Transnational recommendation report. Prepared for DIREKT – Small Developing Island Renewable Energy Knowledge and Technology Transfer Network

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Dear Reader,

Most Small Island Developing States (SIDS) in the ACP region are heavily dependent on the importation of fossil fuels to cover their energy needs, principal among which are electricity production and transportation. The price of fossil fuels, compounded by the price of transporting them to small island states, makes their importation so expensive as to threaten the economic stability of many such states, particularly given current global financial challenges. The sustainable development of SIDS clearly depends on reducing this fuel importation bill, which is typically in the order of 10–15% in many states, and the development and application of renewable energy technologies is the most feasible way to achieve this.

SIDS typically have significant indigenous energy potential in the form of renewable energy resources such as solar thermal, solar PV, wind, wave, ocean thermal, biomass and geothermal resources in some cases, but these technologies have not yet penetrated these communities to the point of significantly reducing the need for fuel importation. It is therefore critical that constraints on this penetration be identified and assessed, and that activities to overcome them be implemented, whether these be lack of awareness and capacity, lack of access to technology and finances, or inappropriate and unsuitable public policies and infrastructure.

Against this background, the project entitled ‘The Small Island Renewable Energy Knowledge and Technology Transfer Network’ (DIREKT), implemented from November 2009 to October 2012, was both timely and important. DIREKT is a partnership among the Hamburg University of Applied Sciences, the University of the West Indies, the University of the South Pacific and the University of Mauritius, and is funded by the ACP Science and Technology Programme, which is a European Union (EU) programme for cooperation between the EU and the ACP region.

There are several aspects regarding the design of the DIREKT project which give it tremendous potential for impact. It facilitates and encourages South-South collaboration, while benefiting from the technological guidance of the northern lead partner. It is deliberately practitioner-oriented, with strong emphasis on facilitating knowledge and technology transfer from universities to national stakeholders. Perhaps most importantly, it focuses explicitly on overcoming current constraints to the development and penetration of renewable energy technologies into the Small Island Developing States that the project serves.

The DIREKT project’s activities have ranged from capacity-building seminars and workshops targeting key and diverse stakeholders, to local, regional and international networking events, to the demonstration of renewable energy technologies in action in the form of pilot projects developed and operationalized in all participating countries, to the identification of strategies for universities to enhance training in research into renewable energy.

We wish to thank all the DIREKT project partners for their collegiality, hard work and commitment to the achievement of DIREKT’s goals and objectives. Their experience, knowledge and expertise are reflected in the recommendations at the core of this report. We also wish to thank the ACP Science and Technology Programme for providing the financial resources required to implement the DIREKT project. We hope that the wide dissemination of this report will ensure that the benefits of the DIREKT project flow well beyond the participating countries, and that the recommendations in the report serve to facilitate the growth of RE technologies in Small Island Developing States for years to come.

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Introducing the DIREKT partners

1. The Hamburg University of Applied Sciences (HAW) has been extensively involved in many local, national and international networks and partnership projects in the field of renewable energies and higher education (e.g. RENET, JELARE, DIREKT, REGSA). HAW is a leading institution in terms of education and raising awareness on renewable energy and has established a Competence Centre for Renewable Energies and Energy Efficiency (CC4E), as well as a Technology Transfer Office for Renewable Energy for Developing Countries (TTO-REDC).

2. The University of the West Indies (UWI) was established in 1948 as a regional institution which serves and is supported by 16 Caribbean countries. UWI is the premier university in the English-speaking Caribbean, with campuses in Jamaica, Trinidad and Barbados, as well as a virtual campus, the Open Campus, with offices in twelve Caribbean countries. The UWI has considerable experience in international collaboration. It is the secretariat for the University Consortium of Small Island States (UCSIS) which also includes the universities of Mauritius, Malta, the South Pacific and the Virgin Islands, and is currently involved in nine collaborative research projects with EU and ACP Partners. The UWI has a long history of research in solar thermal energy, which has now broadened to include research into solar PV, hydrogen fuel cells, wind power and geothermal energy. The UWI has also been expanding its curriculum to place emphasis on Renewable Energy (RE). Several courses in RE are now taught across all campuses and a Masters programme in Renewable Energy Management will be offered for the first time in the current academic year.

3. The University of the South Pacific (USP) is one of the two truly regional universities of the world, the other being the University of West Indies. USP is the premier university of the Pacific region, serving its twelve member countries through its 14 campuses. The university’s interest in renewable energy began as early as the 1970s with the establishment of the first Energy Working Unit at its Laucala Campus in Suva. USP's current Renewable Energy programme consists of one undergraduate and three postgraduate courses, with a dedicated Postgraduate Diploma in Renewable Energy. There are currently two large renewable energy research projects in progress. The university has also benefitted from several student research and demonstration projects in renewable energy funded through various aid agencies.

4. The University of Mauritius (UOM) is the oldest and largest tertiary institution in Mauritius. The University of Mauritius has been involved in several international renewable energy projects/collaborations including CODWAP, SideCap, DIREKT and CARENSA. The Department of Chemical and Environmental Engineering in the Faculty of Engineering is working on energy issues in general, with research applied in such a way as to be of use to the local community. The Faculty has been running a distance-learning Masters program in Sustainable Energy Engineering for the past few years in collaboration with the Royal Institute of Technology in Sweden and also runs a Bachelors degree in Chemical and Renewable Energy Engineering. The university has also been very active in the national project entitled ‘Mauritius a Sustainable Island (Maurice Ile Durable)’.
Executive Summary

The Small Developing Island Renewable Energy Knowledge and Technology Transfer Network (DIREKT) is a partnership among universities with campuses in Germany, Mauritius, Barbados, Trinidad & Tobago and Fiji, geared towards strengthening the science and technology capacity for renewable energy of targeted ACP (African, Caribbean and Pacific) Small Island Developing States (SIDS), through technology transfer, information exchange and networking. The project is funded by the ACP Science and Technology Programme – a European Union (EU) programme for cooperation between the European Union and the ACP region.

Renewable energy is of great relevance to the socio-economic development of countries in the ACP region, particularly in SIDS, as to date these countries have typically relied heavily upon imported fossil fuels to meet their energy demands. Apart from the environmental benefits of renewable energy, and the fact that its use actually contributes to the mitigation of climate change, the local generation and use of renewable energies offer great potential for local economic development through a wide range of local job opportunities, from highly skilled to unskilled and from high-tech to agriculture. It also fosters local investments and reduces the need for imports.

A primary challenge is that the renewable energy sector in ACP countries cannot develop sufficiently at present due to lack of expertise and limited access to the latest technologies and knowledge, in particular in ACP Small Island Developing States (ACP-SIDS). The DIREKT Project was implemented in order to contribute to rectifying this constraint. It is a concrete tool to foster the cause of climate change mitigation in developing countries, by raising their capacity to develop in the field of renewable energy. Due to their innovative work, universities and research institutions in ACP-SIDS countries play very pivotal roles in this sector; both in terms of research and in the education of future employees in this sector.

The overall objectives of the DIREKT project are to:
- Strengthen the internal science and technology capacity in the field of renewable energy of ACP-SIDS;
- Foster sustainable cooperation between the science and technology communities in the participant countries and the EU; and
- Contribute to the transfer of research results on key issues in renewable energies by means of the establishment of “technology transfer centres” in the participant countries.

The specific objectives of the DIREKT project are to:
- Increase the capacity and improve the quality of research within the scientific and technological communities of ACP-SIDS in the field of renewable energy as a tool to fight climate change;
- Develop and establish a market-oriented research framework to better capitalise upon and disseminate research results; and
- Strengthen links which research communities in ACP-SIDS have with regional markets, businesses and legislation (policy) in the field of renewable energy.

The partners in the DIREKT Project include:
- The Hamburg University of Applied Sciences (HAW Hamburg), Germany – Lead Partner
- The University of the West Indies, Cave Hill, Barbados
- The University of the South Pacific, Fiji
- The University of Mauritius, Mauritius
- The University of the West Indies, St Augustine, Trinidad & Tobago

This report outlines recommendations for the formulation and implementation of research and technology transfer policies in the renewable energy sector in the ACP regions. For organisational purposes, barriers and recommendations here are categorized into five groups: financial, governance, technical, informational and social, although not all of the recommendations fit into one particular category.
As well as providing a synopsis of renewable energy development for SIDS in the ACP regions and the activities of the DIREKT project, this report contains four main sections, which are summarised below.

- **Section 4** contains general recommendations applicable to all ACP small developing island states. These include, but are not limited to, enhanced public and private partnerships, use of microcredits, improved policy instruments, support in raising awareness among populations, improvements in RE education, and enhancement of RE capabilities.

- **Section 5** provides recommendations separately for the ACP regions represented in the project, with particular emphasis on the similarities in challenges these regions are experiencing when implementing RE. The key recommendations for the Caribbean region are implementation of EPCs, development of national guidelines and energy security strategies, and raising awareness in terms of energy consumption habits. The key recommendations for the Pacific region are improvement in ability to acquire funding for RE projects, implementation of a framework for regional energy policies, building capacity in communities, and monitoring of RE resources on a national scale.

- **Section 6** focuses on local recommendations for the countries impacted by the project (Fiji, Trinidad & Tobago, St Lucia, Jamaica, Mauritius and Barbados). The key recommendations for Fiji are the creation of an independent RE regulator, enhancement of training for rural/remote communities, and implementation of energy audits. The key recommendations for Trinidad and Tobago are the introduction of FITs and green banks, the development of green building codes, improved visibility of RE projects, and introduction of energy efficiency measures such as LED lighting. The key recommendations for St Lucia are improvement in the capacity and capabilities of the local labour market, and improvements in media awareness and accuracy in reporting. The key recommendations for Jamaica are the introduction of penalties for non-compliance, greater support and motivation from the government, and development of knowledge networks. The key recommendations for Mauritius are the creation of strong governance, and enhancement of particular RE technologies such as small-scale wind turbines, bioethanol and biomass. The key recommendations for Barbados are the creation of databases supporting RE funding, improvement in information distribution, and support of IPPs.

- **Section 7** provides recommendations for research institutes and higher education institutions geared to improving the quality of their research and technology transfer activities, as well as for strengthening their role in regional socioeconomic development. One of the key recommendations repeatedly emerging during this project has been that, in order to address many of the recognised constraints, research into RE and EE at regional research institutes should be enhanced. Research institutes and higher education institutions should not work in isolation, but collaborate with governments, businesses and research centres from other regions.
1. Introduction

Small Island Developing States (SIDS) in the ACP regions can be quite different geographically and culturally, but most of them share similar environmental and economic vulnerabilities and challenges to sustainable development. Small islands are generally dependent on imported energy sources, mainly in the form of fossil fuels (fuel oil, diesel and some coal), which results in low levels of energy security. These imports cover energy needs for transportation and electricity production, and the dependency of SIDS on these imports in order to maintain levels of economic energy intensity make them more vulnerable than most mainland countries to events beyond their control, such as global energy price rises. The small size and isolated locations of SIDS contribute to high energy and transportation costs, diseconomies of scale, and unfavourable power plant management options, which are the main reasons for the high energy prices in SIDS when compared with mainland countries. This situation makes the application of sustainable energy technologies not so much an option but rather necessity for small islands, especially as global energy prices continue to rise [1]. It is paradoxical that these same SIDS often have significant indigenous energy potential in the form of renewable energy resources such as solar thermal, solar PV, wind, hydro, wave, biomass, ocean thermal energy and some geothermal resources. However, to date, many SIDS have not experienced a high penetration of renewable energy technologies into their communities, even though the high price of imported energy creates a good market opportunity for this.

There have been many initiatives in the past to develop better energy policies in SIDS throughout the ACP regions, including the promotion of diversification, the development of renewable energy sources, and increased energy efficiency, but these have often failed to deliver any substantial improvements. Several factors have impeded progress, including problems with governance and policy conflicts, misguided technology choices,
market failures and inefficient institutional structures. Specific problems include: inefficient public electricity systems with old generating plants; inefficient use of energy in manufacturing and other productive sectors such as tourism; inefficient energy use in the public sector, including the extensive use of pumps (rather than gravity feed or solar pumping) to deliver a nation’s water supply; low public awareness of the importance of energy conservation and an inadequate policy framework to promote energy conservation and efficiency.

