the water catchment which is protected from all forms of development additionally the pressure is not enough to drive a generator to produce electricity. Water in Seychelles is a contentious issue and a hydro plant will not be supported by the population as the country is suffering from water shortages and a long drought. This option will be economical not viable and an option that the people will be fervently against. As for waves as no study has been done on the RE source to assess its potential this is not known.

With regards to wave technology environment consideration will need to be taken as was said in the environmental criteria above. In addition to the above conflict with sea users such as shipping companies, recreational users, fishermen will have to be managed. There is potential for this technology as some location especially during the South east monsoon as this is the period where the country experience rough seas and high wind speed. Wave like wind is an intermittent energy source while ocean or sea current is not and this is available all year round. There are certain areas in Seychelles deemed dangerous to swim due to the strong sea current there might lay the possibility of harnessing this energy to generate electricity however this is just an assumption. The potential will have to be assessed.

4.4 Discussion of RE Potential assessment

From this analysis it is clear that some technology have good chances of being deployed in Seychelles. One such RE project is the wind farm which is a gift to the country. The only cost it will bear will be the cost of operating and maintaining the farm once this is handed over to PUC. However as wind is an intermittent RE it will therefore only produce electricity from May to September during the South East Monsoon which is characterise by strong wind and rough seas.

Due to its intermittency it is felt that for the wind farm to be a worthwhile venture and produce electricity all year round, another RET should be paired with it. An option that will work in this case is solar PV; this RE is available all year round during daylight hours in Seychelles. This combination will pair a technology that is seen as affordable in terms of dollar amount per kW in the case of wind. While solar is a technology that does have a high investment cost per kW however the cost of maintaining PV is lower compare to wind as a result these might balance each other out in the long run.

In addition as the wind farm is a gift the only cost to the country will be for its operation and maintenance. While pairing is a good idea it is clear that the government will not be implementing any RET in the country which is understandable as the country cannot afford the high investment cost associated with such technology. Thus the pairing of solar PV with the wind farm will have to be done by the private sector, as part of a well thought out partnership. This represents a great investment opportunity for foreign investors and/or local entrepreneurs interested in becoming electricity provider in the long run. Such opportunity will only be taken if there are legal changes to the PUC Act to allow Individual to sell their excess electricity.

However with a country the size of Seychelles it is not advisable to deploy too many RETs together. This might have an adverse effect on the RE sector the reason being that as the country has limited human and financial resources this will be spread out over several technologies resulting in inefficient use of the available resources. As a result some technology might be sacrificed due to lack of proper maintenance and management which will be a waste of economic resources especially for government. This might not be a problem for Seychelles, but it is a worthwhile concern to be noted even though government is leaving the RE deployment opportunity in the hands of the private sector. It will be up to them to assess the viability of their proposal and whether they can train local staff to do the work required. While this may be the case the government have an active role to play to ensure that the right environment is created to aid the deployment of RET in the Seychelles as the private sector cannot do everything on its own.

Therefore to answer the first Research question: *What type of RET had the potential of being deployed in Seychelles.* From the above table a number of RE have potential of deployment, it is clear that the country does have the RE potential however it currently lacks the financial, technological, Institutional and political capacity to allow this to happen in a successful manner.

Even though this maybe the case, potential for deployment of these following RET exists, but for these to be successful the above weaknesses needs to be managed and ways to do this will be outline in the subsequent chapter. It is clear that not all households or businesses can become IPP and this is not the intention of every Seychellois. However while this maybe the case there is one RET that have the potential to be deployed by many households and businesses, this is SWH. Therefore proper incentives from government are needed to make SWH more competitive to electric water heater. This technology has a great possibility of

being deployed in households and in tourism development current and proposed and can thus become a successful venture in Seychelles if done properly. This deployment will also result in reduction of electricity use for many households, translating into monetary savings in the long run.

SPV on the other hand does have a possibility of being deployed in household looking to make long term energy investment and savings by those who can afford this technology at current prices. Most importantly it is an ideal option for hotels, businesses and for remote application on outer islands due to its low maintenance cost it can thus replace some of the fossil fuel generators. SPV for hotels makes good business sense especially for hotels and islands that brand themselves as eco friendly and sustainable this will not just be a tag but a reality as they will be able to show this aspect to clients with the deployment of RET. Of course with everything new training will be required for maintenance and engineering staff at the hotels on how to install, maintain and operate this technology if they decide to implement this.

Biomass also has the potential of being implemented in outer islands, as these islands used to be coconut plantations and have small seasonal population. While this may be the case, with biomass good resource management on these islands will also be required, which means that Biomass might not be as successful as SPV. However its use can replace some of the diesel oil used on these islands if used properly.

With Biogas and landfill gas there is potential in Seychelles as the government have tendered out for proposal to generate about 15% of the country's electricity need from such technology. With landfill gas potential is there due to the high amount of organic waste that have been land filled in the past, how much gas might be available will have to be assess in the chosen company's feasibility study. Biogas at the landfill site is another potential but this will be a solution for the long term future of the country as this requires the country to have a functioning waste management system and that people learn how to sort their waste, this option might take over once the landfill gas potential has been depleted or can run in parallel once people learn how to sort their waste. In addition investing in RE such as biogas, landfill gas, and wind can also provide other incentive as depending on their size (if they generate 15MW of electricity) can qualify as CDM projects and can thus generate credits for the company implementing the project.

With regards to wind, potential exists especially offshore where there are available wind all year round. Though offshore wind potential might be better it is considerably more expensive to implement such technology between US\$500 to US\$1500 more than onshore wind projects (NREL 2010). In addition offshore wind carries with it more technical risks with installation cost that can be twice of that of onshore wind farms. It also entails high operation and maintenance costs which can be twice as much as that of onshore wind farms (Renewable Energy Focus 2011). Offshore wind farms are also more prone to equipment failure as equipment used were designed for onshore conditions (Renewable Energy Focus 2011). Offshore wind farm also requires good marine surveys to locate areas that will be appropriate for such construction. Such surveys must take in consideration the depth of the sea, type of underlying rocks and distance to customers. If this is too far offshore wind might be perceived as too expensive taking into account the cables which will be required to provide the electricity generated.

However due to economies of scale, lack of resource assessment, limited financial and human resources any future development in this technology will like most other development in the RE field have to be through private sector or foreign investment. This is due to the high

operation, maintenance and cost of spare parts which will have to be bear, as a result, government will only be able to manage and run the one wind farm it will be entrusted with.

The best option for the country is wind coupled with solar PV and SWH though the initial cost is high the subsequent cost of maintenance for solar is however not as high. These solar technologies can be applied on all islands. On the main islands available roof spaces can be rented out by the company implementing the project or the project can be deployed on designated reclaimed land. However in times of rain stored energy can be used or the wind farm can take over.

While potential exists as was said in the assessment it is not clear whether RET will reduce the price of conventional electricity. The current price does make RET competitive with fossil fuel according to the Yamba (2011). However to ensure socio economic benefits for the people it will be better if the introduction of RE resulted in a decrease in electricity prices. However if this occurs government should prepare for potential rebound effect and increase consumption as this will negate the RE benefit. If the price is the same or more this might make RET not viable for the country. Or as a result of continual high prices, this might make people more conscious of the need to be energy efficient so as to reduce their electricity demand hence electricity cost. While the cost of electricity might be the people's main concern, this is not the main concern of government which is more concern with reducing the country's dependence on fossil fuel. The concern voiced by the private sector which has been identified by other SIDS government. Is that if the price of fossil fuel decreases RET might become less attractive to government and the project proposed, implemented under their responsibility might be abandoned or be poorly managed.

5 Current Innovation Environment in Seychelles

This chapter will look at the current innovation environment¹⁹ in Seychelles. Analysing the innovation environment of Seychelles will help identify where problem lies. It will also be a means to find ways to help managed these to ensure that RET gets implemented. The analysis of the current innovation system of Seychelles is based on interviews carried out in Seychelles and literature reviews. Interviews were carried out with the Department of Environment, the Planning Authority, the Seychelles Energy Commission, the local NGO Sustainability for Seychelles and a representative of the Private Sector. To carry out the analysis the Innovation System framework is used. This analysis will be followed by a discussion to outline the possible opportunities for change and recommendations to help guide RE deployment in Seychelles.

