FRAMEWORK FOR DEVELOPMENT OF A RENEWABLE ENERGY POLICY FOR TRINIDAD AND TOBAGO

A REPORT OF THE RENEWABLE ENERGY COMMITTEE

January 2011

MINISTRY OF ENERGY AND ENERGY AFFAIRS
POWER. PROSPERITY. PROGRESS.

REPORT OF THE RENEWABLE ENERGY COMMITTEE

Preface

Trinidad and Tobago's petroleum resources have been and would continue to be the prime driver for the country's growth and development for some time into the future. On a national level, natural gas is now the primary energy source both for fuel and feedstock, whereas the transportation sector is almost completely dependent on petroleum products. Local energy demand for this finite resource is on the increase, making conservation paramount. This could be reasonably addressed by utilization of renewable energy (RE) resources, increasing energy efficiency (EE), decreasing energy demand and the use of alternative fuels in the transportation sector. These initiatives would be consistent with the National Draft Climate Change Policy in development and also with mitigation and adaptation strategies being implemented globally to combat climate change. The Government has expressed a commitment to the development of an Energy Policy for Trinidad and Tobago through a process of public consultations and discussion, which would incorporate the fullest development of the country's RE resources. . To this end a Framework for the Development of a RE Policy for Trinidad and Tobago has been developed for public review and discussion. The Framework recognizes the importance of developing the country's RE resources and the complementary role of EE to achievement of long term sustainable development and energy security and as a mitigation strategy to address the issue of Climate Change. Such development holds great potential for promoting increased investment, enhancing research and development, providing opportunities for the creation of high-value jobs while generating increased foreign exchange and revenues.

Trinidad and Tobago is ideally positioned to meet the challenge to effectively develop its renewable energy resources based on the country's existing energy platform and experience in energy sector developments including the demonstrated success in attracting major investors and financiers.

Cabinet agreed in November 6, 2008 to the establishment of a Renewable Energy Committee (REC). Terms of reference (TOR) of the committee were, inter alia:

- To review the energy balance of Trinidad and Tobago and conduct a current state assessment of RE applications and research activities into PV solar power, solar thermal energy, wind energy, wave energy , and bio-fuels (biomass, biogas, biodiesel and bio-ethanol)
- To identify feasible and practical RE technologies in various sectors, including transportation, industry, manufacturing/commercial and residential, using appropriate criteria relevant to Trinidad and Tobago
- To set realizable targets and timeframes for RE in the energy mix

- To make recommendations with respect to the level of incentives (tax relief, infrastructure support, grants, price subsidies, etc.) required to promote the use of RE technologies in each sector
- To identify:
    - Appropriate research and development which can advance the implementation of renewable technologies in Trinidad and Tobago
    - Opportunities for linkages between energy-based industrial plants to be established and the production of renewable energy components
    - Mechanisms and strategies for financing RE projects by local and international agencies, including carbon trading schemes
    - Legislation and regulation that would be necessary for the exploitation, development and use of RE.

The members the REC are as follows:

Mr. Vernon De Silva	-	Chairman, Director, Energy Research and Planning Division, Ministry of Energy & Energy Industries
Professor Adel M. Sharaf	-	Professor of Energy Systems and Vice Provost Post Graduate Studies-Research and Development, U.T.T
Dr. Indra Haraksingh	-	Lecturer, Department of Physics UWI, St Augustine
Mr. Wayne Punnette	-	Deputy Permanent Secretary (Ag), Ministry of Trade and Industry
Mr Allen Clarke	-	Senior Engineer, Generation Interface, T&TEC
Mr Narine Charran	-	Senior Economist, Ministry of Public Utilities
Mr. Gregory Jones	-	Senior Economist, Research Planning and Technical Services Division, Ministry of Science Technology and Tertiary Education
Ms. Marcia Maynard	-	Team Leader, Business Development National Energy Corporation
Ms. Jasmine Gopaul / *[Alternate - Ms. Denise Hakim]*	-	Environmental Economist, Environmental Policy and Planning Unit, Ministry of Planning, Housing, and the Environment (MPHE)

The REC was launched on February 13, 2009 and on October 6, 2009 the services of the Engineering Institute of the University of the West Indies (U.W.I) were contracted to assist the committee in research and drafting of the Policy Framework. The Framework has been prepared to support development of RE policy measures in the context of a National Energy Policy for Trinidad and Tobago.

Ministry of Energy and Energy Affairs
January, 2011

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 EXECUTIVE SUMMARY

1.1 Background

In 1994, the United Nations Framework Convention on Climate Change (UNFCCC) entered into force with the ultimate objective being the stabilization of greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system. The UNFCCC was later complemented by the 1997 Kyoto Protocol under which member countries are committed to reducing their greenhouse gas (GHG) emissions by an average of 5% by 2012 against 1990 levels[1]. Trinidad and Tobago is a ratified signatory to the UNFCCC and the Kyoto Protocol. Renewable Energy (RE) development is one of the strategies being adopted to mitigate the impact of climate change and investments have been significant and growing over the last decade.

The threat of climate change is very real for small island states like those of the Caribbean where serious negative socio-economic implications could result from an event such as rising sea levels depending on its severity. This is because of their limited size, geographical location, high exposure of infrastructure and limited adaptive capacity. RE development would promote energy security and the sustainable development of these states.

1.2 Trinidad and Tobago Energy Environment

Trinidad and Tobago's hydrocarbon resources are critical for long term economic growth and development. The country is a net exporter of petroleum products while the petroleum sector is the most significant contributor to domestic growth. The growth of the local natural gas based industry has been remarkable and achieved international prominence. As a nation, the shift towards the use of natural gas as its primary means of meeting growing energy demands has been embarked upon in recognition of the need to utilize cleaner energy. Local energy production and consumption have grown significantly in the last few decades and so, despite the increase in the focus on natural gas, local emissions of GHGs such as carbon dioxide continue to grow, with the energy sector being the leading contributor followed by transportation and power-generation.

1.3 Drivers for Renewable Energy Development

Notwithstanding the continued importance of the country's petroleum resources, the Government recognizes that renewable energy (RE), clean energy production and the maximization of energy efficiency are critical elements of the drive for sustainable development.

[1] **Intergovernmental Panel on Climate Change.** *Climate Change 2007.* Valencia : s.n., 2007. Synthesis Report.

It is important that the country, embark on a long-term political and societal commitment to a framework of policies and ideas that would propel local action in these areas.

Accordingly, the development of RE resources is being guided by the following main considerations:

- a recognition that the country's hydrocarbon resources are finite and depleting;
- achieving long term security of energy supply;
- contributing to the country's efforts as a signatory to the Kyoto Protocol to address the climate change issue; recognizing the threat faced as a Small Island State;
- informing and educating the public on alternative clean energy and energy efficiency measures;
- ensuring that a sustainable balance is maintained with the environment;
- providing a sufficient and affordable energy supply for societal needs.

1.4 Renewable Energy Development Strategy

A strategy for the incorporation of RE sources in the domestic energy mix must be undertaken within the context of a broader framework which addresses issues such as the maximization of energy efficiency, and the development of carbon reduction strategies in the three main contributory sectors highlighted. These goals are consistent with the Draft National Climate Change policy that is currently under development and the global objective to reduce the emission of greenhouse gases (GHGs).

In light of the barriers to RE development, in particular high up-front costs, it is important to foster energy efficiency and some basic developments of RE over the short to medium term. Increasing energy efficiency would have a spill over effect on savings in transportation fuels, power generation and utility costs which would contribute to offsetting the cost associated with the introduction of RE. It must be emphasized that, for the most part, the development of RE sources to support heavy industrial growth and development is a long term objective.

1.5 Renewable Energy Policy Measures

Definition of RE

In RE the term 'renewable' is generally applied to energy resources, whose common characteristic is that they cannot be depleted, i.e., they can be naturally replenished with negligible environmental impact. RE resources include wind, solar, hydro-electricity, geothermal, waste materials, ocean, wave and tidal energy.

Objectives of Renewable Energy Policy Measures

The development of the country's RE resources is considered an important element in achieving sustainable growth. Notwithstanding our current energy situation, we must continually focus on safeguarding our energy security while addressing the global threat of climate change, to which Small Island States are particularly vulnerable. RE Policy measures must go hand in hand with supporting programmes to promote energy efficiency and reduce GHG emissions and a number of proposals are recommended accordingly.

Primary Objective

The primary objective of RE policy measures for Trinidad and Tobago in the context of the country's National Energy Policy is to identify and examine strategies and make recommendations for introducing RE into the local energy mix.

RE development will provide greater diversity in the energy mix which is vital to long term energy security and sustainability of energy supply. It also presents an avenue to enhance the country's socio-economic well-being through employment creation, revenue generation and development of a manufacturing capability in new indigenous industries.

Complementary to Primary Objective

It is essential that RE policy measures promote energy efficiency and conservation as very important complementary elements of RE implementation to ensure its effectiveness.

As a small island state, the use or RE would help in the mitigation of GHG emissions. Accordingly, policy measures should make recommendations for supporting carbon reduction strategies which will ensure an optimal and efficient use of the nation's total energy resources.

Carbon reduction strategies recognized in this framework are:

1. Expanding the use of CNG as a transportation fuel in the context that it is a cleaner burning fossil fuel with less harmful effects on the environment;
2. Exploring opportunities for more efficient industrial/petrochemical processes and use of combined-cycle technology in electricity generation; and
3. Exploring other options for reducing GHG emissions such as carbon capture and storage (CCS).

Essential elements of Renewable Energy Strategy Implementation

There are several practical limitations and market barriers to the development and usage of RE sources in Trinidad and Tobago. To initiate the development of RE in Trinidad and Tobago and

drive the country along a new, more efficient path of energy usage, four key elements are addressed:

Capacity Building and Awareness: Training and education are critical to RE industry development and promotion of energy efficiency and conservation**.** Also, an extensive programme of general education to raise public awareness is needed and this would be enhanced through effective communication between national and local Government bodies. The local community centers and the school educational system are strategic media for launching most public education and awareness programmes.

Enabling Environment: The creation of an enabling environment would require Government support through provision of incentives combined with access to financing from traditional and/or non-traditional sources. The Caribbean Renewable Energy Development Programme (CREDP) highlights a number of regional incentive programmes some of which could be adapted locally. Establishing an appropriate legal and regulatory framework for the electricity sector includes consideration of various mechanisms including: open access, feed-in tariffs, net metering and portfolio standards.

Energy Efficiency and Conservation: An RE development strategy should recognize the promotion of energy efficiency and conservation as an important part of any plan to move forward with RE. A rationale for cost effectiveness of implementation of RE technologies should be supported by steps to ensure efficient use of end products by consumers.

Institutional arrangements: Government should consider the creation of a Renewable Energy (RE) and Energy Efficiency Agency responsible for the focused development, implementation and revision of policies and programmes regarding RE and energy efficiency. This is important in order to coordinate efforts at the different levels of government and with the public.

1.6 RE Technology Choices

Local conditions dictate the types of RE sources that are applicable on a commercial basis in different sectors in Trinidad and Tobago – wind, solar and photovoltaics are well developed technologies which are available Wind is the technology of choice for bulk electricity generation for the national grid and a target of 5% of present peak demand (or 60MW) by 2020 is realistic and achievable. In the transportation sector the promotion of R&D in biofuels (bio-ethanol and bio-diesel) should be encouraged.

Quickly Implementable RE and Energy Efficiency Strategies

A number of renewable energy applications and energy efficient technologies can be readily incorporated in the residential, commercial and other institutional sectors. These include: solar

water heaters, small scale solar photovoltaic (PV) systems and energy efficient lighting. The implementation of green building codes will also support these applications.

Alternative Carbon Reduction Strategies

The role of RE as a carbon reduction strategy can be expected to continue to expand with ongoing global research and development in RE technologies which have been increasing the contribution of RE to the energy mix. Other carbon reduction strategies being pursued by the Government include: increased usage of compressed natural gas (CNG) in the transportation sector, exploring opportunities for more efficient industrial processes and exploring other GHG emissions reduction technologies such as carbon capture and storage (CCS).

A summary of the measures which are identified in this framework for consideration are as follows:

Training and Education

- Encouraging R&D into RE technologies;
- Sponsoring a study to determine skill gaps;
- Training to fill skill gaps;
- Public education on energy efficiency, conservation and RE products;
- Utilization of RE workshops and events.

Electricity Sector

- Setting a target of 60 MW of generation by RE by 2020;
- Conducting a study to examine the potential for local wind resources;
- Conducting a feasibility study for a demonstration wind power generation project;
- Revision of Electricity legislation to include: Open access to transmission grids, feed-in tariffs systems, and net metering;
- Revision of the Regulated Industries Commission Act to facilitate the RE industry;
- Encouraging private sector involvement in RE power generation;
- Conducting R&D in waste to energy technologies;
- Conversion of single-cycle to combined-cycle for power generation.

Residential, Commercial and Other Establishments

- Researching household solar photovoltaic (PV) technology;
- Promoting the installation of solar water heaters;
- Introducing consumer incentive programmes for RE products;
- Phasing out the importation and use of incandescent light bulbs and introducing LED bulbs;

- Promoting the recognition and use of energy efficient appliances;
- Developing and enforcing new energy efficiency building codes.

Industry

- Implementing energy efficiency and pollution audits;
- Introducing high-efficiency electric motors;
- Introducing more efficient steam reforming technology;
- Converting existing single-cycle power generation plants to combined-cycle and utilizing combined-cycle technology for new plants;
- Building regulatory and policy environment for carbon trading;
- Encouraging R&D in Carbon Capture and Storage (CCS).

Transportation

- Promoting the importation of cars that run on alternative forms of energy;
- Exploring opportunities for ethanol production and its use as a biofuel;
- Promoting the use of compressed natural gas (CNG) both for private and mass transit;
- Increasing the availability of CNG and researching improvements for CNG canisters.

1.7 Conclusion

In the development of a National Energy Policy for Trinidad and Tobago it is important to note that RE is being pursued as part of a broader sustainable development framework that includes strategies: to encourage energy efficiency and energy conservation; to maximize the use of cleaner burning CNG in the transportation sector; and to foster research into Carbon Capture and Storage.

An important next step to move forward with RE development in Trinidad and Tobago should be the establishment of a **Renewable Energy (RE) and Energy Efficiency Agency**. This agency would be responsible for the assessment and auditing of our local energy market and the implementation of energy efficiency and RE policy measures. The major functions of this body would be as follows:

- **Developing a register of local RE and energy efficiency** businesses and technology providers and experts in green building design and construction;
- **Creating an appropriate regulatory environment** for the introduction of RE and promotion of energy efficiency and conservation;
- **Overseeing a national programme of energy audits** to determine our present level of energy efficiency, and to identify key areas to target in order to improve energy efficiency;

- **Instituting energy efficiency programmes**, which could include exploring the merits of and possibly implementing, a RE and Energy Efficiency Fund that would finance initiatives related to energy efficiency and RE;
- **Overseeing the introduction of RE technology** such as solar water heaters and solar photovoltaic (PV) systems to the public;
- **Promoting public awareness campaigns and education and training** related to RE and energy efficiency to ensure development of local capacity;
- **Developing incentive programmes** to encourage the use of RE technologies;
- **Organizing long-term studies and surveys** to produce wind and solar atlases of the country to determine the optimal sites for installing wind turbines and solar panels;
- **Identifying and assessing proposed RE projects** to determine their economic feasibility;
- **Pursuing funding for RE projects** from international financial agencies and taking advantage of market-based mechanisms such as CDM to allow foreign partners to earn carbon credits by providing funding for local RE projects;
- **Promoting RE businesses** with support from institutions such as the Business Development Company (BDC) for companies embarking on RE development and Energy Efficiency projects; and
- **Establishing working relationships with similar RE authorities** and governing bodies in other nations for mutual benefit, as well as promotion of joint regional action for RE implementation.