The recommendations proposed in this report depend heavily on the fact that knowledge networks are the key to rapid development, dissemination and uptake of new ideas, business concepts and technologies. Effectively operated, knowledge networks act as crucial links between the business community, academics and civil servants, and function across a range of industrial sectors. Assembling and operating functional knowledge networks depends on building more flexible, effective and productive links and partnerships between four key groups, namely:

- Researchers;
- Investors and financiers;
- Entrepreneurs and industrialists;
- Government agencies and ministries with remits in energy and economic development.

There must be a high level of communication between the key groups so that researchers can be better informed as to the changing needs of industry, entrepreneurs are in a position to identify opportunities, industrialists can keep abreast of developments in science and technology, and government agencies can remove obstacles and encourage progress. The evidence from successful models of technological innovation, development, dissemination and uptake is that the key to ultimate success lies in the creation of these structured local networks of researchers, financiers and entrepreneurs.

There are three main areas where action is required: financial resources, public policies and technological innovation. Current investment in energy research worldwide is considered to be inadequate to meet global challenges, but the situation for SIDS in the ACP region is particularly problematic. Investment in RE projects is low, human capacity is limited, and current educational programmes are not producing the human resources required. This means that research, development and demonstration (RD&D) projects, with associated teaching programmes, are the key to future progress with RE for SIDS across the ACP region.

Science provides the basis for understanding energy issues and for identifying research pathways. Engineering supplements this scientific knowledge by optimizing the most promising technologies, and providing practical solutions. Simultaneously, policy and economic analysis is necessary to understand the market and regulatory constraints and facilitate the dissemination and uptake of particular technological solutions.

Against this background, it is clearly important, from the perspective of higher education institutions, to develop undergraduate, graduate and research programmes that provide a strong and comprehensive set of RD&D programmes relating to RE, both in terms of training and research. These can then be used as the basis for forming knowledge networks across small island developing states.
2. Status of Renewable Energy in the ACP Regions

The results of Work Package 2 produced by the DIREKT project described the relative importance of different RE technologies in people’s perception of research and training needs in countries in the three regions served by the DIREKT project. PV, wind and solar thermal were identified as the most important in all three regions. Thereafter, the regions differed. Fiji had hydro and biomass as the next two most important categories. Hydro was the fourth most important in Eastern Caribbean States (OECS), the sixth most important in Trinidad and Tobago, and the sixth most important in Mauritius. Biofuels were identified as much more important in Fiji than in Mauritius, Trinidad and Tobago or Barbados and the OECS [2]. The following sections describe in detail the renewable energy status in the target regions.

2.1 Status of RE in the African Sub-Region

Mauritius is a small island developing state and has no known oil, natural gas or coal reserves. It therefore depends on imported petroleum products to meet most of its energy requirements (see Figure 1 for geographical location of Mauritius). Fossil fuels represent around 80% of the energy used in Mauritius. This is costly and has increased Greenhouse Gas (GHG) emissions by 20% since 2000. As a small island state with no indigenous reserves of fossils fuels and no electricity interconnection, the island is exposed to the risks of being without power and transport as a result of geopolitical, economic or natural crises. The government has therefore developed strategies to reduce the island’s dependency on fossil fuels in the medium and long terms. In 2008, the government of Mauritius initiated the Maurice Ile Durable (Mauritius Sustainable Island) project in order to support efforts to promote more efficient use of energy and increase the use of renewable energy. This long-term energy strategy was developed in order to provide a different approach to increasing the use of renewable energy in Mauritius. The main objective of this strategy is to reduce vulnerability with regard to imported fossil fuels and their volatile prices, promote economic growth and job creation, secure affordable energy to consumers, democratise energy supply and promote long-term sustainable development.

2.1.1 Current Status of RE

Mauritius is highly dependent on fossil fuels to meet its energy demand. However, renewable energy sources have already significantly penetrated society. These sources are mainly biomass, hydropower, wind power, solar energy and landfill gas, and represent around 20% of current total energy use.

Biomass Energy

Mauritius has a very valuable asset in the form of sugarcane biomass (known as bagasse). Bagasse is the fibrous residue of the cane stalk after it has been crushed and the juice extracted. Bagasse is used for generating heat and power during the crop season (June to December). The
2. Status of Renewable Energy in the ACP Regions

Power is sent to the national grid, and the heat is used for processing sugar in the sugarcane factory. It is important to note that the crop season occurs only over six months, which is therefore when bagasse is available. During the off-crop season when there is no bagasse, coal is burned in the same furnace to produce power. The power produced from bagasse represents around 16% of the total power produced by the plant. Mauritius is the only small island developing state in the world where sugar mills sell energy on a large scale to the electricity grid. Private sector participation in this has been very successful.

Hydropower

Many small hydro systems were installed on Mauritius in the 1970s to supply power to remote mines, towns, and industries. Currently, hydropower potential is approaching saturation point, and there are competitive uses of the existing water resources (e.g. domestic water use and irrigation). There are now eight hydropower plants with a combined installed capacity of 59 MW. The total installed capacity can be exploited only during wet periods with heavy rainfall. The Champagne, Tamarind, Magenta, and Le Val power stations are run with dam storage facilities while the remaining stations at Ferney, Réduit, Cascade Cécile, and La Ferme are of the ‘run-of-river’ type. The government has recently commissioned a 375 kW micro-hydro power plant on La Nicollère Feeder Canal, to be finished by the end of 2012. The amount of energy that can be generated from each hydro power station depends on the amount of rainfall over the year. Each station can generate a minimum of 5 GWh in the driest month to an average of 20 GWh in the wet season. A total of about 100 GWh per year can be generated from the eight hydro power plants [4]. Due to seasonal rain conditions and limited storage capacity, only two of the hydro plants generate electricity throughout the year during peak hours, whereas the other six generate electricity as and when water is available, mostly over the period January to March. There are plans to construct other hydro sites, such as the Midlands dam.

Solar Power

Mauritius benefits from a good solar resource around the year. To make use of this solar energy and to promote the development of the solar power industry, the government has installed photovoltaic systems for street lighting at several locations. In addition, with the goal of promoting clean energy and consistent with the vision of democratising the electricity grid, the government has recently launched the Small Scale Distributed Generators (SSDG) project. Through this initiative, Small Scale Independent Power Producers (SIPPs) will be given the opportunity to produce their own electricity from renewable energy sources, and export any excess to the Central Electricity Board (CEB) grid. For the SSDG project to be feasible, a grid code has been established to permit the integration of photovoltaic systems, wind turbines, and mini-hydro technologies within the CEB grid. The maximum permissible installed capacity of the above-mentioned technologies has been set to 50 kW per customer. Since the implementation of the SSDG project, many customers have opted for the installation of photovoltaic systems for power generation for their own use, with the potential to send excess to the grid. A maximum projected capacity of 2 MW has been forecast for this initiative.
Solar water heating remains the most common current form of solar energy conversion in Mauritius. The Development Bank of Mauritius has been supporting the purchase and installation of solar water heaters (SWHs) since 1992 by providing loans to individuals at a competitive rate. However, the price was initially too high for Mauritians, so few people opted for this scheme although those who could afford it did benefit. In 2008, the government introduced a new scheme whereby a grant of 10,000 MUR (USD 333) was provided to anyone interested in purchasing an SWH. This scheme was very popular and many households benefitted from it. In fact, the outcome of the new scheme was beyond expectations, with some forty thousand applications received by the bank. Solar water heating systems have therefore penetrated society much better than solar PV, with some 35,000 SWH units installed on the island to date. This represents an 8% penetration of the household market. However, the government is currently planning a new scheme to encourage wider adoption of solar PV systems in households and other sectors of the economy. Moreover, the government plans to construct a 300 kW PV system to directly displace diesel-fuelled electricity generation. To lessen the impacts of the new road and power line construction required, the facility will be constructed near the existing diesel generation plant [3].

Wind Power

Wind is often the most commercially feasible renewable energy source. The main islands of Mauritius and Rodrigues are exposed to the prevailing southeast trade winds and are suitable for wind energy exploitation. Wind turbines were used in Mauritius from 1987 to 1990 at Grand Bassin. The capacity of this wind farm was 0.1 MW, and the average annual electricity production was 0.16 GWh. However, the wind turbines were damaged irreparably by cyclones. During the 1980s, experts from the UNDP carried out a wind energy resource assessment study in Mauritius. The study confirmed that there are potential sites on the two islands for setting up wind farms, with some areas having an annual average speed of 8.0 m/s at heights 30m above ground level [3]. With technological advancements in the design of turbines, the government intends to support the construction of more wind farms in different regions of the country [4].

Wind farm projects on Rodrigues Island have been implemented and are successful. The wind farm situated at Trefles consists of three wind turbines of 60 kW each. There are two additional units of 275 kW each, which are situated at Grenade (constructed in 2010) and contribute around 10% of total electricity consumption in Rodrigues. The wind turbines are of the tilted type and can be lowered for protection during cyclone periods. The government intends to set up a scheme based on the Build Operate Own (BOO) model for the implementation of future wind farms in Mauritius.

Landfill Gas to Energy

Municipal Solid Waste (MSW) has been disposed of at the Mare Chicose landfill in Mauritius since 1997. During the decomposition of the organic waste, landfill gas, consisting mainly of methane and carbon dioxide, is released. Being greenhouse gases, both methane and carbon dioxide contribute to global warming. Since methane has a bigger global warming potential than carbon dioxide, the landfill gas was previously flared. However, since 2012, a landfill gas to energy plant with a capacity of 2MW has been installed. This 2 MW installation is now contributing to the share of total national energy produced from renewable resources.
2.1.2 Future Initiatives in RE

**Solar Power**
The Small Scale Distributed Generators (SSDG) project was implemented in 2011 with the potential to provide a total installed capacity of 2 MW of distributed generation from households across the island. The CEB has since decided to extend this project, and a second phase will be implemented in 2012 to provide an additional installed capacity of 1 MW.

**Wind Energy**
The government intends to set up a Build Operate Own (BOO) scheme for the implementation of future wind farms in Mauritius. The wind turbines of any new farm should be able to withstand cyclonic wind speed in the order of 280 km/hr. A wind farm of 25–40 MW will be set up at Curepipe Point on a BOO scheme. The government is also encouraging private sector initiatives at Plaine des Roches and Britannia to set up wind farms, with a minimum of 10 MW installed capacity at each site.

**Landfill Gas to Energy**
The Mare Chicose landfill has recently been extended to accommodate more waste. More landfill gas will be generated, and the current landfill gas to energy plant, which is providing a total power of 2 MW, is expected to increase its production capacity to 3 MW in the future.

**Waste-to-Energy**
Waste-to-energy forms part of an integrated solid waste management system. The government of Mauritius is interested in installing a waste-to-energy plant in the future to divert some waste from the landfill. The waste-to-energy plant will be used to incinerate the waste, but at the same time electricity will be produced from the combustion process and will be sent to the utility grid. The future waste-to-energy plant will have a capacity of around 20 MW.

**Other Renewable Energy Technologies**
Mauritius, being of volcanic origin, has a huge geothermal energy conversion potential. However, exploration costs are very high, as deep drilling is necessary to reach the thermal source. Moreover, geothermal energy technology is site-dependent and land consuming. Private operators are being encouraged to take most of the exploratory risks. However, the government can provide some incentives to the private sector and other external bodies.

Ocean Thermal Energy Conversion (OTEC) technology in Mauritius is still under study, and has not yet been commercialized. Use of this source of energy has been planned for the future once proof-of-concept is achieved and the technology has matured.