5.1 Innovation Framework to analyse the local Innovation System in Seychelles

To ensure successful deployment of RE there needs to be an Innovation System to guide this development therefore to assess whether this exist the findings will be analysed against this framework. Van Alphen et al. (2008) stated that IT implies more than just the supply and transportation of hardware across international borders it involves knowledge sharing and adapting the technology to local conditions which thus requires in-depth study of local perceptions and local capabilities in the successful deployment of the technology. Thus to assess how these influence the transfer of RET's the IS Framework is useful to understand all the important factors that influence the deployment of a technology (Van Alphen et al., 2008). According to Hekkert et al. (2007) innovation is important to mitigate the negative effects of economic growth. The innovation System Framework according to Hekkert et al. (2007) has been adopted as an analytical framework and guideline for science and innovation policy by many public organisations around the world to provide insights on the factors that influence the innovation process. According to Bergek et al. (2007) the innovation and diffusion process is both an individual and collective act interconnected within the innovation system that can guide, aid or impede individual actors from performing their role.

Hekkert et al 2007 defined the innovation system as:

“... Systems of innovation are networks of institutions, public or private, whose activities and interactions initiate, support, modify and diffuse new technologies”

In order to understand technological changes there is a need to understand how the innovation system for a new technology begins and works. For emerging Technological

¹⁹ Innovation is the process by which an idea or invention is translated into a good or service for which people will pay, or something that results from this process. To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need. Innovation involves deliberate application of information, imagination, and initiative in deriving greater or different value from resources, and encompasses all processes by which new ideas are generated and converted into useful products (Business Directory.com).

Innovation Environment is the climate in which innovation takes place this can be an organisation, a country or region it includes the structures and resources put in place to help guide, develop a given innovation. This occurs through the sharing of Knowledge and ideas, research and development and the creation of legitimacy amongst stakeholders.

Innovation System which is the case for Seychelles the number of actors and institutions are small which makes it easier to analyse and understand what takes place in such a system. A TIS according to Hekkert et al., (2007) is defined as:

“a network or networks of agents interacting in a specific technology area under a particular institutional Infrastructure to generate, diffuse and utilise technology.”

Therefore the formation and growth of innovation system is based on three structural components firms and other organisations, networks and Institutions, however for a system to evolve and perform well seven functional requirements must be fulfilled, this include Knowledge development, Entrepreneurial experimentation, Knowledge diffusion, Market formation, Legitimation, Resource mobilisation and development of positive externalities (Bergek et al., 2007; Bergek et al., 2008; Hekkert et al., 2007). See Appendix 1 for an explanation of the three structural components and the seven functions. According to Bergek et al 2007 an IS can be analysed at these two levels the structural level which looks at the continuous interplay between the actors in the IS, the network formation and the changes or lack of it within Institutions and at the Functional level which have more direct influence on the performance of the system.

The systems functions are related to the interaction between the components of an Innovation system such as firms and other organisations, networks and institutions. Systems functions are important to stimulate technological development and raise expectations and ensure that the innovation system gets developed and is successful (Hekkert et al., 2007). The outcome of an IS, is therefore dependent on the internal dynamics of the system which can set positive feedback loops in motion involving all the components and functions of the system (Bergek et al., 2007; Bergek et al., 2008). However it should be noted that the linkages between the seven functions are affected by external factors which can influence the internal interaction within the system this influence can be either positive or negative (Bergek et al., 2007; Bergek et al., 2008). By looking at the function of a system and understanding how changes it can help in identifying weaknesses within the system and facilitate decision makers in making quick and decisive changes at policy level.

Therefore to analyse the potential for deployment of RE in Seychelles the three structural components and the seven functions of the IS will be used to analyse the current situation in Seychelles. The research will look at how changes in the structural components of the IS drives the various functions in the Seychelles and look at how external factors influences the seven functions. The analysis will also look at the interplay of the functions and how these drives the system forward in a reinforcing way, through positive feedback loop. Through the analysis the systems weaknesses will be identified and solutions will be formulated to answer the second research question. The ‘how the system is driven’ will be the basis for the formulation of recommendation and way forward of the thesis.

5.2 Past Innovation System

In the Seychelles in the 1980’s due to an interest and the championing of the then Minister of Planning, the government implemented a number of RE pilot projects in the country. Through the Seychelles Research and Development Division RE pilot project were tried on nearby and outer islands. These projects were carried out with the research assistance of two international institutes the Beijer Institute and the Twente University. These projects showed real potential to aid development especially in outer islands. However some of the projects were not viewed well by the population, in addition due to financial aid from the British Government to build thermal power plants in the country and due to low oil prices in those days; these projects were abandoned in favour of oil see section 4.2 for more detail on these

projects. While the other technology such as SWH and SPV the cost of implementing these technologies coupled with a lack of market for such projects were the reason why they were abandoned.

After the failure of these projects not much was done in Seychelles with regards to RE except for a revival in SWH in the 90's. With this revival demand came but mostly from tourism development and to a small degree from private household however this technology is still not widespread in Seychelles. In the Seychelles in the past there was some sort of emerging innovation system as the government had started to build capacity, they had the technical capacity and know how to build these technologies then however they lacked the Institutional and managerial capacity. The country had even started research projects to assess the potential of these technologies with the help of International Institute, as a means to supplement their capacity and share know how to help development. From this it is clear that in the 80's the innovation system was much more develop than it is today but still faced difficulty due to a lack of market and demand, lack of legitimacy, institutional and managerial capacity. If this had continued the country might have come far with regards to RE development.

5.3 Analysing the Current Innovation System of Seychelles

Through the analysis of the various RE and their technical potential we saw that solar PV, wind, landfill gas, biogas and also SWH had good chances of being deployed. However in many cases the initial cost of investment and the subsequent operational and maintenance cost for government implemented project might become an issue. While this might be an issue for government this does not necessarily mean that it will be an issue for the private sector or international investors. It is clear that for the government to implement RE this need to be through financial assistance from the country's international partners as this endeavour will not be feasible without their help. While finance is one of the barrier identified from the findings, other barriers have also been identified this include a lack of information, capabilities, institutional, economical and local attitude which can derail the successful implementation of RE in the country. To ensure that technology transfer in RE does take place there needs to be a well functioning Innovation System in place to help this along. This analysis will assess the existing local innovation system in Seychelles to identify what elements can prevent the successful deployment of RE and what can be done to drive this forward and improve the local IS.

5.3.1 The system components in Seychelles local IS

System components as per the analytical framework are the actors, networks and institutions. The RE sector in Seychelles is still in its developmental stage and most projects are still in the proposal stage. As a result these actors, networks and institutions have been identified as they have a role to play in ensuring RE deployment is successful. For each of these actors and institutions the role that they could play in aiding the deployment of RE is also provided as in many cases this is not being done. In the RE Innovation system RE technology demand will be from electricity producers like PUC which at present provides 95% of electricity, the Island Development Company (IDC) responsible for the development of the outer islands and the IPPs which at present generate 5% of electricity. The important actors in the demand side within the system are the Tourism sector which is an important consumer of electricity, in Seychelles this sector falls under the responsibility of the Seychelles Tourism Board. The STB is responsible to create tourism policies to guide the development of Tourism, they can thus influence the tourism establishment to introduce and adopt RET in their development as this is makes great marketing sense and is a good branding tool to differentiate the establishment from the rest.

The Island Development Company (IDC) is another important electricity supplier especially in the outer islands which it is responsible to develop. They have the responsibility to provide electricity to the sparsely populated outer islands using diesel powered generators and thus can be an important consumer of RET to replace some of the diesel fuel with clean Renewable Energy sources. PUC is another important actor, as the sole provider of electricity to the people is due to the high fuel prices facing so many problems to provide electricity at a low price without heavy subsidy from the Ministry of Finance. Therefore through the introduction of RET this might alleviate some pressure and reduce the dependence on fossil fuel to generate electricity.

The Ministry of Finance is another important stakeholder as it is responsible to approve electricity tariffs and in controlling PUC investment and development (any investment of more than US\$40 000 must be approved by the Ministry of Finance). The Ministry of Finance is also responsible for the financing and subsidising oil imports via SEPEC the sole importer of oil products. With regards to the supply side actors of the system these are mainly foreign companies and investors, the private sector and foreign government. This is because the government is leaving the development of RE in the hands of the private sector and foreign investors. Currently research and pilot projects in RE in the Seychelles are led by the UNDP through GEF funding and to some extent government also share the cost in these projects.

The role of the local NGO with RE development is currently limited due to financial constraints but this role should be more prominent to help raise awareness and to educate people of the benefits of RE. They should also have the role of keeping people informed of proposed RE projects taking place in the country to keep them in the loop. NGOs are also a good way for companies especially those supplying RETs to advertise their products, as NGO's are closer to the public they can be a means to create market and generate demand by raising awareness for such companies.