Effective implementation of strategies will be enhanced by the collaboration and participation among all stakeholders including the public. This will be facilitated through national consultations and in the implementation of plans and programmes.

There should be on-going monitoring and evaluation with respect to all policy measures and an assessment after the first three (3) years to consider any amendments that may be required in policies, targets, or implementation strategies in light of any changes that may have occurred in costs, developments in various RE technologies, availability of funding and so on.

2 BACKGROUND

2.1 The Global Climate Change Issue

International awareness of the need to combat climate change has been building for many years. As early as in the 1960s and '70s, data pointing to an increase in the concentration of carbon dioxide (CO_2) in the atmosphere led to concerns from the international scientific community. In 1988, an Intergovernmental Panel on Climate Change (IPCC) was formed by the World Meteorological Organization and the United Nations Environment Programme (UNEP) to review international research on climate change[2]. The IPCC issued a first assessment report in 1990, reflecting the views of 400 scientists, which highlighted the need to address GHG emissions because of their impact in accelerating global warming.

In 1994, the United Nations Framework Convention on Climate Change (UNFCCC) entered into force with the ultimate objective being the stabilization of greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system, and in a timeframe that would allow ecosystems to adapt naturally so that it will not hamper food production and will allow sustainable economic development.

The UNFCCC was later complemented by the 1997 Kyoto Protocol under which member countries are committed to reducing their emissions by an average of 5% by 2012 against 1990 levels[3]. Trinidad and Tobago is a ratified signatory to the UNFCCC and the Kyoto Protocol. The Fifteenth Session of the Conference of the Parties to the UNFCCC and the Fifth meeting of the Parties to the Kyoto Protocol held in Copenhagen, Denmark in December 2009 resulted in the Copenhagen Accord. This Accord, inter alia, calls for actions by developed and developing countries on reducing greenhouse gas emissions including Small Island Developing States, which may do so voluntarily, depending on technological and financial support.

2.2 Renewable Energy Investments

While the extent to which different nations have introduced the use of RE varies, investment in RE has been significant and growing over the last decade on an international level, though having slowed in the face of the recent economic downturn[4]. According to a report from the UNEP's Sustainable Energy Finance Initiative (SEFI), during 2008, investment in RE generation projects grew by 13% to US$117 Billion, and new private investments in companies developing

[2] **Intergovermental Panel on Climate Change.** *IPCC Web Site.* [Online] [Cited: October 20, 2009.] http://www.ipcc.ch.
[3] **Intergovernmental Panel on Climate Change.** *Climate Change 2007.* Valencia : s.n., 2007. Synthesis Report.
[4] **United Nations Framework Convention on Climate Change.** *UNFCCC Web Site.* [Online] [Cited: October 20, 2009.] http://unfccc.int.

and scaling-up new technologies increased by 37% from 2007 figures to US$13.5 Billion[5]. Appendix I, Figure 1 shows the global trend in new investments in sustainable energy for the period of 2002–2008, indicating the growing interest in and funding for the development of RE technology. Appendix I, Figure 2 meanwhile, shows new investments by region for that same period, indicating a consistent growth in interest in RE in regions across the globe, with the highest levels of investment seen in North America and Europe. Finally, Appendix I, Figure 3 shows the corresponding increase in the share of global energy demands met by RE.

2.3 The Regional Scenario

Potential Impact of Climate Change

The threat of climate change to small island states like those of the Caribbean is very real. According to the Alliance for Small Island States (AOSIS)[6], climate change poses the most serious threat to these countries' survival and viability and undermines their efforts to achieve sustainable development goals. These countries are particularly vulnerable because of limited size, geographical location, susceptibility to natural hazards, high exposure of infrastructure and limited adaptive capacity. Accordingly, the socio-economic viability of these states is challenged by the following:

- damage to coastal zones, where the majority of their socio-economic infrastructure is located;
- saline intrusion into coastal aquifers which will negatively impact on drinking water and agricultural activities;
- destruction to coral reefs and fisheries habitat that result from increases in ocean acidification and rising temperatures; and
- destruction of positive development caused by greater frequency and intensity of hurricanes.

In the case of Trinidad and Tobago, the effect of rising sea levels on Trinidad's Western Coastline is a major concern because of its socio-economic significance. The Caroni Swamp, Oropouche Swamp, beaches, human settlements and the Point Lisas Industrial Estate are all located in this region. A vulnerability assessment study on the Western Coastline conducted by the Petroleum Company of Trinidad and Tobago (Petrotrin) over the period 2004 – 2007

[5] **United Nations Environment Programme's Sustainable Energy Finance Initiative.** *Global Trends in Sustainable Energy Investment 2009.* 2009

[6] The Alliance for Small Island States (AOSIS) is a coalition of Small Island and low lying coastal countries (drawn from Africa, Caribbean, Indian Ocean, Mediterranean, Pacific and South China Sea) that share similar development challenges and concerns about the environment especially their vulnerability to the adverse effects of global climate change.

predicted in a conservative scenario, an increase in sea level of 9.8 centimeters, and in a worst case scenario, an increase of 17.2 centimeters, by the year 2031[7].

Regional Energy Security and Climate Change

The Caribbean has traditionally relied heavily on fossil fuels for meeting its energy for power generation and transportation needs and, except for Trinidad and Tobago, these countries must import these fuels. Promoting energy efficiency and RE development are essential elements of the plan to reduce this import dependency and therefore enhance the region's energy security. Co-ordinated action to bring this about has been advanced through the Caribbean Renewable Energy Development Programme (CREDP) and the Regional Task force that was established to develop a Regional Energy Policy.

The CREDP was launched in 2002 as a result of a region-wide survey to identify barriers to the promotion of energy efficiency and the development of RE. CREDP comprised 12 Caribbean countries including Trinidad and Tobago. The major objectives were to:

- increase the percentage of energy supplied by renewable sources in the Caribbean;
- reduce GHG emissions in the region; and
- reduce dependence on fossil fuels and provide jobs in the regional energy sector.

These objectives were supported by the Regional Task force established to develop a Regional Energy Policy as demonstrated in its report of 2007. CREDP established a regional target of 5%, on average, of commercial power generation capacity for conversion to RE by 2015 and its project implementation schedule included solar, biomass, wind and hydro-power projects in several countries.

Renewable Energy Applications

Today, several Caribbean nations have been introducing renewable energy sources into their power supply mix. Barbados has a well-established solar water heater industry. In Belize 44% of the country's 2008 electricity generation came from hydropower. Dominica also utilizes hydropower systems. Wind energy is being utilized in: Curaçao with an installed capacity close to 12 MW, in Guadeloupe and Martinique with a capacity close to 2 MW, and more recently in Jamaica with approximately 21 MW of installed wind power generation and has an expansion project underway to double this capacity. Furthermore, several islands are conducting wind measurements and wind resource analyses to study the possibility of installing wind power generation systems. Bonaire has been developing a hybrid wind-diesel power project (11MW wind power; 14 MW bio-diesel power plant). Geothermal energy has had a long history of

[7] Petrotrin's Vulnerability Assessment Study, 2004 - 2007

usage in Guadeloupe and steps are being taken to implement geothermal power generation on a large scale in St. Kitts and Nevis by 2011. Table 2.1 shows some Caribbean countries that have set RE targets and have interconnection to the power grid.

Table 2.1: Renewable Energy Targets in the Caribbean

Country	Renewable Energy Target	Renewable Energy in Grid Supply
The Bahamas	NYA[1]	No
Barbados	40% by 2010	Yes
Belize	NYA[1]	Yes (HEP[2])
Dominica	25% by 2010	Yes (22% HEP[2]in 2007)
Grenada	10% by 2013; 20% by 2017	Yes
Guyana	70-80% by 2012 (HEP)	No
Jamaica	15% by 2020	Yes (Wind, HEP[2])
St. Kitts	100% by 2012	No
St. Lucia	30% by 2012	No
Trinidad & Tobago	NYA[1]	No
St. Vincent	NYA[1]	Yes (20% HEP[2])

NYA[1]– Not Yet Available HEP[2] – Hydro-electric Power

Source: CEIS. http://www.ceis-caribenergy.org

3 TRINIDAD AND TOBAGO ENERGY ENVIRONMENT

3.1 Introduction

Trinidad and Tobago is located off the northeast coast of Venezuela and is the most southern of the Caribbean islands. The geographic coordinates are situated between 10° 2' and 11° 12' N latitude and 60° 30' and 61° 56' W longitude. Geographic location in the Tropics means that the islands experience sunny conditions year round with the exception of periods during the rainy season. Trinidad and Tobago is also in the path of, and influenced by the regular blowing of the Northeast Trade Winds.

Trinidad and Tobago is the leading Caribbean producer of crude oil and natural gas, and its economy is heavily dependent upon these resources for its revenue and foreign exchange, but it also supplies manufactured goods, notably food and beverages, as well as cement to the Caribbean region. In addition, the country is a major regional financial centre, and tourism is a growing sector, although it is not proportionately as important as in many other Caribbean islands. GDP per capita is estimated at US$ $23,600 (2008).

3.2 Energy Balance/Profile

A country's energy balance involves a matrix which shows energy consumed using a common unit, BOE (barrels of oil equivalent), which takes into account energy produced, exported, imported, transported and consumed by economic sectors and facilitates the assessment of energy in a country. It includes both renewable and non-renewable energy. Trinidad and Tobago's energy balance shows that primary energy forms consist of crude oil, natural gas; very limited usage of bagasse, charcoal and firewood and a miniscule amount of RE. Only crude oil, natural gas and to a much lesser extent, bagasse have been of any commercial significance.

The energy sector continues to be the mainstay of Trinidad and Tobago's economic development contributing significantly to the country's GDP, Government revenues and foreign exchange earnings. Table 3.1 shows the contribution of the sector to Government revenues and GDP between 2006 and 2009 fiscal years.

Table 3.1: Contribution of the Energy Sector to Government's GDP and Revenues

	2006/2007	*2007/2008*	*2008/2009*
% Government Revenue	55.5	57.1	47.7
% GDP	17.4	20.9	13.0

Source: Central Bank of Trinidad and Tobago Annual Economic Survey, 2009

Crude oil is either exported or processed at the refinery while natural gas is used as fuel and feedstock in the manufacture of petrochemicals mainly for export, or it is exported as LNG or used as fuel mainly in electricity generation, heavy industry, and commercial undertakings or compressed and used as motor vehicle fuel. Current average crude oil production is approximately 103,000 barrels per day and natural gas production stands at 4.1 billion cubic feet per day or 705,963 barrels of oil equivalent. The country is a net exporter of petroleum products. The petroleum reserves scenario is as follows:

	Proved	**Probable**	**Possible**
Crude Oil MMBO (2007)	605.8	334.6	1560.6
Natural Gas MMBOE/Tcf (2009)	2644.9 / 15.37	1358.6 / 7.88	1013.8 / 5.88

Source: Ministry of Energy and Energy Industries

Trinidad and Tobago currently holds a prominent position in the world particularly in ammonia, methanol and LNG production and export; currently ranked as leading exporter of the first two products from a single site and the seventh largest LNG exporter in the world. The slate of heavy industries includes 11 world scale ammonia plants, 7 world scale methanol plants, an iron and steel industry and a gas processing industry. Steps are being taken to diversify the sector mainly through the establishment of secondary processing industries downstream of ammonia and methanol and new gas based industries producing an array of new products.

Electricity Sub-Sector

Installed electricity generation capacity in Trinidad and Tobago is approximately 1600MW. A breakdown of electricity demand by sector (2008) reveals that heavy industry accounts for the greatest demand (38%) followed by residential (28%) and light industry (23%). See Figure 3.2.1 below.

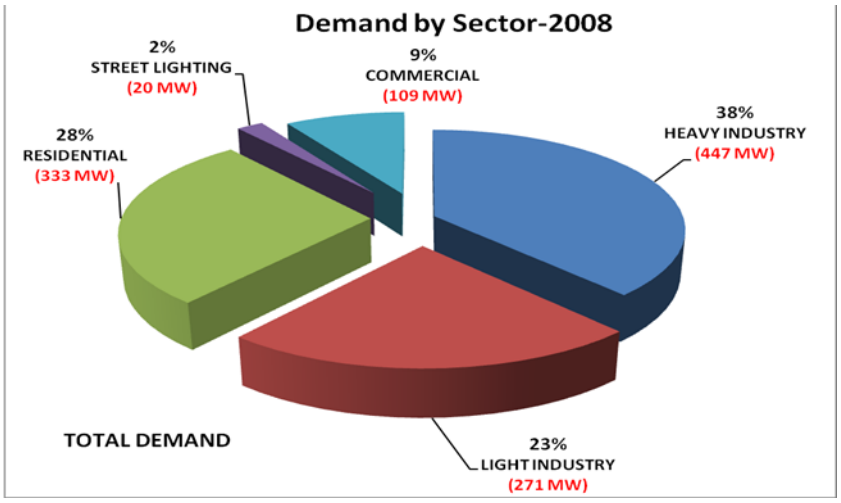


Figure 3.2.1 Demand for Electricity in Trinidad and Tobago by Sector in 2008
Source – Trinidad and Tobago Electricity Commission (T&TEC)

Electricity demand is continuously growing since it is an essential 'commodity' that promotes social and economic growth and development. As shown in Figure 3.2.2, peak demand has been increasing almost linearly with a forecast of 2700 MW in 2020.

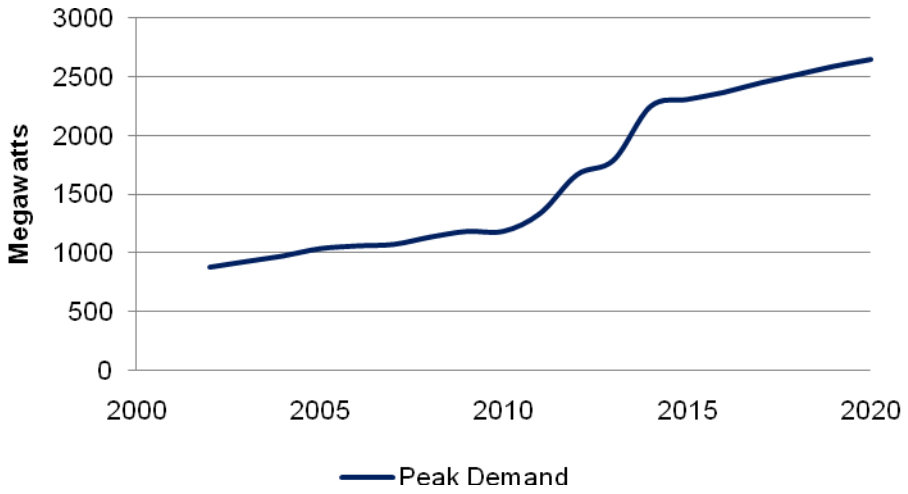


Figure 3.2.2 Present (for period 2001–2008) and Forecasted Peak Power Demand.
Source: T&TEC

The Trinidad and Tobago Electricity Commission (T&TEC) is solely responsible for transmission and distribution of electricity while there are two generation companies namely PowerGen and Trinity, from which T&TEC purchases power that is transmitted and distributed via the national grid. Natural gas accounts for about 99% of primary fuel for power generation

for meeting this demand in Trinidad mainly through single cycle technology, while the recently commissioned Cove power station in Tobago is configured for natural gas but presently utilizes diesel. In addition, a newly constructed combined-cycle power plant with a capacity of 750 MW has been established in La Brea.