2.1.3 Targets for Renewable Energy over the Period 2010–2025

On the basis of the long-term strategic energy plan developed by the government through the Ministry of RE and Public Utilities [4], targets for the percentage of total electricity generation from renewable and non-renewable sources of energy have been established for the period 2010–2025, as shown in Table 1. The idea is to increase the share of renewable energy gradually in the energy mix.
2. Status of Renewable Energy in the ACP Regions

Table 1. Forecast of Energy Mix for Mauritius over the Period 2010–2025 [4]

<table>
<thead>
<tr>
<th>Fuel Source</th>
<th>Percentage of Total Electricity Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td>Bagasse</td>
<td>16%</td>
</tr>
<tr>
<td>Hydro</td>
<td>4%</td>
</tr>
<tr>
<td>Waste to Energy</td>
<td>0%</td>
</tr>
<tr>
<td>Wind</td>
<td>0%</td>
</tr>
<tr>
<td>Solar PV</td>
<td>0%</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0%</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>20%</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>37%</td>
</tr>
<tr>
<td>Coal</td>
<td>43%</td>
</tr>
<tr>
<td>Sub-Total</td>
<td>80%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

2.2 Status of RE in the Caribbean Sub-Region

2.2.1 The Caribbean in Perspective

The Caribbean islands are net importers of energy. The exception is Trinidad and Tobago, which is the only island state with significant oil and natural gas reserves. Barbados has some reserves, but only partially satisfies its own oil and gas requirements. The primary energy supply in the region is dominated by the use of imported petroleum and oil products, which constitutes ~59% of the total primary energy consumed, with a further 34% being supplied by natural gas. An analysis of data from various reports at the Caribbean Community Secretariat (CARICOM) Energy Unit shows an increase to approximately 7% coming from renewable energy sources.

Although the Caribbean sub-region is often analysed as a whole, it is important to differentiate between small island states such as most of the Eastern Caribbean islands, large island states such as Trinidad and Tobago, Jamaica, Haiti and the Dominican Republic, and low lying coastal states such as Belize, Guyana and Suriname. Each nation has a unique energy profile based on its availability of natural resources, population size, and level of economic and industrial development. Despite these differences, there are some defining characteristics that are common to most of these countries, and SIDS in general.

These include:
- Relatively small populations (with the exception of the large island states);
- Relatively high GDPs in several cases (e.g. Barbados and Trinidad);
- Small-scale economies and small energy markets;
- Geographically isolated, with the exception of Belize, Guyana and Suriname;
- A single monopoly electricity provider in most cases (whether state or privately owned);
- Readily available, but mainly untapped, renewable energy potential, e.g. wind, hydropower, solar energy, and geothermal.

These features have shaped the development and energy profile of the region. The energy mix...
of selected Caribbean islands is shown in Figure 6 below.

The imported energy is mainly in the form of fossil fuels. These imports cover energy needs for transportation and electricity production, and the dependency of the countries on these imports to maintain levels of economic energy intensity make them more vulnerable than most mainland countries to events beyond their control, such as global energy price rises. As with most SIDS, the small size and isolated locations of the countries contribute to high energy and transportation costs, diseconomies of scale, and unfavourable

Figure 5. Map of the Caribbean region

Figure 6. Energy consumption pattern of Caribbean SIDS (US EIA, 2010)
2. Status of Renewable Energy in the ACP Regions

power plant management options. These are the main reasons for their expensive energy prices, which are among the highest in the world [see Figure 7] [1].

It is estimated that the region spends USD 2.5 billion annually for the purchase of energy, which represents about 20% of total foreign earnings. For most of the island states, the service industry is the dominant sector, with tourism being the predominant consumer of energy and generator of revenue. This industry accounts for 30-60% of GDP on some islands, while accounting for 40% of all building electricity used in the region.

Although on many islands the electricity grid is far-reaching and has the capacity to adequately serve the entire population, it is very carbon intensive due to large transmission and delivery losses coupled with high production costs.

There is already evidence that the introduction of RETs in the Caribbean can assist with the production of electricity at lower cost than with diesel generators alone, mainly due to the high cost of electricity in almost all countries [Figure 7] [5]. The 2010 report on a Sustainable Energy Framework (SEF) for Barbados [6], produced for the government of Barbados and the Inter-American Development Bank, notes that utility scale wind, biomass cogeneration, small scale hybrid PV/thermal systems, municipal solid waste to energy schemes and sea water air conditioning are economically and commercially viable in the current energy market (oil at $100/barrel). The report also identifies technologies that are likely to be viable in the near future, including certain types of small-scale and commercial solar photovoltaic systems, and solar thermal technologies to provide heat for manufacturing processes (solar water heaters for domestic and commercial use are already commercially viable). Hydropower, notably absent from the SEF for Barbados since it is not suited to that island, is economically and commercially viable in most other countries. This is true for small, medium and large-scale systems. This realisation of economic and commercial viability of RE technologies is true for both grid-connected and off-grid applications, and is particularly promising when considering the rapid advancement in the efficiency of RETs, and how their purchase price has fallen in recent years, with further such improvements widely anticipated [5].

Figure 7. Approximate domestic electricity prices in Caribbean countries (CARILEC, 2010)

2.2.2 Renewable Energy Technologies (RETs)

There is already evidence that the introduction of RETs in the Caribbean can assist with the production of electricity at lower cost than with diesel generators alone, mainly due to the high cost of electricity in almost all countries [Figure 7] [5]. The 2010 report on a Sustainable Energy Framework (SEF) for Barbados [6], produced for the government of Barbados and the Inter-American Development Bank, notes that utility scale wind, biomass cogeneration, small scale hybrid PV/thermal systems, municipal solid waste to energy schemes and sea water air conditioning are economically and commercially viable in the current energy market (oil at $100/barrel). The report also identifies technologies that are likely to be viable in the near future, including certain types of small-scale and commercial solar photovoltaic systems, and solar thermal technologies to provide heat for manufacturing processes (solar water heaters for domestic and commercial use are already commercially viable). Hydropower, notably absent from the SEF for Barbados since it is not suited to that island, is economically and commercially viable in most other countries. This is true for small, medium and large-scale systems. This realisation of economic and commercial viability of RE technologies is true for both grid-connected and off-grid applications, and is particularly promising when considering the rapid advancement in the efficiency of RETs, and how their purchase price has fallen in recent years, with further such improvements widely anticipated [5].
The level of penetration of different RETs across the Caribbean is currently an interesting mix. Despite the perceived future importance of PV, wind and solar thermal (see Section 2 and [2]), hydropower currently provides the largest market penetration, followed by biomass (bagasse cogeneration), wind power (utility scale) and solar thermal, for the Caribbean as a whole. Within the CARICOM region, certain member states have engaged in small and large-scale hydroelectric power generation, particularly Guyana, Suriname, Dominica, St Vincent and Jamaica. Potential exists for significant expansion in this sector in the future. Although many countries have limited space available, there is still a considerable opportunity for large-scale wind use in the Caribbean region, particularly as offshore wind continues to advance technologically elsewhere in the world and prices are reduced. Constant trade winds provide a reliable resource in the region, and due to advancements in design, wind turbine technology has proved capable of withstanding hurricane seasons (for example the 38.7 MW Wigton wind farm in Jamaica has withstood Category 4 and 5 hurricanes, with minimal damage, since its completion in 2004). In addition, special tilting wind turbine designs for hurricane-prone areas (see examples from Fiji in Figure 11) facilitate the dismantling of the tower and turbine prior to the onset of hurricanes. These designs are especially suited for the Caribbean area and are currently utilised on Guadeloupe, Martinique, Cuba, and Nevis.

Solar water heaters (SWHs) are an established technology across the Caribbean, mainly due to their internationally recognised successful development in Barbados. In the 1970s, the SWH industry grew exponentially due to government fiscal and financial incentives and the high standard of local manufacturing of the systems. This was the main reason Barbados’ water heater programme is the most successful in the region and, during the 1990s it was named the country with the second highest market penetration in the world, according to a USAID study. The country now ranks fifth in the world [7]. Other renewable energy technologies with bright futures in the Caribbean include waste-to-energy plants, seawater air-conditioning, geothermal power and wave power.

The potential for geothermal energy on those Caribbean islands which lie within the subduction zone of the Atlantic and Caribbean plates is significant. The only geothermal plant operating in the Caribbean is at Bouillante in Guadeloupe and has a capacity of 15 MW. The island governments of Dominica and Nevis have initiated exploration work for geothermal energy. Nevis has a potential of 700 MW and the government is in the process of setting up a geothermal power plant to develop 24 MW of energy for domestic use, as well as to sell to neighbouring islands [8].

2.2.3 Regional RE Policy

In 1998, fourteen Caribbean countries and two British dependencies agreed to work together on a regional project aimed at removing barriers to the use of RETs and encouraging the development and commercialisation of RETs. This initiative led to the formation of the Caribbean Renewable Energy Programme (CREDP), which was officially launched in 2004. This programme was funded by the United Nations Development Programme (UNDP) and the German Technical Cooperation (GIZ), with co-financing by the island governments. A project steering committee was created with the specific mandate of advising on the project’s implementation in direct consultation with the executing agency and project management [9]. Since its inception, CREDP
has been highly instrumental in accelerating the growth of renewables in the region in terms of policy development, project implementation, upgrading of existing facilities, training and capacity building among other initiatives. The first phase of the CREDP project has been completed and the second phase will continue until the end of 2012 with an emphasis on energy conservation and energy efficiency.

In April 2008, the CARICOM Secretariat established an energy programme unit within the Directorate of Trade and Economic Integration to ensure a programmatic approach to regional energy sector developments. This programme aims to facilitate greater responsiveness in carrying out the community’s mandates, as well as to provide a more harmonized approach to energy issues. One key task of the energy programme is the finalisation and implementation of the CARICOM Energy Policy, which is currently in draft and is intended to be ready for presentation at the Inter-Sessional Heads of Government Meeting in 2012 [10].

A significant focus of the CARICOM Energy Programme is the advancement and development of RE. In this regard, great emphasis is being placed on establishing enabling policy, as well as regulatory and legislative frameworks, to encourage the increased development of RE (see Table 2). This is against the background that:

1. RE remains important to the long-term energy security of the region,
2. RE forms the indigenous energy resources of most CARICOM countries, and
3. Diversification of the energy supply will provide a buffer to the negative impacts of oil price volatility.

Energy is also an important issue in perhaps the most important human development challenge of today; i.e. climate change. It is considered that, inter alia, CARICOM countries could bolster their moral position in their bid to have developed countries make greater commitments to emissions reduction, by lowering their own carbon footprints and positioning the Caribbean energy sector on a more sustainable energy path [10].

### Table 2. Sustainable Energy Status of Caribbean countries [12]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Antigua &amp; Barbuda</td>
<td>0.08</td>
<td>Draft started 2010</td>
<td>No Indepnt; Gov</td>
<td>Pub - Act; Indefin</td>
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<td>100</td>
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<td>Bahamas</td>
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<td>Draft started 2010</td>
<td>No Indepnt; Gov</td>
<td>Pub/Pvt; Lic 2054</td>
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<td>99</td>
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<td>0.27</td>
<td>Draft since 2006</td>
<td>Fair Trading Com</td>
<td>Pvt; Lic 2028</td>
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</tr>
<tr>
<td>Belize</td>
<td>0.32</td>
<td>No Policy</td>
<td>PUC - Multi sect</td>
<td>Pvt; Lic 2015</td>
<td>44</td>
<td>90</td>
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<tr>
<td>Dominica</td>
<td>0.08</td>
<td>Draft 2009</td>
<td>Indep; IRC</td>
<td>Pvt-Unbundled 2015</td>
<td>25</td>
<td>100</td>
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<td>Grenada</td>
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<td>Draft 2010</td>
<td>No Indepnt; Gov</td>
<td>Pvt; Lic 2073</td>
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<td>99</td>
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<tr>
<td>Guyana</td>
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<td>Expired 2004</td>
<td>IRC</td>
<td>Pub; Lic 2024</td>
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<tr>
<td>Haiti</td>
<td>9.3</td>
<td>Started Policy</td>
<td>No Indepnt; Gov</td>
<td>Pub;</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Jamaica</td>
<td>2.7</td>
<td>Approved</td>
<td>Off of Utility Reg</td>
<td>Pvt/Pub; IPP, 2021</td>
<td>6</td>
<td>95</td>
</tr>
<tr>
<td>St Kitts &amp; Nevis</td>
<td>0.04</td>
<td>Draft 2009</td>
<td>No Indepnt; Gov</td>
<td>Pub; Act; Indefinite</td>
<td>0</td>
<td>95</td>
</tr>
<tr>
<td>St Lucia</td>
<td>0.16</td>
<td>Approved</td>
<td>No Indepnt; Gov</td>
<td>Pvt; Lic 2045</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>St Vincent &amp; Grenadines</td>
<td>0.1</td>
<td>Approved</td>
<td>No Indepnt; Gov</td>
<td>Pub; to 2033</td>
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<tr>
<td>Suriname</td>
<td>0.49</td>
<td>Draft RE Started 09</td>
<td>No Ind; GovReg</td>
<td>Pub; Act; to 2022</td>
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<td>Trinidad &amp; Tobago</td>
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<td>Pub/Pvt - Indefinite</td>
<td>0</td>
<td>95</td>
</tr>
</tbody>
</table>
2. Status of Renewable Energy in the ACP Regions

2.2.4 Future Capacity Building

As reported in a CARICOM press release in October 2011 [12], CARICOM and the Inter-American Development Bank (IDB) formalized a technical cooperation agreement that made available USD 400,000 in grant funding to pave the way for the preparation of the Caribbean Sustainable Energy Roadmap and Strategy (C-SERMS) to cover activities over a thirty month period. The C-SERMS has the following objectives and characteristics:

- Define a strategic and targeted regional approach to increasing the contribution of RE and EE to the energy mix;
- Set achievable short, medium and long-term targets (2015, 2020, 2025), and outline steps for specific actions at country and regional levels;
- Provide the basis for firm commitments by governments within CARICOM and development partners in achieving these objectives;
- Allow for coordination, harmonization and optimization of efforts in sustainable energy development among energy sector stakeholders and identify potential synergies;
- Provide a reference point or baseline for measuring progress in sustainable energy development within CARICOM;
- Be a dynamic and living document to be developed in phases and refined and updated over time.