The various Ministries can also play a supportive role with RE deployment through their regulations and policies. The Ministry of Finance can provide financial incentives such as tax exemptions on RE products, cheap loans and grants to help implement RE project to local businesses and households through the Seychelles Development Bank with low interest loans. The Ministry of Internal Affairs Environment Energy and Transport through the Department of Energy will in the future have the responsibility to formulate and implement energy policies and oversee RE development in Seychelles and to raise awareness amongst the population with regards to energy issues. Another important actor is the SEC which is currently working on everything energy related in Seychelles as the Department of Energy is not functioning. However in the long run the SEC will have the role of the country's energy regulator and facilitator and will only be responsible to set electricity, feed in tariffs and develop grid codes for IPPs selling their excess electricity to the grid.

The SEC is currently the point of contact, information and Knowledge for potential investors and RE researchers. It is also the focal point of all government departments with regards to RE matters and broadly energy matters. The SEC has to assist all other department (Planning and Environment) with their assessment of RE development as they are the only ones with the human capacity and knowledge on this subject. Thus they are the ones responsible to carry out resource assessments, capacity building training and policy formulation though this still needs to be done.

Departments such as the Seychelles Investment Bureau, Department of Environment and the Planning Authority also have a role to play in RE deployment. The SIB is the first line of contact for foreign in any field, they provide investors with development guidelines and detail

information on the current investment environment in their field of interest. SIB can promote the field of RE to foreign investors and raise their interests by outlining the existing RE potential and where development opportunity exists. They can thus become the network connectors between foreign suppliers and local institution and companies a role currently being played by the SEC.

The Department of Planning can aid the deployment of RE by introducing RE use within its building codes and standards and by designating land to be use solely for RE development projects and by creating planning guidelines to assess such projects. The Department of Environment also has a role to play in the policies it creates to assess such projects and through the EIA process to ensure that the RE deployed is environmentally sound for the people of Seychelles. Currently these two departments do not have the technical capacity, know how to do these things. There is therefore a need to build capacity through training and policies to ensure effective and appropriate assessment which will help reduce delays in delivering planning decision. Another important actor within this system is the Department of Industry; currently this department is not doing much with regards to RET. Therefore being the department which controls industry it should have an important role to play to aid the deployment of RE.

Other important supportive actors and networks in RE deployment are the financial ones such as the government of Abu Dhabi, the Abu Dhabi Development Bank, the government of china, MASDAR as it is through them these support that many RE projects will be implemented in Seychelles. Identifying these components is important to see how these work and influence each other and in turn how this influences the current innovation system to identify its strength and weaknesses. The following will assess the functions of the current IS in Seychelles.

5.3.2 Creating Adaptive Capacity

Currently the government has committed itself to developing the country's RE sector as a means to ensure energy security within the country due to unstable oil prices. However at present this commitment is not being matched by concrete action. There are at present no clear policy, incentives or institutional guidelines to support this commitment. Except for the planned change in the PUC Act to the electricity Act, which will allow private electricity producer to sell their excess electricity to the grid. There is also the proposed Energy Framework Act which will redefine the role of the energy commission to become the country's energy regulator and facilitator of RE projects. The Energy Framework Act will also outline the role of the Department of Energy and Transport as the country's energy policy maker and overseer of Energy projects in Seychelles and also define the roles of the other departments with regards to RE project implementation.

However with the change in the PUC Act this does not necessarily mean that this will lead to the introduction of RE within the electricity mix as current private electricity providers use diesel oil generators to generate electricity. Apart from these two proposed law changes which do not specifically speak of RE introduction there are no other policy or institutional guidelines to aid the deployment of RE. Currently there is no independent energy regulator; the PUC is the one that set tariffs with approval from the Ministry of Finance, issues permits to private electricity producers for their own use. In addition there is a lack of capacity in the supportive ministries and department such as Environment and Planning. These departments are important supportive structure to ensure smooth implementation. Especially when it comes to the project location, pre construction and construction advice, which can help speed up the approval and the subsequent implementation, process to reduce risk of investors pulling out of the project (Joubert, 2011; Hoareau, 2011).

The SEC is currently the only place with the capacity and knowledge of RE in the country and as a result are the ones doing the work of the planning authority, and the Department of Environment when it comes to advising clients on RE related issue (Jean Louis, 2011; Imaduwa, 2011; Joubert, 2011; Hoareau, 2011). Though they are well verse in the field of RE they are however not verse in the planning and construction field which means that their advice will be deficient in certain aspects. In addition the five person staff of the SEC is also doing the job of the newly created Department of Energy which is currently not functioning. The problem here lies in the way government currently works not with a well thought out plan in mind and decisions are thus made in an ad hoc fashion. This has now resulted with the existence of two bodies the SEC and the Department of Energy with the same function, though one is not functioning. Therefore clear responsibilities and roles will need to be outlined for each of these two bodies, this according to the SEC is coming where they will become the country's energy regulators and facilitators and the energy department the policymakers. However even with this distinction the issue of who will create policy remains as all those with RE knowledge are currently working for the SEC.

This outline another big problem in Seychelles the country's lack of trained personnel with the capabilities and knowledge of RE to make policies, assess, plan, implement and monitor such projects. With the issue of trained personnel also comes a lack of trained technicians to operate and maintain these RET when they do get deployed as at present there are no one trained with these capabilities. This problem is partly due to the size of the country but also because many with technical capacities have been trained to manage and run fossil fuel powered plants. In addition there is a lack of public participation in the country and this has led citizens to not feeling involved in government actions (Joubert, 2011; Webber, 2011; Martine, 2011).

This stem from the attitude created and perpetuated under the one party state where people accepted all and did not speak against government decisions. While public participation is a problem government also does not provide the forum for other stakeholders to get involve with such decision, in some cases timely involvement could have meant avoiding choosing the wrong location for a project which is the case for the current proposed wind farm. As these stakeholders may have better knowledge than government agencies.

5.3.3 Knowledge Diffusion through networks

Currently in Seychelles few stakeholders (Government agencies, companies, foreign government) are involved in the development of RE. However in many cases many stakeholders like some government agencies and NGO do not know that they have an important role to play with regards to RE and are thus not actively participating in this development. NGO act as a bridge between private companies, investors, government and consumers. This is currently not the case as currently the NGO working with sustainability issue (Sustainability 4 Seychelles S4S) are not involved with RE development in anyway. This lack of involvement is not through lack of interest but more due to lack of knowledge of the various RET and importantly due to a lack of finance (Martine, 2011).

Additionally in many cases government agencies due to a lack of communication amongst themselves are unaware of energy projects. In many cases one department sits on the information without sharing leading to development that are usually uncoordinated, haphazard and not fully functional. Governmental knowledge of RE are available at one point the SEC while the rest lies with the private sector and external stakeholders. This creates a fragmented information source. Though some knowledge is available the problem lies with the networks to diffuse the available information. While the SEC is the bridge between external stakeholders and government, this network also faces certain problem. As the SEC in

many instances do not have good or complete energy information on the Seychelles. In so, instances they do not have access to research data and findings carried out in the past with regards to RE potential in the country to share with these stakeholders. This means that in many cases these stakeholders will have to generate such research which represents delays in deploying a given technology.

The SEC holds the bulk of the RE knowledge in Seychelles, however it is doing a poor job in diffusing these information to the general public and private sector. The general public of Seychelles in many cases has no idea what RE is and what benefits it can have for the country. This is because people rarely hear about what is going on in this field and when they do it is only once and for three minutes in the news which is mostly a gloss over piece (Joubert, 2011; Webber, 2011; Martine, 2011).

5.3.4 Demand Articulation

Demand articulation or Direction of Search relates to the opportunities that exist for the development of a technology (Bergek et al., 2007). For development to take place according to Van Alphen et al. (2008) there has to be clear and well defined needs from technology users. However before this can be met there is a need to identify what these needs are and to what extent the needs can be met through the deployment of RET. In Seychelles the direction for search or demand articulation came from government wanting to reduce its dependence on fossil fuel and ensure energy security for the country. This resulted in RE targets being set 15% by the year 2020 and 30% by 2030. However it is difficult to identify and assess this need and the extents RET can meet such needs in Seychelles.

As was said in the section 5.4.3 there are no readily available information on the potential of these resources in Seychelles. There is also a problem with locating past research in the field of RE which could be helpful as a means of knowing what has been done and what the findings were. This will prevent duplication and make the assessment and subsequent deployment much quicker. The only information available is the wind feasibility study carried out by MASDAR for their use, daily sunshine hours and climatic information. The availability of research and data on RE potential would have made it easier to identify which RE source have the most potential for investors and users and prevent unnecessary research.