3.3 GHG Emissions

Appendix II, Figure 1 shows the rapidly increasing trend in production and consumption of natural gas in Trinidad and Tobago over the period 2002 - 2009. The country has been moving rapidly towards the use of this relatively clean-burning resource as its primary means of meeting its growing energy demands. Appendix II, Figure 2 shows that natural gas produces less emissions overall compared to crude oil and coal.

As shown in Figure 3.3.1, Trinidad and Tobago is a very insignificant contributor to aggregate global GHG emissions, by comparison to larger industrialized nations. However, Trinidad and Tobago is ranked 7th globally with respect to carbon emissions per capita. Approximately 30 million tonnes of CO_2 are emitted per year in Trinidad and Tobago. However the level of CO_2 emissions has been experiencing significant increases over the years.

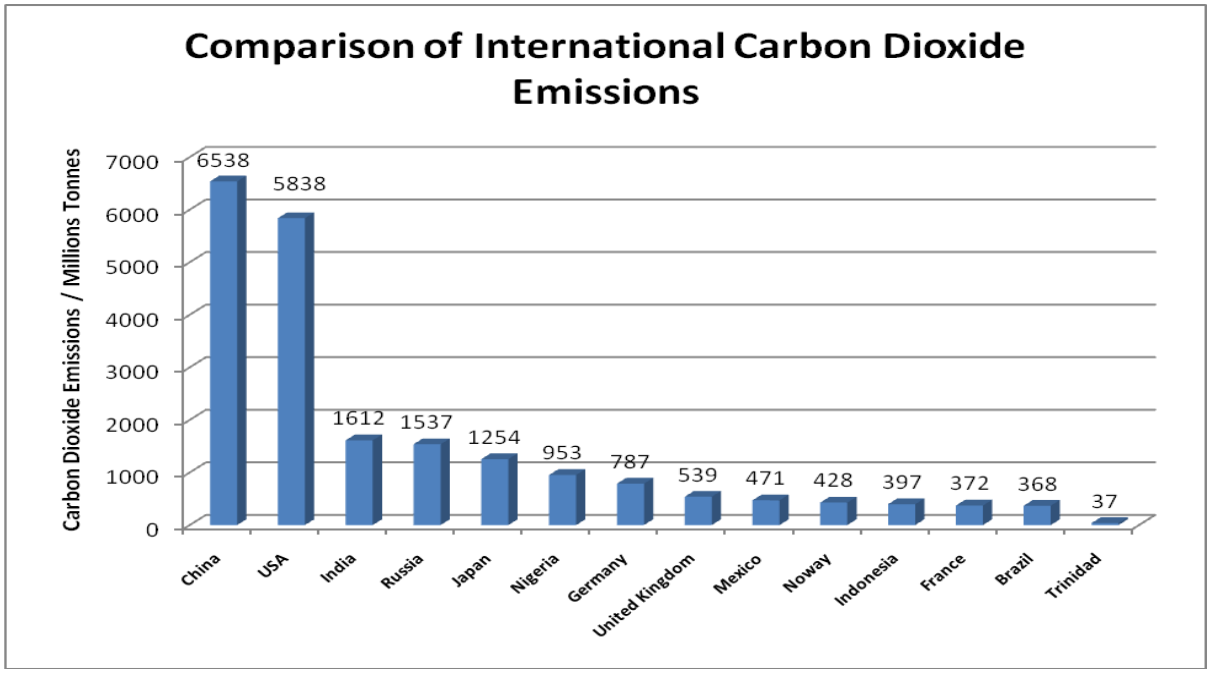


Figure 3.3.1 Comparison of Estimated 2007 CO_2 Emissions in Trinidad and Tobago to a few Large, Industrialized Nations
Source: Millennium Development Goal Indicators, United Nations Statistical Division (UNSTATS)

The Draft Climate Change policy[8] notes that carbon emissions from the energy sector account for total emissions arising as a result of direct combustion of fossil fuels and includes emissions arising from power generation and transportation. It reveals that CO_2 emissions arising from the energy sector increased 278% over the period 1990 – 2006. This followed naturally with the expansion of the heavy industrial sector. As shown by Figure 3.3.2, the petrochemical and heavy industry sector is the main contributor of GHG emissions, followed by power generation and then the transportation sector.[9]

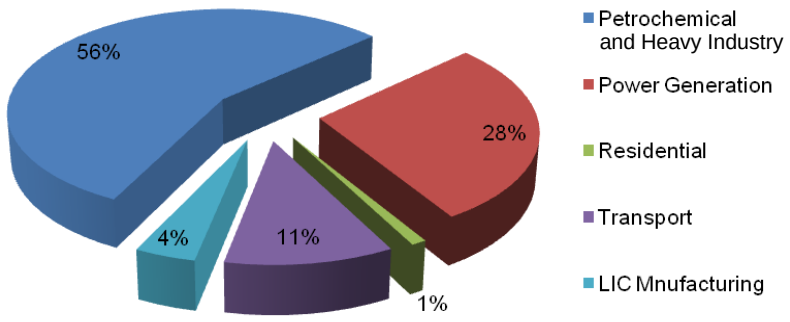


Figure 3.3.2 Trinidad and Tobago's CO_2 emissions by sector for 2007
Source: Boodlal, Furlonge & Williams, 2008

3.4 National Energy Policy Framework

The development of RE policy measures is seen as part of the evolving national energy policy framework which is guided by several factors including; the size of crude and natural gas reserves, depletion rates, monetization of reserves, energy security and affordability, local content and participation, value maximization, pricing and market characteristics, economic sustainability, environmental considerations and the international environment. RE and energy efficiency policy measures are a critical aspect of the nation's continued development.

3.5 Renewable Energy Current Scenario

RE development in Trinidad and Tobago is currently at a rudimentary stage. A few RE initiatives and research projects were undertaken in the past and focused mainly on solar (photovoltaic and thermal), wind and wave (see Table 3.5.1). Such experiences could now be used to enlighten the development of policy measures. These initiatives reveal important and

[8] A Draft National Climate Change Policy is currently under development by the Ministry of Planning, Housing and the Environment.
[9] Draft National Climate Change Policy. Pg. 7 Sect. 2.3 Line 241 to 247.

useful information on RE technologies and the level of planning that is required to ensure success of RE programmes.

Currently, there exists a number of RE related activities as follows:

- Promotion for the promotion of small scale RE and energy efficiency applications in community centres, schools and homes;
- Small scale applications of RE technologies in use include solar water heaters, solar PV systems, and industrial Supervisory Control and Data Acquisition (SCADA);
- Entrepreneurs are engaged in the importation, installation and maintenance of RE and energy efficient applications;
- Several local architects are incorporating energy efficiency and green design into new residential and commercial developments. In addition, some of these architects are certified as Leaders in Energy Efficient Design (LEED);
- Organizations are increasingly implementing a 'green' mandate through the incorporation of RE technology into plant operations;
- Ongoing capacity building in the tertiary sector through incorporation of RE and energy efficiency into the academic programmes of institutions such as the University of Trinidad and Tobago (UTT) and the University of the West Indies (UWI);
- Collaboration between the Government and the United States Department of Energy (DOE) in the proposed establishment of a RE Research Centre in Trinidad and Tobago; and
- Consideration is being given to several RE related project proposals, both locally and regionally, such as waste to energy plants, biofuels, wind turbines and hydroelectricity.

Table 3.5.1: Renewable Energy Past Initiatives in Trinidad and Tobago

Year	Project	Location	Agencies	Comments
1994/1995	Experimental 10kW Wind turbine	Bacolet, Tobago	T&TEC	Revealed some favourable results but project was short-lived.
2004	Demonstration Solar PV	Chickland, Freeport, Cumaca Village, Valencia and Paria, Blanchisseuse	T&TEC	Off-grid PV systems shown to be quite competitive for small loads and performed satisfactorily
2006 - 2008	Pilot Solar Water Heating Project	10 host-homes at various locations in Trinidad and Tobago	MEEI, BPTT, THA &TDC with the UNDP as Project Manager	Represented the first real attempt to deepen interagency cooperation in facilitating a local RE project
Ongoing	Research activity particularly solar & wave	na	UWI & UTT	

Source: Ministry of Energy and Energy Affairs

4 DRIVERS AND BARRIERS TO DOMESTIC RENEWABLE ENERGY DEVELOPMENT

4.1 Drivers

RE development is identified as a strategy to achieve sustainable growth and development in Trinidad and Tobago. Notwithstanding our current favourable energy situation, we must continually focus on safeguarding our energy security while addressing the global threat of climate change, to which Small Island States are particularly vulnerable. The key drivers for decreasing the use of non-renewable fossil fuel and developing RE systems are summarized below.

Summary of key drivers for RE development

1. **Climate change –** A major driver for the introduction of RE systems is the mitigation of climate change; through reduction of GHG emissions.

2. **Energy security –** The supply of fossil fuels is subject to significant changes and fluctuations as revisions are made to proven resources and reserves. The introduction of power generation from RE sources provides an alternative energy resource, the availability of which is not subject to the cost fluctuations as is the case of fossil fuels.

3. **Fossil fuel depletion –** Reducing the demand for conventional energy sources will extend the lifetime of the country's limited fossil fuel reserves and RE could be developed as an alternative energy source.

4. **National development –** Through research, development and demonstration (RD&D), RE systems are becoming more affordable and accessible and also attractive to new investors. This will foster local innovation and entrepreneurship and expand opportunities for participation of all citizens.

5. **Increase domestic export of petroleum products** - The reduction in domestic demand for petroleum products through the use of RE technologies would make greater quantities of these products available for exports.

6. **New employment opportunities** – The introduction of RE systems will open up new job markets for the local development, manufacture, installation and maintenance of these systems.

4.2 Barriers

There are several practical limitations and market barriers to the implementation of RE sources in Trinidad and Tobago. It is important that these barriers be taken into consideration when planning for the introduction of RE systems locally. An important barrier is a direct result of Government policy to subsidize electricity rates and transportation fuel prices as an indirect means of ensuring that citizens share in the wealth generated from the country's crude oil and natural gas resources. This poses a challenge for RE to compete with traditional energy sources and also serves as a disincentive to consumers to conserve energy. These barriers are discussed under specific heads as follows:

4.2.1 Subsidized Petroleum Product Prices

Energy in Trinidad and Tobago is highly subsidized and this has resulted in this country having the lowest diesel fuel and commercial and industrial electricity prices in most of the Latin American and Caribbean region, as shown at Appendix III. Subsidies significantly lower final energy prices, putting RE at a competitive disadvantage. An enabling tax incentive regime would be required to make the market viable for renewables. Figure 4.2.1 shows the increasing trend in subsidies for petroleum products paid by the Government of Trinidad and Tobago. The spike in the subsidy liability shown in 2008 reflects the sharp increase in crude oil prices during that year. Thereafter, the subsidy declined in 2009 as crude oil prices decreased.

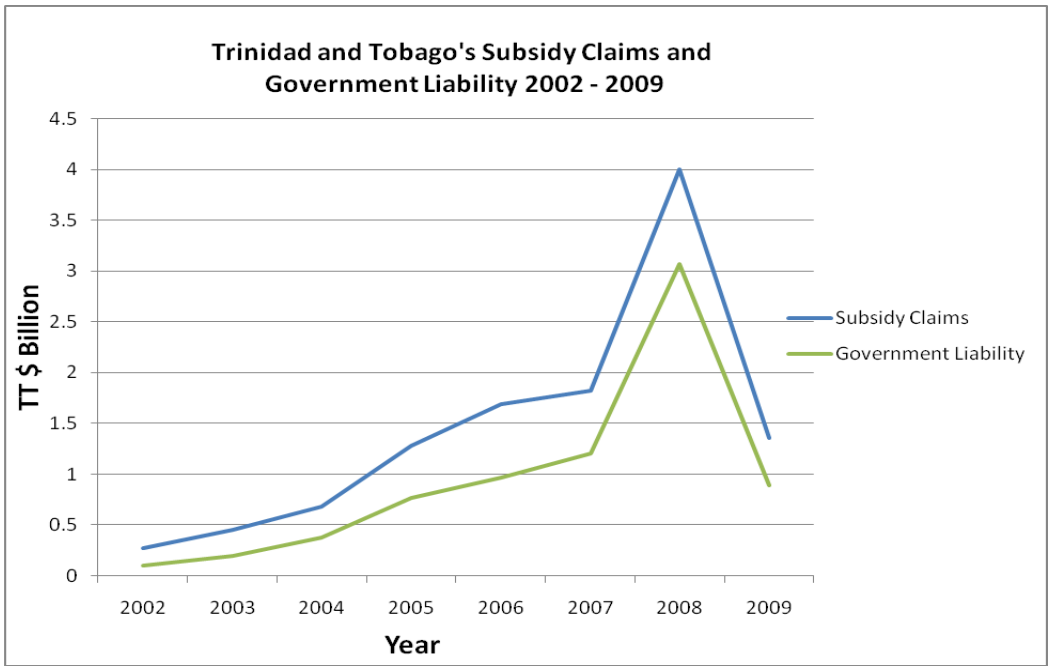


Figure 4.2.1 Petroleum Products Subsidy Liability by the Government of Trinidad and Tobago for the period 2002 – 2009
Source: Ministry of Energy and Energy Industries

4.2.2 Legal Framework

Trinidad and Tobago does not have a legislative framework to treat with RE development.

- Lack of a facilitative environment for potential RE businesses, investors and independent power producers to assess their potential risks to be able to plan for long term investments;
- No regulation under the Trinidad and Tobago Electricity Commission (T&TEC) Act that makes provisions for interconnection by potential RE power generators to the national electrical grid; and
- No guidelines to set feed-in tariffs for potential independent RE producers feeding into the electric power grid. (Such guidelines would need to address the issues of 'locational' value and 'variability' of the RE sources).

4.2.3 Finance and Market

- **High initial costs –** RE has higher initial capital costs than conventional energy sources, providing less installed capacity per initial dollar invested. Thus, RE investments generally require higher amounts of financing for the same capacity as compared to conventional fossil fuel systems which may result in higher lending rates. The higher initial capital costs for RE is reflected in the cost of generation. Figure 4.2.2 shows a comparison of the costs of producing electricity with different renewables. Currently in Trinidad and Tobago, the actual cost of electricity to local consumers is approximately US 4 cents/kWh on average, which makes renewables very uncompetitive economically, except for biomass, wind and small hydro.