The first phase of C-SERMS will be developed based on existing resource assessment and information including sector policy, legislation and regulations, and refined periodically based on the results of new resource assessments, studies and initiatives. Additional activities include the design and operation of a sustainable energy platform and the provision of training and capacity building for research and development in sustainable energy, as well as to design and prepare research and innovation projects.

2.3 Status of RE in the Pacific Sub-Region

2.3.1 The Pacific in Perspective

In the context of renewable energy, Pacific Island Countries (PICs) (Figure 8) can be divided into three different groups: (1) large countries with diverse renewable energy options and substantial un-electrified regions, with electrification confined to urban and peri-urban areas (Fiji, Papua New Guinea, the Solomon Islands and Vanuatu); (2) small islands with limited space availability and small populations, where size limits the potential for large-scale renewable energy penetration (Federated States of Micronesia (FSM), Kiribati, and the Marshall Islands); and (3) countries with a high rate of electrification, often approaching 100%, and populations that are engaged primarily in the money economy (Cook Islands, Nauru, Niue, Palau, Samoa, Tokelau, Tonga and Tuvalu).

Hydropower is available in some of these countries, and wind power has some potential, but biofuels in the form of coconut oil processed as a diesel fuel substitute are recognized as having the largest potential [13].
2. Status of Renewable Energy in the ACP Regions

2.3.2 Renewable Energy and Power Generation

Due largely to its volcanic geology, Fiji (Figure 9) has an abundance of available renewable energy resources. Some of the renewable energy resources available in Fiji are hydro, solar, wind, geothermal, biomass and ocean. Due to the increase in the demand and global price of fossil fuels, the country is actively engaged in research in the field of renewable energy to find potential sources for electricity generation. The total electrical generating capacity in Fiji is presently in the vicinity of 190 MW. Between 45% and 60% of grid electricity is generated from renewable energy sources, most of which is in the form of hydropower (Table 3). Other renewable energy resources used are wind energy, solar energy and biomass in the form of hog fuel from the timber milling industry and bagasse from the sugar industry. However, without hydropower renewable energy would provide only a small fraction of the total generation capacity in Fiji. Moreover,

Table 3. Commercial-based Hydropower Scheme in Fiji

<table>
<thead>
<tr>
<th>Project/Scheme</th>
<th>Location</th>
<th>Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monasavu</td>
<td>Interior of Viti Levu</td>
<td>80</td>
</tr>
<tr>
<td>Wainikasou</td>
<td>Interior of Viti Levu</td>
<td>6.4</td>
</tr>
<tr>
<td>Nagado</td>
<td>Nadi, Viti Levu</td>
<td>3</td>
</tr>
<tr>
<td>Wainikeu</td>
<td>Savusavu, Yanua Levu</td>
<td>0.8</td>
</tr>
<tr>
<td>Nadarivatu</td>
<td>Interior of Viti Levu</td>
<td>40</td>
</tr>
</tbody>
</table>

Figure 8. Map of Pacific Island Countries (PICs)

Figure 9. Map of Fiji Islands
2. Status of Renewable Energy in the ACP Regions

2.3.3 Renewable Energy Policy and Finance

Energy policy and planning for the promotion and development of renewable energy resources is the responsibility of the Fiji Department of Energy (FDoE). The FDoE implemented the National Energy Policy (NEP) in 2007 to ensure the effective development of renewable energy in Fiji. The review of the NEP is scheduled to be carried out every five years, and is due this year (2012).

The FDoE is also engaged in looking for financial institutes that can provide funding for the development of renewable energy projects in Fiji. It is...
encouraging to see that the FDoE is already liaising with financial institutes such as the World Bank and the Australia and New Zealand Banking Group Limited (ANZ) for assistance to boost the implementation of renewable energy projects in Fiji at potential sites.

The FDoE is also liaising with the Taukei Land Trust Board (TLTB) to resolve land issues in order to secure the development of the renewable energy projects, since almost 90% of the land in Fiji is native owned. Furthermore, there is now a Framework for Action on Energy Security in the Pacific (FAESP) and its associated Implementation Plan (IPESP) [14]. This is designed to provide guidance to Pacific Island Countries and Territories (PICTs) in their national efforts to achieve energy security in line with the principles of the Pacific plan, and to clarify how regional services can assist countries to develop and implement their national plans. The framework is based on eleven guiding principles and the following seven themes which embody the principles:

1. Leadership, governance, coordination and partnership
2. Energy planning, policy and regulatory frameworks
3. Energy production and supply
   - Petroleum and alternative liquid fuels
   - Renewable energy;
4. Energy conversion
5. End-use energy consumption
   - Transport energy use
   - Energy efficiency and conservation
6. Energy data and information
7. Finance, monitoring and evaluation.

An important aim of the FAESP is to assist Pacific Island Countries in developing their energy roadmaps. The energy sector in the region has benefitted from several donor-funded renewable energy projects, which have generally been directed towards either the improvement of the quality of life in rural areas, or to Greenhouse Gas (GHG) abatement through renewable energy. Projects that are ongoing or have recently concluded include REP5 [15], North REP (both renewable energy development projects for rural communities) [16] and PICCAREP (a greenhouse gas abatement project). In addition, there is an ongoing USD 66 million Japanese government-funded project called the Pacific Environment Community Fund (PEC Fund) project. This project is administered by the Pacific Island Forum and will provide USD 4 million to each of 14 PICs for the installation of desalination and/or solar PV systems.

2.3.4 Biofuels – Present and Future

Since biofuels play an important role in import fuel substitution in the power generation sector, they are indispensable as alternative fuels for the transportation sector of Fiji and the Pacific. They can fulfil this role through the provision of biodiesel and its blending with petroleum diesel for diesel (i.e. compression ignition) engine vehicles, and ethanol and its blends for petrol (i.e. spark ignition) engine vehicles. Possible biofuels that can be produced in the region are biodiesel from coconut oil (CNO) and ethanol from molasses. Other types of feedstock being considered are jatropha, pongamia and castor oil.

Fiji currently produces 5 million litres of CNO from its 15,000 ha of coconut plantations. It also produces 113,000 tonnes of molasses annually from its sugarcane industry. It has been estimated that this is sufficient to produce 4.2 million litres of pure coconut methyl ester (CME) for diesel engines, and 30.5 million litres of ethanol per annum respectively [17]. If used as pure fuels, this amounts to 4.2% of the country’s total automotive diesel consumption (of 98 million litres), and 47% of the total petrol consumption by land transportation (of 65 million litres). However, if these quantities were to be used in the production of B5 (5% biodiesel blend with petroleum diesel) and E10 (10% ethanol blend with petrol), this would result in 85 million litres of B5 and 305 million litres of E10. These quantities amount to 85% and 469% respectively of the country’s land transport requirements for diesel and petrol engine vehicles. Thus the potential for biofuel production for land transportation in Fiji is great.
The DIREKT project was specifically designed to enhance collaboration between institutions in ACP regions and EU institutions and to promote the development and use of RE technologies in ACP countries, particularly those directly involved in the project. Activities conducted, information generated and lessons learned during the implementation of the DIREKT project are therefore clearly relevant to, and helped to shape, many of the recommendations for member states, regions and countries articulated in this report.

The principal component of Work Package 2 produced by the DIREKT project was a study entitled ‘Assessment of Needs for Market-Oriented Research and Technology Transfer’. There were two core activities in this study. The first was a comparative analysis of political and institutional frameworks in the field of renewable energy in the ACP regions and in Germany, and a consequent identification of policy and institutional needs in the ACP countries. The second was an assessment of research, innovation and training needs in RE technologies, particularly from the perspective of the business sector, and the ability of tertiary level institutions in the ACP countries to conduct the relevant research and provide the relevant training. Some important lessons learned from Work Package 2, relevant to the recommendations in this report, were that: based on the situation in Germany, it is clear that appropriate policies and legislative frameworks must be developed to underpin the penetration of RE technologies into national communities; there are significant differences in RE policy and legislative development among the ACP regions; there is a shortage of renewable energy data specific to the ACP regions; and there is a need to develop research and technology transfer capacity in the ACP regions.

Work Package 3 focussed on the critical issue of technology transfer of knowledge on renewable energy technologies to all relevant stakeholders in the national communities. It required the ACP Partners in the DIREKT project to think through and articulate research and technology transfer strategies in renewable energy, to establish centres or operations which would facilitate the transfer of RE information to stakeholders, and to establish technology transfer pilot projects to demonstrate the operation of RE technologies to national stakeholders. The technology transfer pilot project component is particularly important in the context of sustainability of the goals and activities of the DIREKT project, since the pilot...
projects will remain in place and operational as demonstration facilities following the completion of the DIREKT project. An important lesson learned from this work package is that the practical demonstration of RE technologies in operation is by far the most appropriate way to convince stakeholders of the feasibility and practical and financial value of the use of RE technologies.

Work Package 4 focussed on capacity development for renewable energy in the ACP countries. The emphasis was on conducting national, regional and international seminars and workshops to increase awareness and knowledge of RE technologies and to enhance skills relevant to these technologies. The persons trained represented businesses and other private sector organisations, the public sector and educational institutions, including schools and universities. Given the value of demonstrating RE technologies in operation, an important component of the workshops and seminars were site visits to demonstrate different RE technologies in practical operation in the countries in which the workshops and seminars were conducted. The workshops and seminars covered a wide range of RE technologies including photovoltaic, solar thermal, wind, hydro, biofuel and geothermal, and focussed both on the technical and financial aspects of implementing these technologies. Important lessons learned from the responses of seminar partici-

pants were that there needs to be continued emphasis on stakeholder capacity development through more frequent and longer seminars and workshops, and that there is an important need for the development of research capacity in RE in ACP institutions that is particularly focussed on the knowledge needs of ACP countries.

An essential product of Work Package 5 produced by the DIREKT project is the production of this transnational recommendations report which will guide the activities that must be undertaken for continued developed of RE technologies in ACP countries and for their penetration into national communities. Work Package 6 focussed on the important issue of international collaboration, networking and the dissemination of information emerging from the DIREKT project and relevant to RE technologies in general. Large quantities of promotional material in the form of brochures, posters and newsletters were developed and distributed. This occurred at local and regional networking events specifically organized for this purpose, and at relevant regional and international conferences and workshops. A DIREKT website was developed and made available, and a transnational EU-ACP DIREKT network for 'science and technology for renewable energies’ was established to facilitate international collaboration in current and future RE projects.
4. General Recommendations for ACP Member States

This section has been compiled from information provided by the DIREKT partner universities in Mauritius, Fiji, Trinidad and Tobago, Barbados and Germany, as well as from the outputs of Work Packages 2, 3, 4 and 6 of the DIREKT project.