5.3.5 Creation of Legitimacy

In the past a few feasibility studies were carried out in the field of RE, while those who carried out these research saw its potential then and still see the potential today (Webber, 2011). Concern exists that due to a reduction in fossil fuel prices, provision of loans and assistance in favour of fossil fuel power plants, people's misconceptions and belief that the deployment of RET might end up like the past projects, and get shelved (Webber, 2011). Therefore to ensure that this does not happen there is a need to turn this tide, the Innovation system is still in its formative years and it is possible to create legitimacy.

According to the Joubert (2011) currently when it comes to RET there is a lack of environmental criteria or guidelines specific for RET. Such criteria might help reduce conflicts with other land uses in the long run and facilitate RE deployment and increase legitimacy of project. There is therefore a need to educate and raise awareness of the RE benefits for the people, the potential users and the country's decision makers.

5.3.6 Resource Mobilisation

The Ministry of Finance is responsible for providing subsidies to the PUC and the SEPEC the sole electricity provider and sole oil importer respectively in Seychelles. It is also responsible

to providing financial aid to all parastatal bodies which along with the above two also include the Island development Company. This can lead to conflict of interest as the amount of profit made by SEPEC will be greatly reduce as it will be selling less oil to PUC and other oil purchaser if these decide to use RE instead of fossil oil. The Ministry does not have any energy related plans as yet to deal and manage the potential conflict that could arise due to the above mention effect. In addition the Ministry does not provide financial assistance to the private sector. There are currently no loan scheme either from commercial bank or development banks to aid the deployment of RE. This is still a new sector as such it is seen as an area with high risk with a long payback period which is not attractive for governmental agency such as the IDC. In Seychelles resource mobilisation by government in the field of RE is mostly for pilot projects run through financial assistance obtained partly from GEF and the government.

RET is still a new field with very high investment cost and high risk as such most proposed development in the field of RE are ones being financed by foreign governments. This is the case for the US\$ 28 million wind farm project which is being financed by the government of Abu Dhabi through its Development Bank and MASDAR. The proposed small scale biogas plants which will be financed by the government of China and the proposed Waste to Energy project which the government has tendered for private investors with an interest in this field.

5.3.7 Market Formation

Currently the government heavily subsidising the fossil oil generated electricity this has the effect of making fossil oil generated electricity more competitive than RET. Even with the increase in electricity price fossil fuel generated electricity still remains the cheapest option. This is due to the special fund of SCR27 million (US\$2.16 million) created by the Ministry of Finance to help PUC with its cost of purchasing fossil oil to generate electricity which have increased by 24%. In addition most of the generators in use by PUC are gifts from foreign governments which do not provide incentive to purchase RET.

There are no economic incentives in place to aid with the formation of markets for RET in Seychelles or to encourage the deployment of RE. Import duty on RET are same as electric appliances. A case in point is SWH and electric water heater, a SWH costs about US\$800 excluding installation cost while an electric water heater cost SCR2875 (US\$223) in Seychelles. This shows the lack of fair competition in the country. Due to this price difference it is clear that the majority of Seychellois will choose the electric water heater as it is cheapest option.

5.3.8 Entrepreneurial activities

At the moment there is a lack of interest in the RE field in the Seychelles from the private sector. Those that have shown interest are the ones with some knowledge in the field and hence know the long term benefits of RE. However these are not enough to generate growth in the field locally. This is due to a lack of market for RE, above all there is a lack of economic incentives. This is a point which was raised by the private sector the difficulty in obtaining low interests loans for RE development. In addition RE projects have high investment costs, which can scare investors especially since feasibility of many sources are currently unknown.

Currently entrepreneurial activity are from foreign investors who have shown interest in investing in the RE sector to generate electricity in the Seychelles and from foreign partners wanting to help the country develop its RE sector. GEF funding in assessing the solar potential of the country is another activity to try and influence the RET sector. However these activities are still at the early stage of development one is at the planning stage, the other at the proposal stage. With the many issues, discussed before and red tapes to go through there is a

real fear that this might scare potential investors and proposed projects might not get implemented. This is a reality in Seychelles where proposed projects do not get implemented because it took too long to get approval or the necessary information.

5.4 Discussion on Local Innovation System

The IS in Seychelles has started off in an ad hoc way and the projects planned are not enough to aid the introduction and deployment of RE in Seychelles. In Seychelles the IS for RET started from the urgency of the government wanting to reduce its dependence on fossil oil, as a result of the high prices of this commodity and its desire to ensure the country's energy security. From this guidance or articulation of Demand, the SEC the focal point of RE knowledge in the country started albeit slowly to share its knowledge. While also trying to find other ways to gain more knowledge and identify ways to get entrepreneurial activities started in the country. As a result of this articulation RE targets were set by the government as a sign to show its interest in developing this sector.

Currently with Knowledge development and diffusion this is a slow process where the SEC seems to be doing everything by itself when it comes to energy issues. It is however not sharing its knowledge very well to help build the capacity of other department. If this is happening it is a slow process that is hard to notice. The sharing of knowledge to build capacity and help increase the legitimacy of such projects amongst government departments, private sector and the general public is important for the success of the system.

The search for solution generated by the need of the government has led to some entrepreneurial activities. These activities originate from foreign investors, foreign aid from the country's bilateral partners wanting to help develop this sector and through GEF funding to implement pilot project. Interest in this field is however limited this is understandable since this system has just started.

In Seychelles currently the only functions that can be identified though these are still weak, are demand articulation which is still not well defined due to lack of knowledge on the topic of RE and where potential lies. Knowledge development and diffusion is weak. While information is not being shared with the various sectors or the general public to help build up the RE markets and generate demand from potential users. Entrepreneurial activities are limited as the country currently does not have a market for RET making this field full of uncertainties. There is also a limited number of suppliers of RET technology and this is mostly for SWH and no other RET have established supplier in the country. With regards to the networks and actors at play their role are also weak especially the role of the private sector and the NGO. There are no advocacy coalition at play to help influence the institutions to remove barriers to the deployment of RET in the country. To have a successful innovation system, all function needs to be fulfilled. While these functions have been identified they are still weak and if they are not reinforced this can lead to failure of the RET system.

Therefore to answer the second research question, *What are the challenges and weaknesses that are impeding the deployment of RET in the country?* The following challenges and weaknesses were identified. There is currently a lack of capacity and qualified human resources to guide this deployment through the creation of policies, regulations and to assess potential and development proposal. There are no fiscal incentives to increase entrepreneurial activities, create markets and demand and to further mobilise resources. There is a lack of information and know how available to users, decision makers and investors. While the network used to share the available knowledge is limited leading to such information not reaching these stakeholders. There is also a lack of consultation and public participation to further strengthen the knowledge creation process and aid diffusion of said knowledge. The only thing being

done currently in Seychelles with regards to policy is the introduction of IPPs as provider of electricity. While this is a step in the right direction it is not enough. Introduction of IPP does not translate to RE generated electricity being introduced in the energy mix.

It is clear that the government do not have any plan to do more to stimulate the development of RE and to provide a competitive environment for RET to develop after the implementation of the wind farm. However to ensure that the current RE innovation system, though, highly deficient does not fail but grows and strengthens over time more needs to be done by government as the private sector cannot do all on its own. However while government may not have intention to do more this can change. If interest is shown from NGOs, the private sector and foreign investors as they can and should exert pressure on government to create an environment conducive to RET. This should include policies, regulations and fiscal incentives. However if such changes does not happen RE deployment will not take place especially if the price of fossil fuel goes down on the international market.

Another concern is that due to the limited human capacity, the current system the way it is set up will perpetuate and not much will be change. This will result in the SEC's capacity being spread thin as they are the ones with most of the RE knowledge in the country. The result will lead to no knowledge growth in RE within the other governmental department, increase delays in decision and too much work for one small department.

5.5 Proposed Solutions and recommendations

From the analysis a table was created to show the system weaknesses and which function they are currently impeding and the opportunity available to try and remove such weaknesses. This will form the basis of our solution and recommendations which will also answer the third research question *How can these weaknesses be surmounted to create an environment conducive to the deployment of RET and the growth of the local RE system?*. The solutions and recommendations suggested are to provide the government with possible ways to improve the various weaknesses identified in the IS. While also strengthening this system by removing or providing ways to manage and remove these weaknesses. Table 5-1 below shows the identified systems weaknesses from the analysis and the proposed solutions to manage these.

To ensure the appropriate deployment of RET in Seychelles and ensure that the IS started does not fail a number of things needs to be done to achieve this. The solutions and recommendations have been prioritised according to importance.