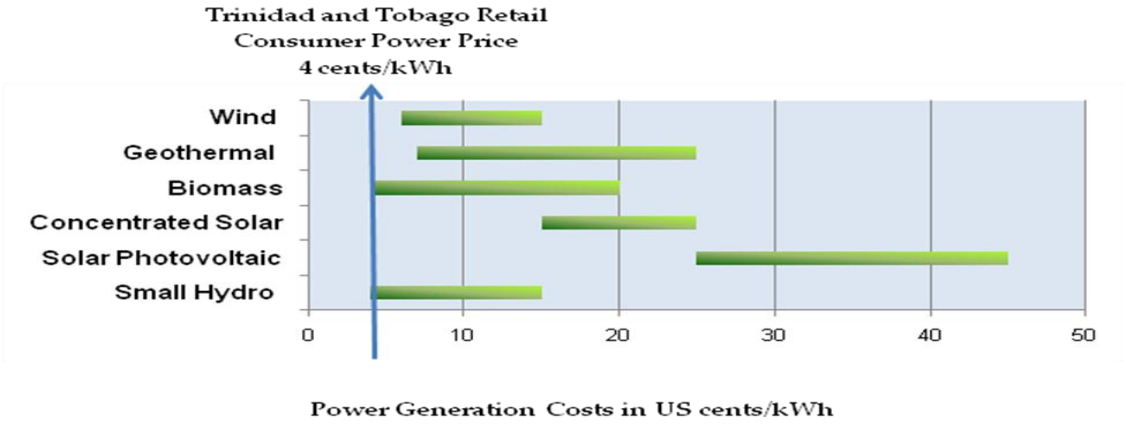


Figure 4.2.2 Cost Competitiveness of RE Sources for Power Generation[10]
Source: Data provided by University of Trinidad and Tobago

[10] Cost estimates ranges are based on current commercial and industrial long term Turn-key Energy Buy-back Contracts. Costs vary from location to location.

- **Commercialization barriers –** As a new technology, RE systems will encounter a number of challenges to commercialization. These relate mainly to the following:

    i. undeveloped infrastructure;
    ii. lack of economies of scale in production of RE products;
    iii. identification of appropriate sites with accessibility to transmission lines;
    iv. development of new RE Industry standards;
    v. determination of competitive tariffs for RE usage; and
    vi. training of local personnel in all aspects of RE industry.

- **Transaction costs –** RE projects usually require additional information not readily available and additional time for planning and financing compared to conventional energy projects. This is mainly because of unfamiliarity with the technologies and uncertainties about their performance.

- **Market barriers –** The local RE market is still in an infant stage and as a result, the penetration of RE technologies faces the following barriers: inadequate information, lack of access to capital and high transaction costs.

- **Fiscal incentives –** Limited fiscal incentives have been introduced for the importation, manufacturing and use of RE technologies and products. These incentives need to be expanded.

4.2.4 Education and Awareness

- **Lack of Education and Awareness** - The general population of Trinidad and Tobago are not sensitised to several issues that would facilitate RE development. For instance:
    - the importance of energy, the real cost of producing it, the need to conserve it and the relationships between energy and critical issues such as global climate change;
    - the long-term cost savings to the consumer over the lifetime of RE technologies, which can offset the high cost of installation; and
    - Capacity in the RE field is minimal locally and needs to be built further through increased training and skills development.

4.2.5 Other

- **Local data –** Trinidad and Tobago does not have a strategy to collect the local RE data which can be easily accessed by the general public. Such data include: national wind, solar and wave resource maps; average local costs of installation and operation of small-scale RE

systems; basic information about local needs for installation and operation of small-scale RE systems and local suppliers of RE systems.

- **Environmental concerns –** Research has indicated that **h**azardous materials used in the manufacture of Photovoltaic modules (PV) could pose a health and safety hazard. These materials include cadmium compounds, arsenic compounds, carbon tetrachloride, tellurium compounds and a number of flammable gases. However, proper area and personal monitoring, as well as established proactive programs in industrial hygiene and environmental control can diminish these risks. On the other hand, the emissions of particulates, heavy metals, carbon dioxide, sulphides and nitrides produced during the entire life cycle of the modules (thin film) are extremely low ie 100 – 360 times lower than that of coal and oil power plants and as a result, the associated risks are minimal. In the case of wind technologies potential adverse environmental impacts may be associated with the noise of operating turbines and erection of turbines in the migratory path of birds.

- **Competing land use issues -** Land use may pose a barrier for large scale power generation as wind farms require more land area than conventional gas-fired power plants of equivalent capacity; albeit this land can also be used for agricultural purposes. In the case of current solar technologies, 5 to 10 acres per megawatt of power are required; however, small scale applications are feasible for residential and commercial areas. With respect to bio-fuel production, the dedication of crops and land is required, which can impact negatively on food security.

5 FRAMEWORK FOR DEVELOPMENT OF A RENEWABLE ENERGY POLICY

Vision Statement

An energy economy based on hydrocarbons with a sustained and long-term political and societal commitment to the optimum growth and development of the country's RE resources, maximization of opportunities for clean energy and clean production and development of a culture for energy efficiency and conservation.

Definition of RE

In RE the term 'renewable' is generally applied to energy resources, whose common characteristic is that they cannot be depleted, i.e., they can be naturally replenished with negligible environmental impact.

Renewable energy resources include:

Solar: Solar energy is used to generate electricity, heat water, cool and illuminate buildings. For example, Photovoltaic (PV) systems capture the energy in sunlight and convert it to electricity.

Wind: Wind energy utilizes the naturally occurring energy of the wind either directly as in wind mills or to generate electricity and can be used for example to charge batteries or to pump water.

Hydro-electricity: Hydro power uses the movement of water under gravitational force to drive turbines to generate electricity.

Geothermal: Geothermal activity in the Earth's crust is derived from the hot core of the Earth. For example, the natural geysers are hot water sources employed for power generation.

Biomass: Biomass energy (from organic matter) can be used to provide heat, make liquid fuels, gas and to generate electricity e.g. fuelwood and residues from agriculture and forestry.

Waves, ocean currents and tidal energy: Waves, ocean currents and tidal energy can be used to drive turbines to generate electricity.

Waste materials: Waste to energy is the process of creating energy in the form of electricity or heat from the conversion of waste materials.

This policy framework is focused on those resources that can be established as commercially viable and cost effective applications in Trinidad and Tobago.

5.1 RE Strategy in National Energy Policy Framework

The evolution of a National Energy Policy for Trinidad and Tobago should be guided by several factors including: the size of crude and natural gas reserves, depletion rates, monetization of reserves, energy security and affordability, local content and participation, value maximization, pricing and market characteristics, economic sustainability, environmental considerations and the international environment.

The development of RE policy measures should form part of this evolving energy scenario and is a critical aspect of the nation's continued development and the development of its energy policy, i.e. ***the upgrade of our energy infrastructure to maximize efficiency and incorporate RE sources***.

Trinidad and Tobago is preparing a Climate Change Policy which involved national consultations on the draft document. . The policy recommendations with respect to RE should support and complement the Climate Change Policy.

Trinidad and Tobago's framework for sustainable development includes a number of policy measures to address energy security, the environment, clean energy and clean production.

Primary Objective

The primary objective of RE policy measures in the context of the country's National Energy Policy is to identify and examine strategies and make recommendations for introducing RE into the local energy mix.

RE development will provide greater diversity in the energy mix which is vital to long term energy security and sustainability of energy supply. It also presents an avenue to enhance the country's socio-economic well-being through employment creation, revenue generation and development of a manufacturing capability in new indigenous industries.

Complementary to Primary Objective

It is essential that policy measures promote energy efficiency and conservation as very important complementary elements of RE implementation to ensure its effectiveness.

As a small island state, the use or RE would help in the mitigation of GHG emissions. Accordingly, the policy measures should include recommendations for supporting carbon

reduction strategies which will ensure an optimal and efficient use of the nation's total energy resources.

The carbon reduction strategies recognized in the policy framework are:

1. Expanding the use of CNG as a transportation fuel in the context that it is a cleaner burning fossil fuel with less harmful effects on the environment;

2. Exploring opportunities for more efficient industrial/petrochemical processes and use of combined-cycle technology in electricity generation; and

3. Exploring other options for reducing GHG emissions such as carbon capture and storage (CCS).

These objectives can be achieved by:

- Promoting energy efficiency and the use of RE resources through education and training and capacity building;
- Pursuing R&D in energy efficiency measures and RE technologies applicable to Trinidad and Tobago through co-operation with regional and international bodies;
- Encouraging private sector participation and investment in energy efficiency and RE technologies by providing appropriate financial and tax incentives; and
- Developing the institutional capacity to move forward with the appropriate plans and programmes.

The pursuance of these measures can be expected to result in:

- A strategy and action plan for the implementation of a percentage of RE-based electricity generation;
- A reduction in GHG emissions;
- The creation of jobs in the energy sector (manufacturing, supply, installation and after-sale services);
- The mobilization of financing from local commercial and regional development banks and other international funding agencies, and creation of opportunities for venture capital.

5.2 ESSENTIAL ELEMENTS FOR RE STRATEGY IMPLEMENTATION

Several approaches to RE development/implementation, including those identified and/or recommended by CREDP, were explored and considered in this report. Essential elements to address key issues related to the RE are:

1. Capacity Building and Awareness Creation
2. Enabling Environment
3. Energy Efficiency and Conservation
4. Institutional Arrangement

5.2.1 Capacity Building and Awareness Creation

Overview

Capacity building and creation of public awareness are essential to effective execution of plans and programmes that seek to engage the nation. Local experiences such as the Pilot Solar Water Heating Project[11] and global best practices point to the need for training and education in RE systems, energy efficiency and conservation to develop the required skill-sets to service these industries. A local capability for research and development is also desirable, while public dissemination of information would help stimulate local demand and industry.

Education and Training

Human resource development should focus on capacity building in RE education, establishing priority areas and strategies for each priority area at the national level, developing labour market statistics and indicators to establish human resource needs in all facets of RE development.

Research and Development

An environment must be created to promote and facilitate RE research and development through engagement of the private sector, formation of partnerships between local and foreign institutions, and expansion of existing programmes being offered by UTT and UWI to increase capacity. This would necessitate close monitoring and evaluation of the RE technologies which are critical in establishing their effectiveness and assist Government in the certification and approval of systems.

[11]**United Nations Development Programme.** *End of Project Report – Pilot Project on the Use of Renewable Energy in Trinidad and Tobago – Introduction of Solar Water Heating Systems in Tourism (Host Homes) Sector.* 2009.

Public Awareness

There must be the dissemination of information regarding RE to the public. It is necessary to ensure that the role and benefits of RE technologies are effectively communicated to citizens so they are better able to understand and appreciate them and that they are made aware of the opportunities for education, training and employment. This would be enhanced by effective communication of plans and programmes between the national and local government bodies. Hence the regional community centers are being considered as strategic venues to demonstrate the use of RE and energy efficiency and conservation devices and for the launch of public education and awareness programmes.

***Goals for* capacity building and awareness creation:**

- Effectively educate the public on the advantages and importance of moving towards RE and practising energy conservation;
- Provide the public with readily available information about the cost, availability and incentives for installation of RE systems as the technology is introduced;
- Educate the public with regards to any new energy efficiency standards and guidelines that are introduced; and
- Provide education in the field of RE technology development and operation and management in this sector, as well as technical training for the installation and maintenance of RE systems.

Based on the goals, the following recommendations should be considered for capacity building and awareness creation:

1. Government, through community based initiatives and the education system (eg. using community centers as venues and science fairs at schools) should promote/sponsor programmes aimed at increasing RE, energy efficiency and conservation;
2. Government should promote 'advertising campaigns' and 'technology fairs' for local distributors of RE and energy efficient systems and devices;
3. Government should sponsor a study to determine the RE skills gap through **c**ollaboration with local technical education centres;
4. Methodologies in the pedagogy of RE in curricula development should be developed that would provide linkage among RE education at Primary, Secondary and Tertiary (including technical/vocational education) to enhance continuity and consistency.

5. Government should introduce a RE grant and scholarship scheme;

6. Government should encourage RE R&D through **w**orking with local tertiary education centres and technical training institutions to incorporate RE into syllabi; and

7. Government should **c**ollaborate with the national standards body and relevant stakeholders to develop standards, accreditation and certification procedures for RE.

5.2.2 Enabling Environment

There is need to create an enabling environment for RE in light of the challenges to the introduction of RE technologies discussed in Chapter 4. It should also be noted that the current price structure for energy derived from hydrocarbons does not reflect the costs that production has on the environment. Even after taking these costs into consideration, there is still need to provide support to RE industry. It is expected that the required level of support will be significantly high at first and could be relaxed as the industry achieves the required economies of scale, technology development and investor confidence.

(a) Government Incentives and Other Support Mechanisms

Government support through incentives and other mechanisms are critical to facilitating RE growth and development and the level and type of these incentives would depend on various factors including RE technology option and economics. Appendix IV indicates the type of support mechanisms employed in various countries. Trinidad and Tobago would be able to draw from the experiences of its Caribbean neighbours which have adopted some of these measures. In this regard CREDP has highlighted the following:

- Grants to encourage the replacement of immersion electric water heaters with solar water heaters;
- Tax deductions on the purchase of solar water heaters;
- Grants to existing and new commercial entities for technical and marketing studies;
- Grants for energy audits in the hospitality and other sectors to identify opportunities for solar water heating and other RE technologies;
- Rationalisation of electricity tariffs to reduce and ultimately remove subsidies and thereby reflect the 'true' costs of production for each customer class (i.e. residential, commercial, industrial etc.);
- Provision of concessionary land leases for RE sites;
- Provision of export credit for local manufacturers for RE technologies and systems;

- Direct investment by Governments (eg. budgetary allocations) and partnerships with the private sector in RE projects; and
- Supporting the trade of carbon credits for RE projects.

Direct Government funding should be supported by facilitation of traditional and non-traditional financing. Traditional financing is available from international banks and private equity funds. Many large RE projects require syndication with one bank as the lead arranger. Funding for RE projects from multi-lateral and bi-lateral agencies continue to be important for emerging markets. Non-traditional funding is facilitated at the international level through agencies like the Inter-American Development Bank (IADB), Economic Commission for Latin America and the Caribbean (ECLAC), Global Environmental Facility (GEF) and the Clean Development Mechanism (CDM) of the Kyoto Protocol.

Clean Development Mechanism

As a ratified signatory to the UNFCCC and Kyoto Protocol, Trinidad and Tobago is provided with the framework for tapping international funds via the CDM to reduce GHGs.

Green Fund

Renewable energy initiatives are eligible for funding from the Government's Green Fund. The Fund provides financial support to Organisations and Community Groups for projects that support the National Environmental Policy. In order for projects to be eligible, they must be primarily engaged in activities related to remediation, reforestation and conservation of the environment. Through the Green Fund Levy a tax of 0.1% on gross sales is imposed on a company carrying on business in Trinidad and Tobago. An organisation may apply to the MPHE for certification of an activity that relates to remediation, reforestation or conservation of the environment in order to access public money disbursed from the Green Fund Levy.

(b) Legal and Regulatory Environment

The importance of creating the appropriate legal and regulatory environment cannot be underscored enough. Several instruments are widely adopted in the electricity sector and it is recognized that these instruments could be adapted for other RE applications such as bio-fuels in the transportation sector. **Trinidad and Tobago needs to give priority to reviewing the legal and regulatory framework to incorporate the instruments briefly discussed below.**

Open access: This policy mechanism will guarantee non-discriminatory access to the distribution and transmission grid network and reduce problems associated with interconnectivity, helping to provide a foundation for a competitive electric power market.

Feed-in Tariff : The focus of this energy-supply policy is 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 by renewable sources at a calculated percent of the retail price or its 'avoided cost'

Net Metering: This programme is designed 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.

Renewable Portfolio Standard: This standard requires the increased production of energy from RE sources by setting a target prescribing how much national demand must be met with renewable resource production.