A valuable output of the DIREKT project has been the detailed level of information collected on barriers to the implementation of RE. These barriers are summarised briefly in this section before recommendations are provided and discussed. The recommendations have been broken down into common recommendations that can be applied to all ACP member states (this section), recommendations that are relevant to the individual sub-regions involved in the DIREKT project (African, Caribbean, Pacific) (section 5), and recommendations that are relevant to individual countries involved in the DIREKT project (section 6). These countries are Fiji, Mauritius, Trinidad and Tobago, Barbados, Jamaica and St Lucia. Jamaica and St Lucia were included in the analysis to provide a broader perspective of the Caribbean region.

For organisational purposes, the barriers and recommendations here are categorized into five groups: financial, governance, technical, informational and social, but not all of the recommendations fit neatly into a particular category. Financial, informational and technical barriers/recommendations are self-explanatory, but the distinction between governance and social barriers is often unclear. There are several interpretations of governance, but here it is understood to consist of both structure and processes, and involves public, public-private and private activities. In this report, governance is divided into two main categories: policy processes (i.e. government support, legislation), and stakeholder management. Social barriers are the obstacles...
created not only by the end-users, but also those ‘affected’ by the implementation of energy projects, such as local communities, people living in the area where the construction takes place and those engaged in public consultations.

Table 4 summarises the common barriers to the implementation of RE identified for all ACP member states. Recommendations for overcoming these barriers are provided in sections 4.1 to 4.5. Barriers common to the individual sub-regions involved in the DIREKT project, and recommendations for overcoming them, are provided in section 5. Barriers experienced by individual countries and recommendations for overcoming them are provided in section 6.

4.1 Financial

Collaboration between private and public sectors – partnerships between private and public sectors allow the private sector to lower its degree of risk and the public sector to reach further energy savings using the capacities and capabilities of the private sector. In most cases this collaboration should take a turnkey approach. Examples of such partnerships are PPP and ECP, described in section 5.2 of this report.

Improved knowledge on accessing funding – a clear observation emerging from the DIREKT project was that many of the RE stakeholders lacked understanding of how to access sources of funding. These included academia, commercial companies and government agencies. Knowledge gaps in this area included how to seek relevant and appropriate funding opportunities as well as how to make successful applications. Subsequently, DIREKT workshops were organized that addressed this issue (Work Package 4).

Improved range of incentives for RE and EE – fees, subsidies and taxes should be used to change the prices of activities that interfere with energy efficiency and sustainability (i.e. use of fossil fuels) vs. those that are compatible with them (i.e. energy generation via renewable energy technologies).

Use of microcredits – this allows the provision of financial services for individuals with low income. Microcredits have been shown to reduce the socio-demographic context barrier, which creates a paradox in that the more affluent end-users, who can afford the installation of EE and RE systems, are less likely to respond to the price signals in energy supply, but those end-users who would respond to price signals (cost benefits) cannot afford the high installation costs. This can have an adverse effect on market uptake and penetration of the EE and RE technologies. Micro-financing has already been used in ACP regions and should be incorporated into national guidelines on access to RE and EE options (see the ACP-EU Microfinance Programme [18]).

4.2 Governance

Institutional changes – currently there is a lack of flexibility in institutions when dealing with issues of sustainability. Many financial institutions are built on the assumption of growth and therefore have to face major restructuring if they are to move towards a sustainable green economy.

Many institutions have fragmented policies and do not use market or non-market mechanisms optimally to resolve sustainability-related issues. They often use short-term planning approaches and make inappropriate use of incentives.

Many institutions lack knowledge and understanding of sustainability issues and are slow in responding to
new information and values. In addition, the information is not always freely shared or disseminated, which prevents public access to decision making.

Most of these problems are the result of the bureaucratic structure of these institutions. Many institutions will therefore have to be de-bureaucratised and made more flexible in order to ensure their effective response to the changes required by decarbonisation; i.e. the progressive removal and replacement of CO₂ and GHG releasing activities, with carbon neutral or carbon negative activities.

**Improved policy instruments** – a wide variety of policy instruments, including regulations, standards, property rights, permits, fees and subsidies should be introduced. Criteria for the selection of policy instruments should include, but not be limited to, equity, efficiency, scientific validity, consensus, frugality and environmental effectiveness.

In order to promote the appropriate use of financial, legal and social incentives regulatory reforms should be encouraged. As observed during Work Package 2 produced by the DIREKT project, a study of Germany’s RE initiatives reveals the important role policy and legislation can play in such development programmes [2, 19].

**Decarbonisation as a goal** – a consistent goal of decarbonisation should be incorporated into all institutions at all levels, from individual households to national governments. The prevailing values and decision-making processes could therefore be informed by an increased awareness of decarbonisation and energy efficiency both within institutions and at an individual level.

Systematic, long-term thinking should be promoted in the decision-making process. This should be spearheaded by energy specialists and sustainability activists from both public and private institutions, as well as local communities (as was the case for the Maurice Ile Durable initiative referred to in section 2.1 and the Green Economy Scoping Study for Barbados [20]).

Decarbonisation as a policy goal will clearly meet initial opposition, but this is likely to change as more information is gathered and disseminated about the benefits of decarbonisation. It is critical not only to develop and publicise this policy goal, but also to operationalize activities required to achieve the goal.

**Development of a standardized regulatory framework** – a regulatory framework for renewable energy with a specific focus on planning requirements for different technologies should be developed.

**Stakeholder involvement in consultations** – a wide range of stakeholders (e.g. community representatives, businesses and the education sector) should be involved in consultations whenever a framework for sustainability is developed (as was the case in the Green Economy Scoping Study for Barbados [20]). The implementation of any regulations related to EE and RE requires a partnership among many stakeholders. Consultations within these partnerships should be frank and transparent since this will encourage continued participation.
4. General Recommendations for ACP Member States

4.3 Social

Support in raising awareness – people must be made aware of the link between new technologies and personal financial savings, as users frequently do not associate low energy consumption with financial savings.

RE as a factor in improving quality of life – this is particularly important in the context of gender inequality. Women’s empowerment through the use of RE can contribute to the improvement of women’s position in society and the safety of their environments, as well as reducing the cost of running a household. In addition, quality of air can be improved by wider implementation of RE, particularly as a substitute for using oil for electricity generation which is the principal practice on small islands.

Fighting fuel poverty – a clear definition of ‘fuel poverty’ should be developed and disseminated, with emphasis on the importance of expanding the understanding of the term to include general energy use rather than simply use for maintaining a comfortable level of warmth [18]. The use of RE can reduce spending on heating and cooling, thereby increasing the amount of money available to be spent on improving general quality of life and on raising awareness by allowing the investment of savings into internet access and communication devices, training courses inter alia.

4.4 Informational

Greater collaboration and experience sharing among ACP members – this should include an internet resource that brings together information on good practice, including an online directory of existing and planned energy projects, access to information on energy projects, and an increase in the quantity and quality of information available from governments, including advice on forthcoming changes in policy. The use of more conventional methods of information dissemination, such as the organisation of regular inter-regional conferences and the publication of their outputs, should not be overlooked.

Distribution of information on RE and EE options – this is an absolute requirement for all stakeholders and is a common theme throughout these recommendations. Knowledge generation and sharing through enhanced research and dissemination should continue and be enhanced.

Research into feedback on sustainability projects and policies – it is important to understand how the preferences of both institutions and individuals impact the success and failure of decarbonisation policies and projects. Post-implementation evaluation of the effects of various policy instruments on institutional and individual behaviour should be routine practice. This will provide the feedback necessary to improve policy instru-
ments. The use of broad benefit-cost analysis should also be encouraged, and should include both market and non-market benefits and costs.

**Education** – many education systems currently aim at specialisation, but this can lead to disciplinary isolation. Education must also provide a fundamental understanding of the environment and how human activities and social institutions are a part of this. In addition, media awareness of the common concepts of sustainability and climate change should be improved to avoid inaccuracy in reporting. Education will be further discussed in section 7 of this report.

### 4.5 Technical

**Enhancement of RE capabilities** – the correct and careful installation of RE and EE technologies, particularly in the context of manufacturing and engineering, has a dramatic effect on the performance of the installed systems and, therefore, the perception of these technologies.

**Improved connectivity to the grid** – many SIDS are beginning to develop the capacity to allow individual homeowners and businesses to connect their RE systems to the grid. This should continue and be expanded, and should be complemented by stimulating financial mechanisms (i.e. FITs) and widespread communication of the benefits of grid connection. An example of this is a project being implemented by the Barbadian electricity utility company. The project, termed the Barbados Light & Power’s Renewable Energy Rider (RER) pilot, has been implemented in collaboration with the island’s Fair Trade Commission (FTC). This is a positive initiative, but participation has been slow due to limited advertising. In order for the project to be successful and promote trust among customers, the timescale should be adjusted beyond the current two years, and the connection limit of 200 customers or 1.6 MW should be increased.

**Net metering** – this should be used to allow small electricity customers who generate their own renewable electricity to ‘store’ power on the grid in times of surplus production and to take from the grid in times of need.

**Monitoring and feasibility studies** – insufficient or unreliable resource data are available for the development of renewable energy projects. Projects are therefore entirely dependent on feasibility studies to determine the value of their implementation.

**Implementation of energy audits** – audits should be performed in the industrial sector to determine whether any steps can be taken to reduce power requirements and levels of GHG emissions. During these energy audits, a focus should also be made on determining whether there are any possibilities for the inclusion of RE sources in the power flow of the sector [21].
5. Recommendations for Individual ACP Regions

5.1 Caribbean States

The barriers identified in Table 5 (below) and later in Table 6 are faced by many countries in the Caribbean region. These barriers became apparent during the implementation of many of the activities of the DIREKT project. They form the basis upon which the recommendations outlined in the remainder of this section have been proposed.

Table 5. Barriers to RE and EE development in the Caribbean sub-region

<table>
<thead>
<tr>
<th>Financial Barriers</th>
<th>Governance Barriers</th>
<th>Social Barriers</th>
<th>Informational Barriers</th>
<th>Technical Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>High initial costs.</td>
<td>Inadequate regulatory framework.</td>
<td>Lack of familiarity/knowledge.</td>
<td>Lack of information on RE.</td>
<td>RE and EE are not readily available/mature.</td>
</tr>
<tr>
<td>Limited access to capital.</td>
<td>Disconnection between policy makers and policy implementers.</td>
<td>Lack of confidence in the acceptance of RE.</td>
<td>Lack of experience/technical training.</td>
<td>Lack of FITs/net metering.</td>
</tr>
<tr>
<td>Lack of incentives.</td>
<td>Lack of qualified labour.</td>
<td>Socioeconomic context.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low rates of investment.</td>
<td>Bureaucracy.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of strong political will/governance on large-scale RE projects.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.1.1 Financial

Creation of Public-Private Partnerships (PPP)

– PPP is a cost-effective method of financing municipal renewable energy projects for public facilities through low-interest bonds, traditional power purchase agreements (PPAs) and government tax. It allows local government to have access to renewable energy at a lower price without any debt obligation. PPP uses a turnkey approach with the difference that the finance provided at the lower cost of capital is obtained by the government. This allows cheaper financing for the renewable energy development community as well as preserving the utilities’ capacity to borrow from private capital lending sources for other
projects. This will allow financial flow into solar PV and other RET installations on public buildings without extra financial burden on the government [19].

Implementation of Energy Performance Contracting (EPC) – EPC can be broadly defined as a contract between Energy Service Companies (ESCO) and a client involving an energy efficiency investment in the client’s facility, the performance of which is guaranteed by the ESCO, with financial consequences for the ESCO. Under EPC, the ESCO provides the finance for a specific set of measures for an energy efficiency retrofit. This model will allow implementation of energy efficiency measures without initial financial investments, as the guaranteed savings will cover the costs.

5. Recommendations for Individual ACP Regions

5.1.2 Governance

National guidelines/green scoping studies – the focus of scoping studies should be to consider steps and frameworks that would allow SIDS to move towards green economies. These studies should take into account several sectors (e.g. tourism, water, agriculture, energy,) and should utilize the specialists from each sector. An example of such a study is the Barbados Green Economy Scoping Study [20]. Once the steps towards greener development are identified and articulated, they can be translated into national guidelines for each sector, which would provide the sectors with information on ways to achieve energy sustainability and a reduction in energy consumption.