The most important aspect with the improvement of the IS lies in the strengthening and the building of local capacity both technical and Institutional. This will help strengthen the role of the various actors in the system and improve the various institutions. It will also improve and increase the networks available for information to circulate within the Seychelles. Knowledge build up from external research institutes, the country's bilateral partners and the sharing of such knowledge through pilot studies will help with the diffusion of information and data within the country and with external partners. This will help with identifying needs which will help create demand. This will further strengthen the country's local adaptive capacity and increase legitimacy and acceptance of such projects amongst the general public and investors.

To encourage market formation and entrepreneurial activities the research proposes changes with regards to policy. It also encourages the participation of the tourism sector and the formation of regional partnership. This coupled with the proposed financial incentives; provision of land for the implementation of such project will help stimulate these two functions. However to ensure the development of the IS, pressure needs to be applied

constantly on government from the private sector and NGOs. Otherwise the RE sector will not get develop and the country will go back to the status quo.

5.5.1 Develop Local technical and institutional capacity

Capacity building could be carried out by the government to strengthen and broaden its knowledge base in RE. The SEC is best place to do this as they have knowledge in RE and are currently the one helping other departments. They can start by assessing local capability with regards to RE and identify where the deficiency within this sector lie. This can be done through workshops with all stakeholders including the private sector, governmental department, foreign investors that have shown interest. Through the discovery of where the weaknesses lie programme can be prepared to manage these. By bringing all stakeholders together it will prevent duplication and help identify focal person in the various governmental department which will be responsible to share RE knowledge in their Departments.

Additionally the country through the Department of Industry and through the policies it will create could assess the potential and viability of fabricating some of the RET components locally. This will help reduce the cost of such technology and further showcase the government commitment to the deployment of RE.

To develop local technical capacity the Seychelles Industrial Training centre could provide training to students interested or could provide new courses related to RET. The Training centre is best place to provide such training as they have experience with training people in technical and industrial aspects. Training can be provided through the country's partners with knowhow with the various RET. Example knowhow on wind technology and its technical aspects, installation, maintenance and operation can be provided by the government of India through a bilateral agreements to help develop this RET. With regards to Solar this can be done in the same way from the help of China. In the long run those with the local know how can share this with other students and other interested party to further develop this field.

The problem with the development of capacity in Seychelles is that while some people get trained in the field to help train others in many cases this does not happen. This occurs due to changing priority within the departments, lack of finances, internal conflicts and lack of time to train others. In such cases those trained ends up leaving the departments with the knowledge gained without having shared these. To prevent these above mentioned issues the knowledge sharing could be made mandatory in relevant departments. This could be incorporated within the departments' budget with a designated amount of time allocated for such training in a given month.

5.5.2 Develop RE awareness amongst people to form advocacy coalition

There is a need to raise awareness amongst the general public to make them aware of the potential of RE and the benefits for them with using this form of energy. As was said in section 5.2 for RE deployment to occur coalition needs to be form. This will help influence government to make changes in existing policies, laws, regulations and to provide financial incentive to aid the deployment of RE. NGO are important stakeholders in raising awareness and advocating for change. As they are closer to the people they are best place to carry out education programme. Therefore to raise awareness and educate people on the benefits of RE so as to gain support, this should be the done in part through the NGO.

Through the NGO and with the help of finance from the private sector and foreign donor interested in RE deployment. Education campaigns can be made and conducted in all the 25

districts in the country with relevant stakeholders to raise awareness, advertise the technology that are being supplied by private company within Seychelles. Information campaigns can be carried out in all the media especially television to further raise awareness. Small scale projects being implemented in RE could be showcase to the public to increase legitimacy of such project and gain support and acceptance. These information and education campaign could be repeated regularly by the media so that people do not easily forget the topic.

Awareness and acceptance of RET can be furthered through the design and implementation of RET pilot projects in the country. This will help assess the technical and economical feasibility of such technologies. It can also be used to identify weaknesses to be managed and removed to aid the deployment of a given technology. The pilot projects can also be used as a means to assess the local capacity with regards to monitoring and evaluating such projects. Demonstration projects can also help increase the local capacity and be a means to train local technicians who will work with such technologies.

Additionally this can be a means to raise awareness. Where RET has been successfully implemented these should be shown as part of educational programmes to raise awareness and educate. Such programmes could be formulated for the general public to show the findings of the project and the way it was implemented. This can help encourage the public and other sector to invest in these technologies.

The Department of Energy could either on its own or through the proposed CDM National Authority establish an RE information centre. This will provide the public and all other stakeholders with relevant information on RE. It will also facilitate the sharing of information and knowledge in the field of RE

While raising awareness is important to get people on board to form coalitions the issue remains, that the general public will show no interest in RE. They might view it as a complicated field out of their ability or capability to comprehend. This can result in a lack of support from the general public, limited demand for RET and valuable knowledge not getting to those who need it and the formation of weak coalitions.

5.5.3 Create supportive policy to guide and help RE deployment

RET cannot compete with fossil fuel under current conditions as this is heavily subsidise as is the electricity price. Government could provide incentives as they are the best place to do this to promote RE deployment. These can help stimulate market growth, increase demand for RETs, increase entrepreneurial activities and mobilise resources. Though this is planned it is yet to happen. Therefore it is important to reiterate this; there is a need to create an energy regulator which is independent from government in all aspects. This will help prevent conflict of interest amongst the various energy stakeholders, and government. Government currently controls the sole supplier of fossil oil SEPEC and sole supplier of electricity PUC. This will also have the added benefits of improving the country's appeal to potential investors as it will be a start to the creation of a truly transparent and open energy system.

The government could also through the Department of Energy create an Energy Strategy. This will set out the plan of action on how things should be achieved and who is responsible for doing what and how long they have to achieve proposed actions. This will make each department more accountable and responsible to ensure that they achieve what have been set out. Such a strategy could also look at how to develop RE, incentives that might be required, in what sector RE can be used and the price of such technologies for the country.

The Government could also carry out an energy study to look at the energy supply and demand for the whole country including the outer islands. To assess the needs of the country and to also ensure that the country have up to date energy data. The government as a way to lead by example could carry out an energy audit within its departments and institutions. This can be used to assess its energy use and how and where savings can be made to reduce energy cost and consumption. The Energy study can be carried out by the National Statistics Bureau as they have the capacity to carry out such studies. The NSB with the help of the Department of Energy and the SEC can create energy indicators and energy criteria to be used in the collection of energy statistics for the country.

The SIB as the focal point for new investment in the country can also play an active role in promoting RET. SIB can therefore ensure that future investment proposal contain an RET element in their proposal.

The government could also provide incentives to households, businesses, the private sector and foreign investors interested in implementing RE. Such incentives can be in the form of long term Power Purchasing Agreements for IPPs. These should be clear and transparent regulations which would be beneficial for private involvement in the development of renewable electricity to reduce risk in investing in RET (Van Alphen et al., 2008; Vreden et al., 2010; SEC, 2011). While the government is thinking of introducing IPPs this does not necessarily mean that RE generated electricity will enter the electricity mix. Therefore clear targets needs to be set by the government through the Department of Energy in collaboration with the SEC of the percentage of RE generated electricity it wants introduced in the electricity mix. This will also be an incentive for IPPs to try and develop this sector.

Incentives can also be in the form of feed in tariffs, investment subsidies, consumption taxes on energy intensive products, removal of import duty on RET and EE products, concession tax and investment tax credits. These incentives could be explored and evaluated and the best mix which will aid RE deployment formulated and implemented. With regards to households, incentives should be provided in the forms of grants or low interest loans to implement decentralized RET such as SWH or small scale PV system if conducive. These do not require economies of scale technically to get implemented. However due to the small size of the country, limited suppliers and installers, this can lead to a lack of competition and result in relatively high prices for these technologies. Therefore for SPV and SWH to get implemented financial incentives will be required. A solution implemented in other SIDS for SWH has been through the removal of tax on this system while charging high taxes on electric ones. This might be a solution for the country to aid the deployment of more SWH in households. In addition government might consider removing the heavy subsidies it affords fossil fuel which will make RET more competitive. The Ministry of Finance can be responsible for the setting up and provision of financial incentive schemes. While the SEC through its proposed role as the new energy regulator can set the feed in tariffs and create the PPAs.

As per section 5.4.2 currently the SEC is doing everything that has to do with RE, while this is good for now it is not a solution for the future. The SEC does not have the human resources to do all this work by itself. While the SEC knows about Energy they may not know about Planning regulations, requirements and how to assess such plans with a planning perspective. The planning department could therefore have a few staff trained to be able to assess these projects. This could be done with the help of the SEC with the assistance of a consultant.