In order to encourage further growth and development of RE, additional pieces of legislation need to be examined, noting where industry incentives can be included and in compliance with the RE policy measures being considered. Below is a list of some legislation which should be reviewed and amended where necessary to incorporate RE.

1. Trinidad and Tobago Electricity Commission, Chap 54:70, Order No.42 of 1945
2. The Regulated Industries Commission, Chap 54:73, Act No.26 of 1998
3. The Fiscal Incentives Act, Chap 85:01, Act No.22 of 1979
4. The Petroleum Act, Chap 62:01, Act No.46 of 1969
5. The Petroleum Production Levy and Subsidy Act, Chap 62:02, Act No.14 of 1974
6. The Tourism Development Act, Chap 87:22, Act No.9 of 2000
7. Income Tax (In Aid of Industry) Act, Chap 85:04, Act No.12 of 1950
8. The Town and Country Planning Act, Chap 35:01, Act No.29 of 1960
9. The Environmental Management Act, Chap 35:05, Act No.3 of 2000
10. The Public Transport Service Act, Chap 48:02, Act No.11 of 1965
11. Motor Vehicle and Road Traffic Act, Chap 48:50

(c) International Co-operation

Trinidad and Tobago is committed to a process of regional and international co-operation to ensure the widest exposure and obtain the best advantage in development of a local RE industry.

The potential benefits of such collaboration include:

- Potential for the attraction of Foreign Direct Investment (FDI);
- Creation of a pathway to access the latest green technology and technical advice;
- Increased opportunity for access to grant funds from worldwide climate change initiatives;

- Showcase the country's commitment to mitigating the impacts of climate change;
- Global exposure from taking steps to reduce the nation's carbon footprint; and
- Increased opportunities for other avenues for growth and development as a nation.

A good indication of the Government's commitment in this area is the recent hosting of an international meeting with CARICOM and several member states, the United States Department of Energy (US DOE), and other international organizations. This meeting aimed to establish the framework for the creation of a RE Research Center in Trinidad and Tobago. In accordance with the proposal, Trinidad and Tobago and the US DOE will partner in this venture allowing this country a leadership role in the region to address climate change issues. The DOE has offered to provide technical and strategic support to Trinidad and Tobago.

5.2.3 Energy Efficiency and Conservation

Promoting energy efficiency and conservation is critical to ensuring effectiveness of RE implementation. Energy efficiency is a measure of the savings of energy which is used to produce goods and services while maintaining the desired benefits. Conservation is the reduction in the amount of energy consumed in a process or system, or by an organization or society, through economy, elimination of waste, and rational use.

Reducing energy demand through increased conservation and efficiency is a least cost approach to offset the additional cost of RE. This is also the most practical and in some cases readily implementable means of reducing the use of non-RE resources and thereby extending the lifespan of these resources. The necessary steps to proceed with these measures are relatively inexpensive and/or could be implemented over the short to medium term, making this approach to addressing energy needs an integral part of any plan to move forward with RE.

5.2.4 Institutional Arrangement for Policy Implementation

Government should commission and fund a **RE and Energy Efficiency Agency** with responsibility for the development, assessment, implementation and audit of energy efficiency and RE policies and programmes. This agency would be well placed to ensure consistency and continuance of the programmes and policies. Furthermore the agency should also be responsible for continuous revision of policies and programmes/projects necessary for promoting the use of various non-conventional and RE sources of energy in the country
The key responsibilities of the proposed Agency should be as follows:

- **Developing a register of local RE and energy efficiency** businesses and technology providers and experts in green building design and construction;

- **Creating an appropriate regulatory environment** for the introduction of RE and promotion of energy efficiency and conservation;
- **Overseeing a national programme of energy audits** to determine our present level of energy efficiency, and to identify key areas to target in order to improve energy efficiency;
- **Instituting energy efficiency programmes**, which could include exploring the merits of and possibly implementing, a RE and Energy Efficiency Fund that would finance initiatives related to energy efficiency and RE;
- **Overseeing the introduction of RE technology** such as solar water heaters and solar photovoltaic (PV) systems to the public;
- **Promoting public awareness campaigns and education and training** related to RE and energy efficiency to ensure development of local capacity;
- **Developing incentive programmes** to encourage the use of RE technologies;
- **Organizing long-term studies and surveys** to produce wind and solar atlases of the country to determine the optimal sites for installing wind turbines and solar panels;
- **Identifying and assessing proposed RE projects** to determine their economic feasibility;
- **Pursuing funding for RE projects** from international financial agencies and taking advantage of market-based mechanisms such as CDM to allow foreign partners to earn carbon credits by providing funding for local RE projects;
- **Promoting RE businesses** with support from institutions such as the Business Development Company (BDC) for companies embarking on RE development and Energy Efficiency projects; and
- **Establishing working relationships with similar RE authorities** and governing bodies in other nations for mutual benefit, as well as promotion of joint regional action for RE implementation.

5.3 RENEWABLE ENERGY TECHNOLOGY CHOICES – ELECTRICITY GENERATION AND TRANSPORATION SECTORS

5.3.1 Electricity Generation

Overview

The electricity sector to-date has no plans for the use of RE technologies mainly because fossil fuels are readily available at relatively low cost. There is however some opportunity for utilization of RE for power generation in the future. T&TEC demonstrated through a pilot project that PV is cost competitive with natural gas generation in providing a limited power supply to certain remote off-grid locations. In the case of power supply for the grid, globally, the technologies that are shown to have made the most significant advances are hydroelectricity and wind. In the local scenario, strictly on the basis of resource availability, hydroelectricity is not a practicable option; on the other hand, the cost of wind generation has been declining making this technology very competitive even with local electricity generation utilizing natural gas.

Goals

Consideration should be given to the implementation of RE technologies to possibly generate 5% of the present peak demand for electricity by 2020, which would account for approximately 60 MW of generation. This is based on what is observed as achievable globally for large scale RE power generation projects for grid supply and the specific circumstances of Trinidad and Tobago.

It is clear that RE technologies for power generation require an existing grid. Therefore, it cannot function on its own and must coexist with the conventional generation using natural gas. An equivalent supply of back-up power for the grid from natural gas generation is needed due to the variability of supply from RE sources. Notwithstanding the challenges, available RE options being considered to achieve this goal are:

1) Wind energy
2) Solar energy
3) Waste to energy

1. Wind energy

Wind energy could be utilized for bulk power generation but may also be an option for small independent power providers particularly in rural districts. The existence of the North East Trade Winds, coastal plains, and other undeveloped land acreage are some of the favourable

conditions that exist in Trinidad and Tobago that may support a viable wind project. However before wind turbines are erected, the expected energy yields has to be predicted as precisely as possible to determine the economics of the project to minimize the investment risk. This requires the conduct of site surveys and various wind resource analyses. Also to be factored into the assessment is the eventuality of a tropical storm or hurricane which may pose a risk to infrastructure and equipment. This assessment is absolutely necessary to inform an investment decision.

It should also be noted that wind energy systems require substantial funding. In addition, huge land acreage is needed (albeit less acreage than solar PV systems); a 20 MW wind plant could require an area of approximately 5 km^2 (500 hectares).

2. Solar energy

Solar energy can be of two basic forms, i.e.:

- Photovoltaic (PV)
- Concentrated solar power (CSP)

Solar Photovoltaics (PV)

Photovoltaic technology is one means of producing electricity from solar energy. Solar PV panels use crystalline silicon semiconductor cells to produce electric current when exposed to sunlight (photovoltaic effect).

PV Off-grid: T&TEC has demonstrated that it is cost effective to utilize solar photovoltaics for certain remote locations not connected to the national grid. These opportunities where they exist should be explored over the short to medium term.

PV Grid Connected: Solar photovoltaics installations could also be connected to the national grid. This involves high capital costs as well as require a large land area (2 to 4 hectares per megawatt), which is a concern for us as an island nation. In creating an enabling environment for this application, a number of technical and legislative issues with respect to grid connectivity must be resolved.

Concentrated Solar Power

Another solar technology which has been rapidly evolving in recent times is concentrated solar power (CSP). CSP utilizes lenses and mirrors, in the form of parabolic troughs, heliostats or dish engine systems to concentrate sunlight over a large area onto a small target. This concentrated sunlight can readily be used for heating or to produce steam to drive turbines for electricity generation, or could be concentrated onto PV cells. Like PV systems a major barrier to introduction of this technology in Trinidad and Tobago is the need for very large land acreage.

3. Waste to Energy

The Government has received several proposals from investors interested in projects to convert 'waste to energy'. Waste to energy is the conversion of solid waste to produce energy which is harnessed to turn a turbine generator which could supply power to the grid or support small industries. Waste to energy projects can result in less carbon dioxide emissions than fossil fuelled power generation plants. This technology is attractive because it provides an opportunity for the Government to treat with the issue of waste management at existing landfill sites. However, it would require a programme for waste segregation to be a viable option.

Preferred Technology for Power Generation

From analysis of the options, wind energy is the preferred technology for power generation for supply to the national grid. Wind has the greatest potential for providing a supply to the local power grid during the short to medium term, notwithstanding the challenges, as it is the most competitive in the local scenario compared with the existing consumer cost of electricity generated by combined cycle natural gas generation.

Studies in different countries on the power grid interconnection aspects of wind energy have proven that low levels of penetration of wind energy are acceptable and do not require any considerable changes in the planning and operation of the power system[12]. Most studies recommend a figure close to a maximum of 10% in terms of the total installed capacity in the system as acceptable. If the penetration level is higher, considerable investments have to be devoted to reinforce the power system with additional backup conventional generation, additional transmission lines and transformers, sophisticated wind forecasting tools and in some instances very expensive additional ancillary support elements.

However, it is important to note that most of these studies have been done in electrical systems that are very large, with several interconnection points to other large electrical systems and with a variety of power sources. The case of Trinidad and Tobago is basically the opposite, with a small isolated (without any interconnections to other electrical systems) electrical system, dominated by natural gas generation. Accordingly, for Trinidad and Tobago a penetration

[12] Technically, wind generators are very different from conventional generators used in typical electrical utilities. These differences make it impossible to equate a wind generation plant with a gas turbine generation plant in terms of its relationship to the power system. These peculiarities of wind generation (or other renewable resources as well) impose very critical restrictions on the planning and operation of power systems. Some of these important issues include: the wind is variable and as such the electrical operator does not have control on the quantity of power than can be generated by the wind generation plant. This imposes new and difficult constraints on the planning of future generation capacity, dispatch of generation and operation of the system; and the electrical machines used for wind generation cannot provide several of the ancillary services normally provided by generators to the power systems. These services support many important areas of the power system such as: maintaining voltage levels, generating reactive power, maintaining frequency levels and providing critical support of the system during faults]

factor of 5% of total installed capacity (80 MW) is deemed practical. At this stage, however, a lower target of 5% of existing peak demand (or 60MW) is being recommended for Trinidad and Tobago.

The proposed target of 5% of existing peak demand (or 60MW) is realistic and achievable by 2020 from this source. It is possible that this figure could be increased in the future depending on the results of the proposed wind assessment study and technological developments.

Recommendations for the electricity sector:

1. Government should commission a study to determine the potential energy from local wind resources;
2. Government should undertake a feasibility study for wind power generation for electrification of a community based project;
3. Government should foster research and development into other forms of RE for power supply to the grid;
4. Government should plan a system for waste segregation which would allow for the use of suitable waste products for power generation via technologies including gasification;
5. Existing legislative and regulatory frameworks should be reviewed and amended and these include the Electricity and Regulated Industries Commission (RIC) Acts to incorporate/facilitate renewable energy development and usage;
6. Government should develop RE pricing policies which will include a fixed price and guarantee the purchase of RE generated electricity up to a stipulated percentage of electricity usage;
7. Government should encourage private sector investments for power generation using RE technologies through such incentives as tax concessions, preferential land lease rates and development grants;
8. Government should create a facilitative environment for financing for RE technologies/ equipment.

5.3.2 Transportation

Overview

Transportation sectors globally are heavily dependent on hydrocarbons. In Trinidad and Tobago, the use of hydrocarbons for transportation is subsidized by the Government and as a consequence, there has been little effort to promote the use of alternative energy as transportation fuels. There has been a steady increase in the purchase of gasoline and diesel fuelled vehicles especially with the opening of the foreign-used vehicle market which has resulted in a steady increase in GHG emissions. Today the local transportation sector is said to account for 2.4 Tonnes per year of CO_2.[13]

Biofuels (bio-ethanol and bio-diesel)

A major rationale for developing a local biofuel industry would be the positive impact such a measure would have on long term energy security and sustainability. Biofuel includes fuels ranging from ethanol to diesel, as long as organic matter (biomass) is used as a chemical starting point to produce it. Methods of producing the fuels can include the formation of alcohols by fermentation of biomass in bioreactors containing microorganisms and the gasification of biomass in reactors to form syngas (carbon monoxide and hydrogen mixture), which can then be used to produce numerous hydrocarbon fuels such as diesel. The biomass used in these processes can potentially range from sugarcane and switchgrass to algae to biodegradable waste, with different raw materials providing better product yields dependent on production method. Ethanol which can be produced from sugarcane or imported can be blended with gasoline to produce a cleaner burning fuel, thereby releasing less carbon dioxide.

A major limitation to the development and use of biofuels is the necessary commitment of land and food crops to provide the biomass needed to produce the fuel which could adversely affect food security. As a result, waste may be the only feasible raw material for a nation with limited land mass. Initially, a waste segregation system must be implemented locally in order to separate biodegradable waste suitable for producing biofuel.

Biofuels can provide the local transportation sector with fuel in a carbon neutral cycle, i.e. vehicular CO_2 emissions equals CO_2 absorbed by the photosynthesizing plants used to produce the fuel. However, this is conditional on the choice of technology. There is need to monitor research and development in gasification and other processes used in the production of biofuels to determine the applicability of this technology in Trinidad and Tobago in the future.

[13] UTT Study

Goal for RE in the transportation sector:

Reduce the carbon emissions by the choice of fuels used for transportation.

Recommendations for the transportation sector are as follows:

1. **Government should promote R&D on Biofuels (ethanol and diesel) -** Further research and development of gasification and other processes is vital in order to make the production of biofuels a practical method of reducing GHG emissions and providing RE;

2. **Government should promote the importation of cars that run on alternative forms of energy –** Steps would be made to upgrade the local fleet of cars to be more environmentally friendly by providing incentives for the importation, sale and purchase of hybrid vehicles;

3. **R & D should be encouraged into alternative energy to** continuously improve the efficiency of the transportation sector and reduce GHG emissions; and

4. **Government should give consideration to t**he gradual phasing out of existing subsidies on gasoline and diesel fuels to encourage conservation and a switch to alternative fuels.

5.4 SHORT TERM RENEWABLE ENERGY/ENERGY EFFICIENCY STRATEGIES

5.4.1 Overview

Opportunities for small scale, low cost applications of RE technologies are present in the residential, commercial and other institutional sectors. These applications include solar water heaters e.g. households and hotels; solar for water desalination; solar PV systems for households especially in rural districts, and for water pumping and purification; solar and wind for agricultural use eg. crop driers, and single wind turbine systems for irrigation. These technologies are scalable, require minimum maintenance and have very low operational costs. To ensure effective implementation of RE in these sectors it is important to accompany such implementation with appropriate measures involving efficiency and conservation i.e. demand side management. These measures would reduce utility costs to consumers which in effect could offset some of the cost associated with the introduction of RE technologies.