Energy security strategies – RE strategies need to emphasize that the use of RE and EE systems is the most economically and politically efficient way of both generating energy and decreasing dependency on the import of fossil fuels, and the strategies identified need to be supported by appropriate regulations.

5.1.3 Social

Raise awareness of energy consumption habits – the change in behaviour necessary will not occur unless energy users are philosophically committed to sustainability and understand that they themselves can benefit from changing their behaviour. This can be aided through the introduction of smart metering systems and detailed monthly bills with predicted future costs and suggestions for improvements in energy efficiency. It is important to provide measurable and quantitative information using performance indicators of the current and improved habits of energy users as the necessary feedback to demonstrate the benefits of changed behaviour. Such information enhances users’ understanding and increases the visibility of the impacts of their energy consumption habits.
5. Recommendations for Individual ACP Regions

The barriers to RE and EE development in the Pacific region are presented in Table 6 below. From these identified barriers, recommendations have been proposed that apply specifically to the Pacific region.

### Table 6. Barriers to RE and EE development in the Pacific sub-region SIDS

<table>
<thead>
<tr>
<th>Financial Barriers</th>
<th>Governance Barriers</th>
<th>Social Barriers</th>
<th>Informational Barriers</th>
<th>Technical Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of funds and funding mechanisms.</td>
<td>Would you like to see this information formatted in a table?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of funds and funding mechanisms.</td>
<td>Lack of capability in communities to manage energy projects.</td>
<td>Lack of competent researchers.</td>
<td>Lack of support-ing infrastructure for technological development and maintenance.</td>
</tr>
<tr>
<td></td>
<td>Lack of funds and funding mechanisms.</td>
<td>Lack of capability in communities to manage energy projects.</td>
<td>Insufficient data on RE (particularly biofuel).</td>
<td>Land leasing issues.</td>
</tr>
</tbody>
</table>

5.2 Pacific States

The barriers to RE and EE development in the Pacific region are presented in Table 6 below. From these identified barriers, recommendations have been proposed that apply specifically to the Pacific region.

#### 5.2.1 Financial

Improved financial instruments – most members of the community find it difficult to acquire funding for the purchase of RETs. Several PICs, assisted by donor agencies, have introduced micro-financing schemes in support of their small home systems (SHS) projects for supplying RETs to their rural communities. However, the need to widen such provisions to include a wider cross-section of the general public is only now being recognized. In response, the Fiji Development Bank has recently embarked upon a sustainable energy funding scheme. This type of financial scheme should be adopted by other commercial banks.

Improved ability to acquire funding – donor agencies often advertise for appropriate candidates to apply for funding support. However, due to a lack of expertise and inability to understand the requirements of the proposal, many candidates cannot respond appropriately. Potential applicants require training if PICs are to be successful in accessing these funds.
5.2.2 Governance

Implementation of regional energy policies – one of the important aims of FAESP is to facilitate the development of national energy policies/energy road maps throughout the Pacific Region. A barrier to this process that has become evident is the shortage of staffing/expertise within the government departments necessary to develop and administer such policies at a national level. Frequently, the ‘energy departments’ consist of one or two staff stationed within some other department. This situation has to be redressed if effective national energy policies are to be developed and effectively implemented. Many of the PICs simply lack proper institutional structures to administer their energy programmes.

Capacity development of project developers within PICs – hiring consultants from outside of the region to implement renewable energy projects is costly. There is therefore a need to build the capacity of local project developers in the PICs, thereby ensuring that they can design, manage, monitor and report on the projects.

5.2.3 Social

Capacity building for Pacific communities - many people, especially in rural/remote communities, need to be more knowledgeable about the importance of RETs. It is evident that their limited knowledge of RETs is a barrier to energy access for these communities. The landed cost of diesel in any PIC is very high, and the added cost of transportation to the rural communities makes it more expensive. As a consequence, communities that have diesel generators are challenged to operate them. In many cases, stand-alone solar PV systems are already economically feasible for these remote rural communities, but supply channels and operation and maintenance support is weak. NGOs, international organisations such as UNDP, and the universities in PICs should provide basic renewable energy awareness courses to these communities and emphasize the advantages of using RETs.
5.2.4 Informational

National monitoring of renewable energy resources – there is an urgent need for improved data on renewable energy resources such as wind and solar, and for climatic data for example on rainfall. Such data will help stakeholders interested in the installation of RETs to determine the most appropriate RET for a given community. Several agencies are already in the process of setting up monitoring stations for the collection of such data. However, due to a lack of coordination amongst these activities, the data are likely to be stored in separate databanks and be inaccessible for general use. Regional organisations should assist in the collation of such data into a central repository, through negotiations with the individual organisations involved. This is important, particularly since the establishment and operation of monitoring stations is expensive and time-consuming.

5.3 African States

There have been several initiatives by the government of Mauritius to encourage the promotion of renewable energy technologies in the country. These include grants for solar water heaters and, more recently, the establishment of a grid code to encourage household installation of renewable energy technologies. The government has also recently set up an office for energy efficiency to assess different energy management measures and to provide the necessary national coordination for the initiative. Despite these actions, there remain several barriers to the development of renewable energy and energy efficiency in Mauritius. These are presented in Table 7 below and later in Table 8.

Table 7. Barriers to RE and EE Development in Mauritius (African sub-region)

<table>
<thead>
<tr>
<th>Financial Barriers</th>
<th>Governance Barriers</th>
<th>Social Barriers</th>
<th>Informational Barriers</th>
<th>Technical Barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>High investment costs.</td>
<td>Absence of regulations, despite the existence of national RE strategies.</td>
<td>Lack of awareness on job opportunities in RE.</td>
<td>Lack of dissemination of information on RE.</td>
<td>Most RE technologies are not easily available.</td>
</tr>
<tr>
<td>Limited access to funds.</td>
<td>High level of bureaucracy.</td>
<td>Lack of willingness to use the new RE technologies.</td>
<td>Lack of information on different funding opportunities for RE projects and financial opportunities for installing RE.</td>
<td>Limited experience in the management of the intermittent power supply generated by RE as it relates to the grid</td>
</tr>
</tbody>
</table>
5.3.1 Financial

Given the high level of investment required for the implementation of RE technologies, the government encourages public-private partnerships (PPPs) as a strategy for overcoming this problem. Such partnerships ensure a proper supply of power at a lower cost. In the case of PPPs, a power purchase agreement (PPA) is required since the power is eventually supplied to the utility company for transmission and distribution. The Build-Own-Operate concept is also encouraged.

5.3.2 Governance

The government has a long-term energy strategy in which the share of power production provided by RE is intended to increase. However, there is no regulation enforcing private companies to attain a minimum target level of RE or EE in their activities. Despite the absence of such regulations, some private companies have implemented RE and EE initiatives in order to help the government increase the share of RE in national energy production.

A significant governance/procedural constraint is that the processing time of applications, such as applications for grid connections or applications for grants for solar water heaters, can be very long. This results in long waits for stakeholders, slowing the implementation of these technologies.

5.3.3 Social

There are job opportunities in RE, mainly in the installation and commissioning of RE, the operation and supervision of RE, and in some cases, the maintenance of the RE technologies. However, there is a lack of public awareness of these job opportunities.

5.3.4 Informational

There is a general lack of awareness of the nature and potential benefits of RE technologies, and consequently an urgent need for an intensive public awareness programme. There is also limited information on potential funding opportunities for RE projects and the procedures required to apply for these funds, and limited information on the financing available to install RE technologies. A comprehensive database incorporating such information would be valuable and could guide the decision-making process. There needs to be more information available and increased capacity in energy management, particularly in the management of energy in industrial processes.

5.3.5 Technical

There is limited technical experience in managing the power supply to the grid from small independent power producers (SIPP) and thus a lack of capacity to do so. The consequence is that the total amount of power currently supplied to the grid in this way is limited to about 3 MW. Technical constraints resulting from the fact that many RE sources are intermittent will make it difficult to convert 100% of energy usage to RE.
6. Recommendations for Individual ACP Countries in the DIREKT Project

A list of barriers that could hinder the development of RE and EE in the individual countries impacted by the DIREKT project is presented in Table 8 at the end of this section. There may be additional barriers that are not listed for a particular country as they have previously been discussed in sections 4 and 5, but the major ones are identified here. As is evident in Table 8, many of the barriers are common across countries, and these were summarised and presented in section 5. The recommendations for removing the barriers specific to the target countries are presented in this section (sections 6.1 to 6.5 below). St Lucia and Jamaica were also included in the analysis to further improve understanding of the barriers across the whole Caribbean region.

6.1 Mauritius

As a SIDS with no indigenous reserves of fossil fuels, and no electricity interconnection, Mauritius is vulnerable to the risk of being without power and transport in the event of geopolitical, economic or natural crises. Policy development to ensure energy security will involve diversification of energy resources to the degree that it is financially feasible. As a consequence, the government of Mauritius is obliged to lessen the reliance on fossil fuels, for both economic and environmental reasons. The government has recently introduced a sustainable island programme fund to support recycling and to encourage more efficient use of the renewable energy resources available locally. The government plans to double the use of renewable energy resources by 2025. To do this, it will focus on broadening the island’s energy supply, improving energy efficiency and adapting the energy infrastructure through modernisation. Apart from the challenges of energy supply, energy efficiency and affordability, Mauritians need to move rapidly towards lifestyles requiring low carbon use. It is against this background that the recommendations specific to Mauritius are developed and provided below.

6.1.1 Governance

Decisive governance – the government needs to develop and implement decisive policy actions to encourage a complete change in energy usage and consumption habits at all levels. For this to be effective, it will be critical to obtain the collaboration and participation of the private sector, local as well as overseas stakeholders, public organisations and indeed the support of every Mauritian citizen.

Introduction of Build-Own-Operate (BOO) – to lessen the financial burden on the government in developing large-scale RE plants, such as geothermal plants, wind farms, solar PV power stations and OTEC plants, the support of privately owned BOO schemes should continue to be promoted.

Support of feasibility studies – feasibility studies need to be supported to allow comprehensive assessment of sites in terms of RE resources and to include the feasibility of installation, testing and commissioning in order to ensure effective project implementation.
6.1.2 Technical

**Embedded generation** – it is necessary to improve technical capacity to ensure the production of electricity via small-scale distributed generation, e.g. the use of photovoltaic panels.

**Small-scale wind turbines** – technical capacity must be further developed to allow installation of small wind turbines in some regions of Mauritius situated on the east and south-east coasts of the country, as these areas are well exposed to the south-east trade winds. These regions have high wind energy potential and vast areas of land.

**Development of bioethanol from lignocellulosic biomass** – the commercial feasibility of bioethanol production from locally available renewable lignocellulosic sources depends on both the availability and the low cost of these sources. Locally produced renewable fuel, in the form of ethanol, has the potential to broaden the energy portfolio, lower dependence on foreign oil and improve the trade balance in oil-importing nations.

**Cogeneration of electricity from biomass** – as an agricultural island, Mauritius has more than 70% of arable land producing sugar cane. The major biomass formed is bagasse, which is currently being burnt to produce energy. These efforts need to be further expanded where feasible.

6.2 Barbados

Energy policy in Barbados is currently in a state of flux due to the clear realisation of the need to address the predominance of imported fossil fuels within the energy sector. This realisation rose to the forefront at a national level as a consequence of the inaugural speech of the Prime Minister of Barbados in February 2008. He stated that “the single biggest challenge to our generation is the drain on foreign exchange created by the high cost of oil”, and followed this by saying that the government was prepared to be bold and move aggressively in the area of energy conservation, reducing the oil import bill and preserving the country’s delicate environment for future generations. Following this speech, a sustainable energy framework (SEF) for Barbados was commissioned and the final report states that the three main objectives related to energy are: to reduce energy costs; to achieve greater energy security; and to improve environmental sustainability [6]. For the production of this report, an economic analysis was performed with four different scenario projections: business as usual, high levels of renewable energy, high levels of energy efficiency and a ‘sustainable energy scenario’ combining both renewable energy and energy efficiency measures. The sustainable energy scenario included the opportunity for CO\textsubscript{2} emission reductions in electricity generation. This scenario produced the greatest net cost savings by 2029. This sustainable energy framework is now being used to guide future energy policy in Barbados. Specific energy recommendations for the different sectors in Barbados are provided in the following.
6.2.1 Financial

Guides to finding funding and financing – an important aspect of this would be an updated database of sources of funding available for the supply of energy to communities and information on typical costs.