Government will therefore need to develop training programme for the supportive departments such as Planning and Environment, in ways to assess such developments. In the same line government should revamp existing planning and environment law to provide

guidance for this sector. Through the aid of energy consultants the planning and environment departments can also develop planning and environmental policies, regulations and codes to guide RE deployment and implementation in the country. New building codes and standards should be developed to allow for the inclusion of RET within housing design and development. In addition such codes and standards should also take in consideration energy consumption and should thus try to encourage low energy houses that provide natural ventilation. Better or appropriate planning and environmental law and guidelines will be a plus for the country as it can reduce bureaucracy and delays in obtaining a decision.

Policies and incentives created especially financial incentives should be well formulated. To prevent loopholes where investors may get financial benefits but then show no interests in implementing RET or in developing this sector. Therefore the SIB and the SEC needs to ensure that proposal accepted will get implemented. Otherwise the proponent could be made liable to reimburse the country/government for not fulfilling its requirement. With regards to the Energy regulator's independence while this will be the ideal. However the reality remains that nothing set up by government is truly independent. This might be different if the regulator obtained its finances through the services it provides and not from government, in that case it will have a hard time operating without such funding.

5.5.4 A Resource Assessment should be carried out in the country

The Department of Energy should through foreign agency aid such as UNDP, SADC or World Bank carry out an in depth resource assessment. However before resource assessment is carried out first the country needs to assess whether it has the capacity to carry out such assessment. If there is a lack, such assessment can be carried out through cooperation via the University of Seychelles with external research institutes. This will have the added benefits of allowing the sharing of knowhow from international network, further broadening the country's knowledge base and networks. Assessment of potential in RE such as Biomass, wind, solar, wave should be carried out around the country. Such an assessment will ensure that the best site gets selected for RE deployment in the future. Through the RE resource assessment a database should be created and made available to all stakeholders. This will also add to the amount of information available on RE sources and potential. Such an assessment will be a plus for the country and be an incentive for investors as information will be available on the area with potential which will facilitate the quick deployment of RETS in the country.

The SIB can also provide RE assessment data on its website to show investors where potential in the country lies to encourage future investment in the field.

A resource assessment is important for a country. However the concern remains that once this is done the findings obtained will remain within the Department of Energy and not get shared amongst the various stakeholders. This will lead to the perpetuation of the status quo, a lack of interest and the lack of deployment of RET in the country.

5.5.5 Create an RE fund to aid the deployment of the technology

The government through the Ministry of Finance with foreign financial aid through multilateral banks like the AfDB should create a fund which can be administered by the Development Bank of Seychelles. This fund will be available to those wanting to implement RET projects in the country. Repayment or interest rates for such financial assistance should be favourable to encourage RET development. Government can generate the money by taking a small percentage of the money made from the taxes on goods and services or through taxing energy inefficient products coming into the country a solution applied in Mauritius.

The creation of such a fund will be a great way to help the implementation of RE projects. However without the low interest rates for repayment, many RET will still remain out of reach for the majority of the population and many businesses in the country.

5.5.6 The provision of land for the implementation of RET

The Ministry of Land Use and Habitat should set aside land especially those located on reclaimed islands which will be allocated to RE development. These lands can be used for pilot projects, for local research and development and implementation of RE projects. This will be a boost for entrepreneurial activity in the country. It will also create interest amongst local businesses which will further show the government interests in RE development.

The government should make sure that land is used for the designated purpose. That allocation is fair and that all applicants have equal opportunity of being selected. Government should also as per the projects proposal set conditions. This should include a time frame for projects to get implemented from pilot to the full projects. This will ensure that land does not remain idle for years and if this should happen project proponent should provide plausible reasons. Otherwise the land could be taken and allocated to other applicants willing to implement such projects.

5.5.7 The tourism industry should play an active role in RET deployment

This sector is a heavy consumer of electricity. This sector can thus play an active role in the introduction of RET in the country through the policy develop by STB to encourage the use of such technologies. STB to garner interest can provide incentives for tourism establishment in form of tax break on RET. Certain among of concession, depending on the size of establishment could be provided the smaller establishment might get the bigger concession to encourage their participation. Investing in RET is an investment that will pay for itself in the future and will provide savings for these establishments. It will be great advertisement for these establishments and improve their branding as truly eco friendly establishments. The use of RET in the tourism development which exists or proposed in the future will be a great way to showcase the Seychelles as a truly green destination.

Incentives provided such as concession should be fairly allocated as said before smaller establishment should get the bigger concession to ensure that they can implement RET. Otherwise smaller establishment will find it hard to be able to introduce RET. Especially if they are mandated through STB's policies to introduce a certain amount of RET within their development.

5.5.8 Increase Regional Partnership to aid the deployment of RET in Seychelles

As Seychelles is a member of SADC and COMESA it can through regional cooperation develop its RE sector. Through regional cooperation the country can benefit from the sharing of knowhow from other country in the region. It can benefit from the importation of RE products from the region at zero tax. In addition it can also encourage investors from the region to invest in this sector to help its development. Through regional cooperation with other SIDS in the region such as Mauritius they can enter into partnership to share the cost associated with the transfer and deployment of such technologies. Thereby increasing their economy of scale however such partnership needs to be beneficial to both parties otherwise it will not work.

Due to the size of the country and lack of economic diversity, countries in the region may not see Seychelles as a worthwhile partner to invest with compare to let's say Mauritius. Therefore the country needs to provide worthwhile incentives to regional investors and partners while ensuring that both parties end up as winners in such partnership. The government thus needs to be more open. This can be through the provision of up to date energy information and data and through the creation of a transparent energy market to attract potential investors and partnership.

5.5.9 Using CDM as a means to deploy RE

The government can create a National CDM authority in Seychelles to promote CDM project which can encourage and raise interest in RE deployment and development in Seychelles. This should provide information to interested parties on projects that will be eligible, the modalities and procedures and criteria that such projects have to meet. However for such an authority to exist there need to be capacity including knowledge and expertise to provide up to date information on potential area for CDM development in the country. This authority can also be responsible to find ways to help find RE projects that qualify for CDM. It can also help potential investors identify funding opportunities that may be available for small scale CDM projects.

This should also include funding to validate such projects. This can be done through the proposed fund in section 5.6.5 or through a new fund set up through financial assistance from international donors or bilateral partners to help develop the country's CDM potential Through the fund, loans can be provided to set up projects and the money repaid once project is stable (Mundaca et al 2005). With CDM project that are comparable the authority can help coordinate such projects and allow the bundling of small scale CDM projects to help reduce associated transaction costs (Mundaca et al., 2005). CDM project can be a means to generate economic benefits through the sale of credits generated by the project.

With CDM there is always issue with transaction cost however as per section 2.6 small projects generating 15MW can benefit from certain exemptions to help reduce transaction cost. However if the project does not have a 15MW capacity it is not eligible for exemptions. As a result the associated transaction cost will be the same for those wishing to implement small scale RET. Transaction cost is a big reason why small scale CDM project does not get implemented. This might also end up being a reason for Seychelles, if external assistance is not obtained to help reduce such costs.

Table 5-1 Showing the Weaknesses of the IS in Seychelles and the proposed solutions

Weaknesses	Function	Proposed solution
<ul style="list-style-type: none"> -Lack of technical, Institutional capacity in RE -Limited regulatory framework to promote the use of renewable -Lack of a Renewable energy strategy to guide RE implementation -Lack of independence in the function of certain department -Too much Bureaucracy 	Creating adaptive capacity	<ul style="list-style-type: none"> -Education and training programmes -Knowledge transfer from foreign organisation -Formulation of development guidelines and policies -Creation of an independent energy regulator
<ul style="list-style-type: none"> -Limited information networks -Limited stakeholder participation -Conflict of interest amongst department and energy stakeholders 	Knowledge diffusion through network	<ul style="list-style-type: none"> -Establish an RE information centre -Identify focal person to share information in govt. Departments -Education programme with stakeholders -Greater role for NGO with RE deployment
<ul style="list-style-type: none"> -Lack of Resource Assessment on RE -Incomplete or lack of energy data -Lack of information on RE 	Demand creation	<ul style="list-style-type: none"> -Assessment of RE resources -Carry out feasibility studies
<ul style="list-style-type: none"> -Negative past experiences -Lack of awareness of RE among the general population -Limited use of RET 	Legitimacy	<ul style="list-style-type: none"> -RE information campaigns -Workshop with stakeholders -Pilot projects demonstration
<ul style="list-style-type: none"> -Lack of Finances to implement RE projects -Lack of economic incentives -Lack of economies of scale 	Resource mobilisation	<ul style="list-style-type: none"> -Create fund for RE deployment and development -Develop Regional Cooperation and bilateral agreements with country's economic partners -Provision of land for local R&D
<ul style="list-style-type: none"> -Subsidies on fossil fuel -No independent tariff setting mechanism -No tax relief for RET 	Market formation	<ul style="list-style-type: none"> -Provide economic incentives -Remove subsidies on fossil fuel to create level playing field -Long term PPA to protect RET investment -Identify small project with CDM potential can benefit from trading of credits
<ul style="list-style-type: none"> - Lack of involvement of important sector such as the tourism sector Limited financial assistance for private sector 	Entrepreneurial activity	<ul style="list-style-type: none"> -Tourism sector participation -Private sector involvement -IPP introduction - Inclusion of RET development in design guidelines and policies