5.4.2 Forward Strategy

The strategy for introducing these quickly implementable RE and energy efficiency measures to ensure the greatest national participation involves the inclusion of these technologies in schools and community centres. These initiatives would have a major impact on capacity building, awareness creation, public outreach and market growth and expansion. Efforts are being made by the MEEI and Ministry of Community Development (MCD) to implement RE technology and energy efficiency (EE) in community centres. Similar initiatives will be made to incorporate RE and EE into schools. The use of these institutions will demonstrate the benefits to the community while facilitating the growth of a knowledge base and supporting their use as natural disaster emergency shelters. The introduction of RE technologies in Government's housing programme is another area of critical importance.

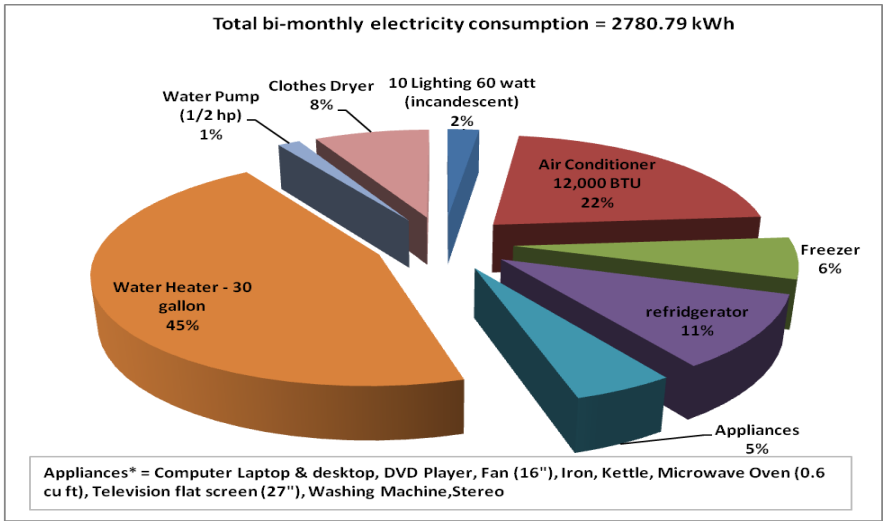
5.4.3 Solar Water Heaters

The replacement of traditional water heaters with solar-powered units could potentially result in a significant reduction in local utility costs over the long term. This can be deduced from Figure 5.4.3 which demonstrates that the electric water heater accounts for 45% and 58% of a typical household electricity consumption with and without an air condition unit respectively.

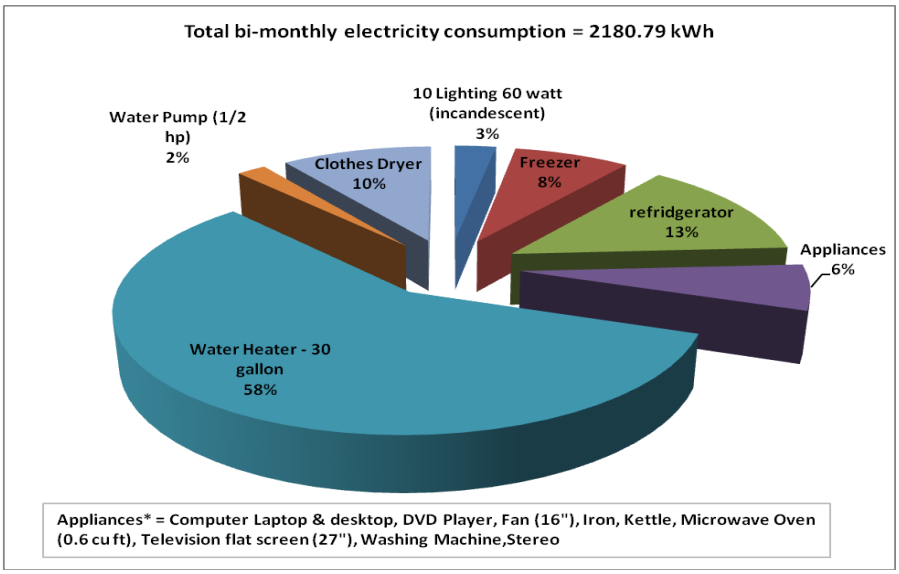
According to a REN21 report, global solar hot water capacity increased by 15% in 2008 to reach an estimated 145 gigawatts-thermal (GWh), or double the capacity in 2004[14]. Most of this is

[14] **Renewable Energy Policy Network for the 21st Century.** *Renewables Global Status Report 2009 Update.* Paris : s.n., 2009.

located in China and, to a lesser extent, the European Union.[15] The technology has already found a market in neighbouring Caribbean nations such as Barbados and is well suited for implementation locally.



(a) Electricity Consumption With Air Condition



(b) Electricity Consumption Without Air Condition

Figure 5.4.3 Breakdown of Major Electricity Consumption in a Typical Household

[15] Typically, a solar collector is placed on the roof of a building to absorb solar radiation and transfer it, as heat, to water that is then piped into a storage tank for use in the building. A solar collector usually takes the form of an insulated box containing a black metal sheet and built-in water pipes, which are attached to an external storage tank. The black metal absorbs sunlight and heats the water in the pipes.

Appendix V, Table 1 shows the approximate savings brought to present value over a 10-year period that would be achieved by replacing existing water heaters in the country with solar models. The implementation of such a programme would provide a market for the development of a solar water heater manufacturing industry in the domestic economy.

5.4.4 Solar Photovoltaics

There may be opportunities for small scale applications of solar PV for off-grid supply to provide backup power for various uses e.g. security lighting and emergency radio systems.

5.4.5 Energy Efficient Lighting

The replacement of incandescent light bulbs with efficient compact fluorescent models results in greater energy efficiency as the latter utilizes approximately 75% less power. Local energy demand can be further reduced by the introduction of LED light bulbs, which are even more energy efficient than compact fluorescents. These improvements translate into energy savings for consumers and help reduce the demand on electricity generation. Appendix V, Table 2 shows the approximate savings in energy usage and electricity bill as well as the reduction in GHG emissions that can be achieved by consumers replacing ten (10) 60W incandescent bulbs with compact fluorescents.

5.4.6 Energy Labelling

A good example of a programme geared to improve the efficient use of energy is the ENERGY STAR® Programme of the USA. This is a joint programme of the U.S. Environmental Protection Agency and the U.S. Department of Energy geared to saving money and protecting the environment through energy efficient products and practices. It is a voluntary labelling programme designed to identify and promote energy-efficient products to reduce greenhouse gas emissions. The ENERGY STAR label is now placed on over 60 product categories including major appliances, office equipment, lighting, and home electronics.

Appendix V, Table 3 shows the approximate savings in energy usage and electricity bill as well as the reduction in GHG emissions that could be achieved by households that replace standard appliances with ENERGY STAR® qualified products and gives an idea of the savings that might be realized locally. These savings are calculated for households using incandescent bulbs, and are based on the average energy savings outlined in the ENERGY STAR ® 2007 Annual Report for consumers using ENERGY STAR® qualified televisions, computers, fans and audio equipment[16].

[16] *ENERGY STAR® and Other Climate Protection Partnerships 2007 Annual Report.* 2008.

5.4.7 Green Buildings

The implementation of green building codes will also support energy efficiency and conservation. In this way, new buildings could be constructed to save energy cost. The goal of these improvements should be to meet an internationally recognized standard for building efficiency such as the Leadership in Energy and Environmental Design (LEED) green building certification, which requires that buildings be constructed to improve energy efficiency thus reducing carbon dioxide emissions[17].

Goals for residential, commercial and other institutions:

1. Increase energy efficiency and use of RE in residential and commercial properties and other institutions;
2. Establish new energy efficient design standards for buildings;
3. Promote energy-efficient life-styles; and
4. Introduction of RE technologies in Government building and housing programmes.

Recommendations for residential, commercial and other institutions:

- **Government should expand its incentive programme** to assist potential RE users to acquire and install renewable energy technologies eg. tax rebates and reduced import duties on equipment (this programme was established in 2010/2011);

- **Government should promote the use of RE technologies in its facilities.** Practicable targets for installations include the Government buildings and local housing programme, hospitals, schools, medical clinics and community centers. The provision of solar water heaters can be readily incorporated and implemented in the design and construction of buildings at relatively low cost;

- **Government should phase out the use and importation of incandescent bulbs** and eventually replace these with compact fluorescent or Light Emitting Diode (LED) lighting;

- **Government should promote the use of energy-efficient appliances -** steps will be taken to encourage the manufacture and importation of equipment that meets with the highest standards of energy efficiency and cost competitiveness; and

- **Government should develop new 'green' building codes –** Building regulation and codes will be updated to include energy efficient designs whereby all new constructions and any

[17] **U.S. Green Building Council.** *Leadership in Energy and Environmental Design Green Building System Web Site.* [Online] [Cited: November 15, 2009.]

major alterations to existing properties must comply as determined by Town and Country planning. Additions to building codes should include:

1. Insulated windows, doors and walls to reduce cooling costs, solar water heaters with insulated hot water pipes;
2. Exclusive use of low-energy lighting;
3. 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.

5.5 MEDIUM TO LONG TERM ENERGY EFFICIENCY AND CARBON REDUCTION STRATEGIES

Globally, RE is one of the strategies being deployed to deal with the issue of carbon reduction and through significant R&D the economic and technological obstacles which limit its penetration into the energy mix are being addressed. The reality is that while the move to use non-GHG emitting sources of energy is desirable, it is not always practical for a number of reasons identified in this policy and it would be some time before RE could become a significant part of the energy mix of Trinidad and Tobago. Accordingly, a Task Force comprising members of the Government, private sector and academia has been set up by the MEEA, and is currently identifying Carbon Reduction Strategies (CRS) for the energy sector. Some of the carbon reduction strategies currently being utilized and/or considered include:

1. Exploring carbon reduction strategies for the transportation sector: (i) Expanding the use of Compressed Natural Gas (CNG) as a transportation fuel in the context that it is a cleaner burning fossil fuel with less harmful effects on the environment; (ii) exploring other options for mass transit;
2. Exploring opportunities/mechanisms for more efficient industrial/petrochemical processes;
3. Exploring opportunities for conversion of existing single-cycle power generation plants to combined-cycle, and the use of combined cycle in all new power generation plants;
4. Exploring opportunities for piping of natural gas to homes and businesses; and
5. Exploring other options for reducing GHG emissions such as carbon capture and storage; in a dynamic process CO_2 could be utilized for enhanced oil recovery (EOR) and then stored.

In effect these strategies can be expected to result in a significant reduction in GHG emissions and more efficient and optimal usage of the country's non-renewable energy resources. These strategies target mainly the transportation and heavy industrial sectors.

5.5.1 Transportation

Compressed Natural Gas

There is a clear advantage to the expanded use of CNG over the short to medium term as a means of reducing GHG emissions in the Transportation sector (as CNG is a cleaner burning

fuel). Though the use of CNG to-date has had little impact, the limitations faced in the past will be addressed by increased filling station capacity and appropriate incentives to encourage usage.

The expansion programme that is currently being developed by the Government will target private cars, commercial vehicles, taxis, maxi taxis, and PTSC buses; and will involve an increase in the number of CNG filling stations, the introduction of fast-fill pumps and the provision of financial support for conversion and purchase of CNG kits and canisters. The programme will target 20% of the estimated 500,000 vehicular population by 2015, for conversion to CNG. It is estimated that this programme would reduce total carbon emissions from 2.86 to 2.46 Mn Tonnes (a reduction of 0.40Mn Tonnes or 14%).

As illustrated in Table 5.1, 20% displacement of diesel and gasoline in 2009 would have resulted in a 5% reduction in CO_2 emissions in the transportation sector, which is quite significant.

Table 5.1: Possible GHG Emission Reduction that would be accomplished by the Conversion of 20% Vehicles in the Local Transportation Sector to Use CNG

CNG CO_2 emissions (tonnes/Billion Btu)		53.07	
Gasoline CO_2 emissions (kg/L)	2.32	**Gasoline energy content (Btu/L)**	33,021.51
Diesel CO_2 emissions (kg/L)	2.66	**Diesel energy content (Btu/L)**	36,640.66
Annual transportation gasoline consumption (million litres)	124	**Annual gasoline emissions (tonnes)**	287,680
Annual transportation diesel consumption (million litres)	116	**Annual diesel emissions (tonnes)**	308,560
Total transportation gasoline and diesel emissions (tonnes)		596,240	
Total energy in transportation gasoline and diesel (Billion Btu)		8344.98	
Equivalent CNG emissions for 8344.98 Btu of energy (tonnes)		442,868.29	
Emissions reduction (tonnes)		153,371.71	

The recommendations in support of this initiative are:

- Government should provide financial incentives for conversion of vehicles to run on CNG to encourage motorists to make the switch;

- Government should provide subsidies on CNG conversion equipment and on alternative energy vehicles to encourage their importation; and

- Government should promote the importation of vehicles that run on alternative forms of energy – Steps would be made to upgrade the local fleet of cars to be more environmentally friendly by providing incentives for the importation, sale and purchase of alternative energy and/or hybrid vehicles.

Several of the above measures have been introduced in 2010/2011.

Improving Mass Transit

- **Promoting carpooling –** reducing the number of vehicles on the nation's roads is of critical importance to an effort to reduce fuel consumption and GHG emissions. One approach to achieving this is through the introduction of mechanisms to encourage carpooling such as the introduction of high occupancy vehicle (HOV) lanes on the Nation's Highways; and

- **Mass Transit System –** considering the introduction of a more comprehensive and reliable mass transit system inclusive of a rapid rail network would have many benefits in terms of sustainability and reduce GHG emissions.

5.5.2 Heavy Industry

The industrial complex in Point Lisas is critical to the economic growth and development of Trinidad and Tobago. However, the estate is responsible for both a large share of local energy consumption and a large share of our GHG emissions. This is especially true since a number of ammonia and methanol plants were brought online to take advantage of our abundant supply of natural gas. The pie chart below shows the breakdown of contribution of CO_2 emissions by energy industries.

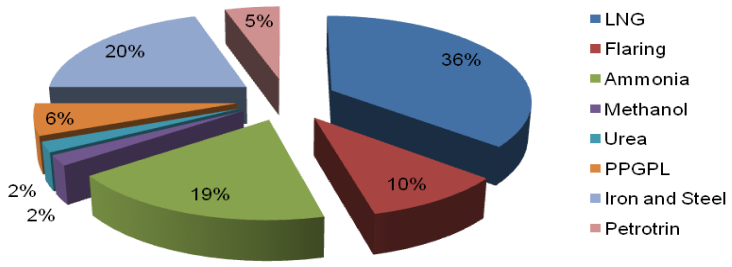


Figure 5.2 Trinidad and Tobago's CO_2 Emissions from the Energy Sector for 2007
Source: Boodlal, Furlonge & Williams, 2008[18]

The chart clearly shows LNG as the greatest CO_2 emitter and this is mainly due to the electricity produced from the plant's own generation, mainly natural gas single cycle turbines. The iron and steel industry is the second largest emitter, followed by ammonia.

Introducing the use of combined cycle technology by Atlantic LNG (ALNG) in the production of power for own use by its plants can have a significant impact on its energy use efficiency and result in a consequential reduction in GHG emissions.