Information to support the financial management of projects – this should include information about funding opportunities but also guidelines on tender processes, the financial implications of different RE options, the cost of feasibility studies and case studies of financed projects, including payback periods.

6.2.2 Information

Overall guides to governance structure – the roles and responsibilities of different departments and other actors in relation to energy governance need to be discussed, agreed upon and documented.

Freely available advice – there is a need for advice on RETs that is not constrained by industry sponsorship and is available to the general public. This should include advice on what training and education is available, which approaches have worked, and the non-financial benefits of projects, e.g. thermal comfort, air quality and environmental gains.

Information distribution as a part of RE and EE installations – developers should be encouraged to share their knowledge with end-users. For example, when installing PV systems, developers should provide the client with information on the most efficient use of the equipment and optimum maintenance regimes, inter alia.

6.2.3 Technical

Independent power producers (IPPs) – a framework should be explored for allowing the connection of large-scale non-utility electricity producers to the electricity grid. There is currently a limit of 150kWp.

6.3 Trinidad and Tobago

Trinidad and Tobago’s Vision 2020 recognises that the issues of energy security, efficiency, conservation, and the environment are crucial to economic stability. The government therefore commissioned a ‘Framework for Development of a Renewable Energy Policy for Trinidad and Tobago’, which has undergone the process of public consultation and has now been approved by the cabinet. The framework promotes the development and utilisation of renewable energy resources and increased research and development in renewable energy technologies. Pursuing RE technologies is consistent with the Kyoto Protocol, which the country signed and ratified in 1999.

There are several barriers to the implementation of RE technologies in Trinidad and Tobago, as outlined in the ‘Framework for Development of a Renewable Energy Policy for Trinidad and Tobago’. These include low conventional energy prices, an absence of subsidies, financial and market mechanisms, an appropriate legal framework, and lack of social awareness [22].
6.3.1 Financial

Introduction of FITs – these can be used to support the development of new renewable power generation by setting the right price to drive renewable energy deployment. This mechanism places an obligation on electricity utilities to purchase electricity generated from renewable sources at a calculated percentage of the retail price or its ‘avoided cost’, and has proved to be successful in many countries worldwide.

Introduction of Renewable Portfolio Standard (RPS) – this requires the increased production of energy from RE sources by setting a target prescribing how much national demand must be met through production using renewable resources.

Creation of green banks – the role of these banks is to advise on and invest in the best RE and EE options.

6.3.2 Governance

Development of compliance regulations – these need to be developed for both industry and private businesses.

Creation of green jobs – this can be achieved through a curriculum shift in training and education.

Development of green building codes – building regulations and codes need to be updated to include energy-efficient designs to which all new constructions and any major alterations to existing properties must comply, as determined by regional and national planning laws. Additions to building codes should include: insulated windows, doors and walls to reduce cooling costs and solar water heaters with insulated hot water pipes; exclusive use of low-energy lighting; the use of climate-suitable architecture that emphasizes natural ventilation and cooling as an alternative to expensive, power-consuming air-conditioning units; and regulations for the energy efficiency of appliances installed in buildings.

6.3.3 Informational

Installation of RE and EE projects on public buildings – the government should promote the use of RE technologies in its facilities. Practical targets include government buildings and local housing programmes, hospitals, schools, medical clinics and community centres which can become good examples for others to follow. The use of solar water heaters can be increased and incorporated into the design and construction of buildings at a relatively low cost.

6.3.4 Technical

Ban on incandescent light bulbs – further use of incandescent light bulbs should be banned and current bulbs (incandescent and compact fluorescent) eventually replaced with light-emitting diode (LED) lighting.

Use of combined-cycle technology for the generation of electricity – Trinidad & Tobago is one of the few SIDS that generates a significant amount of its electricity from natural gas. The continued introduction of combined-cycle gas turbines will enable substantial efficiency gains in the electricity generation sector.
6.4 St Lucia

The government of Saint Lucia has a vested interest in reducing its fossil fuel dependency in order to reduce pressure on its foreign reserves. In support of this, a number of incentives have been provided, including duty free concessions on components for renewable energy installation. The government is hoping that its citizens will take advantage of these incentives, thus increasing the share of renewable energy in the national energy mix. Some of the main constraints and recommendations regarding the expansion of renewable energy services in Saint Lucia are provided below. These include an important social issue that was not recognized in the reports from the other ACP countries.

6.4.1 Social

The media must become more aware of renewable energy matters and their link to climate change, and be more accurate in reporting. Enthusiasm for renewable energy can be increased, and negative public attitudes towards climate change removed if the media provides trustworthy information, accurately identifies the benefits of RE and the challenges of climate change, and raises the profile of renewable energy and climate change programmes nationally.

6.4.2 Financial

Schemes must be put in place to mitigate the high upfront costs of implementing RE technologies.

6.4.3 Informational

There is a lack of accurate information relating to the types of technologies available, their efficiency and payback time, and the benefits of using renewable energy technologies.

6.4.4 Technical

There is a strong need to increase the capacities of both individuals and institutions.

6.5 Jamaica

There have been many past initiatives to develop better energy policies in Jamaica, including the promotion of diversification, the development of renewable energy sources and increased energy efficiency, but these have failed to deliver substantial improvements. There are several factors that have effectively impeded progress, including problems with governance and policy conflicts, misguided technology choices, market failures, and inappropriate institutional structures. These challenges are faced by many developing countries. Problems that may be specific to Jamaica include: an inefficient public electricity system with old generating plants; inefficient use of energy in manufacturing and other productive sectors; inefficient energy use in the public sector; including the extensive use of pumps (rather than gravity feed) to deliver the nation’s water supply; low public awareness of the importance of energy conservation; and an inadequate policy framework to promote energy conservation and efficiency.
6.5.1 Financial

Introduction of penalties for non-compliance – better monitoring is needed with respect to not meeting the renewable energy targets stated in the national energy policy. Penalties have to be specified and guidance on how to reach the established targets must be provided.

6.5.2 Governance

Government as instigator/motivator of EE and RE projects – the government should seek to play a motivating and enabling role in EE and RE activities and projects through pro-innovation incentives and regulations. This must include innovation in both management practices and in technological solutions.

6.5.3 Information

Development of knowledge networks – knowledge networks are the key to rapid development, dissemination and uptake of new ideas, business concepts and technologies. In the best case scenarios knowledge networks act as crucial links between the business community, academics and civil servants, and function across a range of industries. Functional networks involve building more flexible, effective and productive links and partnerships between four key groups: researchers, investors and financiers, entrepreneurs and industrialists, and government agencies and ministries with remits in energy and economic development.

Development of knowledge transfer partnerships (KTPs) with industry – there must be a high level of communication among the key groups identified above so that researchers can be better informed as to the changing needs of industry, entrepreneurs are in a position to identify opportunities, industrialists can keep abreast of developments in science and technology, and government agencies can remove obstacles and encourage progress. The evidence from successful models of technological innovation, development, dissemination and uptake is that the key to success lies in the creation of these close-knit local networks of researchers, financiers and entrepreneurs.

6.6 Fiji

Fiji is one of the more economically developed islands in the Pacific, with a number of forest, mineral and fish resources. However, like most PICs, Fiji spends a significant amount on importing fossil fuel. In order to reduce these import bills and the country’s dependence on fossil fuels, the Fijian government is promoting renewable energy development. There are many organisations involved in introducing and implementing RETs in Fiji. However, there are several constraints that need to be removed for Fiji to be able to meet its renewable energy targets. In the course of conducting workshops, networking, and conducting surveys and research, much of which occurred through the DIREKT project, several issues that should be addressed in order to improve the renewable energy industry in Fiji were identified. The recommendations identified in this section have been developed to address these constraints.
6.6.1 Governance

Legislation on net metering – Fiji currently lacks any legislation on net metering. In order to expand the market for solar and other distributed forms of energy in Fiji, the appropriate laws must be in place to facilitate the installation of the relevant RET. To address this, the USP DIREKT team organized a special workshop to discuss the issue. The workshop had participants from government departments and utilities who are currently involved in setting up the appropriate legislation.

Need for an independent regulator – there is a need for an independent regulator to determine tariffs and ensure suitable power purchase agreements. During one of the DIREKT networking events in Fiji, a businessman pointed out that he was willing to sell power to the Fiji Electricity Authority, but the price being offered to him was very low. Independent regulators who can determine tariffs and vet power purchase agreement can address such issues.

6.6.2 Social

Provision of training in managing RETs for rural/remote communities – setting up stand-alone renewable energy systems in remote/rural communities is an initiative that some organisations in Fiji are involved in. However, many of the systems that have been set up do not last very long, primarily because the communities do not know how to operate and maintain the systems. Training community members in the operation and maintenance of RET systems before they are installed in rural/remote communities is therefore important.

6.6.3 Informational

Renewable energy resource studies and forecasting – the surveys conducted in Work Package 2 produced by the DIREKT project indicated that most businesses and organisations wish RE feasibility studies to be conducted. The absence of information typically produced in feasibility studies often results in unsuccessful implementation of projects. An important issue is resource forecasting, especially in relation to changes in the availability of wind and water resources, but the necessary data to allow this is often unavailable.

Implementation of energy audits – the survey conducted in Work Package 2 showed that very few respondents understood the importance of energy audits, and many participants in the DIREKT workshops expressed an interest in training on how to carry out energy audits. Organisations in Fiji, such as the Fiji Department of Energy (FDoE), the Secretariat of the Pacific Community and the university have the potential to provide this training. When the USP hosted a DIREKT workshop in the Republic of the Marshall Islands (RMI), the importance of energy audits was discussed thoroughly. Many participants were keen to have energy audits done for their businesses or homes. An important case study shared at the RMI workshop was the energy audit conducted for the USP-RMI campus.

Data on the availability of land for the production of biofuel feedstocks – there is a lack of data on land available to be used for biofuel production. Fiji has been setting up standards for the use of biofuels, and many companies have shown an interest in planting biofuel feedstocks. However, the lack of information on available land resources and available feedstocks has been a constraint. Although there is information on total available land, the exact location of the land parcels is not specified.
Table 8. Barriers to RE and EE development in the individual ACP Countries – part 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Mauritius</th>
<th>Fiji</th>
<th>Barbados</th>
<th>Jamaica</th>
<th>Trinidad &amp; Tobago</th>
<th>St Lucia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong></td>
<td>High initial cost</td>
<td>High initial cost</td>
<td>High initial cost</td>
<td>High initial cost</td>
<td>High initial cost</td>
<td>High initial cost</td>
</tr>
<tr>
<td></td>
<td>Low energy prices (from coal-fired power stations)/lack of competitive tariffs</td>
<td>Lack of funds and funding mechanisms</td>
<td>Long payback period/lack of financial feasibility</td>
<td>Lack of incentives/dedicated grants</td>
<td>Lack of financial feasibility (no economies of scale)</td>
<td>Long term investment</td>
</tr>
<tr>
<td></td>
<td>Financial constraints (limited access to capital)</td>
<td>Low rate of investment in RE</td>
<td>Lack of incentives/limited access to capital</td>
<td>Low energy prices (from fossil fuels)/lack of competitive tariffs</td>
<td>Limited access to capital investments</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Economic regulatory distortion</td>
<td>Lack of economically viable contractual agreements</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Governance</strong></td>
<td>Lack of strong governance on key issues</td>
<td>Lack of enabling legislation</td>
<td>Disconnection between policy-makers and policy implementers</td>
<td>Inadequate regulations/ policy framework (penalties for non-compliance)</td>
<td>Lack of legislative framework for RE</td>
<td>Absence of an appropriately supportive regulatory environment</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of understanding of energy security</td>
<td>Lack of understanding of energy security</td>
<td>Lack of qualified labour</td>
<td>Lack of understanding of energy security</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regulations</td>
<td>Bureaucracy/longer implementation of RE projects</td>
<td>Longer implementation of the projects due to low familiarity with EE and RE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Skills gap/lack of qualified labour</td>
<td>Power company monopoly</td>
<td>Issues with the use of land</td>
<td></td>
<td></td>
<td>Lack of strong governance on large-scale RE projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td>Lack of familiarity/knowledge</td>
<td>Low public awareness</td>
<td>Lack of familiarity/knowledge</td>
<td>Lack of familiarity/knowledge</td>
<td>Lack of familiarity/knowledge</td>
<td>There is lack of capability in communities to manage community based energy projects</td>
</tr>
</tbody>
</table>