6 Conclusions

The Government has embarked on its journey to introduce RE within the country's electricity mix. Currently the country is 100% dependent on fossil oil to provide all of the country's energy needs which are costing the government about 10% of the country's GDP. As a result of this heavy dependence the Government of Seychelles made a decision to try and reduce this heavy dependence through the introduction of RE, which will reduce the country's oil dependence, increase the country's energy security and reduce the amount spend on oil import. This decision has been translated into the formulation of short to long term RE targets of 15% by the year 2015 and 30% by the year 2030.

This research aimed to assessed the country's RE potential and to identify the barriers to RE implementation so as to provide solutions to aid the successful implementation of RE in the country. To achieve these aims the country's RE potential was first assessed through an adapted framework to show where potential in the country lies. However while assessing the potential is an important step which past research had not done it was also important as per the aim of the research to identify the weaknesses or barriers that have impeded past RE pilot projects from being implemented. To identify such barriers the Innovation System Framework was used, to show where the weaknesses lie. This was also used to help formulate solutions and recommendations that government can use to aid the implementation of RE. Through the analysis the three research question posed in chapter 1 was answered.

6.1 Findings from the Research

RQ 1- What type of RET has potential of being deployed in Seychelles?

From the assessment carried out a number of RET have potential of being deployed in the country. These have the potential to be successful ventures if done appropriately. Potential in Seychelles is there for the successful deployment of Solar Water Heater (SWH) in many households and businesses, which can help reduce electricity demand and translate into monetary savings. There is also potential for the deployment of SPV in household looking to make long term energy investment and savings, but most importantly it is an ideal option for hotels, businesses and also for remote application on outer islands due to its low maintenance cost and can thus replace a good amount of the oil generated electricity. Biomass also has the potential of being implemented in outer islands; however this needs to be coupled with good resource management plans. Biomass does have the potential to reduce the use of diesel oil on outer islands.

Landfill gas is another RE with potential in Seychelles due to the high amount of organic waste that have been land filled in the past. However the quantity of gas that might be available will have to be assess in feasibility study. Biogas at the landfill site is another potential however this will be a solution for the future as this requires that the country possess a functioning waste management system. Biogas might be the solution to replace landfill gas once this is depleted. As per the criteria used in the assessment the above mentioned RET have great potential of being deployed in Seychelles in terms of their simplicity, triability and compatibility. While this is the case due to a lack of sound quantitative data the research cannot with certainty show how economically feasible or socio economical these technologies will be for Seychelles. Further research is needed to assess these in much more depth.

Potential for future wind projects also exists but this requires further in depth research to assess this potential. However due to economies of scale and limited financial and human resources and a lack of resource assessment any future development in this technology will

like most other development in the RE field be through private sector or foreign investment. The reason being that due to the high operation, maintenance and cost of spare parts which will have to be bear, the government of Seychelles will not be able to implement more than one RE project. The best option for the country is wind technology coupled with solar PV and SWH as sun is available all year round though the initial cost of solar technologies is high the subsequent cost of maintenance is however not as high and these technology can be applied on all islands.

RQ 2- What are the challenges and weaknesses that are impeding the deployment of RET and affecting the local Innovation system within the country?

While the country has available RE potential it currently lacks a conducive environment to aid the proper deployment of RET. As a result of the analysis of the current local innovation system a number of challenges and weaknesses were identified. This includes the lack of local capacity and qualified human resources to create policies, regulations, to assess potential and development proposal. There are no fiscal incentives to help such deployment. Information and know how available to users, decision makers and investors are limited and the sharing of such knowledge is limited leading to important information not reaching these stakeholders. Public consultation and participation are not viewed well so many people do not bother to exercise this right.

Government according to some stakeholders do not have any plan to further stimulate the development of RE or to provide a conducive environment for such development. However if government wants to attract investors it will need to do more than it is currently as the private sector cannot do all on its own. Therefore local NGOs, the private sector and foreign investors can and should exert pressure on government to create a conducive RET environment through policies, regulations and fiscal incentives. The only thing that has been proposed by government with regards to policy is the change of the PUC Act to the Electricity Act to allow the introduction of IPP however this does not guarantee that the electricity entering the grid are generated using RE.

The concern voiced out by some stakeholders, if government does not play a more active role with the introduction of RE are valid. Such concerns includes the possibility that the price of fuel oil drops on the international market, this coupled with the high cost associated with RET and the high transaction cost associated with its deployment. Then the country will go back to the status quo leading to the end of RE deployment. Another concern lies with the current set up of the Energy system due to the limited human capacity, the current system may perpetuate resulting in the SEC capacity being spread too thin. This therefore requires that government invest in building human capacity and training. Otherwise the projects proposed or planned will be the only ones that get implemented in the country.

RQ 3- How can these weaknesses be surmounted to create an environment conducive to the deployment of RET?

To ensure the appropriate deployment of RET in Seychelles and ensure that the Innovation system started does not stagnate a number of things needs to be done. The most important aspect with the improvement of the IS and the management of weaknesses and challenges lies in the strengthening and the building of local capacity both technical and Institutional, through training programmes and workshops. This will help strengthen the role of the various actors in the system, improve the various institutions and also improve and increase the various networks available for information to circulate within the country.

Knowledge build up from external research institutes and the country's bilateral partners and the sharing of such knowledge through pilot studies will help with the diffusion of information and data within the country and with external partners. This will help with identifying needs which will help create demand, and will further strengthen the country's local adaptive capacity and increase legitimacy and acceptance of such projects amongst the general public and investors by showcasing the potential. Knowledge build up will be further strengthened through the Resource assessment which will provide much needed information to potential investors interest in RE implementation and benefit all stakeholders.

To encourage market formation and entrepreneurial activities a number of changes with regards to existing policies and the creation of new ones, the provision of financial incentives, the encouragement of the tourism sector and creation of regional partnership along with the provision of land for the implementation of such project will help stimulate these two functions. However to ensure the development of the RE system does take place, pressure needs to be applied constantly on government from the private sector and NGOs through advocacy coalitions otherwise the RE sector will not get develop and the country will go back to the status quo.

6.2 Recommendations to Audience and further research

This research has outlined a number of solutions that can be applied by the government of Seychelles, and governments of SIDS yet to implement RET within their energy mix. It has also outline the potential role of NGOs, the country's economic partners and the role of UN bodies in the implementation of RET in the Seychelles and elsewhere. While the solutions can apply to any developing countries, what is being proposed is for SIDS. SIDS as was outlined in the section 1.1 has specific issues not found anywhere else. These include their small but growing populations, limited resources, remoteness, susceptibility to natural disasters, vulnerability to external shocks, excessive dependence on international trade and fragile environment. In addition SIDS are affected as a result of the high communication, expensive public administration, infrastructure, energy and transportation costs. This situation is made worse due to these countries small size, and their lack of opportunity to create economies of scale especially when it comes to the deployment of RET.

Suggested solutions provided which this research will recommend their implementations are prioritised and outlined. As these will be a step towards the creation of a conducive RET environment not just for Seychelles but for other SIDS in the world, wishing to introduce RET. For government these are as follows:

1. Develop the country's local technical and institutional capacity through training programmes and workshops through the help of the country's economic partners, UN bodies
2. Prepare the country's Energy Strategy to help guide the development of the Energy sector hence the RE sector.
3. Carry out an energy study/census through the NSB (with the help of SEC and the Department of Energy to create energy criteria and indicators) to ensure that up to date energy information are available in the country for use in future research.
4. Carry a Resource Assessment for the country to identify where the country's potential lies this can be carried out with the help of UNEP or UNDP or through foreign research institute
5. Create supportive policy to guide and help RE deployment this can be in the form of (financial incentives, regulations, guidelines, through the provision of land for the

implementation of RET or a mix of incentives. Examples could be through the provision of feed in tariffs along with investment subsidies to IPPs, tax concession for tourism establishment, financial grants for household and small businesses, tax exemptions for RE products imported and changes in planning policy to encourage RET deployment in future developments)

6. Encourage the deployment of decentralised small scale SPV or SWH (along with financial incentives) as these do not require economies of scale to be successful.