Catalytic steam reforming is used to produce the hydrogen gas required for ammonia synthesis from natural gas (CH_4). This reforming process relies on the burning of natural gas to provide the heat required to drive the endothermic reforming reaction and the resulting emissions include CO_2. It should be noted that sixty percent (60%) of all emissions from ammonia plants are scrubber (captured) as part of the manufacturing operation, of which some of it is used in urea manufacture, while some of it is used in the manufacture of methanol.

Methanol plants also use steam reformers, but, as the CO and CO_2 are themselves used in the synthesis of methanol, there is little CO_2 emissions. There are substantial GHG emissions because of the use of conventional steam methane reformers.

It is imperative to address this sector to reduce our energy consumption and GHG emissions. However, the use of RE cannot replace traditional or even complement local industry power generation demands. Initial emphasis in the industrial sector to reduce GHG emissions should be on energy efficiency. .

[18] *Trinidad and Tobago's CO2 Inventory and Techno-economic Evaluation of Carbon Capture Options for Emission Mitigation.* **Boodlal, Donnie, Furlonge, Haydn I. and Williams, Rachael.** Lowlands, Tobago : s.n., 2008

New technology exists which makes steam reformation more energy efficient and less reliant on the burning of GHG producing hydrocarbons[19].

1. *Autothermal reformers*: By combining the endothermic reformation reaction with the exothermic oxidation of methane to form syngas (CO + H_2), the overall reaction can be driven without the need for burning additional natural gas;
2. *Combined reforming*: The addition of an autothermal reformer downstream of an existing primary reformer can reduce the need for combustion of natural gas; and
3. *Combined reforming with heat exchange:* Heat generated by the autothermal reformer can be used to provide heat for the reaction in the primary reformer, further reducing or even eliminating the need to burn any fuel.

Currently, there are facilities at Pt. Lisas, which utilise combined reforming technology. This technology should form part of energy efficiency requirements for new industries seeking to be established in Trinidad and Tobago.

The introduction of any of these or other new, efficient reformer technologies could greatly reduce local energy needs and GHG emissions of local ammonia and methanol plants. Only about 1% of the natural gas going to these plants will be burned in reformers, but this can have an appreciable effect on GHG emissions as shown in Table 5.2.

Table 5.2: Approximation of GHG Emissions That Could be Avoided by Upgrades To Ammonia and Methanol Plants Using Autothermal Reformer Technology

	Ammonia	Methanol	Total
Total NG demand (mmcfd)	643.86	597.87	1241.73
NG for burner fuel (mmcfd)	6.44	5.98	12.42
CO_2 flue emissions (tonnes/d)	350.47	325.43	675.90
CO_2 flue emissions (tonnes/y)	127920.04	118782.90	246702.94

Source: Engineering Institute, U.W.I

5.5.3 Power Generation

The use of combined cycle technology in electricity generation, although requiring a higher initial capital cost, provides a significant increase in energy efficiency and a consequential reduction in GHG emissions. Therefore, an important Government policy measure would be the conversion of all power plant turbines from single cycle to combined cycle. It is estimated

[19] **U.S. Green Building Council.** *Leadership in Energy and Environmental Design Green Building System Web Site.* [Online] [Cited: November 15, 2009.] http://www.usgbc.org/DisplayPage.aspx?CategoryID=19

that conversion from single cycle to combined cycle generation units at existing power generation plants can result in a decrease in natural gas consumption from 260 mmcfd to 160 mmcfd and sufficient revenue savings varying from US $644 million to US $1797 million. When combined with the practice of water injection to further enhance efficiency, CO_2 emissions can be reduced by 50% in the power generation sector[20].

5.5.4 Natural Gas for Domestic Use

The piping of Natural Gas to homes and businesses is another means of reducing the country's carbon footprint. Natural gas can be used domestically to fuel stoves, water heaters, air conditioners, clothes dryers and standby generators. This can be introduced by the establishment of a transmission network for natural gas, as well as a metering system for its sale and distribution. The use of natural gas in homes offers many benefits, which include:

- The conservation of energy and hence reduction in carbon emissions, as natural gas is directly in homes instead of using it to generate electricity;
- The reduction of the consumer's dependence on electricity by the availability of this additional energy source; and
- The increase in value added energy exports from energy savings.

5.5.5 Carbon Capture and Storage (CCS)

CCS is a technology that has received considerable interest and support in recent years. The first stage of this CCS process involves the capturing of CO_2 produced by burning fossil fuels in power stations or through petrochemical processes, such as ammonia production. This is followed by the compression and transmission of this CO_2 via pipeline to be injected into a suitable underground geological storage feature, typically an old oil reservoir. This trapped CO_2 is stored for the long term thereby reducing the quantity of carbon dioxide in the atmosphere.

CCS was the subject of a special report by the Inter-Governmental Panel on Climate Change (IPCC), released in 2005 which indicated that this procedure is likely to be economically and technically feasible in certain circumstances, with important variables being the pricing of CO_2 credits, available CO_2 capture technology and the proximity of point sources of CO_2 to potential geological reservoirs.

A major recourse available to Trinidad and Tobago for mitigating the emission of GHGs, is a form of CCS involving enhanced oil recovery (EOR). By dynamic sequestration, CO_2 is continually injected and re-injected into a reservoir for enhanced oil recovery (EOR), and is

[20] Study done by University of Trinidad and Tobago

eventually sequestered in the reservoir for long term storage. The use of CO_2 from petrochemical plants for injection into mature oil and gas fields for EOR significantly improves on the economic feasibility of oil production locally[21].

A number of factors make Trinidad & Tobago a potential location for CCS, and CO_2 EOR. These include:

- A well developed and rapidly expanding petrochemical and metals sector, which has resulted in a number of existing and potential point sources of CO_2 emissions;
- A mature oil industry with a large number of on and near-shore oil wells in close proximity to point-sources of CO_2, and existing pipeline access routes from the point sources of CO_2 emissions to these oil fields; and
- There has been some initial experience with using CO_2 in enhanced oil recovery.

5.5.6 Recommendations

The Government has established a Carbon Reduction Strategy (CRS) Task Force to examine possible CRS for Trinidad and Tobago, which is currently ongoing.

Carbon Reduction Objectives for the industrial sector include:

1. Increase the energy efficiency of local industrial plants;
2. Minimize GHG emissions caused by the industrial sector; and
3. Exploring opportunities for Carbon Capture and Storage (CCS).

Recommended strategies to achieve these objectives are:

1. **Implementing energy audits (including pollution audits) –** Audits should be performed in the industrial sector to determine whether any steps can be taken to reduce power requirements and the levels of GHG emissions. During these energy audits, a focus could also be put on determining whether there are any possibilities for the inclusion of RE sources into the power flow of these industries;

2. **Promoting the adoption of high-efficiency motors –** Industries should be encouraged to change to new, more efficient electrical motors;

3. **Promoting the use of combined-cycle technology for the generation of electricity;**

4. **Introducing more efficient steam reformer technology;**

[21] South Trinidad Chamber of Industry and Commerce (The Energy Chamber) presentation at Commonwealth Heads of Government Meetings (CHOGM)

5. **Establishing legislation for new emissions and efficiency guidelines –** While a cap-and-trade system may not be feasible, it can still be explored for applicability within the sector;

6. **Implementing an energy efficient certification program for industrial plants;** and

7. **Develop a regulatory and policy environment** to target and lobby investment from institutions, companies and research bodies interested in exploring possibilities for CCS.

6 CONCLUSION

Renewable energy could potentially play a significant role towards this country's energy security and environmental sustainability over the long term. A strategy for RE development and implementation is a critical initial step to make this happen. The strategy should provide a framework for rational and prudent decision making by the Government on matters involving RE and energy efficiency in Trinidad and Tobago. It is also a tool to inform stakeholders, including the general public, on Government's intentions, educate them on the relevant issues and ultimately obtain their support and buy-in.

With the prudent application of financial incentives, capacity development and appropriate legislative and regulatory instruments, an enabling environment could be developed to facilitate RE growth and development. Noteworthy however, is that practical solutions for improving energy efficiency are essential to complement RE programmes. These measures would contribute to offsetting some of the initial costs associated with RE. As a measure to reduce the nation's carbon footprint much more research and development is needed if RE is to have a significant impact. Other carbon reduction strategies included in this report could have a significant impact on reducing the nation's carbon footprint, such as CNG for transportation, combined cycle technology for power generation, CCS and efficient steam reforming technology in the petrochemical sector. These measures are essential for achievement of the country's long term development goals. Accordingly, the recommendations made for a forward strategy address issues beyond the narrow confines of renewable energy technology usage.

Once finalised, there should be on-going monitoring and evaluation with respect to all policy measures and an assessment after the first three (3) years to consider any amendments that may be required in policies, targets, or implementation strategies in light of any changes that may have occurred in costs, developments in various RE technologies, availability of funding etc. Extensive multi-stakeholder collaboration in the development and implementation of the policy would be extended to monitoring and evaluation.

The recommended way forward for RE in Trinidad and Tobago is to establish a **Renewable Energy and Energy Efficiency Agency.** This Agency would be responsible for the assessment and auditing of the local energy market and implementing energy efficiency and RE policies.

Stakeholders as well as society in general, should note that the RE implementation strategy proposed by the Renewable Energy Committee in this report is conditioned by concrete local

energy supply conditions, public opinion, markets and economics. Therefore, as a populace, we are all key players.

January 2011

7 GLOSSARY

Biofuel: A fuel that is derived directly from organic matter.

Biomass: Organic matter, such as plant material, used as a fuel or RE source.

Carbon credits: A market mechanism via which governments, individuals or organizations can commit to reducing greenhouse gas emissions without reducing their own emission by buying credits in order to fund RE or other greenhouse gas emission mitigating technology and processes.

Climate change: Significant long-term changes in the regular weather patterns of a region.

Compact fluorescent bulb: A fluorescent bulb replacement for incandescent models, which uses a phosphor coating to convert ultraviolet light (emitted by electrically exciting mercury vapour) into visible light. The excitation of mercury vapour that occurs within a compact fluorescent bulb requires significantly (approximately 75% on average) less energy than is used in the filament of an equivalent incandescent bulb.

Compressed natural gas (CNG): A liquid fuel produced by the compression of natural gas (primarily composed of methane). It can be used in automotive vehicles with combustion engines specially designed or converted to use CNG.

Concentrated solar power (CSP): A system that uses parabolic troughs or power towers (heliostats) to concentrate sunlight over a large area onto a small area for heating or for power generation via a photovoltaic surface.

Economy of scale: A decrease in the average cost of a product or service resulting from operation on a large scale (e.g., mass production of an item).

Feed-in tariff: A policy measure for promoting the implementation of RE by obligating local utilities to purchase electricity generated from renewable resources at guaranteed prices.

Fossil fuel: An organic fuel such as oil, coal or natural gas formed naturally from the remains of living organisms.

Fuel cell: An electrochemical device that produces a continuous electric current directly from the oxidation of a fuel supplied to the device (e.g., hydrogen fuel oxidized by oxygen).

Gasification: The conversion of a raw material, such as biomass, into a mixture of carbon monoxide and hydrogen (syngas), which can be used as a fuel directly or to produce hydrocarbon fuels.

Geothermal energy: Energy obtained by extracting the earth's heat, ideally in locations such as sites near to volcanoes.

Global warming: An increase in the earth's average atmospheric temperature that can cause climate changes. This may be precipitated by the heat-trapping effect of greenhouse gases in the atmosphere.

Greenhouse gases (GHGs): Any of a number of atmospheric gases that absorb infrared radiation emitted from the earth's surface when it is heated by the sun, impeding cooling of the earth. They include carbon dioxide, methane, nitrous oxide and water vapour.

Hydrocarbon: An organic compound, such as methane or other alkanes, containing only hydrogen and carbon.

Hydropower: Electrical energy generated by conversion from the energy of falling water.

Incandescent bulbs: A bulb that produces visible light by the heating of a tungsten filament with an electric current. Much of the electrical energy needed to produce light in this manner is converted into heat instead of visible light.

Insolation: The rate of delivery of solar energy to the surface of the earth per unit area.

LED (light-emitting diode): A semiconductor diode that emits light when conducting a current.

Ocean Thermal Energy Conversion (OTEC): Technology still in the developmental stage for utilizing the temperature difference between deep and shallow waters to run a heat engine and generate electricity.

Peak demand: The electric power demand at times when power is expected to be provided for a sustained period at a significantly higher than average level, determined by period of day when consumption of electricity is highest.

Per capita emissions: Emissions figures for a country expressed as a ratio of the total emissions to the total population of the country.

Power-purchase agreement: A contract between a utility and an independent power producer, such as a RE producer, for the purchase of electricity from the independent producer.

Renewable energy: Energy derived from a natural, continuously replenishing resource such as solar, wind or tidal sources.

Renewable energy targets: A government-legislated target percentage of a nation or state's total electricity supply to be provided from renewable sources.

Renewable resource: A naturally occurring, theoretically inexhaustible resource such as solar energy or wind.

Solar photovoltaic (PV): Arrays of cells that generate electric current through photoemission triggered by exposure to light.

Solar water heater: A device that uses a solar collector in order to utilize sunlight to heat water, which can be pumped through it and then stored in a tank.

Steam reforming: Process by which hydrogen gas can be produced commercially by the reaction between methane and steam in the presence of a catalyst.

Subsidies: A grant given out by the government that can be used to support a product and allow it to be more competitive in a market by selling at a lower price.

Sustainable energy*: See* renewable energy.

Tidal energy: A form of hydropower that uses the energy of the tides to produce electricity.

Wave energy: The use of the energy in ocean waves to produce useful energy.

Wind plant: A large group of wind turbines, ideally located in an area of consistently strong winds, for the generation of electricity.