Cyan: Country specific barriers
### Table 8. Barriers to RE and EE development in the individual ACP Countries – part 2

<table>
<thead>
<tr>
<th>Country</th>
<th>Informational</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mauritius</td>
<td>Lack of use of RE and EE by the public (lack of existing examples)</td>
<td>Development of tourism industry often a higher priority than development of RE</td>
</tr>
<tr>
<td></td>
<td>Lack of adoption of technology</td>
<td>Lack of information on RE and EE options</td>
</tr>
<tr>
<td>Fiji</td>
<td>Lack of information on RE and EE options</td>
<td>Development of tourism industry often a higher priority than development of RE</td>
</tr>
<tr>
<td>Barbados</td>
<td>Lack of information on RE and EE options</td>
<td>Landowners found to be fiercely resistant to wind farm installation due to misinformation</td>
</tr>
<tr>
<td>Jamaica</td>
<td>Socioeconomic context</td>
<td>RE resource data unknown</td>
</tr>
<tr>
<td></td>
<td>Lack of access to cutting edge research</td>
<td></td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>Lack of information that could facilitate investment/incentives</td>
<td></td>
</tr>
<tr>
<td>St Lucia</td>
<td>Lack of access to climatic data/installation possibilities etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of information on investment opportunities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Cyan: Country specific barriers
7. Recommendations for Research Institutes and Higher Education Institutions

Goldstein and Luger [23] characterize the university as “a multi-product entity that effects regional economic development in eight ways, including formal technology transfer, but also through the training of students, the informal transfer of know-how, the building of a knowledge infrastructure and supporting a creative regional milieu”. This statement highlights the important part to be played by universities across the ACP regions in the introduction of RE and EE technologies. One of the key recommendations emerging frequently during this project has been that in order to address many of the recognized constraints, research into RE and EE at regional research institutes should be enhanced. Research institutes and higher education institutions should not work in isolation, but collaborate with governments, businesses and other research institutes from other regions.

It is recommended that the partner universities should increase their research capabilities by establishing research groups that focus on critical developmental areas. This can be achieved by creating more positions for research fellows who would work together with senior staff and PhD students in the areas of RE and EE. Possible research areas are suggested in section 7.1.

An important issue for research institutes is the realisation that the dissemination of accurate and detailed research information is the crucial factor in the widespread adoption of technology based on this information. Trusted actors should be responsible for the dissemination of information, and qualified specialists involved in relevant research should also be involved in the distribution of information. This should not only be the kind of information distribution where those receiving the information remain passive, but should incorporate various approaches to learning, such as learning by searching, learning by doing, learning by using and learning by interacting.

Specific recommendations for research, training, and dissemination of information are provided in sections 7.1, 7.2, and 7.3 in the following.

7.1 Research

Development and analysis of EE and RE case studies – this should focus not only on case studies that provide examples of best practice, but also on less successful projects so that people can learn from past errors and mistakes. The studies should show clearly how barriers were overcome in these cases.

Increase in research into post-installation evaluation – there is a significant need for feedback from consumers who have installed EE and RE technologies, as well as information about the costs and benefits of different approaches. The evaluation should include the lifestyle and behaviour of the consumers and the extent to which their good practices may be transferable to others.

Collection and analysis of data on RE – specific data on energy and the energy industry should be made available for analysis. This should range from raw user data to performance measurements of the main energy provider/Distribution Network Operator (DNO). This should include...
7. Recommendations for Research Institutes and Higher Education Institutions

data on what is already installed, split by parish/state and the performance of different technologies, including energy consumption data and the cost and performance statistics of the full range of RE systems. Such data would also allow the development of models of future scenarios and more robust estimations of future energy costs and trends in the energy industry.

Research into potential low-carbon technologies suitable for SIDS – this area of research could include, but is not limited to, sea-water air conditioning, wave power, solar PV energy, geothermal power, biofuels (including bio-algae, cogeneration, waste-to-energy and anaerobic digester technologies), storage efficiency, demand side management and smart grids, inter alia.

Research into energy-efficient buildings – this could include simulation and testing of low carbon buildings and their suitability for tropical climates (i.e. PassivHaus), and research into the best ways to reduce solar heat gain in dwellings. This type of research should take full advantage of modern software for building and urban simulations (e.g. EnergyPlus, Ecotect, eQuest) and knowledge of construction materials.

Research into the social, economic and governance aspects of energy – this should include evaluation of policies, regulations and standards, and the impact that these have on communities and businesses.

Assessment of the impact of current incentives – many countries have recently introduced, or are in the process of introducing, incentives to promote RE and EE penetration. Detailed assessments of these incentives are required to gauge their success and determine which incentives provide the best returns.

Further collaboration with international research centres in the areas of EE and RE – all three ACP universities involved in the DIREKT project have benefitted significantly from the collaboration. These connections, now established, should be maintained and improved to allow successful sharing of experience at a global level. Additional collaborative partnerships should also be encouraged.

The focus of training and education – the focus of training and energy education should begin at primary school level and continue through to college/university. It should also take place in the workplace. It is important to ensure that specialists teaching sustainability are up to date with the recent developments in the area of EE and RE. EE and RE jobs are not limited to high-end skills. Attention should also be paid to training those involved in the installation, operation and maintenance of such systems.

Sustainability should be incorporated in more/all teaching courses – universities should integrate teaching on the philosophy of sustainability into a broader range of disciplines, rather than just on those specific courses teaching RE and EE. Sustainability should be incorporated into other science subjects in particular, but also into other areas, such as management studies, economics, politics and law.

Development of industry-based training and qualifications – this is important and can be achieved through work placements or years in industry on undergraduate courses so that students have an opportunity to learn first-hand about the installation, operation and maintenance of EE and RE systems, and gain the necessary experience for their future careers. Research degrees based in industry (such as D.Eng or knowledge transfer partnerships (KTPs)) are a good way to stimulate research capabilities in areas relevant to businesses.

Training of trainers/educators – training in sustainability should be offered to both university staff and school/college staff.

7.2 Training
Expansion of RE and EE in universities – the universities involved in the DIREKT project should expand their RE and EE departments by employing additional specialists with both industry and research experience.

University short courses for managerial personnel – the universities involved in the DIREKT project should develop RE and EE courses for managers which focus on broad design and sizing issues, product maintenance, product specification and evaluation, and policy understanding, inter alia.

Expansion of curricula in RE and EE – the universities involved in the DIREKT project should expand their curricula in energy studies into an interdisciplinary approach (combining technology, environmental law and policy, and economics and management). This interdisciplinary approach should be applied to wind power, solar PV energy, SWH engineering, RE engineering and environmental architecture, inter alia.

7.3 Dissemination of information

Data sharing – this should focus on the use of the Internet, but also not neglect any other outlets such as newspapers, leaflets and brochures, inter alia.

Organisation of information evenings/open days – these will allow wider community engagement. The potential end-users will be able to learn about the RE and EE systems from knowledgeable specialists in academia and industry. These can take the form of introductory lectures, visits to installations and DIY sessions, inter alia.

Organisation of workshops/seminars – the success of the DIREKT project’s workshops highlights the important part that they play in information dissemination, with workshop participants benefitting from face-to-face interactions with RE and EE experts. These workshops should be continued. Workshops are a useful tool for knowledge sharing since those who already use the technologies can be invited to discuss them with potential users in industry and business.

Coordination of EE and RE events – information about EE and RE-related events organized by governments, academia, businesses and other stakeholders should continue to be coordinated, and access to information about the events widely distributed. Such events may include seminars, webinars, conferences, workshops and courses, inter alia.

Collaboration with regional tertiary level education establishments – to minimize duplication of research efforts in RE and EE initiatives, it is important that tertiary level education institutions communicate, coordinate their efforts and share their research and educational aims. A regional workshop, bringing together RE and EE leaning staff from universities, colleges, and vocational institutions, along with local industry leaders, has the potential to accelerate research and educational programmes. A good example of this was the CARICOM sponsored “regional workshop on research, development and capacity building to support renewable energy development in the Caribbean”, which was held in Paramaribo, Suriname from 19–20 October 2011 [24].
8. Acknowledgements

The DIREKT Partner Consortium would first like to thank the ACP Science and Technology programme for funding the project and for its positive collaboration with their committed programme managers. The DIREKT partners greatly appreciated the opportunity provided for cooperation and collaboration between EU and ACP universities. This has created a platform for productive transnational cooperation that will continue after the project’s closure.

We are also grateful for the continuous support that the DIREKT team received from our own universities over the last three years. This included support from presidents, deans and administrative departments, as well as from professors and research fellows in several faculties.

Finally, we would like to express our gratitude to all the people from other universities, ministries, NGOs and companies who provided valuable input into the DIREKT project as survey respondents, speakers at workshops and seminars, advisors and collaborators in pilot projects, and as participants in the various DIREKT seminars and conferences.

The productive collaboration and exchange of ideas with a wide diversity of stakeholders throughout the duration of the DIREKT project strongly motivated and inspired us to produce this recommendation report.

The DIREKT project team

Figure 17. Members of the DIREKT project team (from left to right): Walter Leal (Germany), Thomas Rogers (Barbados), Julia Gottwald (Germany), Dinesh Surroop (Mauritius), Natasha Corbin (Barbados), Pritika Bijay (Fiji), Debbie Emamdie (Trinidad and Tobago), Jagdish Ramnanan (Trinidad and Tobago), Anirudh Singh (Fiji), Varsha Persaud (Barbados), Veronika Schulte (Germany)
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**Glossary**

ACP         African, Caribbean and Pacific  
ANZ         Australian and New Zealand Banking Group Ltd  
BOO         Build-Own-Operate  
C-CERMS     Regional Sustainable Energy Roadmap and Strategy  
CARICOM     Caribbean Community  
CNO         Coconut Oil  
DIREKT      Small Developing Island Renewable Energy Knowledge and Technology Transfer Network  
DNO         Distribution Network Operator  
EE          Energy efficiency  
EIA         US Energy Information Administration  
EPC         Energy Performance Contracting  
ESCO        Energy Service Company  
EU          European Union  
FAESP       Framework for Action on an Energy Secure Pacific  
FDoE        Fiji Department of Energy  
FIT         Feed-in Tariff  
GHG         Greenhouse gases  
GIZ         Deutsche Gesellschaft für Internationale Zusammenarbeit  
ha          Hectare  
HAW         Hamburg University of Applied Sciences  
IPESP       Implementation Plan for Energy Security in the Pacific  
IPP         Independent Power Producers  
KTP         Knowledge Transfer Partnership  
kWp         Kilowatt peak  
LED         Light Emitting Diode (concerning energy efficiency lighting)  
MID         Maurice Ile Durable  
NEP         National Energy Policy (Fiji)  
NGO         Non-governmental Organisation  
O&M         Operation and Maintenance  
OTEC        Ocean Thermal Energy Conversion  
PIC         Pacific Island Country  
PICT        Pacific Island Countries and Territories  
PPP         Public-Private Partnership  
R&D         Research and Development  
RE          Renewable Energy  
RET         Renewable Energy Technology  
RMI         Republic of the Marshall Islands  
RPS         Renewable Portfolio Standards  
SEF         Sustainable Energy Framework  
SIDS        Small Island Developing States  
SHS         Small Home System  
SWAC        Sea Water Air Conditioning  
SWH         Solar Water Heater  
TLTB        Taukei Land Trust Board  
UNDP        United Nations Development Programme  
UoM         University of Mauritius  
USP         University of the South Pacific  
UWI         University of the West Indies