For NGOs it is recommended that they start to develop RE awareness amongst the general public, private sector and foreign investors to form advocacy coalition to help exert the required pressure on government to aid the implementation of RET.

For UN bodies, SADC, COMESA and International Economic partners their role encompasses a range of aspects as they can aid in the capacity building and training. They can help with the resource assessment and they can also help increase Regional Partnership which can aid the deployment of RET in Seychelles.

As for Further research in the field of RE, it is suggested that the government actively think of carrying out a resource assessment in the country to assess the RE potential available and to carry out an energy study/census in the country to gather up to date data to aid future energy research in the country. This will also be valuable for use by future investors in the field of RE.

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Appendix 1 Descriptions and Role of the Structural and functional elements of the Innovation System

Structural Components

Components	Description and Role
Firms	Firms are located along the whole value chain of the technology; they bring in knowledge, capital and Resources.
Other Organisations	Other Organisations include NGO's, government, educational organisation, these add to the system by providing an arena for discussion and by promoting the IS.
Networks	<p>One type of network is the learning network which provides the link between suppliers and users, competitors and researchers. These networks are important modes to transfer implicit and explicit knowledge. It can also influence individual and collective perception of what is possible and desirable which guides future decision and the type of investments made and in which technology.</p> <p>The other type is those that seek to influence political agenda where a group of actors with the same beliefs through advocacy coalitions compete to influence policy in line with their beliefs. These are formed when firms and other organisations enter the IS and depending on their beliefs they give a collective voice to such belief in the political arena.</p>
Institutions	<p>Institution is at the center of the IS process. This includes Institutional alignment which refers to change in the legal and regulatory aspects and also include culture and norms.</p> <p>Institutions in the IS regulate the interactions between actors and also looks at the beliefs and perception that influences actors within the learning process.</p>

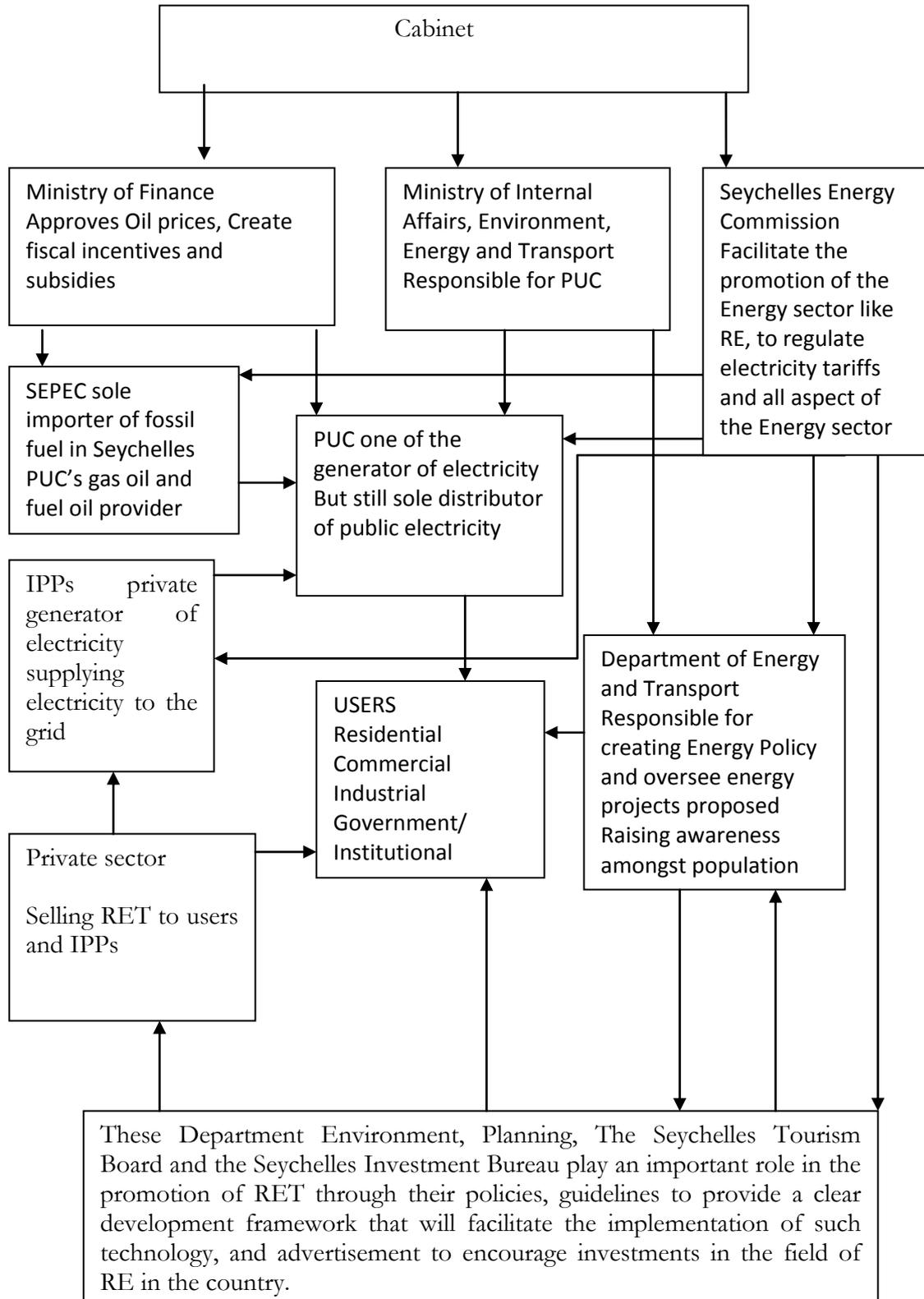
Source: Bergek et al 2007, Hekkert et al 2007 and Bergek et al 2008

Functions of the IS

Functions	Description and Role
Knowledge Development and Diffusion (Learning) (2 functions)	Is at the heart of the IS and looks at the knowledge base of the IS globally and also looks at how the local IS performs within its knowledge base and its evolution within this base. This function analyses how knowledge is shared and combined in the system amongst the various actors. It encompasses learning by doing and learning by searching
Entrepreneurial Experimentation	For an IS to get developed there needs to be experiments done to assess the feasibility or potential of a technology. This is done through continuous experiments the failures and success adds to the learning process and guides the refinement of experiments to make it better otherwise an IS will get shelved and not be formed.
Direction of Search or Demand Articulation	This looks at how the IS can develop and the path it will follow. For development to take place opportunities for the development must exist and there must be incentives and pressures for firms to invest in the system. This also involves coordinating investment between firms to provide an environment to ensure that investment takes place to develop the IS.
Legitimation	This involves society embracing the IS and having the IS complying with the relevant institutions guidelines. Once social acceptance has been gained from the various actors resources will get mobilised, demand will be created and the IS will gain political strengths. Legitimation is a way for new IS to overcome the 'Liability of newness' and generate momentum for change.
Market Formation	For an emerging IS markets may not exist or be underdeveloped therefore markets need to be formed. Market formation occurs in three phases the nursing market is the learning phase in which the IS start to form markets and these are limited in number. Then comes the bridging market where volumes increase and the IS grows in size and then we get the mass market which shows that the IS has been successfully implemented this however takes many years after the nursing markets.
Resource Mobilisation	As an IS grows different resources need to be mobilised this can be technical, scientific, financial it also looks at how the IS can influence the mobilisation of these resources.
Development of Positive Externalities	Development of Positive Externalities is dependent on the changes in the whole system. This occurs when the emerging IS evolve and grow further which strengthens some functions in the IS and create positive externalities for other companies within the system.

Source: Bergek et al 2007, Hekkert et al 2007 and Bergek et al 2008

Appendix 2 The Energy sectors future organisation structure



Appendix 3 The Interview Lists

Interviewee	Position and Sector
Gerard Hoareau	Chief Executive Officer Planning Authority
Tony Imaduwa	Seychelles Energy Commission
Andrew Jean-Louis	Chief Executive Officer Seychelles Energy Commission
Flavien Joubert	Director General
Michelle Martine	Chairperson Sustainability for Seychelles
Radley Webber	Importer and Supplier of RET and Energy Expert
F. D Yamda	SADC Consultant