8 APPENDICES

Appendix I

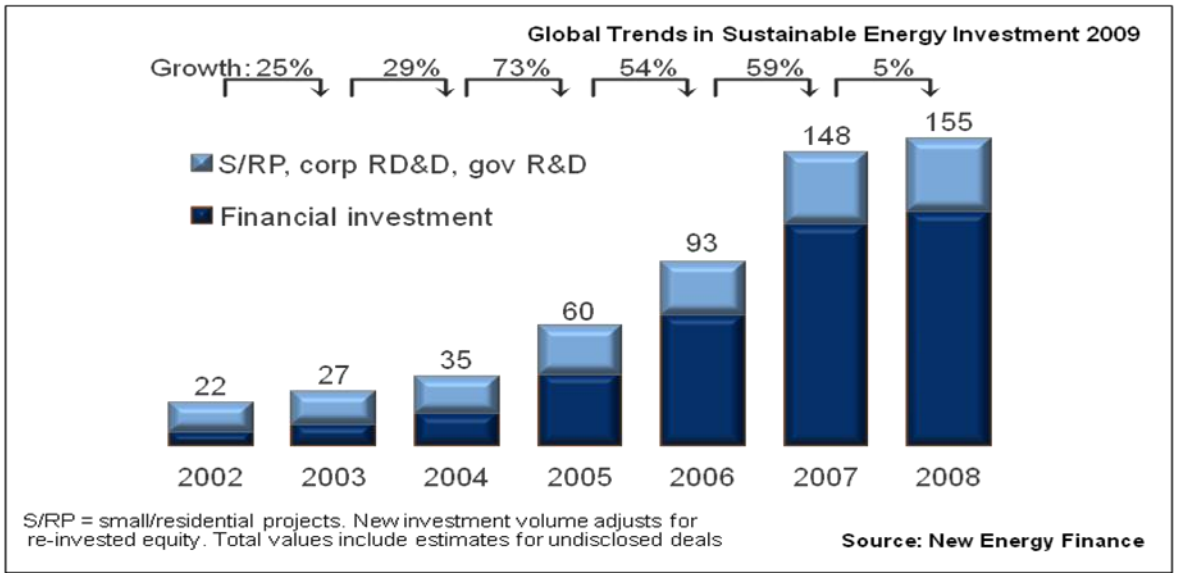


Figure 1: Global New Investment in Sustainable Energy, 2002-2008 ($ billions)
Source: United Nations Environment Programme's Sustainable Energy Finance Initiative.
Global Trends in Sustainable Energy Investment 2009

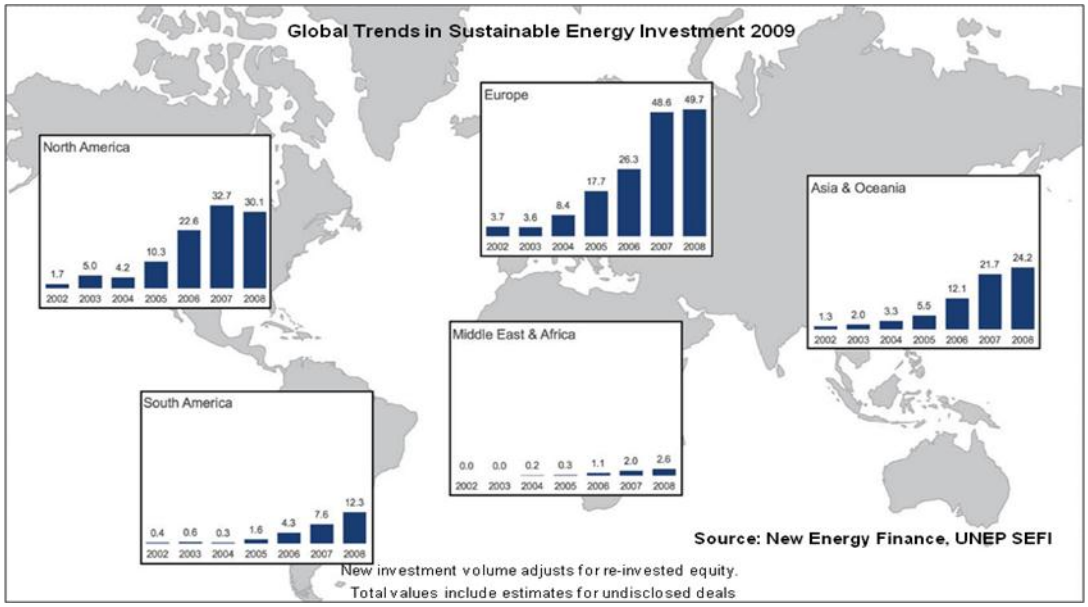


Figure 2: Global New Investment in Sustainable Energy by Region, 2002-2008 ($ billions)
Source: United Nations Environment Programme's Sustainable Energy Finance Initiative.
Global Trends in Sustainable Energy Investment 2009

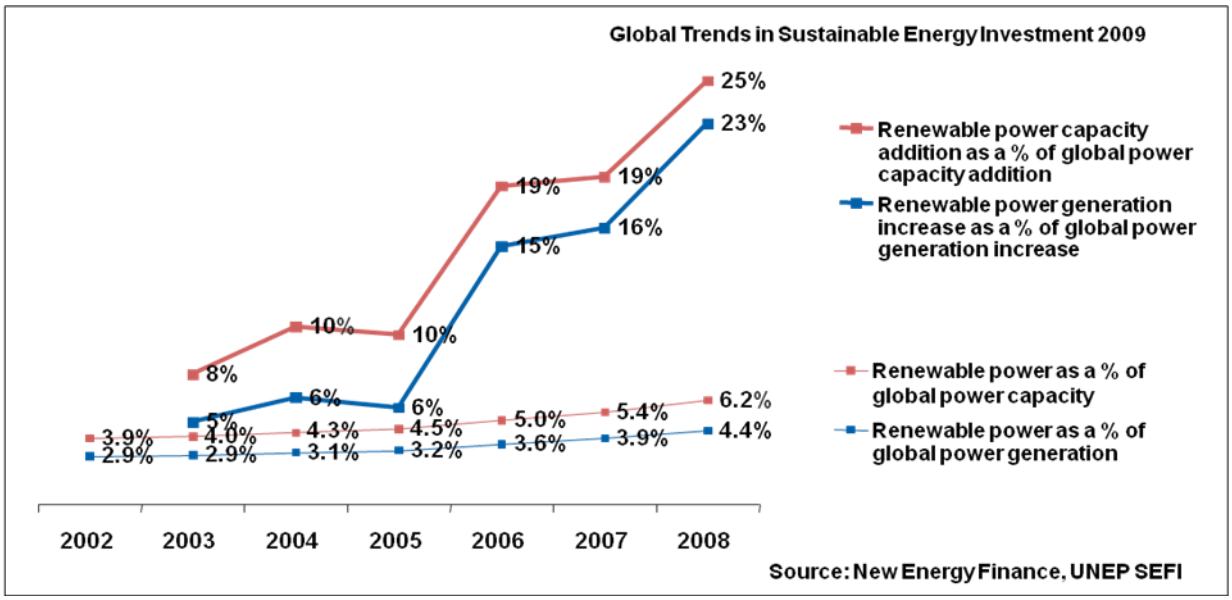


Figure 3: Renewable Power Generation and Capacity, Excluding Large Hydropower, As a Proportion of Global Power, 2002-2008 (% share)
Source: United Nations Environment Programme's Sustainable Energy Finance Initiative. *Global Trends in Sustainable Energy Investment 2009*

Appendix II

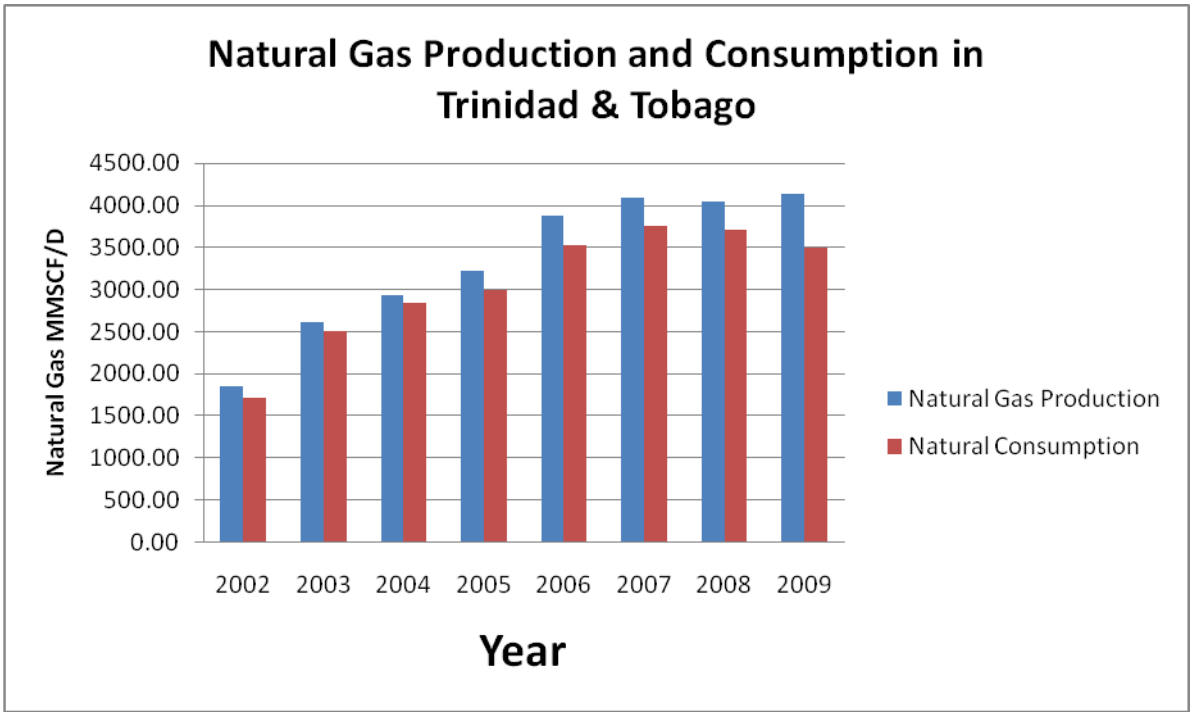


Figure 1: Production and Consumption of Natural Gas in Trinidad and Tobago. Source: Ministry of Energy and Energy Industries

Fossil Fuel Emission Levels - Pounds per Billion Btu of Energy Input			
Pollutant	**Natural Gas**	**Oil**	**Coal**
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulphur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	0.000	0.007	0.016
Source: EIA - Natural Gas Issues and Trends 1998			

Figure 2: Comparison of Emissions from Natural Gas to Those from Oil and Coal. Downloaded from http://www.naturalgas.org/environment/naturalgas.asp

Appendix III

Regional Domestic Fuel Prices and Electricity Rates (2009)

COUNTRY	DOMESTIC FUEL (USD/ GALLON)		ELECTRICITY USD cent/ kWhr		
	GASOLINE TRANSPORT	DIESEL OIL	RESIDENTIAL	COMMERCIAL	INDUSTRIAL
ARGENTINA	3.57	2.70	2.92	8.16	4.80
BARBADOS	2.57	2.02	17.60	18.40	18.30
BOLIVIA	2.00	1.99	7.65	10.59	5.33
BRASIL	4.77	3.87	20.10	18.09	15.58
CHILE	3.64	2.86	21.29	22.50	15.71
COLOMBIA	3.64	2.70	13.61	12.87	13.16
COSTA RICA	3.37	2.93	11.34	14.46	11.45
CUBA	1.70	1.21	22.59	11.49	10.31
ECUADOR	1.28	0.92	8.99	7.77	6.43
EL SALVADOR	3.24	2.60	20.38	16.10	16.10
GRENADA	3.48	3.46	31.00	32.82	26.37
GUATEMALA	2.93	2.47	16.59	16.59	17.69
GUYANA	2.58	2.38	25.00	34.00	29.00
HAITI	4.93	3.26	30.00	38.80	38.69
HONDURAS	3.55	3.03	10.89	17.85	15.57
JAMAICA	1.86	1.55	25.56	23.63	19.07
MEXICO	2.51	2.13	7.89	15.25	8.55
NICARAGUA	3.35	2.85	14.94	25.21	19.48
PANAMA	2.64	2.23	16.44	17.98	15.86
PARAGUAY	3.58	3.26	7.00	7.00	5.10
PERU	3.82	3.23	11.93	9.70	6.09
REP. DOM	3.82	2.80	17.75	15.50	25.92
SURINAME	2.11	1.55	17.10	17.30	13.10
TRINIDAD & TOBAGO	1.93	0.89	4.40	5.97	2.30
URUGUAY	4.88	n/d	22.10	17.20	11.80

1 Barrel = 42 US gallons = 158.98 liters

Source: Energy Economic Information System - Version #20, Equador, October 2010

Appendix IV

Comparison of Various Countries RE Targets and Incentives

Country	RE Target for electricity	Feed-in-Tariff	RPS	Capital Subsidy/Grants or rebates**	Investment or Tax Credits	Tradable Renewable Certificates	Production Payments	Net Metering	Public Investment, Loans or Financing*	Bio-fuel mandate
Algeria	6% by 2015	✓			✓	✓				
Australia	20% by 2020	✓	✓	✓		✓		✓	✓	✓
Brazil	70% by 2020	✓				✓			✓	✓
Canada	17GW by 2020	✓	✓	✓	✓			✓	✓	✓
China	21% by 2020	✓	✓	✓	✓		✓		✓	✓
India	15% by 2020	✓	✓	✓	✓	✓	✓		✓	✓
Indonesia	17% by 2025	✓	✓							✓
Iran		✓								
Ireland	40% by 2020	✓		✓	✓	✓				
Jamaica	15% by 2020				✓					✓
Malaysia		✓							✓	✓
Mexico	40% by 2014			✓	✓			✓	✓	
Russia	4.5% by 2020			✓		✓				
South Africa	13% by 2020	✓	✓	✓	✓		✓		✓	✓
Spain	30.3% by 2010	✓	✓	✓	✓					✓

Source: www.ren21.net

*- examples include interest-free green loans from renewable energy fund

**-includes sales tax, energy tax, excise tax or VAT reductions

Note- Many countries have utilised public competitive bidding mechanisms, but because this is not T&T's main focus presently, thus it has been left out. (e.g. Brazil, Canada, China, Ireland, South Africa)

Appendix V
Table 1

Possible Energy Savings and Reduction in GHG Emissions for Conversion from Single-Element to Solar-Powered Water Heaters in Trinidad and Tobago

Total No. of Rate A customers with an electric water heater	26,538
Total units used bi-monthly (kWh) by 26,538 Rate A customers	91,058,431
Bi-monthly energy usage of 1 single-element water heater (kWh)	1,260
Bi-monthly energy usage of 26,538 Rate A customers with 1 single-element water heater (kWh)	33,437,880
Amount of units to be substituted by solar energy (kWh) for water heating	33,437,880
Energy usage by 26,538 Rate A customers without single-element water heater (kWh)	57,620,551
% Reduction of energy usage	36.72%
Bimonthly electricity bill savings at $0.25/kWh	$8,359,470.00
Annual savings	$50,156,820.00
Savings over a 10-year period brought to PV at a base rate of 8%	$336,552,262.20
Annual reduction in CO_2 emissions from power generation (tonnes)	148,266.05
Reduction in peak demand based on 2008 value	1.96%

Source: University of the West Indies, Engineering Institute 2009

Table 2: Possible Savings for a Typical Domestic Customer in Trinidad and Tobago from Replacing 10 60W Incandescent Bulbs with Equivalent Compact Fluorescent Bulbs

	10 60W incandescent bulbs	10 equivalent compact fluorescent bulbs	Savings
Bi-monthly usage (kWh)	360	90	270
Bi-monthly bill at $0.25/kWh	$90.00	$22.50	$67.50
Annual bill for lighting	$540.00	$135.00	$405.00
Annual CO_2 emissions per customer from power generation for lighting (tonnes)	1.5962669	0.3990667	1.1972001
Aggregate annual lighting bill for 314,480 domestic customers	$169,819,200.00	$42,454,800.00	$127,364,400.00
Aggregate annual CO_2 emissions from power generation for lighting (tonnes)	501,994.00	125,498.50	376,495.50

Source: University of the West Indies, Engineering Institute 2009

Table 3: Possible Savings for a Typical Domestic Customer in Trinidad and Tobago from Replacing Standard Appliances with ENERGY STAR® Qualified Ones

	Standard Appliances	ENERGY STAR® Appliances	Savings
Bi-monthly usage (kWh)	1129.4	951.95	177.45
Bi-monthly bill at $0.25/kWh	$282.35	$237.99	$67.50
Annual bill	$1,694.10	$1,427.93	$266.18
Annual CO_2 emissions per customer from power generation (tonnes)	5.007844	4.221017	0.7868265
Aggregate annual bill for 314,480 domestic customers	$532,760,568.00	$449,053,854.00	$83,706,714
Aggregate annual CO_2 emissions from power generation (tonnes)	1,574,866.73	1,327,425.52	247,441.21

Source: University of the West Indies, Engineering Institute 2009